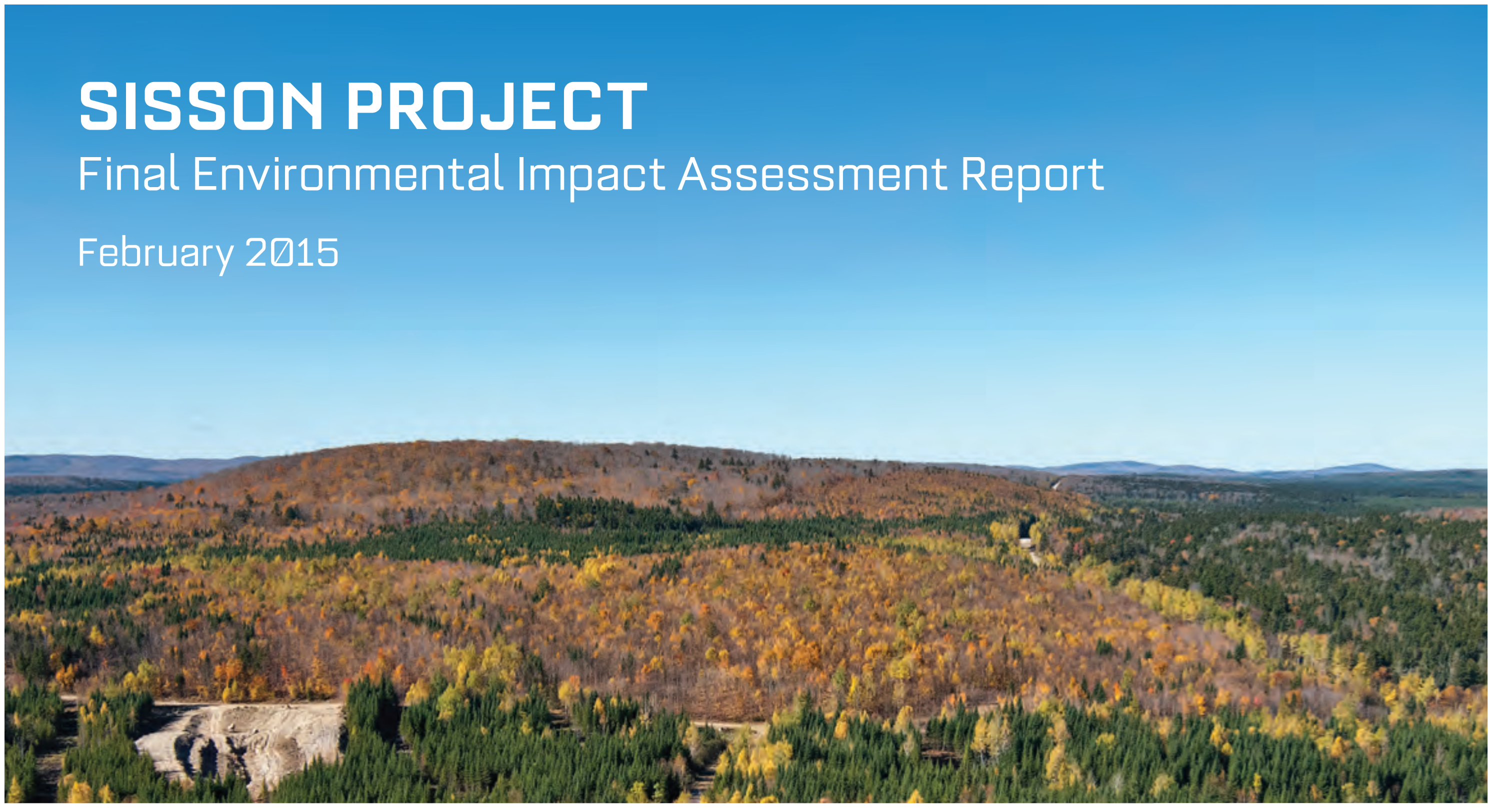
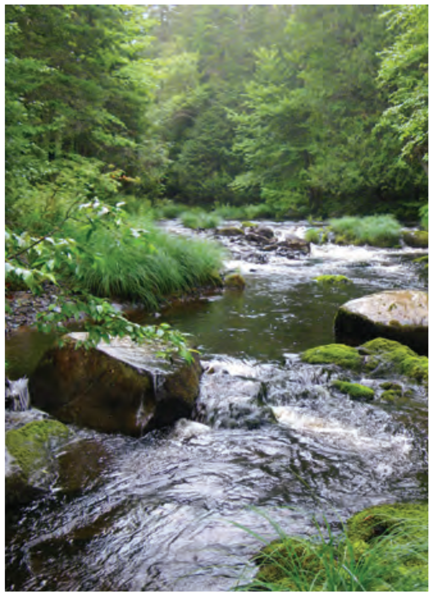
SISSON PROJECT

Final Environmental Impact Assessment Report

February 2015



Volume 1



Prepared For:

Sisson Mines Ltd.
15th Floor - 1040 West Georgia Street
Vancouver, BC V6E 4H1

THE SISSON PARTNERSHIP

Prepared By:

Stantec Consulting Ltd.
845 Prospect Street
Fredericton, NB E3B 2T7

Stantec

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Volume 1

Volume 2

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TABLE OF CONTENTS (VOLUME 1)

LIST OF TABLES (VOLUME 1)

LIST OF FIGURES (VOLUME 1)

ABOUT THIS DOCUMENT

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The information provided in this report was compiled from existing documents, data collected during field studies carried out in support of the EIA, and data provided by SML and by applying currently accepted industry standard mitigation and prevention principles. This report represents the best professional judgment of Stantec personnel available at the time of its preparation. Stantec reserves the right to modify the contents of this report, in whole or in part, to reflect any new information that becomes available. If any conditions become apparent that differ significantly from our understanding of conditions as presented in this report, we request that we be notified immediately to reassess the conclusions provided herein.

This document is the Final Environmental Impact Assessment (EIA) Report for the Sisson Project (the Project), pursuant to the New Brunswick *Environmental Impact Assessment Regulation – Clean Environment Act*. It has been translated from its original English version by the firm BeTranslated (www.betranslated.com). The English version of this report constitutes the official version. In the event of conflict between the English and French versions, the English version shall prevail.

Ce document est le Rapport final de l’évaluation de l’impact sur l’environnement (ÉIE) du Projet Sisson (le Projet), en vertu du *Règlement sur les études d’impact sur l’environnement* du Nouveau-Brunswick – *Loi sur l’assainissement de l’environnement*. Ce document a été traduit de sa version originale anglaise par la firme BeTranslated (www.betranslated.com). La version anglaise de ce rapport constitue la version officielle. En cas de conflit entre la version française et la version anglaise, la version anglaise prévaudra.

ABOUT THE PROPONENT

After submission of the Sisson Project EIA Report to governments in July 2013, Northcliff Resources Ltd. and Todd Minerals Ltd. entered into a limited partnership agreement to advance the development of the Sisson Project. As a result of this agreement, the Sisson Project is now being developed and advanced by Sisson Mines Ltd., on behalf, and as general partner, of the Sisson Project Limited Partnership. Thus, the Proponent of the Sisson Project is now Sisson Mines Ltd., and all references to Northcliff Resources Ltd. (Northcliff) in this document can be read as referring to Sisson Mines Ltd.

EXECUTIVE SUMMARY

This is the Final Environmental Impact Assessment (EIA) Report for the Sisson Project ("the Project") proposed by Sisson Mines Ltd. ("SML", "the Proponent"). After submission of the Sisson Project EIA Report to governments in July 2013, Northcliff Resources Ltd. (the Proponent at the time) and Todd Minerals Ltd. entered into a limited partnership agreement to advance the development of the Sisson Project. As a result of this agreement, the Sisson Project is now being developed and advanced by Sisson Mines Ltd., on behalf, and as general partner, of the Sisson Project Limited Partnership. Thus, the Proponent of the Sisson Project is now Sisson Mines Ltd., and any references to Northcliff Resources Ltd. (Northcliff) in this document can be read as referring to Sisson Mines Ltd.

The Sisson Project involves the development of a tungsten and molybdenum open pit mine, ore processing and associated facilities and infrastructure near Napadogan, in central New Brunswick. An environmental impact assessment (EIA) of the Project is required under the *Canadian Environmental Assessment Act* (*CEAA*) as well as under the New Brunswick *Environmental Impact Assessment Regulation–Clean Environment Act* (EIA Regulation). For the purpose of the provincial EIA process, this final version of the EIA Report supersedes the July 2013 version of this report (Stantec 2013g) submitted to both the provincial and federal governments for review. The July 2013 version remains the official version of the EIA Report for the purpose of the federal environmental assessment under *CEAA*.

The purpose of the EIA Report is to document the results of the EIA required to satisfy the requirements of *CEAA* and the EIA Regulation. The EIA Report describes the Project and its potential environmental effects, as well as measures to avoid or minimize environmental effects, through construction, operation, and closure of the Project. The significance of potential environmental effects (including cumulative environmental effects) of the Project is assessed, and methods for avoiding or minimizing adverse environmental effects that may result from the Project and for capturing environmental benefits are identified. The report recommends a follow-up and monitoring program as and where appropriate.

The scope of the Project is the construction, operation, and decommissioning, reclamation and closure of the Sisson Project mine, ore processing and associated facilities and infrastructure.

The Sisson Project Site

The Sisson Project site is on provincial Crown land in a sparsely populated rural area of Central New Brunswick, approximately 10 km southwest of the community of Napadogan and approximately 60 km directly northwest of the City of Fredericton (Figure E.1). The Project area is generally rolling, forested upland; small lakes and wetlands are common in low-lying areas. The Project site is drained by small headwater brooks, primarily Bird and Sisson brooks, to Napadogan Brook and then to the Nashwaak and the St. John rivers. Wildlife populations are like those in the rest of Central New Brunswick. Brook trout and several other species of fish are common in brooks in and around the site, and Atlantic salmon have been identified in Napadogan Brook.

Land use in the vicinity of the Project is dominated by forest resource harvesting, and the site is well serviced with forestry roads connected to the provincial highway system. Land uses also include hunting, fishing, and other outdoor recreational activities. There are about 39 recreational campsite leases (including cabins) nearby, the nearest of which is about 1.5 km to the east of the proposed open pit location. The nearest permanent residence is in Napadogan. The land and resources in the Project area are reported to be currently used for traditional purposes by Maliseet First Nations people.

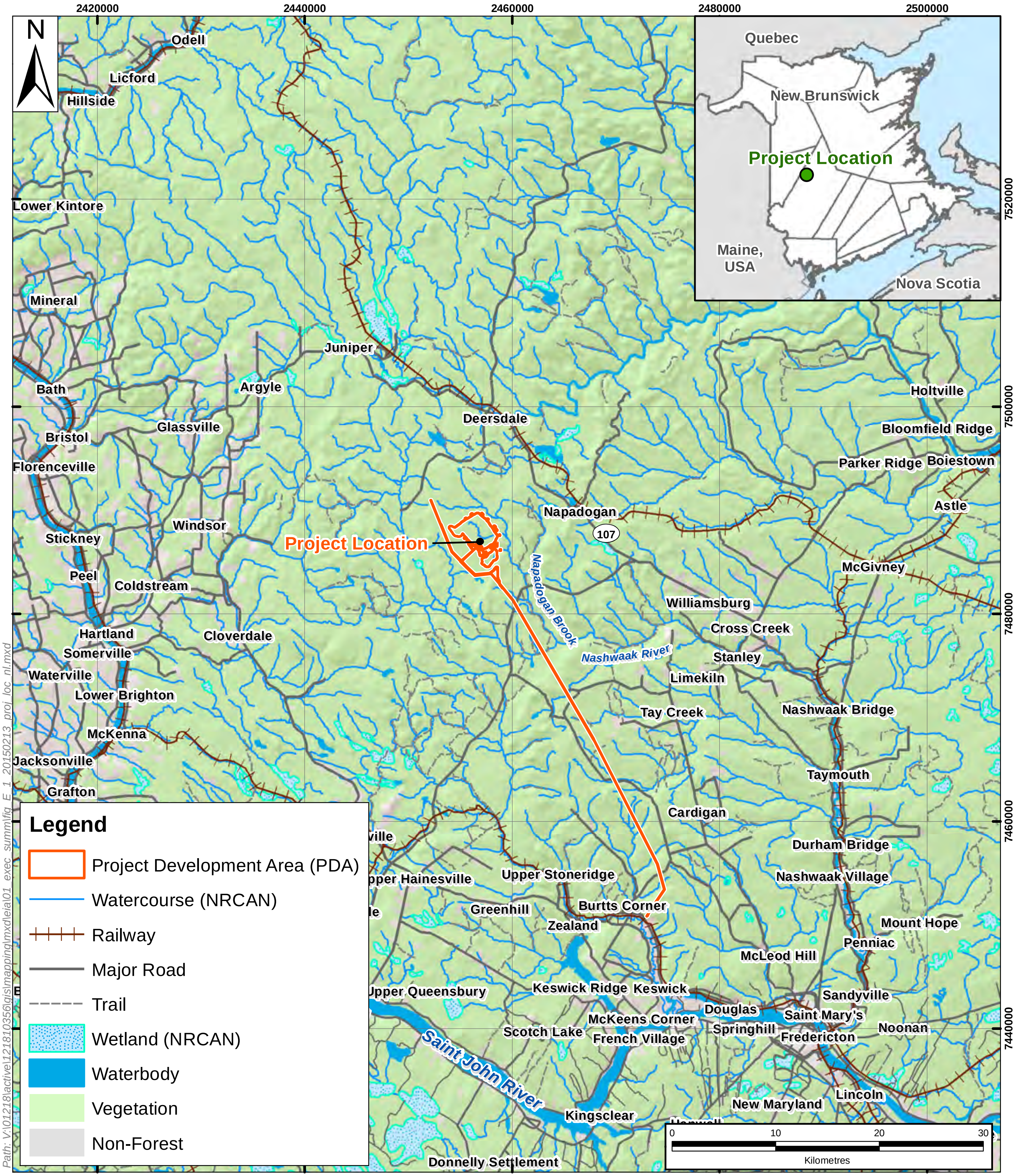
Project Description

Following an approximate two-year construction period, the Sisson Project will operate for about 27 years after which it will be decommissioned, and the site will be reclaimed and closed. The capital cost of the Project is estimated at C$579 million, and the expenditures for the entire period of Operation are estimated at C$3,730 million. The Project will create up to 500 direct jobs at the peak of Construction and up to 300 direct full-time jobs over its operating life.

The Sisson mineral deposit is near surface and thus is only suitable for open pit mining. An average of 30,000 tonnes per day of ore will be mined by conventional drilling, blasting and hauling methods, then crushed and conveyed to an on-site ore processing plant. The ore will be processed to tungsten and molybdenum concentrates using conventional flotation technology. The tungsten concentrate will be further refined on-site to produce a higher value crystalline tungsten product, ammonium paratungstate (APT). The APT plant design is based on proven metallurgical and chemical processes, using alkali pressure leach technology, in a series of continuous and batch operations. The final mineral products will be packaged and trucked off-site to rail facilities or directly to markets. A new electrical transmission line from the Keswick terminal will be constructed by NB Power to supply the Project with electricity.

Mine waste rock and process tailings (*i.e.,* fine ground host rock remaining after mineral removal, in a water slurry) will be stored in a tailings storage facility (TSF), along with wastes from the APT plant. All waste rock and APT waste, as well as potentially acid generating tailings, will be stored sub-aqueously in the TSF to effectively mitigate the potential onset of acid generation. The TSF embankments will be constructed of non-potentially acid generating rock quarried on-site. The embankments are designed to exceed the requirements set forth in the Canadian Dam Association's "Dam Safety Guidelines", and in so doing, will readily withstand extreme storm events and earthquakes.

Except for a small amount of fresh water supplied by wells, all Project water requirements will be met by re-using surface and groundwater collected on-site and stored in the TSF. The water management systems include open pit dewatering, water management ponds (WMPs) to collect TSF embankment run-off and seepage for pump-back to the TSF, and engineered drainage channels to either divert clean water away from Project facilities or to collect "mine contact" water for Project use. Wells will be developed below the WMPs to monitor groundwater quality and, if necessary to ensure acceptable water quality downstream, pump it back to the TSF. Tailings "beaches" will be developed around the inside perimeter of the TSF to keep the supernatant pond away from the embankments. Water in the pond will be recycled to the process plant and returned with the tailings. About eight years into Operation, the Project will have a surplus of water which will be treated as needed to meet discharge permit requirements and then discharged to the natural environment via the former Sisson Brook channel.



NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Project Location

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Sisson Mines Ltd.

Scale: 1:500,000

Project No.: 121810356

Data Sources:
SNB
NRCAN, ESRI

Fig. No.: E.1

Date: (dd/mm/yyyy) 13/02/2015

Dwn. By: JAB

Appd. By: DLM

Map: NAD83 CSRS NB Double Stereographic

At Closure, drainage from the TSF will be routed to the open pit, which will fill in about 12 years. After this, the level of the pit lake will be maintained at an elevation that ensures groundwater only flows into it; surplus water will be treated as necessary before discharge. This practice will continue for as long as is necessary to ensure acceptable discharge water quality. When the pit lake can be directly discharged without treatment, treatment will cease, and the lake level will be allowed to rise so that it drains naturally to the former Sisson Brook channel. A decommissioning, reclamation and closure plan been developed, and the cost of a financial security to ensure acceptable closure at any stage of the Project life is included in the Project costing.

Project facilities will permanently take up parts of the watersheds of the small brooks draining the site. Since some water is trapped in the tailings voids within the TSF during Operation, there will be downstream flow reductions until the open pit is filled during Project Closure. A plan to offset for lost fish habitat and the consequent environmental effects on fish habitat must be approved under the federal *Fisheries Act* before the Project can proceed; a fish habitat offsetting plan has been developed and is included in the estimated Project cost. Similarly, a compensation plan for wetland losses must be approved under the New Brunswick *Clean Water Act* before the Project can proceed.

Reclamation Cost Estimate

The estimated costs for closure and reclamation throughout the mine life will increase over time. It is proposed that the bonding requirement be reviewed on a five-year “look forward” basis once the mill reaches full production and be adjusted as required.

The estimated maximum bonding requirement is $9 million at the start of construction (*i.e.*, beginning of Year -2), at $49.8 million at the commencement of full production (*i.e.*, beginning of Year 2), and at $65.3 million at the end of the estimated life of the mine after 27 years. Note that no discount or interest rate was utilized for estimating the bonding requirements for each of these periods. Note also that these estimates are subject to change as further discussions are carried out on the planned reclamation and closure approach, in concert with the approval of the Project under the *Mining Act*.

The closure bonding requirement generally increases over the mine life as additional development takes place and the Project footprint expands, which requires additional reclamation work and greater water treatment capacity.

The principal reclamation work areas included in the cost estimate were the TSF (including the contained barren rock and mid-grade ore), infrastructure decommissioning, and ongoing post-Closure monitoring and reclamation activities.

Environmental Management

The potential environmental issues to be addressed in the EIA of the Sisson Project have been comprehensively determined by the governments of New Brunswick and Canada, and have been further refined through engagement of the public, key stakeholders, and First Nations during the conduct of the EIA. The Final Guidelines for the EIA were approved by the Province of New Brunswick in March 2009 after consultation with the public, stakeholders, and the Aboriginal community. After similar consultation, in April 2012, the governments of New Brunswick and Canada approved the Terms of Reference for the EIA that define the specific requirements of both the provincial and federal EIA processes. Together, the Final Guidelines and the Terms of Reference define the scope of the Project, factors to be considered, and the scope of factors to be considered in the EIA to meet *CEAA* and the EIA Regulation, which culminated in the submission of the Sisson Project Environmental Impact Assessment (EIA) Report to the federal and provincial governments in July 2013 (Stantec 2013g). For the purpose of the provincial EIA process, this final version of the EIA Report supersedes the July 2013 version of this report (Stantec 2013g) submitted to both the provincial and federal governments for review. The July 2013 version remains the official version of the EIA Report for the purpose of the federal environmental assessment under *CEAA*.

The planning and design of the Sisson Project has incorporated several features to avoid or minimize potential adverse environmental effects, and to respond positively to the principles of sustainable development and the precautionary approach. Key features of the Project include the following.

- The configuration of the open pit has been optimized to maximize the recovery of ore from the Sisson deposit while minimizing its footprint.
- The ore processing plant, TSF, and associated facilities are all sited within a single watershed, Napadogan Brook, for maximum effectiveness of responsible water management and ultimate closure of the project.
- The TSF has been designed to exceed the safety requirements of Canadian Dam Association guidelines.
- The TSF has been sited to avoid waterbodies to the extent possible, and its proposed location avoids disturbing lakes in the area, some of which support recreational fisheries. The size and configuration of the TSF have been optimized to avoid unnecessary disturbance or destruction of fish habitat as well as areas having concentrations of sites with elevated archaeological potential.
- All potentially acid generating tailings will be stored sub-aqueously in the TSF to effectively mitigate the potential onset of acid generation. For the same reason, all waste rock (some of which is potentially acid generating) will be stored sub-aqueously in the TSF rather than in a separate waste rock storage area on the land surface.
- No waste rock will be used to build the TSF embankments, since some of it is potentially acid generating. Instead, a quarry will be developed on-site to provide non-potentially acid generating rock for the embankments.
- APT will be produced on-site as an added-value end product, thereby enhancing job creation and economic benefits for the people of New Brunswick and Canada.

SML has developed a framework Environmental and Social Management System (ESMS) for the Sisson Project. The framework ESMS provides an outline of various environmental and social management plans, policies and procedures, and describes their implementation schedule and responsibilities. The ESMS is an operational document to ensure implementation of the commitments and mitigation strategies identified in the EIA Report, and to otherwise meet SML's "Principles of Responsible Mineral Development". The ESMS will become more developed and detailed as the

Project progresses through detailed design and permitting, and will be updated as required for continuous improvement over the life of the Project.

Key elements of the ESMS include:

- an site-specific Environmental Protection Plan (EPP) for construction that will be developed and submitted to the appropriate regulatory agencies for review and approval prior to the commencement of construction;
- an Emergency Preparedness and Response Plan (EPRP) for all phases of the Project;
- specific operational plans for the management of, for example, water and air quality, land and biodiversity, hazardous materials and waste, noise, community health and safety, cultural heritage, and EIA follow-up and environmental effects monitoring; and
- a Public, Stakeholder, and First Nations Engagement Plan to ensure the effective continuation of SML's engagement activities with the public, First Nations and stakeholder groups through all phases of the Project. These activities include a proposed Community Liaison Committee with a Follow-up and Monitoring Subcommittee.

Environmental Effects Assessment

Project interactions with all Valued Environmental Components (VECs) prescribed in the Terms of Reference were analyzed to determine the potential environmental effects associated with Project components and activities. Fourteen VECs were identified as relevant and important to the EIA of the Project. The analysis of potential environmental effects of the Project on each VEC was carried out for all Project phases, including the cumulative environmental effects of the Project in combination with other projects or activities that have been or will be carried out. These analyses were based on thresholds of significance that were defined in the Terms of Reference within appropriate boundaries for the assessment. The environmental effects of potential credible accidents, malfunctions and unplanned events were also assessed, as were the effects of the environment on the Project. The analysis used qualitative and, where possible, quantitative information available from existing knowledge and appropriate analytical tools, as well as considering identified mitigation measures. To eliminate or reduce any anticipated environmental effects, mitigation measures were incorporated into the Project design.

Residual environmental effects were predicted for VECs following the application of planned mitigation measures. The residual environmental effects of each Project phase were evaluated as either not significant ("NS"), significant ("S", with likelihood of occurrence identified in such cases), or positive ("P"), based on thresholds of significance previously defined in the Terms of Reference. The significance of residual environmental effects, as determined for each of the VECs, is summarized in Table E.1 below.

Table E.1 Summary of the Significance of Residual Environmental Effects

Valued Environmental Component (VEC)	Project Phase			Accidents, Malfunctions and Unplanned Events	Project Overall
	Construction	Operation	Decommissioning, Reclamation and Closure		
Atmospheric Environment	NS	NS	NS	NS	NS
Acoustic Environment	NS	NS	NS	NS	NS
Water Resources	NS	NS	NS	NS	NS
Aquatic Environment	NS	NS	NS	NS	NS
Terrestrial Environment	NS	NS	NS	S/U (SAR only) NS (all others)	NS
Vegetated Environment	NS	NS	NS	NS	NS
Wetland Environment	NS	NS	NS	NS	NS
Public Health and Safety	NS	NS	NS	S/U	NS
Labour and Economy	NS	NS/P	NS	NS	NS/P
Community Services and Infrastructure	NS	NS	NS	NS	NS
Land and Resource Use	NS	NS	NS	NS	NS
Current Use of Land and Resources for Traditional Purposes by Aboriginal Persons	NS	NS	NS	NS	NS
Heritage Resources	NS	NS	NS	NS	NS
Transportation	NS	NS	NS	NS	NS
Effects of the Environment on the Project	NS	NS	NS	NS	NS

Notes:
NS = Not Significant Residual Environmental Effect Predicted.
S = Significant Residual Environmental Effect Predicted.
L = Residual Environmental Effect is Likely to Occur.
U = Residual Environmental Effect is Unlikely to Occur.
P = Positive Residual Environmental Effect Predicted.
SAR = Species at Risk.

The EIA determined that there would be no significant adverse residual environmental effects from the Sisson Project during all phases and in consideration of normal Project activities. Positive environmental effects were predicted for Labour and Economy, specifically for employment, incomes and government revenues, during both the Construction and Operation phases. Effects of the environment on the Project were predicted to be not significant due to the engineering design of Project components that incorporates factors of safety and other mitigation strategies to minimize the likelihood of a significant adverse effect of the environment on the Project. The potential residual environmental effects of Accidents, Malfunctions and Unplanned Events were also found to be not significant for the most part. The EIA determined that the only potentially significant environmental effects due to such events would be if a Project-related fire put the life and/or health of the public and/or Project employees in immediate danger, or if a Project-related fire or vehicle collision resulted in the death of listed species at risk (SAR). These environmental effects were predicted to be highly unlikely to occur. A major failure of containment in the tailings storage facility was determined to be extremely unlikely to occur, with an annual probability of occurrence of 1-in-1 million to 1-in-10 million, though if it did occur the environmental effects of such an event would likely be significant, especially for the Aquatic Environment.

Cumulative environmental effects that can result from the Project in combination with other past, present or reasonably foreseeable future projects or activities were also assessed. Project management and mitigation measures will be applied as part of the Project, such that the potential environmental effects of the Project in combination with other projects or activities that have been or will be carried out are rated not significant.

Follow-up and Monitoring

An appropriate follow-up program has been developed to verify the predictions of this EIA Report and to verify the effectiveness of mitigation. As well, monitoring measures have been developed to measure compliance with regulatory requirements, and to assist in the identification of adaptive management measures as necessary to avoid or minimize potentially significant adverse environmental effects should they be found to occur.

Conclusion

Overall, the EIA concluded that, with planned mitigation and the implementation of best practices to avoid or minimize adverse environmental effects, the residual environmental effects of the Project, including cumulative environmental effects and the effects of the environment on the Project, during all phases are rated not significant, except in the event of certain worse-case credible Accidents, Malfunctions and Unplanned Events, for which some environmental effects could be significant but are highly unlikely to occur.

1.0 INTRODUCTION

This document is the Environmental Impact Assessment (EIA) Report for the Sisson Project ("the Project") proposed by Sisson Mines Ltd. ("SML", "the Proponent"). After submission of the Sisson Project EIA Report to governments in July 2013, Northcliff Resources Ltd. (the Proponent at the time) and Todd Minerals Ltd. entered into a limited partnership agreement to advance the development of the Sisson Project. As a result of this agreement, the Sisson Project is now being developed and advanced by Sisson Mines Ltd., on behalf, and as general partner, of the Sisson Project Limited Partnership. Thus, the Proponent of the Sisson Project is now Sisson Mines Ltd., and any references to Northcliff Resources Ltd. (Northcliff) in this document can be read as referring to Sisson Mines Ltd.

The Sisson Project involves the development of a tungsten and molybdenum mine near Napadogan, approximately 60 km directly northwest of Fredericton, in central New Brunswick. An EIA of the Project is required under the *Canadian Environmental Assessment Act* (*CEAA*) as well as under the New Brunswick *Environmental Impact Assessment Regulation–Clean Environment Act* (the "EIA Regulation"). Though the former *CEAA* was repealed in 2012 and replaced with the new *Canadian Environmental Assessment Act, 2012 ("CEAA 2012")*, any environmental assessments at the comprehensive study level that had begun under the former Act (like the Sisson Project) would continue under the former Act; thus all references to the *CEAA* in this EIA Report are to the Act as it existed before the passage of *CEAA 2012*.

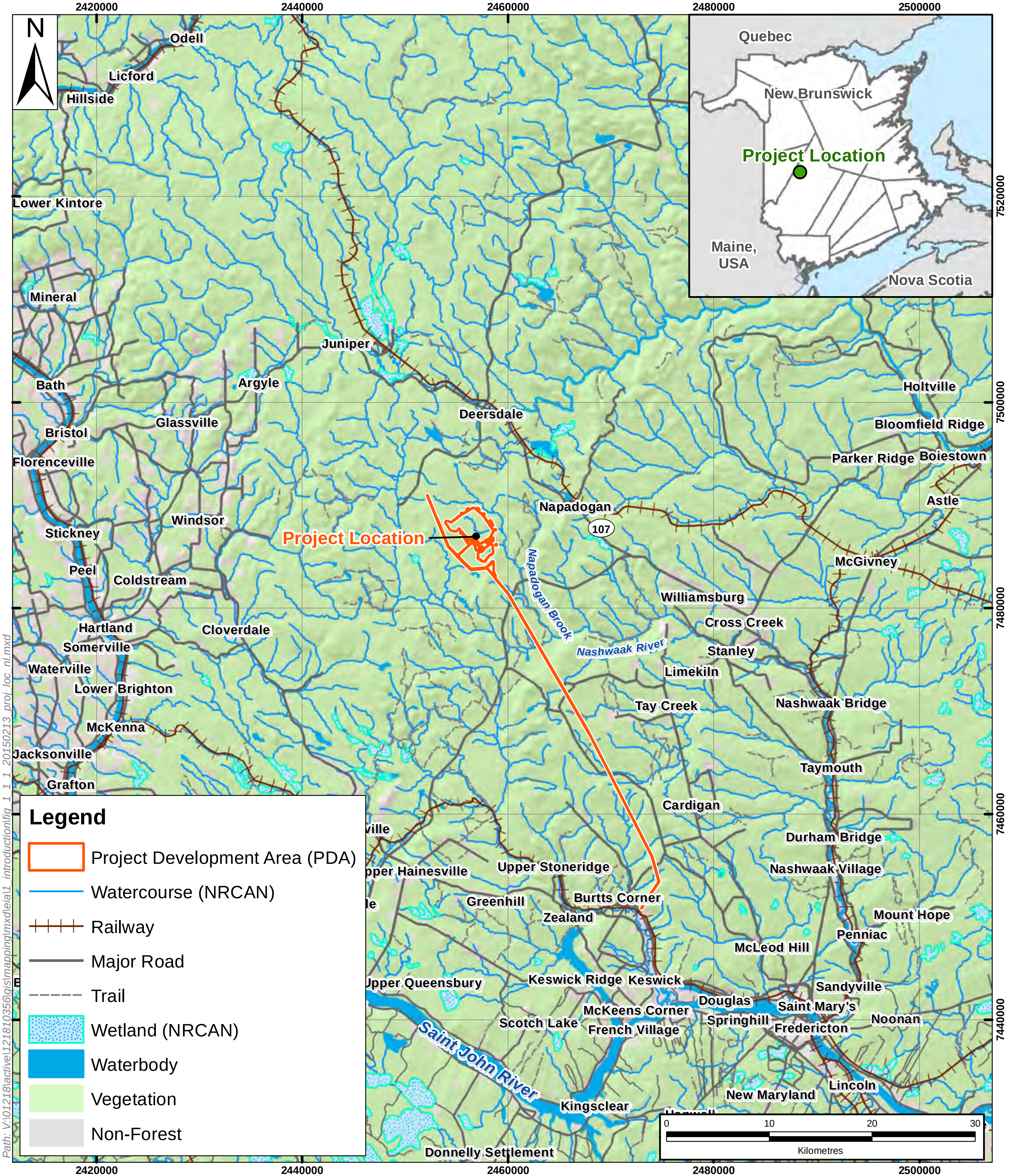
The Project location is shown in Figure 1.1.1. The Project involves the construction and operation of an open pit tungsten and molybdenum mine and associated facilities and infrastructure. An average of 30,000 tonnes per day (t/d) of ore will be extracted from the open pit, and processed in an ore processing facility to produce tungsten and molybdenum concentrates through various crushing, grinding, flotation and drying processes. Tungsten concentrate will be further refined on-site to produce a higher value crystalline tungsten product, known as ammonium paratungstate (APT). Products will be packaged and trucked to nearby rail facilities for subsequent transportation to market. Mining waste (*i.e.,* tailings and waste rock) will be stored in a tailings storage facility (TSF) along with mine contact water collected on-site and re-used in the ore processing plant. A new electrical transmission line will be constructed to supply electrical power to the mine site, and an existing transmission line and forest resource road will be relocated around the site. Following an approximate two year Construction period, the Project will operate for an estimated 27 years. Decommissioning, reclamation and closure will be conducted at the end of mining operations to restore the site to sustainable end land uses agreed with government, First Nations, and other stakeholders.

In September 2008, Geodex Minerals Ltd. (Geodex), a mineral exploration company, registered the development of the Sisson Project under the New Brunswick EIA Regulation. In October 2008, the New Brunswick Minister of Environment determined that an EIA (comprehensive review) was required. Final Guidelines for the EIA (NBENV 2009) were issued by the Minister in March 2009 after public consultation on them. Northcliff secured the mineral development rights to the Sisson ore deposit from Geodex in June 2012, and these rights were subsequently transferred to SML. The federal environmental assessment (EA) under *CEAA* was initiated by the Canadian Environmental Assessment Agency ("CEA Agency") in April 2011, as a comprehensive study. Terms of Reference for the EIA were developed jointly by Northcliff, the CEA Agency, and the New Brunswick Department of Environment and Local Government (NBDELG); were the subject of public and First Nations consultation over the August to October 2011 period; and were finalized in April 2012 (Stantec 2012a). The Terms of Reference define the scope of the project, factors to be considered, and scope of factors to be considered to fulfill the respective regulatory requirements for the provincial EIA and federal EA of the Project. A feasibility study and associated Technical Report (Samuel Engineering 2013), further environmental studies, an engagement program for stakeholders, the public and Aboriginal peoples, and other planning and development activities were conducted in parallel to the EIA, many of which are ongoing.

The Sisson Project Environmental Impact Assessment (EIA) Report (Stantec 2013g) was submitted to the federal and provincial governments for review in July 2013. Comments and information requests (IRs) on the July 2013 report were received from the provincial and federal governments, the public, and First Nations, and SML responded to those IRs between October 2013 and November 2014. This Final EIA Report has been prepared to meet the requirements of the provincial EIA Regulation, incorporating, where applicable and appropriate, the responses to IRs submitted by SML to governments. Thus, for the purpose of the provincial EIA process, this final version of the EIA Report supersedes the July 2013 version of this report (Stantec 2013g) submitted to both the provincial and federal governments for review. The July 2013 version remains the official version of the EIA Report for the purpose of the federal environmental assessment under *CEAA*.

The purpose of the EIA Report is to document the results of the EIA required to satisfy the requirements of the EIA Regulation and *CEAA*. It has been prepared by Stantec Consulting Ltd. ("Stantec") on behalf of SML, with contributions from other consultants and firms that carried out specialized studies aimed at further defining the Project, and its potential environmental effects and mitigation. The EIA Report describes the proposed Project and its potential environmental effects, as well as measures to avoid or minimize environmental effects, to mitigate or compensate for residual environmental effects as needed, and to manage potential environmental effects through Project construction, operation and closure. The report recommends a follow-up or monitoring program as appropriate.

SML is an informed and responsible proponent through its association with Hunter Dickinson Inc., a Vancouver-based mining company with a proven 25-year record of successful mineral developments throughout the world in a progressive and responsible way. To this end, SML is committed to life-of-Project environmental management as described in Chapter 2 of this EIA Report to avoid or minimize the adverse environmental effects, and to enhance the benefits of the Project. SML will carefully plan and manage all aspects of the Project from development to closure and beyond, and employ a comprehensive environmental management strategy to implement its "Principles of Responsible Mineral Development" (SML 2013; see Section 1.3.2). Throughout the planning, design and execution of the Project, SML will use a number of approaches and tools to avoid, minimize, and otherwise manage potentially adverse environmental effects, and to capture potential benefits, in a manner that promotes sustainable development for the people of New Brunswick and Canada.



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NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Project Location

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Sisson Mines Ltd.

Scale: 1:500,000

Project No.: 121810356

Data Sources: SNB NRCAN, ESRI

Fig. No.: 1.1.1

Date: (dd/mm/yyyy) 13/02/2015

Dwn. By: JAB

Appd. By: DLM

Stantec

Map: NAD83 CSRS NB Double Stereographic

1.1 PROJECT TITLE AND PROPONENT

The Project may be cited as the “Sisson Project”. The Proponent of the Project is Sisson Mines Ltd., a body corporate governed by the laws of Canada and the Province of British Columbia. The Proponent contact information is as follows:

Name of Project:	Sisson Project
Name of Proponent:	Sisson Mines Ltd.
Mailing Address of Proponent:	Head Office: 15th Floor – 1040 W. Georgia Street Vancouver, British Columbia V6E 4H8 Project Office: 47 Avonlea Court Fredericton, New Brunswick E3C 1N8
Chief Executive Officer:	Christopher Zahovskis, P.Eng. President, Chief Executive Officer, and Director
Contact Person for the EIA:	John Boyle, B.Ap.Sc., MNRM, Ph.D. Vice President, Environmental Affairs
Telephone Number:	Head Office: (604) 684-6365 Project Office: (506) 455-0530
Fax Number:	Head Office: (604) 630-0022 Project Office: (506) 455-0533
Electronic Mail Address of EIA Contact Person:	johnboyle@hdimining.com
Websites:	http://www.sissonpartnership.com http://www.northcliffresources.com

1.2 PROJECT OVERVIEW

1.2.1 About the Sisson Deposit

The Sisson ore deposit was first discovered in the late 1950s, and has been studied extensively by various exploration and development companies since that time. It is a tungsten-molybdenum deposit comprising disseminated scheelite and molybdenite occurring in sheeted and shear-hosted quartz veins associated with Devonian-aged granitic intrusions (RPA 2012). The Sisson deposit was initially defined through exploration drilling undertaken by Kidd Creek Mines from 1979-1982. Subsequent delineation drilling carried out by Geodex from 2005-2009 outlined significant mineral resources in two main zones which are open to further expansion.

Northcliff embarked on a program comprised of drilling, engineering and environmental studies over the 2010-2012 period to advance the Sisson Project through feasibility and into environmental assessment and permitting. In addition to increasing the mineral resources in the measured category, the recent drilling has supplied metallurgical, geotechnical, and hydrogeological data to support feasibility work.

The Sisson deposit hosts a large, structurally controlled, intrusion-related tungsten-molybdenum ore body that is amenable to open pit mining. Sisson has excellent potential to be a near-term metal producer, with significant capability to meet increasing tungsten demand from North American and European markets.

A recent National Instrument (NI) 43-101 compliant technical report (“the Technical Report”; Samuel Engineering 2013) states that the Sisson deposit comprises 387 million tonnes of measured and indicated resources containing 25.6 million metric tonne units (mtu) of tungsten (as WO_3) and 178 million pounds of molybdenum (Mo), and 187 million tonnes of inferred resources containing 9.41 mtu of WO_3 and 82.6 million pounds of molybdenum.

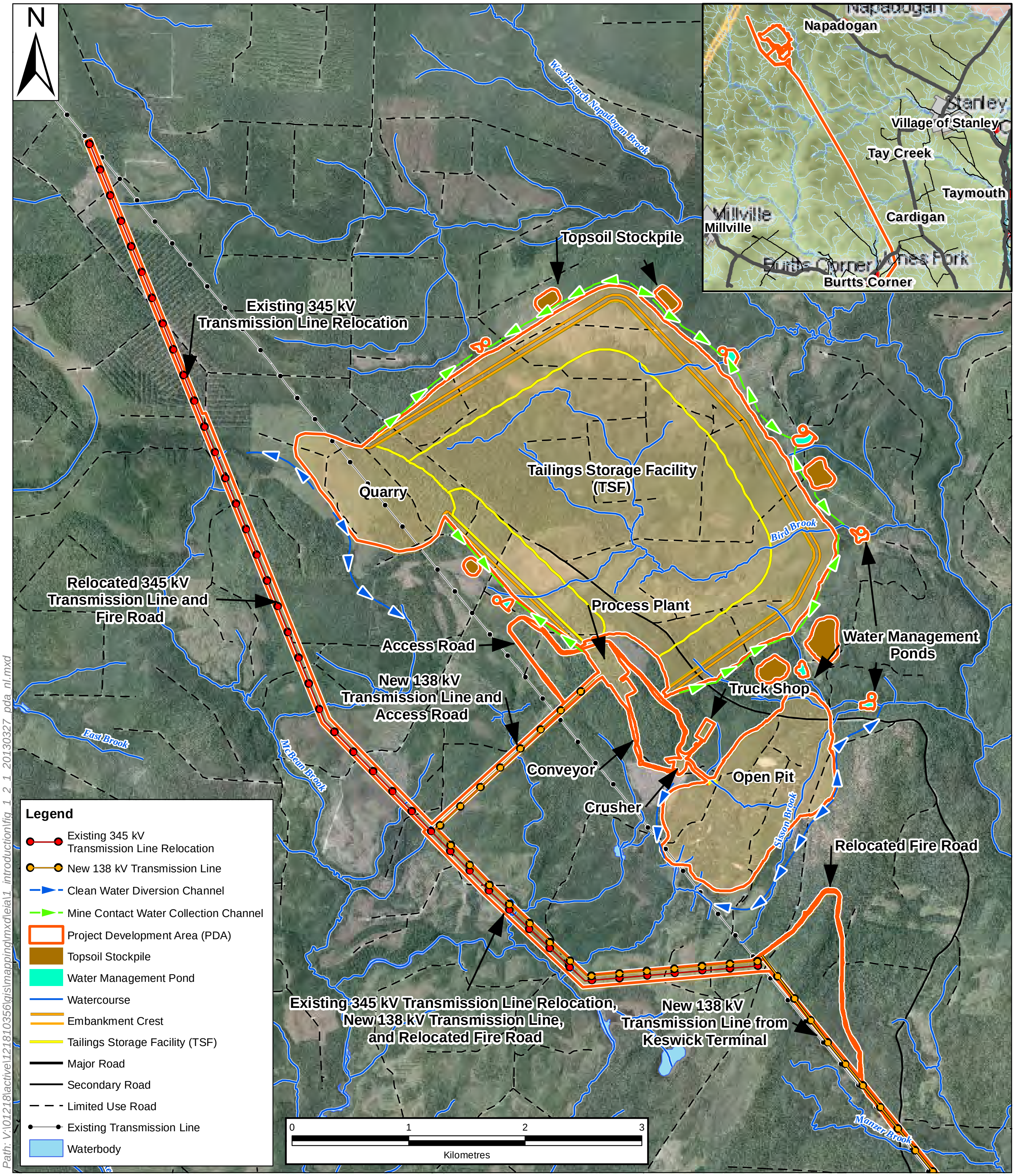
1.2.2 Project Summary and Location

The Sisson Project consists of the construction and operation of an open pit, tungsten and molybdenum mine and associated facilities by SML. The Project site is on provincial Crown land at approximately N 46º22’ by W 67º03’, approximately 10 km southwest of the community of Napadogan, New Brunswick, and approximately 60 km directly northwest of the city of Fredericton (Figure 1.1.1).

Tungsten is a steel-grey metal that is an important alloy in tool making and construction steel as it enhances hardness, cutting efficiency, and speed with a similar hardness to diamonds. Tungsten components are used in lighting technology, electronic industry, transportation, the chemical industries, glass melting industry, medical technology, power engineering, and in jewelry.

Molybdenum is an important alloy in the manufacture of stainless steel and steel. It is also an important material for the chemical and lubricant industries. Molybdenum is used in automotive parts, construction equipment, gas transmission pipes, and turbine parts.

The Project Development Area (PDA) is shown in Figure 1.2.1. The Project will involve an open pit mine and associated ore processing, waste management, and ancillary facilities. The mine will operate for approximately 27 years. Tungsten and molybdenum containing ore will be mined from the open pit at an average rate of approximately 30,000 t/d. The ore will then be processed to concentrate on-site through a series of process steps consisting of crushing, grinding, flotation, and drying. Tungsten concentrate will be further refined on-site to produce ammonium paratungstate (APT), a higher value crystalline tungsten product used in steel making and other manufacturing industries. Waste rock from the open pit, and tailings as a by-product of the ore processing operations, will be permanently stored in a tailings storage facility (TSF, also sometimes referred to as a tailings impoundment area or TIA). The mineral products will be trucked to nearby rail facilities for their subsequent transportation to customers.



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NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Project Development Area (PDA)

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Sisson Mines Ltd.

Scale: 1:45,000

Project No.: 121810356

Data Sources: SNB NRCAN, ESRI

Fig. No.: 1.2.1

Date: (dd/mm/yyyy) 23/11/2014

Dwn. By: JAB

Appd. By: DLM

Stantec

Map: NAD83 CSRS NB Double Stereographic

Organics and overburden material removed during Construction of the Project will be stockpiled on-site for later use in site reclamation activities during Project closure. Engineered diversion channels will keep clean surface runoff water away from mining, processing and waste storage areas. Precipitation falling on the Project site and dewatering from the open pit (referred to as “mine contact water”) will be collected, stored in the TSF and used in Project operations, or released to the environment following treatment as necessary. Water management ponds located around the TSF and downgradient of the Project site (Figure 1.2.1) will collect mine contact run-off water or seepage for return to the TSF to be stored and re-used. Any surplus water from the TSF will be treated, if necessary, and discharged to natural drainages. Other than groundwater wells to supply fresh water for domestic uses and other purposes (*e.g.,* dust suppression, fire suppression, process make-up water), no sources of water beyond precipitation falling on the Project site will be required for Operation of the Project.

The open pit location is fixed based on the location of ore body; its development will intersect a portion of Sisson Brook which will be permanently lost as a consequence (Figure 1.2.1). Additionally, the construction of the TSF will involve the loss of portions of Bird and Sisson brooks, and of a small tributary to the West Branch Napadogan Brook. The configuration and location of the TSF has been the subject of design and siting considerations that have reduced the overall potential environmental consequences on streams.

A new 138 kV electrical transmission line to be built and operated by the New Brunswick Power Corporation (NB Power) will be constructed to supply up to 50 megawatts (MW) of electrical power to the Project site. The 138 kV transmission line will be constructed alongside an existing 345 kV transmission line that currently crosses the Project site (Figure 1.2.1), by widening the existing 50 m-wide transmission line corridor by a further 25 m to accommodate the new transmission line. The new transmission line will originate at the Keswick Terminal operated by NB Power, 42 km southeast of the Project location, and will terminate at the Sisson mine site. As the existing 345 kV transmission line and an existing forest resource road (*i.e.,* the Fire Road) are currently situated within or too close to Project facilities, these linear facilities will be relocated to the southwest of their current location for an estimated 12 linear km.

At the end of mining, decommissioning, reclamation and closure will occur to restore the site to near natural conditions and to meet end land uses agreed with the New Brunswick government. At closure, the water management system will be re-configured to ensure that all water discharged from the site is monitored and, as needed, treated to meet applicable water quality standards for as long as is required. The Project will generate employment and positive economic activity in the area during its lifespan. The capital cost of the Project is estimated at C$579 million (Samuel Engineering 2013), and the projected expenditures for the entire period of operation of the Project are estimated at C$3,730 million (EcoTec 2013). The Project will create up to 500 direct jobs during the Construction phase and up to 300 direct full-time jobs over its operating lifespan (Samuel Engineering 2013). Local contractors and Aboriginal firms will be preferred for site contract work where qualified companies and suppliers can be identified.

1.2.3 Project Schedule

Construction of the Project is estimated to take approximately 24 months following approval of the EIA and the receipt of required permits, approvals, and other forms of authorization. Operation of the Project will be initiated upon completion of construction activities, and will continue for an estimated 27 years, after which Decommissioning, Reclamation and Closure will be initiated. The approximate Project schedule, with estimates for 2014 and beyond, is summarized as follows:

- Complete Feasibility Study: first quarter of 2013.
- Submit EIA Report to federal and provincial governments: July 2013.
- Submit Final EIA Report to the Government of New Brunswick: November 2014.
- EIA/EA decisions received: expected by mid-2015.
- Complete initial permitting, approvals and authorizations: expected in second half of 2015.
- Conduct public and stakeholder consultation, and Aboriginal engagement: throughout the EIA process and the life of the Project.
- Construction: expected to begin in second half of 2015.
- Commissioning and Operation: commencing immediately following Construction, and continuing for approximately 27 years or until the mineral resource is depleted.

The Project schedule is subject to regulatory timelines that are not controlled by SML; therefore, the schedule outlined above is subject to change as the EIA review, approval and permitting processes unfold. The timing of Construction activities will take seasonal restrictions for environmental “windows” into account (*e.g.,* no clearing May through August during critical bird breeding seasons; no in-water work outside the June 1-September 30 window except as may be permitted by DFO). The initiation of construction also depends on financing of the construction costs and a decision by the Sisson Project Limited Partnership to proceed with the Project.

1.3 PROJECT APPROACH AND COMMITMENTS

SML recognizes that the Napadogan area is a rural and relatively undeveloped area of Central New Brunswick. The area has a long history of natural resource development and use, particularly in support of extensive forest resource harvesting activities which have been central to the New Brunswick economy for over a century and are dominant at the landscape level. Mining will be a new natural resource-based development in the Napadogan area, but is well-known elsewhere in the province. While the area is important for resource-based economic activities, SML recognizes that it is also important for hunting, fishing, and outdoor recreation undertaken by the people of New Brunswick, and is integral to the ecology of the Nashwaak and St. John River watersheds. It also lies within the traditional territory of the Maliseet First Nations.

As described in Chapters 2 and 3 of this EIA Report, SML is committed to meet or exceed regulatory requirements, as well as international best practice and its corporate "Principles of Responsible Mineral Development", in the planning, design, management, Construction, Operation, and Decommissioning, Reclamation and Closure of the Project. This includes a commitment to:

- provide governance and oversight of the Project by an experienced and qualified Management team and Board of Directors, who ensure that the Project is developed responsibly for the benefit of shareholders, partners, communities and governments;
- carry out a world-class environmental impact assessment of the Project by an expert team of engineers, scientists, and other subject-matter professionals to ensure that the Project is planned and developed responsibly;
- implement Project planning, design and management strategies that avoid or mitigate potentially adverse environmental effects of the Project, and that enhance positive effects, in a manner that complies with all laws and regulations while supporting the way of life that the people of central New Brunswick know and enjoy;
- engage the public, stakeholders, and Aboriginal communities in a sustained and meaningful way so as to share information about the Project, to address issues and concerns, and to maximize local participation in, and benefits from, the Project; and
- plan and execute the Project in a manner that promotes sustainable development, applies precaution in areas of uncertainty, and enhances the benefits of the Project and of the EIA process itself for Canadians. This includes especially protecting surface water, groundwater and aquatic resources; implementing technically proven and economically feasible components and technologies; minimizing the Project footprint; and designing the Project for closure.

1.3.1 Project Team

Northcliff/SML assembled a world-class team of scientists, engineers, and subject-matter experts in developing the Sisson Project. The Project Team assembled to complete the planning and design of the Sisson Project is shown in Table 1.3.1.

Table 1.3.1 Project Team – Sisson Project

Name of Firm	Lead Office Location	Role
Stantec Consulting Ltd.	Fredericton, New Brunswick	Primary consultant for the EIA and related environmental studies.
Knight Piésold Ltd.	Vancouver, British Columbia	Geotechnical, hydrogeological, waste and water management, TSF design.
SRK Consulting	Vancouver, British Columbia	Geochemical and waste characterization, metal leaching/acid rock drainage (ML/ARD) studies.
Samuel Engineering, Inc.	Greenwood Village, Colorado	Infrastructure, civil, electrical, and mechanical engineering, and compiling the feasibility study.
Moose Mountain Technical Services	Calgary, Alberta	Mine design and production planning.
Bolu Consulting Engineering Inc.	Vancouver, British Columbia	Process design, and design of metallurgical test program.
SGS Canada Inc.	Lakefield, Ontario	Metallurgical testing.

Table 1.3.1 Project Team – Sisson Project

Name of Firm	Lead Office Location	Role
EcoTec Consultants	Québec City, Québec	Economic modelling of benefits to local and regional economies.
Wade Locke Economic Consulting	St. John's, Newfoundland and Labrador	External peer review of economic modelling.
exp Services Inc.	Fredericton, New Brunswick	Road transportation study in support of the EIA.
Jacobs Minerals Canada Inc.	Toronto, Ontario	Value and basic engineering.

1.3.2 Principles of Responsible Mineral Development

SML is committed to working with governments, the public, stakeholders and First Nations to achieve the responsible development of the Sisson Project, and to contribute to the sustainable development of the communities in which it works. These commitments are embodied in SML's "Principles of Responsible Mineral Development" (SML 2013) shown in Figure 1.3.1.

1.3.3 Project Governance and Oversight

The Sisson Project is owned by the Sisson Project Limited Partnership (SPLP), a limited partnership between Northcliff Resources Ltd. (88.5%) and Todd Corporation (11.5%). Governance and management of all aspects of the Project is the responsibility of Sisson Mines Ltd. (SML), the General Partner of the SPLP. SML is controlled by Northcliff subject to certain limits in the shareholders agreements between Northcliff and Todd. Activities carried out and managed by SML are governed by policies and procedures that parallel Northcliff's "Corporate Governance Policies and Procedures Manual" (Northcliff 2012b) and Code of Ethics.

1.3.4 Public, Stakeholder, and Aboriginal Engagement

SML is committed to engaging with the public, stakeholders and Aboriginal communities in an open, transparent, and responsive manner in respect of the Sisson Project. Specifically, SML is committed to:

- listen closely to and consider the input and interests of the public, stakeholders and Aboriginal communities in the planning phase of the Project, particularly for people whose interests may be affected;
- communicate openly, and act with honesty and integrity;
- build trust, respect and constructive relationships through responsible performance from the outset and with a long-term orientation;
- share information early and often, to a level of detail and completeness that will assist all interests to prepare and to act knowledgeably;
- provide early and adequate notice of opportunities for involvement;
- provide opportunities for information exchange and mutual education about interests, objectives and values in an open, transparent, and responsive manner;

THE SISSON PARTNERSHIP

Principles of Responsible Mineral Development

Sisson Mines Ltd. is committed to working shoulder to shoulder with stakeholders to achieve the responsible development of our projects and to contribute to the sustainable development of the communities in which we work.

All activities are guided by the following principles:

Health and Safety	We operate in a responsible manner so that our activities protect the health and safety of our employees and contractors, and of the communities in which we work.
Stakeholder Engagement	We engage with governments, communities, indigenous peoples, organizations, groups and individuals on the basis of respect, fairness, transparency, and meaningful consultation and participation.
Community Development	We establish productive local partnerships to contribute to achieving development goals identified by communities in which we work, to address local priorities and concerns, and to have communities derive substantive benefits from our activities.
Environment and Society	We apply environmental and social best management practices in the planning, design and implementation of our activities, from exploration through to closure of our mining operations. We meet or exceed regulatory requirements in the jurisdictions in which we work.
Resource Use	We use land, water and energy resources responsibly, strive to maintain the integrity and diversity of ecological systems, and apply integrated approaches to land use.
Human Rights	We respect human rights principles, as well as local cultures, customs and values, in our dealings with employees, communities and other stakeholders.
Labour Conditions	We provide fair treatment, non-discrimination and equal opportunity for our employees, and comply with labour and employment laws in the jurisdictions in which we work. We strive for excellence in relations between management and employees.

Sisson Mines Ltd. integrates these ***Principles of Responsible Mineral Development*** within our corporate management and decision-making, and we work to continually improve our performance. From project acquisitions and exploration through to mine closure, we assess the financial, social and environmental benefits and risks of our business decisions. Our goal is international best practice in all our operations, in Canada and around the world.

SISSONPARTNERSHIP.COM

Source: SML (2013)

Figure 1.3.1 SML’s Principles of Responsible Mineral Development

- satisfy all regulatory expectations and requirements for engagement and consultation; and
- positively affect the Project timeline through the development of good relationships with stakeholders.

The intent of the public, stakeholder, and Aboriginal engagement program implemented by Northcliff/SML is to contribute, through constructive dialogue, to the responsible development and implementation of the Sisson Project, meet regulatory public consultation requirements, and inform the Crown's duty to consult with Aboriginal people. Northcliff/SML provided numerous and substantive opportunities for the public, stakeholders, and Aboriginal communities to become involved in the EIA of the Project and to provide input into the scope of issues to be studied in the EIA. The means by which Northcliff/SML sought to provide opportunities for public, stakeholder and Aboriginal input into the EIA were outlined in Chapter 3 of the Terms of Reference (Stantec 2012a) and are updated and further elaborated in Chapter 4 of this EIA Report.

1.3.5 Sustainable Development and the Precautionary Approach

As defined in *CEAA,* "sustainable development" means development that meets the needs of the present, without compromising the ability of future generations to meet their own needs. The purposes of *CEAA*, as outlined in Section 4 of the Act, are to:

- *…"to ensure that projects are considered in a careful and precautionary manner before federal authorities take action in connection with them, in order to ensure that such projects do not cause significant adverse environmental effects'*
- *to encourage responsible authorities to take actions that promote sustainable development and thereby achieve or maintain a healthy environment and a healthy economy;"…*

Environmental assessment provides an effective means of integrating environmental factors into the planning and decision-making process in a manner that promotes sustainable development.

Principle 15 of the 1992 Rio Declaration on Environment and Development states that *"In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."* This principle encourages decision-makers to take a precautionary approach, especially where there is a large degree of uncertainty or risk, in order to ensure that appropriate measures are taken to avoid or minimize environmental risks. The Government of Canada's "Framework for the Application of Precaution in Science-based Decision Making About Risk" (Government of Canada 2003) guides federal decision-making in this regard.

The EIA of the Project, including the alternative means of carrying out the Project that were considered in its development, has contributed to sustainable development by ensuring that Project planning and design has been carried out in a manner that avoids or minimizes adverse environmental effects, enhances environmental and societal benefits wherever possible, and applies the precautionary approach to avoid or minimize the risk of serious or irreversible environmental impacts, in an inclusive and transparent framework for the people of New Brunswick and Canada.

To this end, the Project:

- has been examined, planned and designed in a careful and precautionary manner in order to ensure that its elements and activities required to accomplish its construction, operation, and ultimate decommissioning and closure does not cause significant, irreversible damage to the environment, adversely affect key environmental functions and integrity, or affect the human health of current or future generations (as evidenced by this EIA Report in its entirety);

- has been planned and designed (Chapters 2 and 3) to avoid or minimize the adverse environmental effects of the Project, and enhance its environmental and societal benefits (Chapter 8);

- has considered alternative means of carrying out the Project that are technically and economically feasible, and compared them in light of risk avoidance and adaptive management capacity (Section 3.3);

- has given priority to strategies that avoid the creation of adverse environmental effects, minimizes those environmental effects through design or the implementation of proven mitigation and best management practices (Chapters 2, 3 and 8);

- has described and justified assumptions made in assessing the environmental effects of the Project, and in the methods for minimizing and managing these effects (Chapters 7 and 8);

- has identified contingency plans to address potential accidents and malfunctions for the Project, despite the best planning and design or the implementation of mitigation to reduce residual environmental effects (Chapters 2 and 8, and Appendix D); and

- has proposed a follow-up program and associated monitoring activities, particularly in areas where the prediction of environmental effects of the Project lacked scientific certainty, or where monitoring to determine the effectiveness of mitigation is required, and to ensure its development is in compliance with federal and provincial laws and regulations (Chapter 9).

Specific examples of where Northcliff/SML has incorporated the principles of sustainable development and the precautionary approach in the planning and design of the Sisson Project include the following.

- The configuration of the open pit has been optimized to maximize the recovery of ore from the Sisson deposit while minimizing its footprint.

- The ore processing plant, TSF, and associated facilities are all sited within a single watershed, Napadogan Brook, for maximum effectiveness of responsible water management and ultimate closure of the project.

- The ore processing plant, TSF, and other major Project components are sited in very close proximity to the open pit location, thereby minimizing hauling and pumping distances for maximum energy efficiency.

- The TSF has been designed to exceed the requirements of Canadian Dam Association guidelines to ensure it will readily withstand the effects of extreme storm events and earthquakes.
- The TSF has been sited to avoid waterbodies to the extent possible, and its proposed location avoids disturbing lakes in the area, some of which support recreational fisheries. The size and configuration of the TSF have been optimized to avoid unnecessary disturbance or destruction of fish habitat as well as areas having concentrations of sites with elevated archaeological potential.
- All potentially acid generating process tailings will be stored sub-aqueously in the TSF to effectively mitigate the potential onset of acid generation.
- All waste rock (some of which is potentially acid generating) will be stored sub-aqueously in the TSF rather than in a separate waste rock storage area on the land surface. This conservative design feature avoids the need to collect and treat potentially acidic drainage that could otherwise occur from its storage, and minimizes potential environmental effects. Storing waste rock sub-aqueously in the TSF effectively mitigates acid generation from the rock. This element of the Project represents industry best practice.
- No waste rock will be used to build the TSF embankments since some is potentially acid generating. Instead, a quarry will be developed on-site to provide rock for the embankments which is not potentially acid generating.
- Ammonium paratungstate (APT) will be produced on-site as an added-value end product, thereby enhancing job creation and economic benefits for the people of New Brunswick and Canada.

While the mining of a non-renewable resource may be considered by some to be inherently unsustainable, the Sisson Project is a key element of a sustainable mining industry in New Brunswick that is, in turn, essential to sustaining the New Brunswick economy. *CEAA* recognizes that completing an EIA of a project like the Sisson Project contributes to achieving sustainable development and, when carried out responsibly, can contribute significantly to a sustainable economy to the benefit of the people of New Brunswick and Canada. To this end, the EIA of the Sisson Project has contributed significantly to ensuring that its development, Construction, Operation, and ultimate Decommissioning, Reclamation and Closure will not adversely affect the needs of future generations.

1.3.6 Benefits to Canadians

The Terms of Reference for this EIA Report (Stantec 2012a) require that it describe "how Canadians benefit from the project planning and information gathering process undertaken by the Proponent as part of the environmental assessment."

As a planning tool, environmental assessment is a valuable mechanism for integrating the environmental, engineering, and socioeconomic aspects of the Project, and for bringing issues and concerns raised by the public, stakeholders, and Aboriginal people into the planning, design, review, approval, and development of the Project. As a key component of Project planning and design, the EIA process has benefitted Canadians in the following important ways.

- It has highlighted opportunities for avoiding or minimizing adverse environmental effects, and for garnering beneficial effects, such that the Project as planned will not cause significant adverse environmental effects, and environmental benefits of the Project will be maximized.

- It has provided the opportunity for the principles of sustainable development, including the precautionary principle, to be incorporated into the Project design and development to meet the societal needs for tungsten and molybdenum without compromising ecosystem integrity for present or future generations.

- It has afforded substantive and meaningful opportunities for the public, stakeholders, and First Nations to become informed about the Project, to voice their interests and concerns, and to provide valuable input into the planning and design of the Project. Such engagement activities have been conducted through working groups formed with a variety of stakeholders to share information and discuss issues relevant to the Project, as well as through other meetings, open houses, newsletters, a store-front office, and other means.

- It has provided many opportunities for Aboriginal participation in the EIA to foster dialogue among First Nations, Northcliff/SML, and the provincial and federal Crowns in respect of potential benefits of the Project; to support the Crown’s duty to consult with First Nations; and to provide opportunities for Aboriginal issues, concerns and interests to be heard and addressed. This dialogue has occurred directly between Northcliff/SML and First Nations leadership, between the Crown and First Nations leadership, through open houses in First Nation communities by Northcliff/SML; and importantly through a First Nations EA Working Group formed to share information about, and discuss issues relevant to, the Project.

- It has advanced scientific knowledge of Central New Brunswick ecosystems, not only in determining and documenting the components, current conditions and quality of the various ecosystems of the area, but also in demonstrating how a mine can be successfully developed in remote, relatively undeveloped areas of New Brunswick in an environmentally-appropriate way.

- It has provided opportunities for people to appreciate the economic development, employment, and other social benefits the Project can deliver to New Brunswick communities which have a long history of industrial and resource-based development, but have suffered in recent years from limited development, high unemployment, and reduced economic activity due to mill closures and other societal and economic pressures.

1.4 PURPOSE AND ORGANIZATION OF THE EIA REPORT

This EIA Report has been developed to meet the requirements of the Final Guidelines issued under the New Brunswick EIA Regulation and the Terms of Reference that both form the scope of the EA under *CEAA* and were written to reflect the requirements of the Final Guidelines. The EIA Report is organized in eleven chapters, as follows.

- Chapter 1 provides an introduction to the EIA Report, identifies the Proponent and provides a brief Project overview, provides context for the Project, and outlines the structure and content of the EIA Report.
- Chapter 2 describes the planning of the Project, outlines the principles and philosophies applied by the Proponent in the design, construction, and operation, and ultimate decommissioning, reclamation and closure of the Project, and identifies the environmental management initiatives and practices that will be implemented as part of the Project to minimize environmental effects.
- Chapter 3 provides a detailed Project Description of the proposed elements of the Sisson Project, and describes how the Project will be constructed, operated, and ultimately decommissioned, reclaimed and closed at the end of mine life. Alternative means of carrying out the Project that are technically and economically feasible are discussed. Emissions and wastes, transportation requirements, and employment and expenditure for the Project are described.
- Chapter 4 provides a discussion of the applicable regulatory framework, including the regulatory requirements for the EIA; the scope of the Project and the scope of the EIA; a summary of public, stakeholder, Aboriginal, and regulatory consultation and engagement efforts; and other matters relevant to the scoping of the EIA. The valued environmental components (VECs) that have been selected for the EIA are identified. Additionally, a list of other projects and activities that are considered for the assessment of cumulative environmental effects is provided.
- Chapter 5 provides a description of the methodology used to conduct this EIA to meet the requirements of the EIA Regulation and *CEAA*.
- Chapter 6 provides a summary of the existing environmental setting of the Project area, including the historical setting, ecological context, and socioeconomic context of the region.
- Chapter 7 provides a summary of the key predictive studies that were carried out to provide information or analyses to support the environmental effects assessment of the Project.
- Chapter 8 provides the assessment of potential environmental effects of the Project, including cumulative environmental effects, on various VECs of relevance and importance to this EIA, for all Project phases, as well as for accidents, malfunctions, and unplanned events.
- Chapter 9 describes the follow-up and monitoring program that will be developed in respect of the Project.

- Chapter 10 summarizes the mitigation measures proposed for the Project.
- Chapter 11 provides conclusions of the EIA.
- Chapter 12 provides the references cited or consulted in the preparation of the EIA Report.

Additional supporting information is provided in the Appendices.

1.4.1 Tables of Concordance

Tables of Concordance that list the information requirements of the Final Guidelines (NBENV 2009) and Terms of Reference (Stantec 2012a) in relation to the sections of the EIA Report in which the information is presented are provided in Appendix C.

2.0 PROJECT PLANNING AND MANAGEMENT

2.1 ABOUT SISSON MINES LTD.

Sisson Mines Ltd. (SML), the general partner of the Sisson Project Limited Partnership, is a mineral development company based in Vancouver, British Columbia, that is focused on developing the Sisson ore deposit. SML's commitment is to develop and operate the Sisson Project according to its "Principles of Responsible Mineral Development" (Section 1.3.2) for the benefit of shareholders, partners, communities and governments.

SML is associated with Hunter Dickinson Inc. (HDI), a mining company also based in Vancouver, British Columbia with more than 25 years of mineral development experience. HDI is a private company that provides management and technical services to a diverse portfolio of mineral companies and properties in order to advance them through exploration, development, permitting, and construction into stable and profitable mine operations.

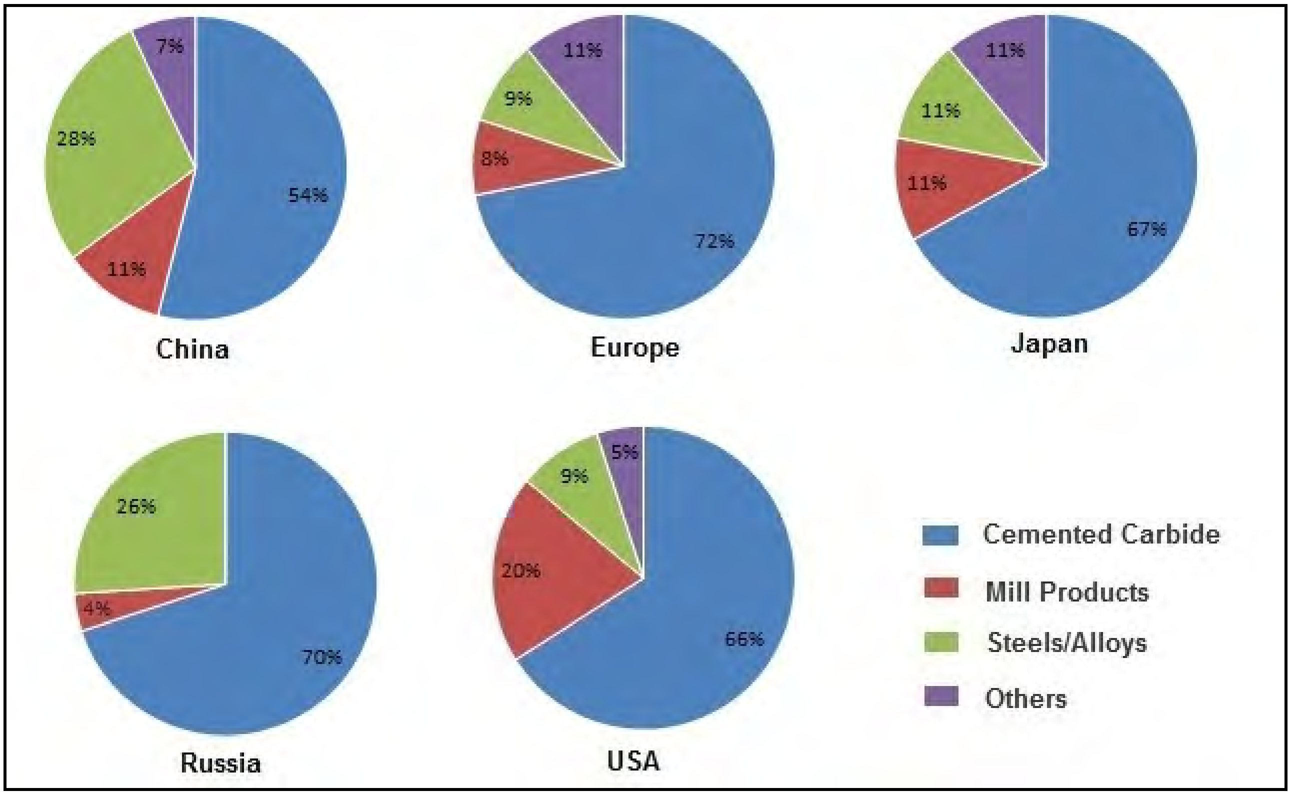
2.2 ABOUT TUNGSTEN AND MOLYBDENUM

2.2.1 Tungsten

Tungsten (chemical symbol W) is a steel-grey metal that is an important alloy in tool making and construction steel as it enhances hardness, cutting efficiency, and speed with a similar hardness to diamonds. Tungsten components are used in lighting technology, electronic industry, transportation, the chemical industries, glass melting industry, medical technology, power engineering, and in jewelry.

According to the International Tungsten Industry Association (ITIA), tungsten has the highest melting point of all metals (3,422 ± 15°C). At this temperature, most of the other engineering metals (*e.g.,* iron, aluminum, copper, titanium) are vapour. Also notable is tungsten's high density, comparable to gold. It is an important metal for thermo-emission applications, not only because of its high electron emissivity (which is caused by additions of foreign elements) but also because of its high thermal and chemical stability (ITIA n.d.).

Primary uses for tungsten are shown in Figure 2.2.1. Cemented carbides, also called "hardmetals", consume the largest portion of tungsten in recent years. Hardmetal tools are used for shaping metals, alloys, wood, composites, plastics and ceramics, and in the mining and construction industries. Tungsten remains important for tool steels, high speed steels, stellites and creep-resistant steels and alloys (ITIA n.d.).



Source: ITIA n.d.

Figure 2.2.1 Primary Uses for Tungsten in Selected Industrialized Nations (2010)

Current global tungsten consumption is estimated to be 93,000 tonnes per year (Roskill 2014). In a base-case demand scenario (Samuel Engineering 2013), demand for tungsten is forecast to reach 112,750 tonnes per year by 2017 and 148,500 tonnes per year by 2025.

World production and demand for tungsten is shown in Figure 2.2.2, and estimated tungsten mine production in 2013 by major producing country is shown in Table 2.2.1. China is by far the major producer of tungsten, though Russia, Canada, Vietnam, Austria, Australia, Bolivia, and Portugal are also important producers. Some of the biggest tungsten deposits are in the areas where access is difficult, or have a low ore grade, making the long-term view of tungsten prices the governing factor in determining their economic viability (ITIA n.d.).

Source: Roskill (2014).

Figure 2.2.2 Worldwide Tungsten Production and Demand (2004 to 2013)

Table 2.2.1 Estimated Tungsten Mine Production by Major Producing Country (2013)

Country	Production in 2013 (tonnes W)
China	60,000
Russia	4,200
Canada	2,100
Vietnam	1,600
Austria	1,100
Bolivia	1,100
Australia	1,000
Portugal	1,000
Other Countries	3,500
World Total (rounded) [a]	**75,600**

Notes:

[a] United States tungsten mine production was not available and is not included in this total.

Source: Roskill (2014).

Worldwide tungsten supply is dominated by Chinese production and export. In 2013, Chinese production accounted for approximately 80% of the world total (Table 2.2.1). China has approximately 54% of the world's tungsten reserves. China was also the world's leading tungsten consumer in 2013 (Roskill 2014).

The Chinese government has managed the tungsten industry in several ways, including:

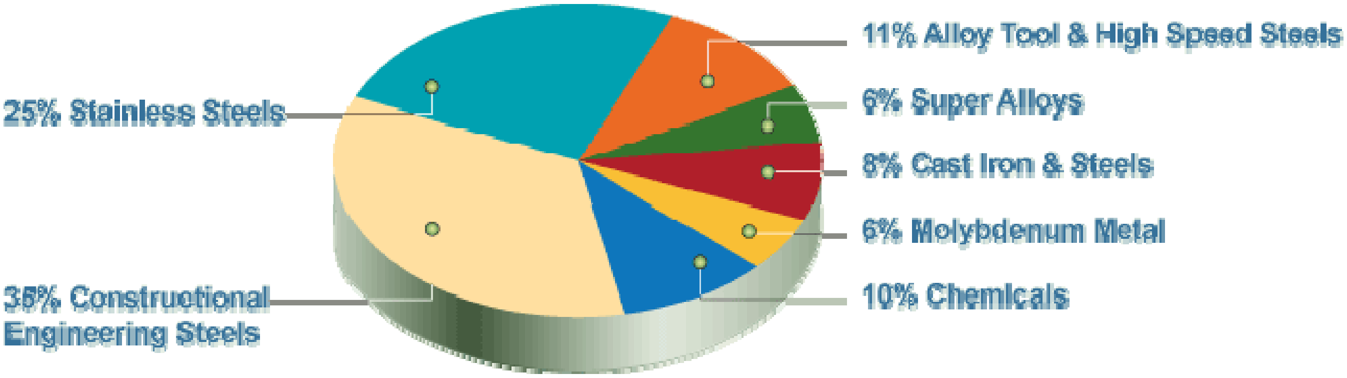
- limiting the number of exploration, mining and export licenses;
- limiting or forbidding foreign investment;
- imposing constraint on mining and processing;
- establishing quotas on production and export;
- adjusting export quotas to favour value-added downstream materials and products; and
- imposing export taxes on tungsten materials (US Geological Survey 2012a).

Thus, alternative supplies outside of China for meeting world demand are highly desirable.

2.2.2 Molybdenum

Molybdenum (chemical symbol Mo) is an important alloy in the manufacture of stainless steel and steel. It is also an important material for the chemical and lubricant industries. Molybdenum is used in automotive parts, construction equipment, gas transmission pipes, and turbine parts.

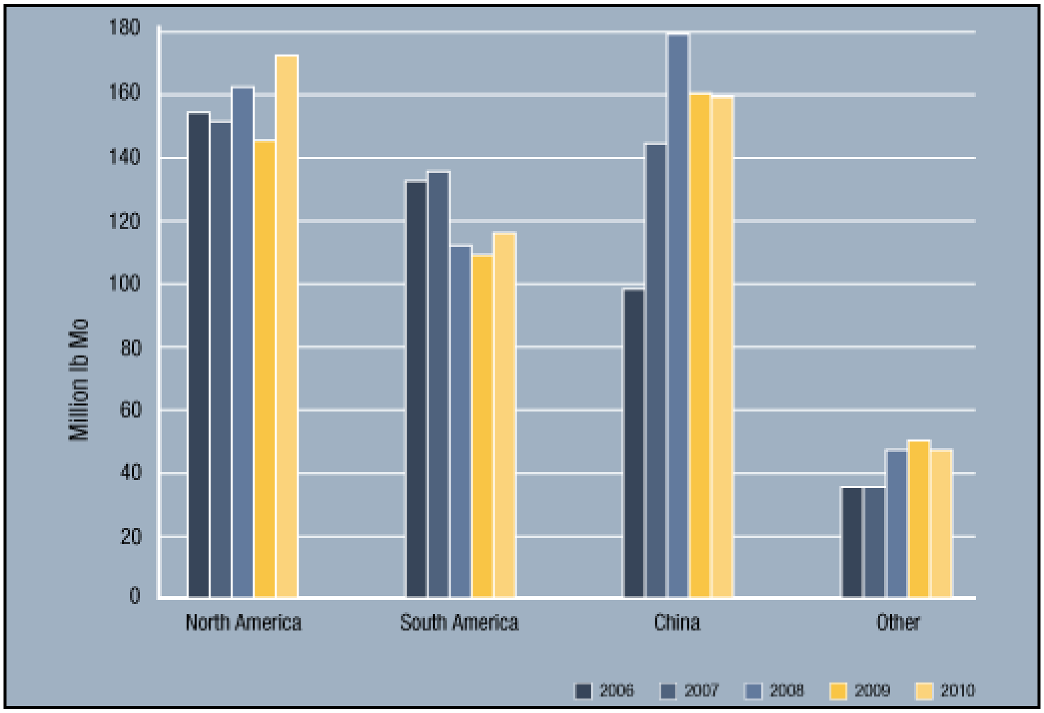
According to the International Molybdenum Association (IMOA), molybdenum has one of the highest melting temperatures of all the elements. When added to steel and cast irons, molybdenum enhances strength, hardenability, weldability, toughness, elevated temperature strength, and corrosion resistance. In nickel-base alloys, it improves resistance to both corrosion and high-temperature creep deformation (IMOA n.d.). The main molybdenum uses are shown in Figure 2.2.3.



Source: IMOA n.d.

Figure 2.2.3 Primary Molybdenum Uses (2012)

The principal producers of molybdenum are the Americas and China. Global molybdenum production is shown in Figure 2.2.4, and estimated molybdenum mine production in 2012 by major producing country is shown in Table 2.2.2. Demand for molybdenum remains strong, despite decreasing prices in recent years (US Geological Survey 2013b).



Source: IMOA n.d.

Figure 2.2.4 Major Molybdenum Producing Regions (2006-2010)

Table 2.2.2 Estimated Molybdenum Mine Production by Major Producing Country (2012)

Country	Production in 2012 (tonnes Mo)
China	105,000
United States	57,000
Chile	35,300
Peru	19,500
Mexico	10,900
Canada	9,400
Other Countries	12,900
World Total (rounded)	**250,000**

Source: US Geological Survey (2013b).

As reported in the Technical Report of the feasibility study for the Project (Samuel Engineering 2013), with the requirement for high grade steel alloys continuing to rise in a number of industries, demand for molybdenum appears set to increase steadily, particularly in the industrializing and emerging economies of Asia and South America. Growth is forecast at 5% per year, resulting in molybdenum demand almost doubling from 225,000 tonnes per year in 2011 to about 435,000 tonnes per year in 2025.

While China was a major exporter of molybdenum in the past, in 2004 the Chinese government reduced molybdenum supply to the rest of the world through production curtailments, export taxes, and export quotas (US Geological Survey 2013b). Thus, alternative supplies for molybdenum outside of China are needed to meet world demand.

2.3 RATIONALE AND NEED FOR THE PROJECT

As described above, demand exists worldwide for tungsten and molybdenum for a variety of products and uses, and those demands are expected to increase in the future. The Sisson Project will be an important source of tungsten and molybdenum, and will help to alleviate tungsten supply shortages caused by export restrictions by China.

Based on the Sisson Project feasibility study (Samuel Engineering 2013), the Project will produce an estimated annual average of 557,000 metric tonne units per year of tungsten trioxide (mtu WO_3/a) contained in ammonium paratungstate (APT). (Note: 1 mtu is equivalent to 10 kg of material). This equates to an annual average production of approximately 5,570 tonnes per year. Compared to tungsten mine production rates in 2012 for major tungsten-producing countries (Table 2.2.1; US Geological Survey 2013a), the Project will increase the worldwide total mine production of tungsten by approximately 7.6%. Furthermore, as approximately 85% of mined tungsten is produced in China, the Project will increase non-Chinese tungsten production by over 50% each year. Unlike tungsten from China that is subject to stringent government limitation, the tungsten produced by the Project will be available to the North American and other markets to meet market demand.

Also, the Project will produce an estimated annual average of 1,860 tonnes per year (4.1 million lb/a) of molybdenum contained in concentrates (Samuel Engineering 2013). Molybdenum demand remains strong worldwide (US Geological Survey 2013b). Compared to mine production for molybdenum in 2012 from major molybdenum-producing countries (Table 2.2.2; US Geological Survey 2013b), the Project will represent approximately 0.7% of the world's mine production, and approximately 1.3% of the world's mine production outside of China.

In addition to helping to meet worldwide market demand for tungsten and molybdenum, the Project will generate profit for the partners in the Project, and tax revenues for the Province of New Brunswick and the Government of Canada. The Project will also generate direct employment (*i.e.,* for mine Construction and Operation) and indirect employment (*e.g.,* services, materials and equipment supply, transportation) in New Brunswick and elsewhere, and will contribute substantially to New Brunswick's gross domestic product (GDP). It will also attract businesses and development to the local region, adding to the economic benefits, local development, and the standard of living. New Brunswick generally has been hard hit by relatively high unemployment and limited economic growth in recent years, and Central New Brunswick has also been greatly affected by mill closures and reduced economic activity in the region. As a major employer and economic driver over its 29 year lifetime (*i.e.,* 2 years of Construction and 27 years of Operation), the Project will bring much-needed employment to the Central New Brunswick communities that surround it, and contribute considerably to the overall well-being of the region. More detailed information on the economic benefits of the Project can be found in Section 8.10, Labour and Economy.

2.4 PROJECT PURPOSE

In light of the world supply and demand for tungsten and molybdenum, and the consequent rationale and need for the Project as described above, the purpose of the Project is to mine tungsten and molybdenum-containing ore from the Sisson deposit, process it to meet market demand for the mineral products, generate tax revenue for New Brunswick and Canada, and create return on investment for the partners in the Project.

2.5 PROJECT ALTERNATIVES

2.5.1 Alternatives to the Project

There are no alternatives to the Project that would meet the Project Purpose as defined in Section 2.4.

Section 3.3(a) of the Final Guidelines (NBENV 2009) requires that: "*The null or "do nothing" alternative (not constructing and operating the mine) must be discussed. The study must examine the implications of not proceeding with the project with reference to environmental (both biophysical and socio-economic) factors/effects*." In this regard, if the Project is not carried out, the biophysical environment would remain unchanged from its existing condition, and the socioeconomic benefits of the Project would not be realized.

2.5.2 Alternative Means of Carrying Out the Project

As part of the feasibility and EIA studies carried out for the Project, various alternative means of carrying out the Project were evaluated by SML and its consultants in the process of developing the feasibility level Project design described in Chapter 3 of this EIA Report. As required by Section 16(2)(b) of *CEAA*, the alternative means of carrying out the Project that are technically and economically feasible are considered and assessed in Section 3.3.

2.6 PROJECT PLANNING AND MANAGEMENT STRATEGIES

SML is committed to developing the Project in an environmentally responsible manner consistent with its "Principles of Responsible Mineral Development", retaining the rural, resource-based character of the region while affording benefits to the community, region and province. To this end, SML will implement Project planning and management strategies that avoid or minimize the adverse environmental effects of the Project, and enhance positive ones, in a manner that complies with all laws and regulations while ensuring that the Project presence is compatible with the way of life that the people of central New Brunswick know and enjoy. This will be done in a variety of ways, some of which include:

- developing a world-class tungsten and molybdenum mine that partially fulfills the demands of world markets for such commodities for use in manufacturing goods and services that society needs;
- implementing progressive environmental protection, mitigation, and management strategies and concepts that avoid or minimize adverse environmental effects, and enhance positive ones;

- adopting guiding principles for design and implementation of the Project, particularly those that protect surface water and groundwater resources, use geotechnically stable materials and concepts, implement technically and economically feasible components and technologies that are proven, limit the footprint and visual effects of the Project, and design the Project components with closure in mind;
- incorporating feedback received from the public, stakeholders, Aboriginal persons, and other parties so as to minimize environmental effects and address issues and concerns; and
- promoting responsible and sustainable development of the mineral resource.

2.6.1 Design Standards and Codes

The Project will be constructed to meet all applicable building, safety and industry codes and standards. The engineering design of the Project will consider and incorporate potential future changes in the forces of nature that could affect its operation or integrity (*e.g.,* climate change), and Project components and infrastructure will be designed and built to adapt to or withstand these effects. The Project components will be designed to meet the National Building Code of Canada, the Canadian Dam Association Guidelines, and other design codes and standards for wind, snowfall, extreme precipitation, seismicity, and other weather variables. These standards and codes provide factors of safety regarding environmental loading (*e.g.,* snow load, high winds, seismic events), and Project specific activities and events. Compliance with these standards and codes reduces the potential for adverse environmental effects as a result of an accident, malfunction or unplanned event.

2.6.2 Environmental Protection Measures

A variety of environmental protection and management measures have been adopted through the development of the Project to date in order to guide the planning, design, construction, operation, and ultimate decommissioning, reclamation and closure of the Project. These include, but are not limited to, the following measures.

- Siting facilities to avoid sensitive areas such as wetlands, watercourses and important habitat types, where possible, and to reduce the size and number of natural drainages that may be affected.
- Minimizing the “footprint” of Project facilities and activities to consequently reduce the amount of disturbed land, wetlands and water resources.
- Employing good planning, design and management practices to comply with:
  - regulated standards for air emissions, water releases, storage or disposal of solid wastes, and handling and disposal of hazardous materials; and
  - regulated and/or industry design and management standards to satisfactorily deal with environmental risks such as seismicity, unusual weather events, flooding, and erosion.

- Preparing and implementing an Environmental and Social Management System (ESMS) (Appendix D) for the Project to ensure the Sisson Project is implemented according to SML's "Principles of Responsible Mineral Development". SML's ESMS includes:
  - a corporate management system including responsibilities for senior and site management, employees and contractors;
  - an Environmental Management Plan incorporating operational policies and practices for monitoring and management of, for example, land and soil resources, air and water, noise and vibration, hazardous materials and waste, and community health and safety, and cultural heritage;
  - an Environmental Protection Plan (EPP) for Construction activities that will be included in, and enforced through, construction contracts;
  - an Emergency Preparedness and Response Plan (EPRP); and
  - a Public, Stakeholder and First Nations Engagement Plan to ensure that, wherever possible, concerns about the Project are accommodated in its design, construction, operation and closure, and employment, business and other benefits are optimized and realized locally.
- Planning the Project with closure in mind and having a Decommissioning, Reclamation and Closure Plan, and a bonding agreement in place with the Government of New Brunswick, from the startup of Construction.
- Planning and financing compensation measures for unavoidable adverse environmental effects to aquatic habitats and wetlands in order to sustain biodiversity in the vicinity of the Project.

With the exception of the open pit (for which the location is fixed by the location of the mineral resource), SML has emphasized Project design and siting so that the location and configuration of the Project facilities considers the above measures wherever possible so as to avoid or minimize the potential environmental effects of the Project. To the extent possible, Project facilities have been sited to avoid and reduce interactions with watercourses, wetlands, areas of elevated archaeological potential, and other sensitive environmental features. Where avoidance was not possible, mitigation or compensation measures have been developed as part of the EIA, and will be implemented in consultation with the applicable regulatory authorities.

2.6.3 Planning for Closure

The Project has a finite life, and as such, SML is proactively planning for closure during all stages of the Project. All elements of the design of the Project are being carried out with eventual closure in mind. This ranges from constructing Project components to facilitate their future closure, to stockpiling topsoil and overburden for future use, to carrying out progressive reclamation and stabilization of Project components throughout Operation as possible, to consulting with local communities and First Nations about their desired future land uses at the Project site. A conceptual Decommissioning, Reclamation and Closure Plan (EvEco 2013) has been developed to meet the requirements of the Terms of Reference (Stantec 2012a) and to provide the basis for developing the more detailed plan required by the New Brunswick *Mining Act.* The main activities planned for Decommissioning, Reclamation and Closure, based on the conceptual plan developed by EvEco (2013), are described at an overview level in Section 3.4.3 of this report. In response to information requests for additional information in the EIA Report regarding the decommissioning, reclamation and closure plan, a new Section 3.4.3.6 has been added to this document to provide further details on the planned approach to this phase, based on the more detailed application for a mining lease submitted to the New Brunswick Department of Energy and Mines in January 2014 (updated in October 2014).

SML is carrying out, and will continue to carry out, various public, stakeholder, and First Nations engagement initiatives to consider (among other issues) the potential post-closure land uses for the Project. Feasible ultimate land uses will be determined based on this engagement and discussions with the Province of New Brunswick, and the Decommissioning, Reclamation and Closure Plan will be updated accordingly as the Project proceeds and planned land uses change. Each update, and the final version, of the plan must be approved by the Province of New Brunswick.

A financial security is required by the Province to ensure acceptable decommissioning, reclamation, and closure of the Project. The amount of the required security will grow over the life of the Project to an estimated value of 50 million dollars (Samuel Engineering 2013). The estimated security amount covers staged decommissioning, reclamation and closure costs beginning one year before mine start-up, and grows progressively to the full estimated value at the final stage of mine development. Thus, at any point during the life of the Project, the amount of the security will be sufficient to accomplish decommissioning, reclamation and closure of the Project.

2.6.4 Follow-up and Monitoring Program

A follow-up and monitoring program will be developed as part of the Project. The objectives of the program are to:

- propose follow-up measures that are intended to verify the environmental effects predictions in this EIA Report and to assess the effectiveness of mitigation, as required by *CEAA*; and
- propose environmental monitoring measures aimed at monitoring the Project's environmental effects; to demonstrate compliance with environmental acts, regulations, and approvals/ permits/authorizations issued for the Project; and to provide a basis for long-term adaptation to changing environmental conditions occurring naturally or as a result of the Project.

The framework for, and proposed elements of, the follow-up and monitoring program for the Project as conceived at this planning stage of the Project are outlined in Chapter 9 of this EIA report. The program will be adjusted as required over the life of the Project in response to the results of follow-up or monitoring initiatives, changes in regulatory requirements, or other factors.

2.7 THE ROLE OF THE EIA REPORT

This EIA Report is a key instrument for implementing the above-noted approaches and measures. Preparation of the EIA Report has involved a substantial field data collection program, a variety of analyses of potential environmental effects, the development of measures for avoiding or mitigating potentially significant adverse environmental effects, the development of measures to compensate for adverse environmental effects that cannot be avoided or mitigated, and the preparation of this EIA Report for public review and government review and approval. This work is an integral part of the engineering design and corporate planning for the Project so that EIA is both a project planning tool and a government review and decision-making tool. As such, the EIA is a key tool for implementing sustainable development for major projects like the Sisson Project.

In carrying out the EIA, potential environmental effects of the Project have been considered for all phases of the Project, including those potentially arising from credible accidents, malfunctions and unplanned events. Potential interactions and overlapping environmental effects with other past, present, or reasonably foreseeable future projects or activities have also been considered. The public and stakeholder consultation, and Aboriginal engagement, program undertaken by SML, and the input received as part of these activities, has informed the EIA and the factors required to be considered as part of it.

3.0 PROJECT DESCRIPTION

3.1 OVERVIEW

A description of the Project as it is currently conceived is provided in this chapter. As described in Chapter 2, a feasibility study of the Project was completed in January 2013. The Project will undergo more detailed engineering, and will be constructed and operated in accordance with currently accepted safety and construction standards and will incorporate technology that is technically and economically viable both in terms of efficient mining and processing as well as for its environmental performance.

This Chapter provides a description of the facilities and equipment that will comprise the Sisson Project, based on the available information at the time of writing. The description that follows is based largely on the feasibility study for the Project as documented in the Technical Report entitled “Canadian National Instrument 43-101 Technical Report on the Sisson Project, New Brunswick, Canada” (“the Technical Report”; Samuel Engineering 2013). Other sources of information include the Project Description for the Sisson Project (“the *CEAA* Project Description”; Stantec 2011), the most recent mineral resource estimate for the Project (RPA 2012), and supplemental information provided by Northcliff/SML.

The Project as described in this document is likely to evolve as detailed engineering design is completed and as a result of the iterative planning process associated with the environmental impact assessment (EIA). So as to not understate the potential environmental consequences of the Project at this planning stage, the Project Description provided in this Chapter presents an “outer envelope” or conservative estimate of the scope, footprint, and environmental effects of the Project, including the magnitude and extent of emissions, discharges and wastes. The Project will ultimately be built and operated within the outer envelope presented in this EIA Report.

The key aspects of the Project are described below, including:

- the Project components, including the likely infrastructure and associated facilities, and planned mitigation for potential environmental effects;
- alternative means of carrying out the Project;
- the activities that will be carried out during Construction, Operation, and eventual Decommissioning, Reclamation and Closure of the Project; and
- Project-related emissions, wastes, and other requirements, and their management.

3.1.1 Project Summary

The Project is a conventional, open pit tungsten and molybdenum mine located near the community of Napadogan, New Brunswick (Figure 1.1.1). The mine will operate for an estimated 27 years at a nominal mining rate of 30,000 dry metric tonnes per day (t/d) of tungsten- and molybdenum-containing ore, processed in an ore processing plant to produce tungsten and molybdenum mineral products. The main activities associated with the Project include:

- mining by conventional open pit methods, and storage of ore and waste rock;
- stockpiling of organics and overburden for future reclamation use;
- on-site processing of ore in an ore processing plant to produce mineral concentrates and tailings, and further processing of tungsten concentrate to a higher-value crystalline tungsten product and solid precipitate waste products;
- development and operation of a tailings storage facility (TSF), and associated storage of tailings;
- diversion of clean surface water away from Project facilities (*e.g.,* open pit, TSF);
- collection and storage of all precipitation on the Project site and groundwater flows into the open pit (termed “mine contact water”) for re-use in the ore processing plant, and discharge of surplus water, with treatment as needed to meet permitting conditions;
- transportation of the mineral products to off-site buyers; and
- decommissioning of facilities, and reclamation and closure of the site at the end of the Project life.

3.1.2 Geographic Location

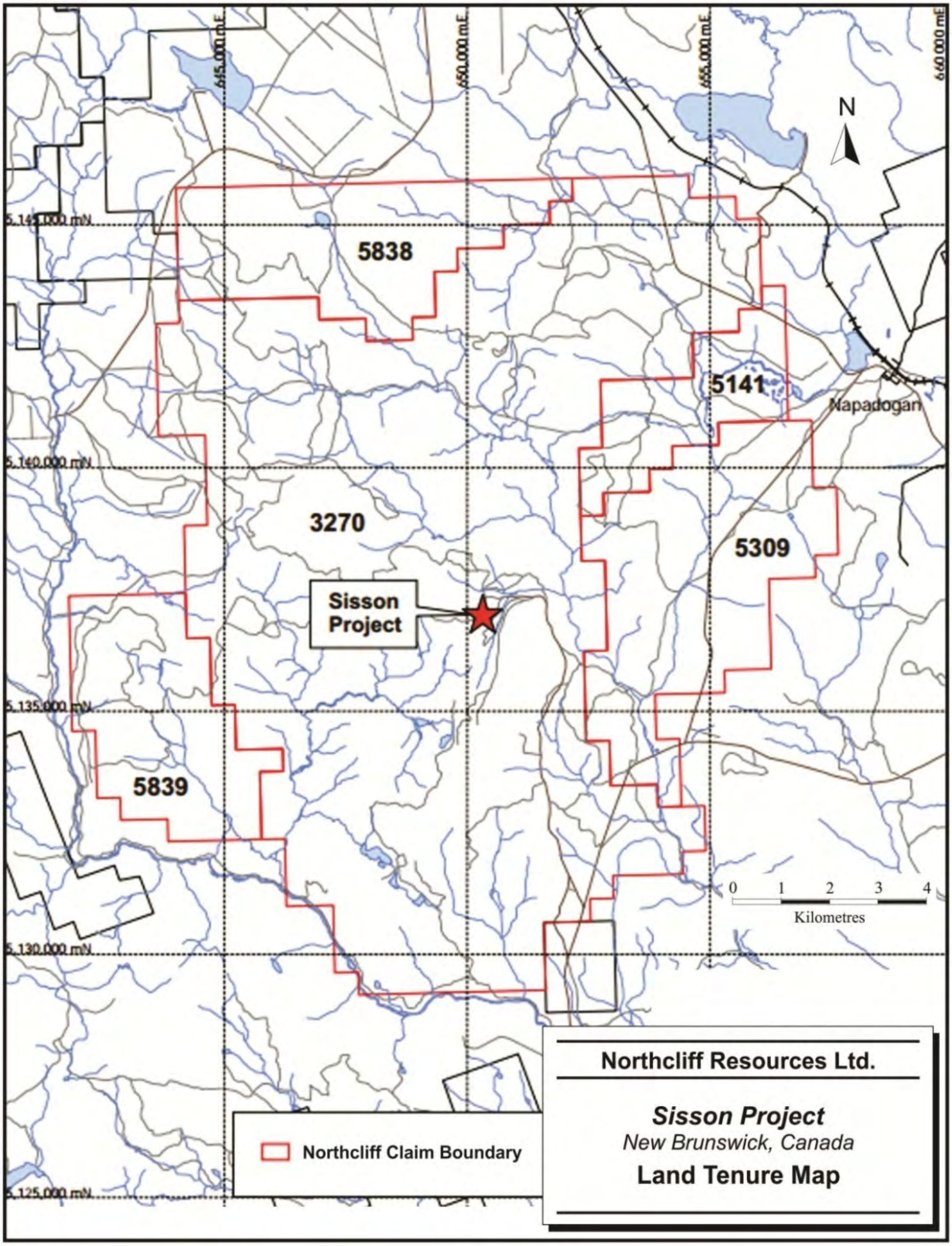
The Project site is located at approximately N 46º 22’ by W 67º 03’, in east-central New Brunswick, approximately 60 km directly northwest of the city of Fredericton, and approximately 10 km southwest of the community of Napadogan (Figure 1.1.1).

3.1.2.1 Property Ownership

The Project will be situated entirely on provincial Crown land, administered by the New Brunswick Department of Natural Resources (NBDNR), within an 18,800 hectare (ha) claim block with mineral rights held by SML. Project elements will be located on a parcel of land identified by Service New Brunswick (SNB) as Parcel Identifier (PID) Number 75140541. This is referred to in this EIA Report as the Project Development Area (“PDA”, defined as the area of physical disturbance associated with the Project), which with the planned linear facilities associated with the Project encompasses an area of approximately 1,253 ha.

3.1.2.2 Land Tenure

Tenure for the mineral rights is held via five contiguous claim groups comprising a total of 850 units (Figure 3.1.1). In New Brunswick, claims are staked online as blocks of units which measure 500 m by 500 m each. The list of mineral claims held by SML is provided in Table 3.1.1.



Source: Samuel Engineering (2013).

Figure 3.1.1 **Land Tenure Map, Sisson Project**

Table 3.1.1 Mineral Claims Held By SML

Claim Group Number	Mineral Claim Name	Mineral Claim Type	Mineral Claim Sub Type	Issue Date	Expiry Date	Status	Units
5141	Turnbull Mountain	Mineral	Claim	2007-06-14	2012-06-14	Active	40
5839	Barker Brook	Mineral	Claim	2010-08-17	2012-08-17	Active	66
5838	West Branch Napadogan	Mineral	Claim	2010-08-17	2012-08-17	Active	77
5309	Napadogan Brook	Mineral	Claim	2007-11-28	2012-11-28	Active	106
3270	Sisson Brook	Mineral	Claim	1997-09-04	2012-09-04	Active	561
						Total	**850**

Source: NBDEM (2013).

SML owns a 100% interest and 100% of the mineral claims for the Sisson Project. Mineral claims for the Project were acquired through two agreements with Geodex, signed in October 2010 and May 2012. There are no royalties on the property or back-in rights. SML does not hold any surface rights within the claim block. The New Brunswick *Mining Act* allows for access and use of the surface for mining through the permitting process.

The mineral resources associated with the Sisson tungsten and molybdenum ore deposit are all located within claim group number 3270.

3.1.3 The Sisson Deposit

3.1.3.1 Property History

As discussed in the Technical Report (Samuel Engineering 2013), the first significant work in the Sisson area was carried out in the late 1950s by Nashwaak Pulp and Paper Co. Twelve holes were completed in 1955 and 43 holes in 1959-1960, which resulted in the discovery of the Nashwaak polymetallic vein deposit.

From 1967 to 1969, Penarroya Canada Ltée conducted geological mapping, a ground magnetic survey, and soil sampling mostly south of the Sisson deposit. Texasgulf Inc. and Kidd Creek Mines Ltd. carried out exploration work from 1973 to 1983 comprising soil sampling, geological mapping, trenching, ground geophysical surveys, and drilling. Relatively limited work was conducted by various operators between 1977 and 2001.

From 2004 to 2009, Geodex, initially in joint venture with Champlain Resources Inc., carried out ground and airborne geophysical surveys, compilation of historical data, trenching, re-analysis of historical drill core, geological mapping and prospecting, and extension of previous soil and till sampling grids over and around the Sisson deposit. Approximately 210 drill holes were completed. Preliminary economic assessments with positive conclusions were completed by Wardrop Engineering Inc. in 2007 and Geodex in 2009. Northcliff signed a joint venture agreement with Geodex in October 2010, and has since conducted diamond drilling and test pitting. In 2012, Northcliff announced an updated mineral resource estimate for the Sisson Project (RPA 2012), and became sole owner of the Project by acquiring Geodex's remaining interest in it.

3.1.3.2 Deposit Geology

The Sisson ore deposit is defined as an intrusion-related, structurally controlled, bulk tonnage tungsten-molybdenum deposit. Deposits of this type are generally hydrothermally similar to porphyry copper deposits and they form in convergent margin to collisional tectonic environments and are related to highly-evolved granitic melts formed from continental crust.

The Sisson ore body was initially identified between 1979 and 1982 and drilling by Geodex between 2005 and 2009 served to better delineate the deposit. Drilling campaigns by Northcliff between 2010 and 2012 further improved the understanding of the mineral resources for the feasibility study and provided sufficient evidence of the resource to move forward with the Project. The most recent mineral resource estimate filed by Roscoe Postle Associates Inc. (RPA) was found to be consistent with historical estimates (RPA 2012).

The location and dimensions of the open pit mine will be determined by the geology and mineralization of the deposit to optimize the economic recovery of the resource. An aerial view looking west over the area of the ore body is shown in Photo 3.1.1.

Source: Sisson Mines Ltd.

Photo 3.1.1 Aerial View of Project Site, Looking West Over the Middle of the Sisson Ore Body

Minimal outcrop exists in the Sisson project area; the geological interpretation is based on various exploration activities in the area and regional interpolation. The Sisson ore deposit area is centred on a north-trending contact between Acadian plutonic rocks, which include the Howard Peak Granodiorite and the Nashwaak Granite to the west, and older metavolcanic and metasedimentary rocks of the Tetagouche and Miramichi Groups to the east. The metavolcanic and metasedimentary host rocks formed during the Taconic Orogeny are of Cambrian to Ordovician age and include the predominantly clastic sedimentary sequences of the Miramichi Group overlain by Ordovician felsic to mafic volcanic strata and clastic sedimentary rocks of the Tetagouche Group. The plutons intruded the host rocks during the Acadian Orogeny. A simplified geology map is shown on Figure 3.1.2 which also illustrates that mineralization occurs in four contiguous zones in the Sisson deposit area. The bulk of the mineralization is hosted in Zone III, with two narrow, structurally controlled zones that extend north, Zone I and Zone II. The Ellipse Zone extends northwest from the southwest corner of Zone III.

The lithologies of the Sisson deposit area from West to East include the following:

- Nashwaak Granite – massive, likely multiphase, equigranular biotite Acadian granite batholith;
- Howard Peak Granodiorite – this occurs in three phases, granodiorite, quartz diorite, and gabbro, as follows:
  - Granodiorite Phase – equigranular biotite granodiorite which grades into quartz diorite to the east and is intruded by the Nashwaak Granite in the west;
  - Quartz Diorite Phase – this rock type hosts mineralization in the western part of the Ellipse Zone and consists of medium grained, subporphyritic, hornblende quartz diorite; and
  - Gabbro Phase – this rock type hosts mineralization in the eastern part of the Ellipse Zone and the western part of Zone III and consists of medium grained, porphyritic pyroxene hornblende gabbro. The eastern contact marks the boundary with the rocks of the Tetagouche Group and is a near-vertical disrupted zone or fault;
- Turnbull Mountain Formation (Tetagouche Group) – consists of bimodal tuffaceous volcaniclastic rocks and biotite wacke, this is the main host to the mineralization in Zone III;
- Miramichi Group – dominated by siliceous wacke interbedded with siltstones and quartzites with minor interbeds of intermediate volcanicalastics; these rocks may host low grade mineralization on the eastern margin of the Sisson deposit; and
- Hayden Lake Formation (Tetagouche Group) – includes black shales, flow banded felsic rocks, and fragmental mafic volcanic rocks that overlie the Miramichi Group east of the Sisson deposit.

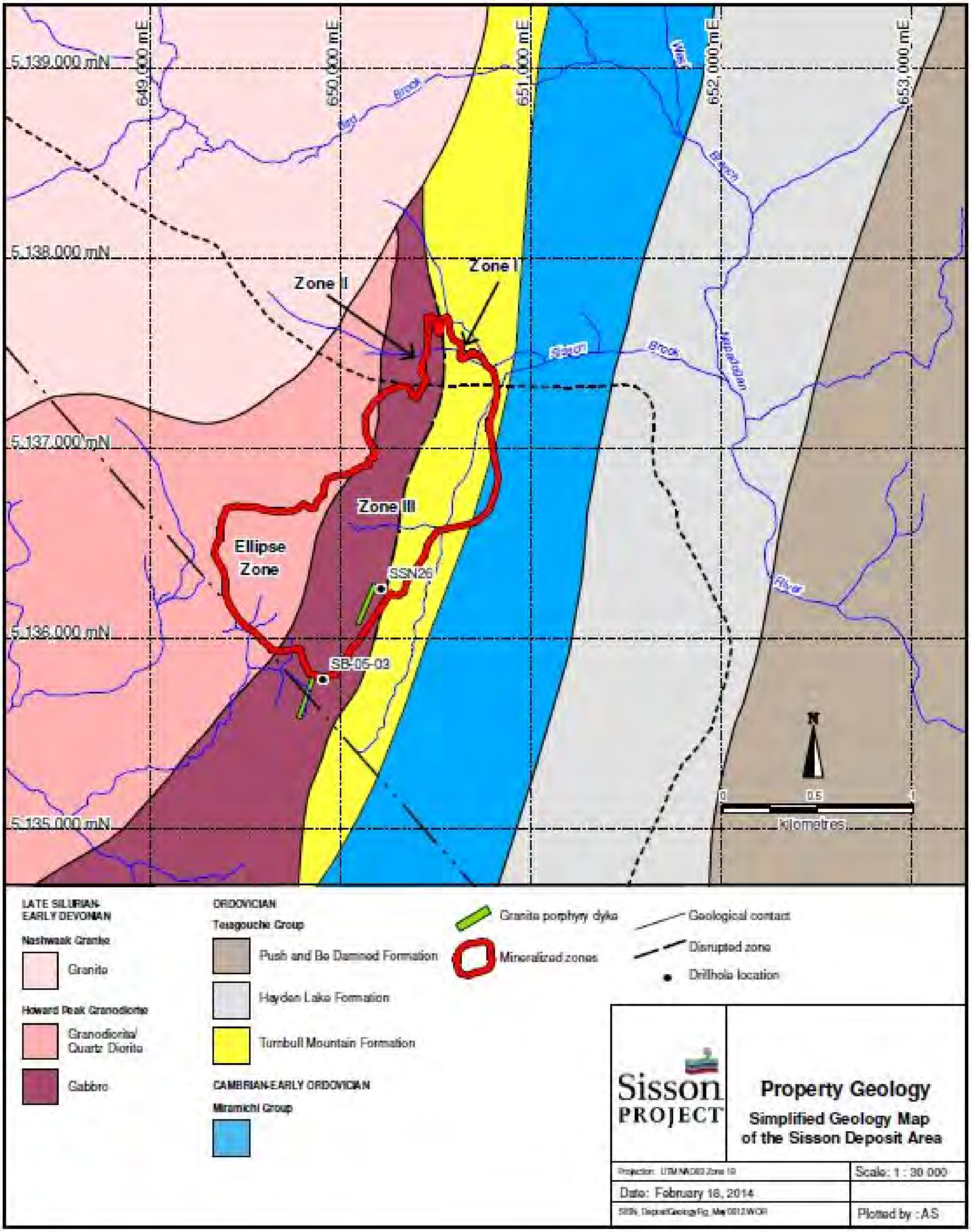


Figure 3.1.2 **Simplified Geology Map of the Sisson Deposit Area**

Mineralization in the Sisson deposit is hosted by:

- the quartz diorite and gabbro phases of the Howard Peak Granodiorite;
- felsic, mafic, and mafic crystal tuffs in the western part of the Turnbull Mountain Formation;
- biotite wacke with minor interbeds of tuff in the eastern part of the Turnbull Mountain Formation; and
- volumetrically minor granite dykes and very rare mafic dykes.

Low-grade mineralization on the eastern edge of the deposit is hosted by more siliceous biotite-sericite wackes that may be part of the Miramichi Group.

Mineralization at Sisson occurs almost exclusively in quartz veins, fractures, and their alteration envelopes. Tungsten and molybdenum are the metals of principal economic interest throughout the deposit. Several other metals, including copper, zinc, lead, arsenic, and bismuth, occur more erratically in geochemically anomalous but sub-economic concentrations.

Deformation of the Sisson Project area is characterized by folding and various types of cleavage and foliation development. The stratified rock sequences were folded into a series of D2 anticlines and synclines that consistently strike north-northeast and dip steeply to the east; this deformation occurred during the Taconic Orogeny predominantly in the Ordovician. The rocks of the Miramichi Group lie in the core of an anticline, flanked to the east and west by conformably overlying volcanic-bearing sequences of the Tetagouche Group. The D2 deformation is characterized by folding. The presence of a fault between the Miramichi Group on the western limb of the anticline was proposed by Fyffe *et al.* (2008) on the basis of their interpretation of missing stratigraphic section and increased intensity of structural fabrics from west to east across the area (Fyffe and Thorne 2010). A number of major, northerly to north-northeasterly trending faults that displace earlier fold structures have been mapped in central New Brunswick. However, no evidence of a fault in this location has been indicated by drilling results in the Sisson deposit. Fyffe and Thorne (2010) determined that a fault would be consistent with the intensely sheared nature of the rocks hosting the Sisson mineralization, but on the basis of drilling results this is more likely caused by the disrupted contact between the Howard Peak Granodiorite Pluton and the sediments of the Tetagouche Group because the eastern margin of the pluton is intensely sheared, cataclastized, and contains abundant xenoliths derived from the adjacent folded host rock.

There is evidence to suggest the emplacement of the Howard Peak pluton, which at least locally contains a strong foliation and has been dated by U-Pb on zircon at 432 million years (Ma) (Lentz, D. Personal communication, 2011), likely took place during the D2 deformational event of Fyffe *et al.* (2008). Granitic dykes which cut and partially assimilate the gabbroic rocks vary from weakly foliated to unfoliated, and have been dated by U-Pb zircon methods at approximately 375-380 Ma, which is equivalent to Re-Os dates on molybdenite of approximately 378 Ma (Lentz, D. Personal communication, 2011). Differing orientations of the foliation in some gabbroic xenoliths indicate that they were rotated during their incorporation into the granite dykes and that the stronger deformation significantly pre-dated emplacement of the dykes, which is consistent with the isotopic ages. The granitic dykes are likely offshoots of the Late Devonian Nashwaak pluton, which therefore must have been emplaced during the waning stage, and after the cessation, of D2 deformation. Granitic dykes were probably emplaced along localized zones of high strain which would, in turn, have provided permeable pathways for the introduction of the hydrothermal fluids which were the source of mineralization. Deformation of the Sisson Project area significantly pre-dates the formation of the deposit.

Very few fractured contacts or faults were identified in the 2011 open pit geomechanical/ hydrogeological site investigation program. The overall rock mass quality at the Sisson deposit is good and the intact rock strength is strong. The identified rubble zones and gouge filled structures were localized in the drillholes, and do not imply any large-scale continuous fractured features at the drillhole locations. The deformation of the Sisson project area likely served to strongly anneal the affected rock types which may account for their current strength and the scarcity of extensive brittle deformation. Exploration drilling at the Sisson deposit has intersected a near-vertical, strongly disrupted zone along the contact between the Howard Peak gabbroic rocks and the metavolcanic rocks of the Turnbull Mountain Formation. Similar disrupted zones passing through the entire deposit area have not been identified to date.

3.1.3.3 Geological Resource and Mine Life

In June 2012, RPA conducted an audit of an updated mineral resource estimate for the Project prepared by Northcliff/SML personnel (RPA 2012). The effective date of this estimate was February 29, 2012, and is considered to be current to December 31, 2012. The mineral resource estimate is summarized in Table 3.1.2.

Table 3.1.2 Mineral Resource Estimate

Category	Tonnage (Mt)	Tungsten (as WO_3) (%)	Molybdenum (Mo) (%)	WO_3 (M mtu)	Mo (M lb)	WO_3 Equivalent (%)	Average NSR ($/t)
Measured	108	0.072	0.023	7.70	55.3	0.096	26.67
Indicated	279	0.065	0.020	18.0	122	0.086	23.42
Measured + Indicated	387	0.067	0.021	25.7	178	0.089	24.33
Inferred	187	0.050	0.020	9.41	82.6	0.074	18.63

Notes:

1) Canadian Institute of Mining (CIM) definitions were followed for mineral resources.
2) Mineral resources are estimated at a net smelter return (NSR) cut-off grade of $US9.00/t.
3) Mineral resources are estimated using a long-term metal prices of US$350 per mtu WO_3 and $US15/lb Mo, and a US$/C$ exchange rate of 0.9:1.
4) Metallurgical recoveries for the NSR calculation were 82% for Mo and averaged 77% for WO_3 over the life of mine. WO_3 recovery is a function of mill head grade.
5) Numbers may not add due to rounding.

Legend:

t = dry metric tonnes
WO_3 = tungsten trioxide
MO = molybdenum
M = million
mtu = metric tonne unit
lb = pounds
NSR = net smelter return

Source: Samuel Engineering (2013).

The mine life has been estimated at 27 years, according to an optimized mining schedule detailed in Section 3.4.2.1.3. That life could be extended depending on further on-site drilling and future metal prices on the commodity markets.

3.1.4 Project Schedule

The Project schedule is as follows.

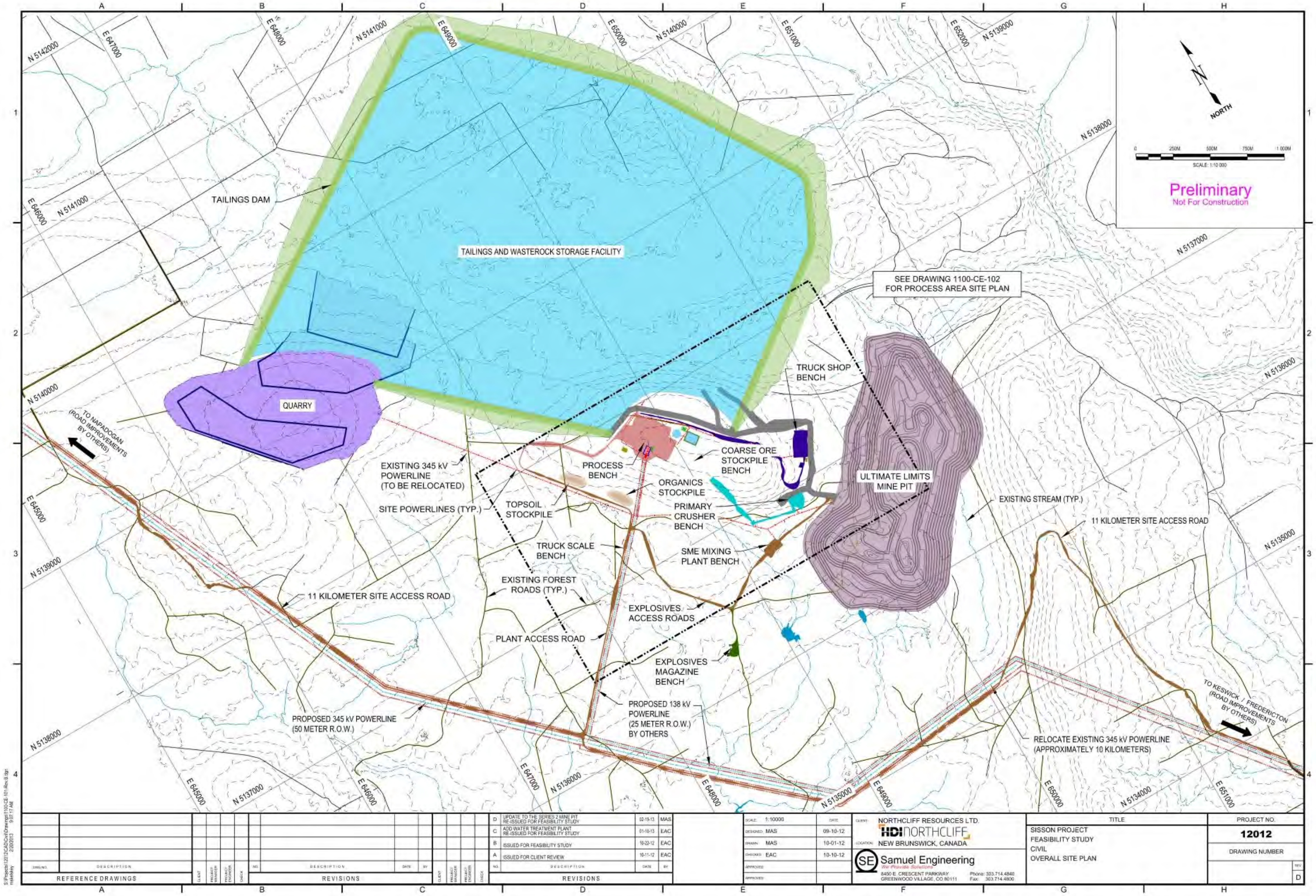
- **Construction:** Construction will proceed for a period of up to 24 months, commencing as soon as the EIA is approved, the applicable permits, approvals or other forms of authorization have been obtained, and Project financing has been secured. For the purpose of this EIA Report, it has been assumed that Construction will begin in the second half of 2015.

- **Operation:** Operation will commence immediately following Construction and will continue for an approximate period of 27 years or until the mineral resource is depleted.

- **Decommissioning, Reclamation and Closure:** Decommissioning of Project facilities and Reclamation of the Project site will occur following the completion of Operation. Closure will commence during the Decommissioning and initial Reclamation period, and will continue until the pit lake fills with water over about 12 years. Post-Closure (*i.e.*, when the pit lake is completely filled) will follow.

3.2 DESCRIPTION OF MAJOR PROJECT COMPONENTS AND FACILITIES

The Project will involve an open pit mine and associated processing, storage, and waste management facilities. In the sections below, each of the major components and facilities for the Project are described. The specific locations of the various Project facilities are shown in Figure 3.2.1.



Source: Samuel Engineering (2013).

Figure 3.2.1 Site Layout

3.2.1 Development of Project Design Since April 2011

In April 2011, the Project Description (Stantec 2011) was accepted by the Canadian Environmental Assessment Agency (CEA Agency) to initiate the federal environmental assessment process under the *Canadian Environmental Assessment Act* (*CEAA*).

Since the filing of the Project Description, engineering design has advanced to support the feasibility study, completed in January 2013. The Project design will continue to evolve as basic engineering, planning, detailed engineering, and procurement is carried out. In consideration of the results of the baseline studies, selection of best-available technologies and economic considerations, the conceptual design of the Project described in Stantec (2011) has since been revised to consider the various environmental and engineering constraints and opportunities.

Some of the major changes that have been made to the Project design since April 2011 include the following.

- The ore processing plant, TSF, and associated facilities are all sited within a single watershed, Napadogan Brook, for maximum effectiveness of responsible water management and ultimate ease of closure of the Project.

- The ore processing plant, TSF, and other major Project components are sited in very close proximity to the open pit location, thereby minimizing hauling and pumping distances for maximum energy efficiency.

- The TSF has been designed to exceed the requirements set out in the Canadian Dam Association's "Dam Safety Guidelines" (Canadian Dam Association 2007) to ensure it will readily withstand the effects of extreme storm events and earthquakes.

- The size and configuration of the TSF have been optimized to avoid unnecessary disturbance of brooks, lakes and fish habitat, and areas of elevated archaeological potential, particularly in the northwest corner of the TSF.

- All waste rock (some of which is potentially acid generating) will be stored sub-aqueously (*i.e.,* under water) in the TSF rather than in a separate waste rock storage area, to avoid the generation of acid rock drainage (ARD) and associated metal leaching (ML).

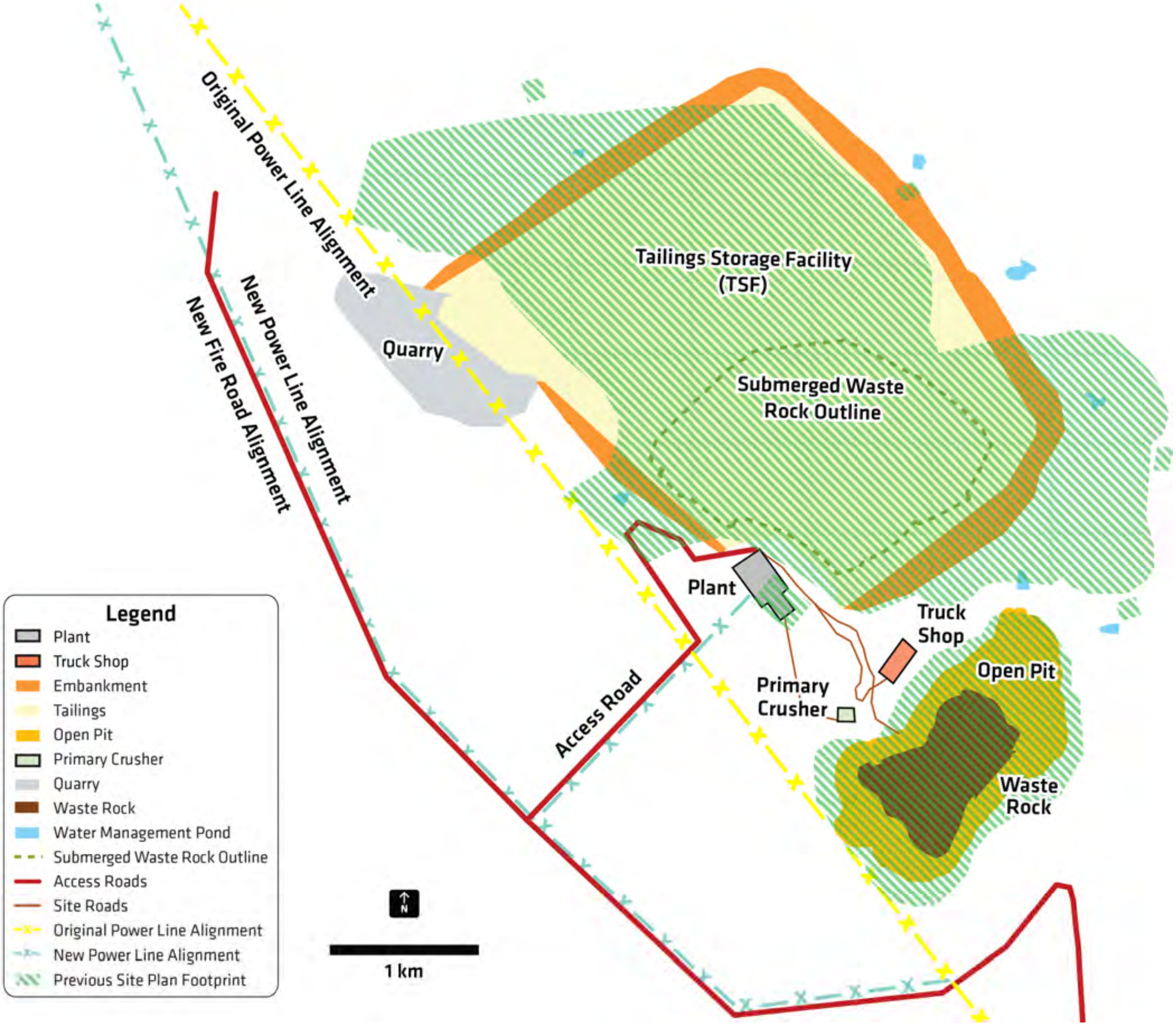
- No waste rock will be used to build the TSF embankments since some is potentially acid generating (PAG). Instead, a quarry will be developed on-site to provide non-potentially acid generating (NPAG) rock for the embankments.

- Ammonium paratungstate (APT) will be produced on-site as an added-value end product thereby enhancing job creation and economic benefits for the people of New Brunswick and Canada.

- An existing 345 kV transmission line and the existing Fire Road that currently cross the Project site will be re-routed to make way for Project facilities, both within the same corridor to minimize footprint and habitat fragmentation.

- Fish habitat offsetting will be included as part of the Project.

An overview of major changes in the layout of Project components since April 2011 is provided in Figure 3.2.2.



Source: Sisson Mines Ltd.

Figure 3.2.2 **Overview of Major Changes in the Sisson Mine Layout Since April 2011**

3.2.2 Open Pit Mine

An open pit mine is an excavation in the ground for the purpose of extracting ore, and which is open to the surface for the duration of the mine's life. To expose and mine the ore, it is necessary to remove surface soils (*i.e.,* overburden), and excavate and relocate waste rock (*i.e.,* material that does not contain the target mineral(s), also called barren rock).

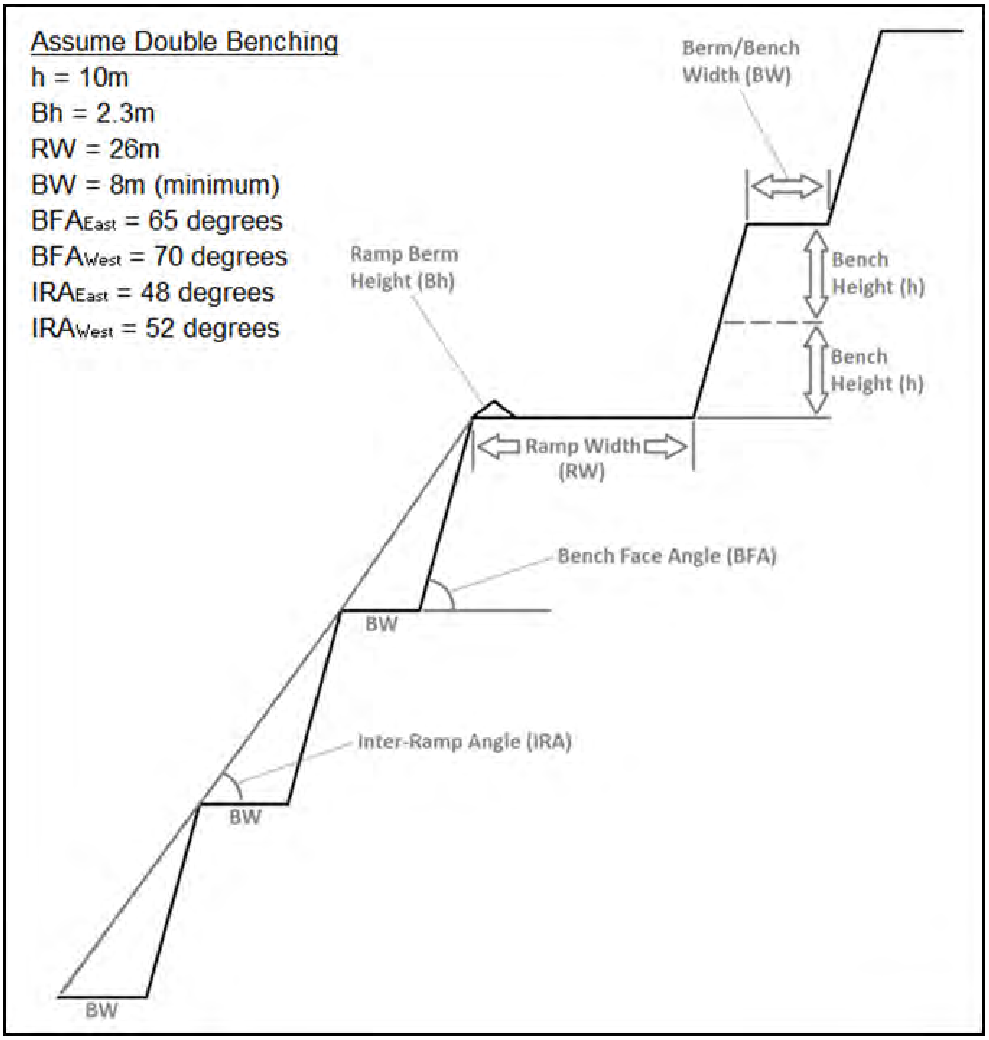
The layout of the open pit is developed to facilitate ore extraction and accommodate the equipment operation in the pit. The open pit includes benches, haul roads, and overburden disposal. A bench is the term used for each ledge that forms a single level of operation within the pit above which mineral or waste materials are mined back to the bench face. The mineral or waste is removed in successive layers, each of which is a bench. Several benches may be in operation simultaneously in different parts of, and at different elevations in, the open pit mine.

The open pit will cover an area of about 145 ha at its ultimate extent, and will be 300 to 370 m deep (compared to current elevations) upon completion of mining at approximately Year 27.

As currently designed, the open pit will intersect several fingertip streams that are tributaries to Sisson Brook, as well as Sisson Brook itself. Some of the smaller fingertip streams that are tributaries to McBean Brook to the south of the pit will also be eliminated. Engineered drainage channels around the open pit will divert some of the Sisson Brook catchment into McBean Brook. Further details on these aspects are provided in Section 7.4.

3.2.2.1 Mine Development and Mining Methods

Geotechnical parameters used in the pit optimization process were provided by Knight Piésold in support of the feasibility study and are summarized in Figure 3.2.3.

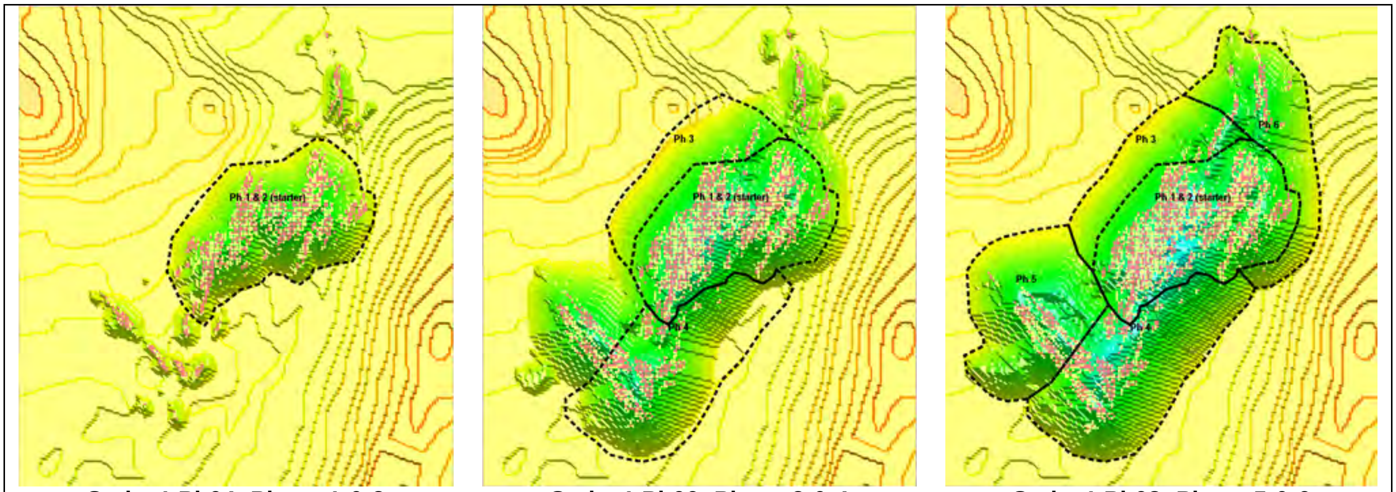


Note: Figure not to scale. Source: Samuel Engineering (2013).

Figure 3.2.3 **Cross-Sectional Schematic of Open Pit Wall with Geotechnical Design Parameters**

3.2.2.1.1 Open Pit Design

The pit design for the Project has six phases (Samuel Engineering 2013). Details considered were the addition of roads and bench access, removal of impractical mining areas with a width less than the minimum working width, and ensuring the pit slopes meet the detailed geotechnical recommendations. The phase designs are presented in Figure 3.2.4.



Series1 Pit04: Phase 1 & 2 **Series1 Pit06: Phase 3 & 4** **Series1 Pit08: Phase 5 & 6**

Note: Figure not to scale. Source: Samuel Engineering (2013).

Figure 3.2.4 Open Pit Phase Design

3.2.2.2 Blasting and Ore Extraction

Open pit mining will operate year-round on a 24 hour per day, seven day per week schedule, for approximately 360 days per year. The pit will be excavated by drilling and blasting successive benches, and removing the broken rock with a hydraulic shovel and/or wheeled loaders. Blasting will occur two to three times per week using emulsion explosives.

The broken rock will be hauled out of the open pit by truck. Ore will be delivered to the primary crusher adjacent to the open pit, or to a small run-of-mine (ROM) ore stockpile located adjacent to the primary crusher. Waste rock will be hauled by truck to the TSF for sub-aqueous storage.

An on-site explosives magazine will be located near the open pit, in a secure area in compliance with applicable regulations. A magazine license will be obtained from Natural Resources Canada. Explosives use will be approximately 20,000 kg per week, with approximately 30,000 kg of explosives in storage at any given time.

3.2.2.3 Primary Crushing and Conveying to Ore Processing Plant

The ore extracted from the open pit will be delivered by truck to the primary crusher and then conveyed to the ore processing plant. The equipment will include:

- a 30,000 t/d primary gyratory crusher, fed via a truck dump hopper, and equipped with a dust collector;
- conveyors from the primary crusher to the coarse ore stockpile located outside the ore processing plant; and
- conveyors from the coarse ore stockpile to the secondary screening surge bin located within the ore processing plant; these conveyors are equipped with a dust collector.

3.2.2.4 Mobile Equipment Fleet

The mine vehicle fleet will consist of common large mining equipment as outlined in Table 3.2.1.

Table 3.2.1 Mobile Mining Equipment

Activity Area	Type of Equipment	Number of units		Fuel Type	Power (kW)
		Initial Quantity	Life-of-Mine Maximum Quantity		
Drilling	Diesel Hydraulic Drill – 165 mm	1	3	Electrical	520
Blasting	Blasthole Loader	1	1	Diesel	75
Loading	ELEC Hydraulic Shovel – 16.5 m^3	1	3	Electrical	900
	Dozer – 433 kW	1	1	Diesel	433
	Wheel Dozer – 372 kW	1	1	Diesel	372
Hauling	Haul Truck – 136 t	3	14	Diesel	1,080
	Water Truck – 4,000 gal	1	2	Diesel	750
	Water Truck – 20,000 gal	0	1	Diesel	750
	Dozer – 306 kW	1	2	Diesel	306
	Grader – 221 kW	1	2	Diesel	221
	Tire Manipulator - 293 kW	1	1	Diesel	293
Pit Maintenance	Dozer – 306 kW	0	0	Diesel	306
	Excavator – 301 kW	1	1	Diesel	301
	Mobile Screening Plant	1	1	Diesel	75
	Light Plant – 20 kW	2	4	Diesel	20
	Forklift – 10 t	1	1	Diesel	110
	Forklift – 30 t	1	1	Diesel	175
	Fuel/Lube Truck – 4,000 l	1	1	Diesel	280
	Jaw Crusher	1	1	Diesel	300
	274 kW - Loader	1	1	Diesel	274
	Crew Van - 15 Passenger	2	2	Gasoline	190
	Warehouse Truck – 1 t	1	1	Diesel	280
	Crew Cab Pickup	4	8	Gasoline	190
	Service Truck – 1 t	1	2	Diesel	280
	Welding Truck – 1 t	1	2	Diesel	280
	Picker Truck	0	1	Diesel	280
	Dozer – 306 kW (Quarry/TSF)	0	1	Diesel	306

Source: Samuel Engineering (2013).

3.2.2.5 Stockpiles and Storage Areas

A 30,000 t coarse ore stockpile will be located outside of the ore processing plant on a concrete pad with drainage to the TSF. Mine waste rock and low grade ore will be stockpiled in the TSF at a rate of approximately 18,000 and 4,000 t/d, respectively. Topsoil storage piles will be established surrounding the perimeter of the TSF, for future use during reclamation activities.

3.2.3 Ore Processing Plant

The principal economic minerals of the Sisson deposit are scheelite ($CaWO_4$) and molybdenite (MoS_2) and the Sisson concentrator process is based on the recovery of concentrates from these two minerals.

The ROM ore will be processed through an on-site concentrator that will produce a molybdenum flotation concentrate and a tungsten flotation concentrate. The molybdenum concentrate will be shipped off-site for further processing, while the tungsten concentrate will be processed on-site to produce a high-purity ammonium paratungstate (APT) product.

3.2.3.1 Concentrator Process Facilities

The concentrator facilities and process design for the Project includes the following major processing steps:

- three-stage crushing;
- single-stage, dual-line grinding and classification;
- molybdenum rougher-scavenger and bulk sulphide flotation;
- molybdenum regrind and four-stage cleaner flotation;
- molybdenum concentrate dewatering and packaging;
- tungsten rougher-scavenger flotation;
- tungsten three-stage cleaner flotation; and
- reagent preparation and utilities.

A simplified block diagram for the concentrator process is provided in Figure 3.2.5. The Sisson concentrator is designed to handle 10.5 million t/a of ROM feed using conventional comminution and flotation techniques, and to operate 365 days per year at an average operating availability of 92%. The daily average operating throughput rate is 28,767 t/d, and the design operating rate is 31,269 t/d.

A description of the concentrator process steps and equipment is provided in Section 3.4.2.2 (Ore Processing). Further details on the process and processing plant design characteristics are described in the Technical Report (Samuel Engineering 2013). These processes, configurations, and design characteristics may change slightly during detailed engineering design, but the outer envelope of resulting emissions and wastes of the Project will not change from that described and assessed in this EIA Report.

The major concentrator facilities consist of:

- equipment to size the materials being processed (*e.g.,* crusher, grinder, ball mill, screen, cyclone);
- flotation cells which are circular tanks in which a slurry is stirred and air is bubbled from below to “float” off the desired product for further processing. Different types of reagents are used to enhance the froth flotation process at different stages (*e.g.,* frother, collector, depressant, and pH conditioner);

- dewatering equipment (*e.g.,* thickener, filter, dryer); and
- various mixing and storage tanks, transfer pumps and piping.

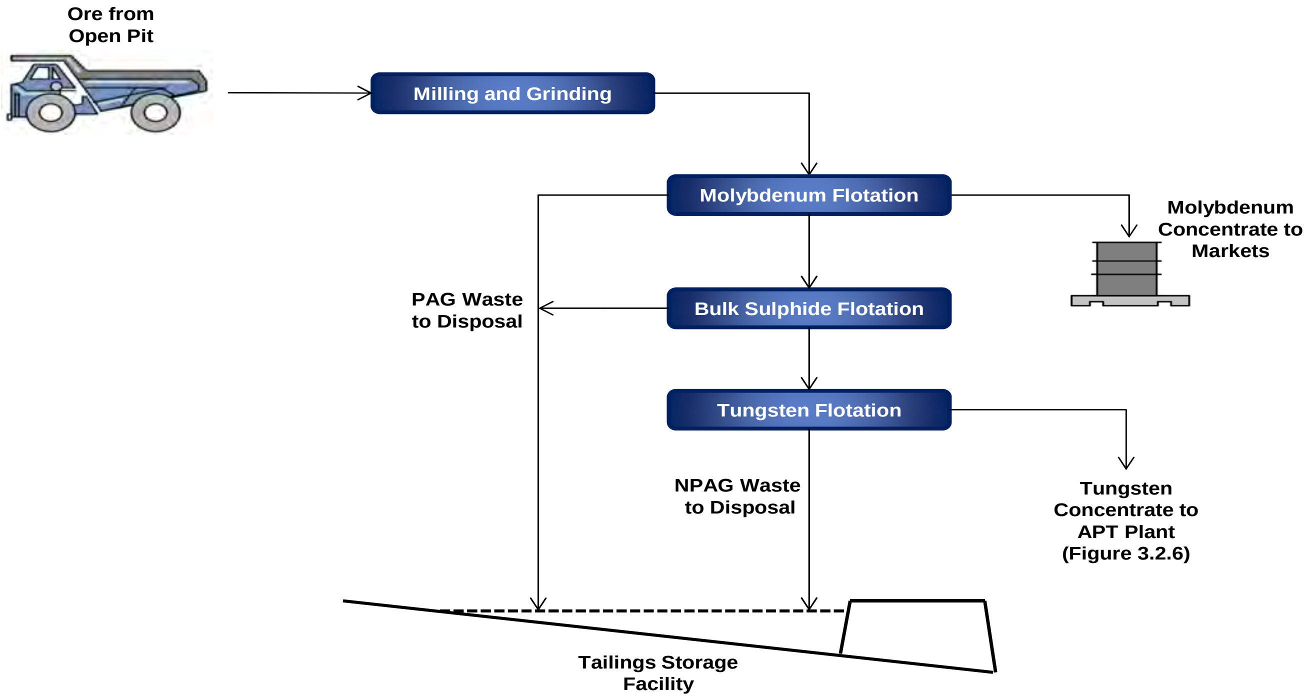


Figure 3.2.5 Simplified Block Diagram of the Ore Concentrator Plant

In summary, the concentrator process involves a three-stage crushing and screening circuit followed by two parallel closed circuit ball mills to produce a suitable feed for flotation.

A molybdenite rougher concentrate is then floated, reground and cleaned in four stages. The final molybdenite concentrate is thickened, filtered, dried and bagged for markets. The molybdenite tailings stream enters an adjoining Bulk Sulphide Flotation (BSF) circuit. The BSF concentrate will contain pyrite and other sulfide minerals which are removed to mitigate their interference in the downstream tungsten flotation process. Furthermore, the BSF concentrate forms the potentially ARD-generating molybdenum tailings stream and is sent to the TSF for sub-aqueous disposal to prevent oxidation.

The BSF tailings stream is then conditioned in two stages with depressants and collectors for tungsten flotation. The conditioned pulp enters the tungsten rougher circuit followed by an adjoining scavenger flotation circuit. The rougher concentrate is cleaned three times, thickened, filtered, dried and then refined to APT in the APT plant. The scavenger concentrate is recycled to the tungsten conditioners while the tailings, containing low levels of sulphides, are disposed to the TSF as NPAG tungsten tailings from the plant.

3.2.3.2 Reclaim Water Clarification

The concentrator will use reclaimed water from the TSF. Reclaim water from the TSF, containing low levels of unsettled fine suspended solids, will first be clarified with lime treatment. The clarification plant major equipment will include two conditioning tanks, a clarifier, and lime and flocculant preparation/mixing systems. After clarification and pH adjustment with carbon dioxide, the clarified water will be pumped to the concentrator process water tank for use in the process. Settled solids from the water clarification plant will be sent to the TSF for storage. The water clarification plant is designed to process approximately 2,635 m^3/h of recycled water.

3.2.3.3 Tailings Disposal

Flotation plant tailings will consist of both PAG and NPAG streams. As the tungsten flotation circuit tailings contain less than 0.1% sulphur, they are expected to be NPAG, and they will constitute approximately 95% of the total tailings mass. The molybdenum circuit tailings are expected to be PAG. The two tailings streams will be pumped to the TSF separately, to allow the sub-aqueous deposition of the PAG molybdenum tailings in the TSF and surface deposition of the NPAG tungsten tailings on the tailings “beaches” within the TSF.

Process water will be reclaimed from the TSF pond by pumps located on a floating barge to the reclaim water clarification plant.

Further details on the TSF are provided in Section 3.2.4.4 below.

3.2.3.4 Ammonium Paratungstate (APT) Production Facilities

The APT plant design was based on proven metallurgical and chemical processes and confirmed by testing conducted at the laboratories of SGS Lakefield, an independent testing facility in Ontario, supplemented by substantial in-house metallurgical expertise relating to APT production and the related technologies. The process as designed is a series of continuous and batch operations, with storage hold points, based on alkali pressure leach technology. The APT plant includes the following major processing steps:

- feed preparation;
- digestion and residue filtration;
- alkali recovery and solution purification;
- conversion to ammonium tungstate;
- APT crystallization;
- APT drying and packaging; and
- reagent preparation and utilities.

A simplified block diagram of the APT plant is provided in Figure 3.2.6. The APT plant is designed to process Sisson tungsten concentrate at a maximum feed rate of 29,000 t/a containing 881,000 metric tonne units of tungsten trioxide (mtu WO_3) per year (note: 1 mtu = 10 kg of material). On average, and based on feasibility study life of mine (LOM) mine plan, the APT plant will process 19,000 t/a of concentrates containing 581,000 mtu of WO_3 per year to produce 555,000 mtu/a of WO_3 contained in a high-quality APT product.

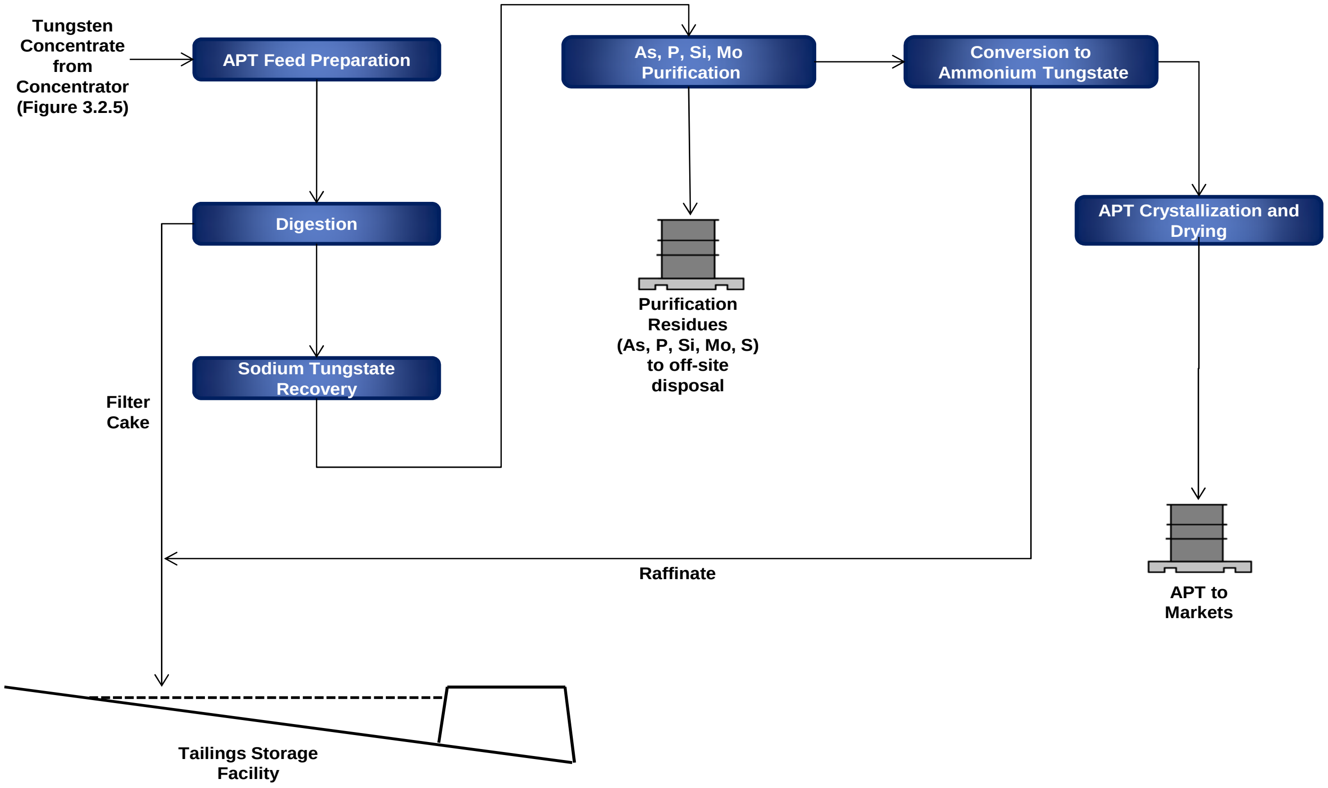


Figure 3.2.6 **Simplified Block Diagram of the Ammonium Paratungstate (APT) Plant Process**

A description of the APT plant process and equipment is provided in Section 3.4.2.2 (Ore Processing). Further details on the APT process and plant design characteristics are described in the Technical Report (Samuel Engineering 2013). These processes, configurations, and design characteristics may change slightly during detailed engineering design, but the outer envelope of resulting emissions and wastes of the Project will not change from that described and assessed in this EIA Report.

The major APT plant facilities consist of:

- equipment to size the materials being processed (*e.g.,* grinding mill, cyclone);
- dewatering equipment (*e.g.,* thickener, filter, dryer);

- reaction vessels and crystallizers; and
- various mixing and storage tanks, transfer pumps and piping.

In summary, tungsten concentrate will first be reground and dewatered in the feed preparation circuit in order to allow a uniform feed ahead of digestion. Tungsten in the concentrates will be digested using an alkali leach system, and the sodium tungstate solution will be filtered from the undigested leach residue. The residue will be stored within dedicated cells in the TSF, while the sodium tungstate solution will be processed through an alkali recovery and purification process. Common impurities will be removed and stored for off-site disposal. The resulting sodium tungstate solution will be converted to ammonium tungstate, and subsequently to APT crystals.

3.2.3.5 Reagent Storage

Reagents and chemicals for the process plants will be used in flotation, dewatering, reclaim water clarification and APT conversion circuits. Reagents will be delivered in bulk or by specific container and stored on-site in separate, secure, designated areas near or attached to process plant buildings. Covered and open storage areas for all reagents will be self-contained and equipped with spill recovery sump pumps as needed. Reagents used in the ore processing and APT processes are discussed further in Section 3.4.2.2.5.

3.2.4 Mine Waste and Water Management

3.2.4.1 Mine Waste

Waste from mining operations includes tailings generated from the mill process and waste rock generated from open pit mining. All tailings will be directed to a TSF for permanent storage and disposal in two streams: the NPAG tungsten tailings (about 95% of the total) and the PAG molybdenum tailings (about 5% of the total). All PAG tailings and waste rock will be stored sub-aqueously within the TSF to effectively mitigate the potential onset of acid generation. Waste rock will be stored in the TSF for the first 21 years of the mine life in layers which will become sequentially inundated under water in the TSF pond. Starting in Year 22 until the end of life of mine, waste rock will back-filled into mined-out parts of the open pit, where it will be flooded along with the pit during Closure.

3.2.4.2 Water Management

The general water management plan is to divert non-contact surface water outside of the PDA back to natural drainages using diversion channels, away from the PDA, to the fullest extent possible, and to collect all mine contact water within the PDA and store it in the TSF. The sources of mine contact water are primarily the water management ponds (WMP) around the TSF (which collect embankment run-off and seepage for recycle back to the TSF) and dewatering of the open pit during Operation. Surface run-off collected throughout the mine site (*e.g.,* precipitation falling on other areas of the site, such as near the ore processing plant) will also be treated as mine contact water and directed to the TSF for storage.

Direct precipitation and groundwater infiltration into the open pit will need to be pumped during mining. Sumps will be installed in the low points within the open pit from which water will be pumped to a water management pond located at the open pit rim, and then to the TSF. The pumps and pipelines will be sized to remove the inflow volume resulting from the 1 in 10-year design flood event within 10 days.

Mine contact water surplus to Project needs will be stored in the TSF and reclaimed as a process water source for the ore processing plant. There will be no need to release any water contained in the TSF during Years 1-7 of Operation. It is expected that there will be a surplus of water starting at about Year 8 of Operation, thus requiring surplus water to be treated as necessary to meet water quality objectives established by government as part of the facility's Approval to Operate, then released to downstream environments via the former Sisson Brook channel. The surplus water will be drawn from the clarifier discharge and further treated in a water treatment plant (WTP) before discharge.

During Closure, surplus water from the TSF and quarry will be directed to the open pit via engineered channels to accelerate filling of the pit. When the pit lake reaches a pre-determined level, this will mark the end of the Closure period, and the beginning of Post-Closure. During Post-Closure, the lake water will be treated in the WTP before discharge for as long as required to meet water quality objectives established by the government's Approval to Operate. When the pit lake water is of sufficient quality that it can be discharged directly, it will be allowed to do so via an engineered channel from the north end of the pit lake to the former Sisson Brook channel.

3.2.4.3 Tailings Storage Facility (TSF)

3.2.4.3.1 Overview

Tailings from ore processing will be transported through slurry pipelines to the TSF where the tailings solids will be deposited, settle and compact over time. PAG tailings will be stored sub-aqueously in the TSF, encapsulated in the NPAG bulk tailings, to effectively mitigate potential oxidation, acid generation, and metal leaching in the TSF. The NPAG tailings will be deposited from pipeline spigots around the TSF embankments to form beaches and thus keep the supernatant TSF pond away from the embankments. The PAG tailings will be deposited at the bottom of the supernatant pond and remain under water.

The TSF will be located in the area formerly covered by Bird Brook and its various tributaries, and will cover an area of approximately 751 ha at its ultimate extent at the end of mine life.

The base of the TSF embankments will be native overburden, compacted as required to minimize seepage. The engineered embankments, constructed of NPAG quarried rock or local borrow materials, will retain the tailings. The TSF embankments and operational procedures are designed to minimize seepage, and otherwise direct seepage to water management ponds (WMPs) located at low points around the TSF embankments. The WMPs will recycle this seepage, and run-off from the embankment faces, back into the TSF. Groundwater monitoring wells will be installed below the WMPs to monitor water quality; if necessary to protect downstream water quality, they may be converted to pump-back wells to return water to the TSF. The base case Project design includes pump-back wells at the northwest corner of the TSF to capture some seepage that is not collected by the WMPs. Monitoring and adaptive management will provide for additional pump-back wells as required to meet water quality objectives. As discussed below, TSF embankments will be designed and built to meet or exceed standards established in the Canadian Dam Association's "Dam Safety Guidelines" (Canadian Dam Association 2007).

The TSF is designed for secure and permanent storage of approximately 282 million metric tonnes (Mt) of tailings, 287 Mt of waste rock (*i.e.,* 270 Mt of barren rock and 17 Mt of mid-grade ore) from the mining operations over a 27-year mine life. All PAG materials will be stored sub-aqueously within the TSF. General arrangements of the TSF over the mine life are shown in Figures 3.4.1 to 3.4.6, and a typical cross-section of the TSF embankment design is provided in Figure 3.2.7.

3.2.4.3.2 Elements of the TSF

Tailings and waste rock will be impounded in the TSF in an area formerly occupied primarily by the Bird Brook watershed, to the northwest of the open pit and immediately north of the plant site. A single TSF, confined by a perimeter embankment on the northwest, northeast, and southeast sides, and a saddle embankment on the southwest side, will be constructed to store all tailings and waste rock produced over the mine life.

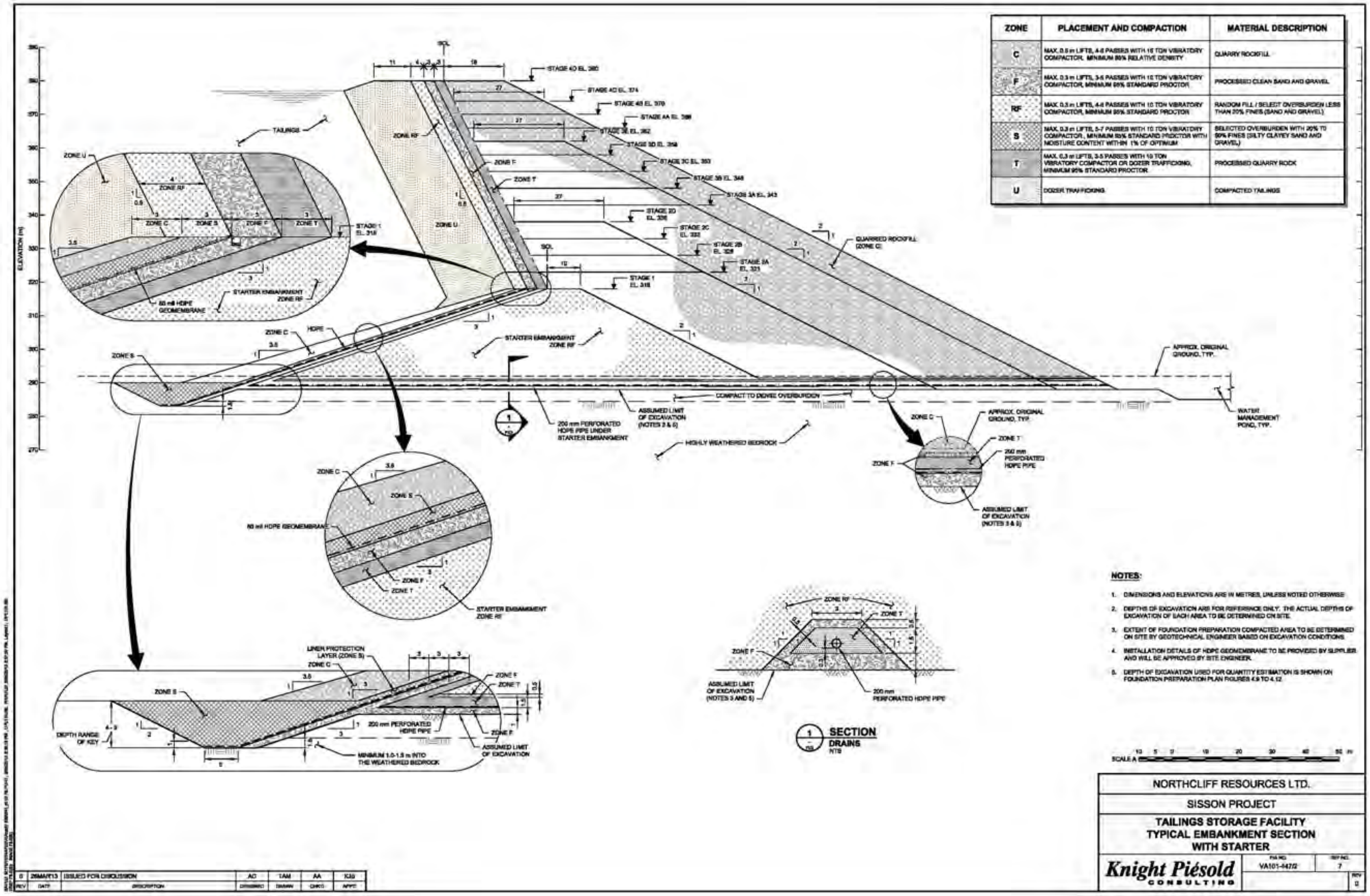
The primary aspects of the TSF design include:

- zoned embankments constructed of earthfill and rock;
- upslope TSF diversion channels;
- access roads and haul roads for embankment construction;
- seepage and embankment run-off collection ditches and ponds;
- tailings transport and deposition system;
- reclaim water system;
- tailings beaches;
- supernatant water pond; and
- sub-aqueous waste rock and mid-grade ore storage.

The TSF embankments are designed for staged expansion as the volume of the stored tailings and ponded water increases with time. Further details on the TSF design and construction are provided below.

3.2.4.3.2.1 Embankments

The embankments will be constructed in stages as zoned rock fill structures. Stage 1 includes the initial starter embankment that will be constructed prior to mill start-up. Stages 2 through 4 represent the ongoing raises throughout the mine life needed to meet tailings storage requirements. The final embankment has an elevation of 376 m above sea level (masl) and a crest length of approximately 8.8 km.



ZONE	PLACEMENT AND COMPACTION	MATERIAL DESCRIPTION
C	MAX. 0.6 m LIFTS, 4-6 PASSES WITH 10 TON VIBRATORY COMPACTOR, MINIMUM 80% RELATIVE DENSITY	QUARRY ROCKFILL
F	MAX. 0.3 m LIFTS, 3-6 PASSES WITH 10 TON VIBRATORY COMPACTOR, MINIMUM 95% STANDARD PROCTOR	PROCESSED CLEAN SAND AND GRAVEL
RF	MAX. 0.3 m LIFTS, 4-6 PASSES WITH 10 TON VIBRATORY COMPACTOR, MINIMUM 95% STANDARD PROCTOR	RANDOM FILL / SELECT OVERBURDEN LESS THAN 20% FINES (SAND AND GRAVEL)
S	MAX. 0.3 m LIFTS, 5-7 PASSES WITH 10 TON VIBRATORY COMPACTOR, MINIMUM 95% STANDARD PROCTOR WITH MOISTURE CONTENT WITHIN 1% OF OPTIMUM	SELECTED OVERBURDEN WITH 20% TO 50% FINES (SILTY CLAYEY SAND AND GRAVEL)
T	MAX. 0.3 m LIFTS, 3-5 PASSES WITH 10 TON VIBRATORY COMPACTOR OR DOZER TRAFFICKING, MINIMUM 95% STANDARD PROCTOR	PROCESSED QUARRY ROCK
U	DOZER TRAFFICKING	COMPACTED TAILINGS

NOTES:

1. DIMENSIONS AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.
2. DEPTHS OF EXCAVATION ARE FOR REFERENCE ONLY. THE ACTUAL DEPTHS OF EXCAVATION OF EACH AREA TO BE DETERMINED ON SITE.
3. EXTENT OF FOUNDATION PREPARATION COMPACTED AREA TO BE DETERMINED ON SITE BY GEOTECHNICAL ENGINEER BASED ON EXCAVATION CONDITIONS.
4. INSTALLATION DETAILS OF HDPE GEOMEMBRANE TO BE PROVIDED BY SUPPLIER AND WILL BE APPROVED BY SITE ENGINEER.
5. DEPTH OF EXCAVATION USED FOR QUANTITY ESTIMATION IS SHOWN ON FOUNDATION PREPARATION PLAN FIGURES 4.9 TO 4.12.

NORTHCLIFF RESOURCES LTD.

SISSON PROJECT

TAILINGS STORAGE FACILITY
TYPICAL EMBANKMENT SECTION
WITH STARTER

Knight Piésold
CONSULTING

P/A NO. VA101-447/2
REF NO. 7
REV 0

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	26MAR13	ISSUED FOR DISCUSSION	AC	TAM	AA	KJB

Source: Samuel Engineering (2013).

Figure 3.2.7 Typical Cross-Section of TSF Embankments

Starter Embankments (Stage 1): Three starter embankments will be constructed at the low points in the TSF impoundment area using select overburden from local borrow sources near the embankment sites. The embankments will have a geosynthetic liner on the upstream face to allow collection of a start-up water pond and for containment of the first year of tailings deposition. The liner will be anchored into a trench keyed into the lower permeability bedrock on the upstream side of the embankment.

Ongoing Embankment Raises (Stages 2 to 4): The TSF embankments will be progressively raised by the modified centerline construction method using quarried rock fill. Transition and filter zones will be incorporated to ensure compatibility and internal stability of the embankment fill materials. A low permeability zone of compacted tailings will be constructed on the upstream side of the exposed tailings beaches using dozer compaction in hydraulic sand cells. The tailings zone will also have a relatively low permeability, and will mitigate seepage migration through the base of the TSF and the embankments.

3.2.4.3.2.2 Access

Temporary roads will be constructed within the TSF impoundment area to provide access to the TSF starter embankments, borrow sources, and the initial water management ponds. Access will be provided by upgrading existing forest resource roads with new extensions built as needed. The construction access roads will eventually be flooded by the TSF.

Permanent access to the TSF and water management ponds will be provided by the active haul roads built by the mine fleet. The crest of the embankments has been sized to allow for two-way haul truck traffic with additional width for safety berms and pipelines. The location of access roads will change throughout the mine life to suit the demands of the mining operations and TSF construction.

3.2.4.3.2.3 Surface Water Diversion Channels

Diversion structures will be constructed upstream of the TSF to limit the inflow of non-contact surface run-off where possible. These diversion channels will consist of trapezoidal ditches or collection berms to divert flow away from the TSF.

3.2.4.3.2.4 Tailings Distribution

NPAG tailings slurry from the tungsten circuit in the mill will be distributed around the TSF in pipelines and discharged from a series of off-takes located along the embankment crest. The coarse fraction of the tailings is expected to settle rapidly and will accumulate closer to the discharge points forming a gentle beach with a slope of about 1%. Finer tailings particles will travel further and settle at a flatter slope adjacent to and beneath the supernatant pond. The beaches will be developed with the intent of maximizing the storage capacity and to control the location of the supernatant pond. Selective tailings deposition will be used to maintain tailings beaches and keep the supernatant pond a suitable distance from the embankments. Effective management of tailings deposition and beach development will reduce seepage through the embankments and ensure that water is accessible for reclaim to the mill.

A separate tailings line will run from the mill directly into the TSF pond for subaqueous discharge of the molybdenum tailings, which are considered PAG and which represent approximately 5% of the total tailings produced over the mine life.

3.2.4.3.2.5 Waste Rock and Mid-Grade Ore Stockpile

The TSF is sized to store the tailings, water, all waste rock (both barren rock and mid-grade ore) produced over the life of the mine. The waste rock will be placed in the TSF by the mine trucks; the active lift will remain above the supernatant TSF pond to provide a safe working platform. The waste rock will be located a sufficient distance from the embankment to ensure that the pile is completely encapsulated by deposited tailings solids.

3.2.4.3.2.6 Seepage and Contact Water Management

Seepage from the TSF will be largely controlled by the tailings beach and the upstream compacted tailings zone; seepage that is intercepted in the embankment will be gathered in piping at the base of the embankment and directed to several lined water management ponds (WMPs) at the bottom of the embankment. Surface water run-off from the embankment faces or other disturbed areas in the vicinity of the TSF will also be collected in the WMPs located at topographic low points along the downstream toe of the embankments.

Water collected in the WMPs will be continuously monitored and pumped back into the TSF depending on water quality. Groundwater monitoring wells will be installed around the TSF to monitor seepage and water quality.

If necessary, pump-back (groundwater interception) wells will be developed where seepage is detected that may jeopardize downstream water quality. Intercepted groundwater will either be pumped to the WMPs, or directly to the TSF. Pump-back wells are planned at the northeast corner of the TSF, and may be installed at other locations depending on the results of water quality monitoring and adaptive management measures required to maintain acceptable water quality in receiving watercourses. Other measures that can be implemented during Operation to reduce seepage losses include:

- maintain low water levels in the perimeter ditches and WMPs to minimize potential seepage;
- line the downstream face of the perimeter ditches in areas with higher seepage losses;
- increase the number of WMPs to reduce the length of the perimeter ditches between WMPs; and
- construct secondary perimeter ditches to capture lost seepage from the seepage collection system.

3.2.4.3.3 Design Basis for the TSF

The TSF is being designed to exceed the requirements set forth in the Canadian Dam Association “Dam Safety Guidelines” (Canadian Dam Association 2007) to ensure it will readily withstand the effects of extreme storm events and earthquakes. These Guidelines are the recommended standard design practice for major impoundments, water management facilities and dams, and are used by the Province of New Brunswick in permitting structures like the Sisson TSF.

Application of the Dam Safety Guidelines requires that a “hazard classification” be made of the TSF to enable appropriate design earthquake and flood events to be determined based on the classification criteria provided by the Guidelines. The classification of a TSF is carried out by considering the potential incremental consequences of an embankment failure. The incremental consequences of failure are defined as the total damage from an event with dam failure minus the damage that would have resulted from the same event had the dam not failed. The incremental losses consider loss of life, environmental and cultural values, and infrastructure and economic impacts. At Sisson, a failure of the TSF embankment and resultant tailings or process water release could significantly affect downstream watercourses and habitats that have substantial ecological and societal value, and the hazard classification of the Sisson TSF was therefore set to ensure a design that will protect these values.

3.2.4.3.3.1 Storm Events

Selection of an appropriate Inflow Design Flood (IDF) was required to carry out a safety assessment of the TSF and to estimate flood storage requirements. The size of the IDF increases with increasing consequences of failure. Based on the hazard classification assigned to the Sisson TSF, an appropriate IDF is a probabilistically-derived event with a return period of two-thirds between the 1-in-1,000-year flood and the Probable Maximum Flood (PMF). The PMF is defined as the most severe flood that may reasonably be expected to occur at a particular location. Although the deterministically derived PMF does not have a probability of occurrence associated with it, it can be compared to approximately a 1-in-20,000 year event. To be conservative, the IDF for the Sisson TSF was set at the deterministically derived 24-hour PMF. The TSF is designed with sufficient capacity and freeboard to store the PMF at all times during Operation. The storm storage volume required during Operation is approximately 4.8 Mm^3, corresponding to an equivalent run-off depth of 0.58 m.

3.2.4.3.3.2 Earthquakes

An assessment of the regional seismicity has been carried out to enable selection of appropriate design earthquake events and ground motions.

Seismicity Assessment

As discussed in Section 6.3.1.4, Eastern Canada is located in a stable continental region within the North American tectonic plate, and has a relatively low rate of seismic activity. However, moderate to large earthquakes have occurred in the region and will occur in the future. Review of historical earthquake records and regional tectonics indicates that the Sisson Project site is situated in a region of low seismicity. A probabilistic seismic hazard analysis has been carried out using historical earthquake data and the regional tectonics to identify potential seismic sources and to estimate the maximum earthquake magnitude for each seismic source. The corresponding median maximum acceleration is 0.07g for a return period of 500 years.

Design Earthquake

Consistent with the current design philosophy for geotechnical structures such as dams, two levels of design earthquake have been considered: the Operating Basis Earthquake (OBE) for normal operations, and the Maximum Design Earthquake (MDE) for extreme conditions (ICOLD 1995). Values of maximum ground acceleration and design earthquake magnitude have been determined for both the OBE and MDE.

The Dam Safety Guidelines recommend that the mean maximum acceleration value should be used for dam design. This is likely to be similar or slightly higher (by about 20%) than the median value provided by Natural Resources Canada (NRCan 2013). Consequently, estimated mean maximum acceleration values have been adopted for the design earthquake events used in seismic stability analyses.

The OBE has been taken as the 1-in-500-year return period event for the design of the TSF. The probability of exceedance for this event is approximately 5% for a 27-year operating period. The mean average maximum acceleration is estimated to be 0.07g for the 1-in-500-year earthquake. A design earthquake magnitude of 7.0 on the Richter scale has been conservatively selected for the OBE based on a review of regional tectonics and historical seismicity. The TSF is expected to function in a normal manner after the OBE.

An appropriate MDE for embankment design has been selected based on the dam hazard classification defined for the TSF and the criteria for design earthquakes provided by the Dam Safety Guidelines. With this classification, the Dam Safety Guidelines require that a dam be designed for a probabilistically-derived event (known as the Earthquake Design Ground Motion) having an annual exceedance probability (AEP) of 1-in-5,000. Consequently, the MDE selected for the TSF is the 1-in-5,000-year earthquake which has an estimated mean average maximum acceleration of 0.37g. A design earthquake magnitude of 7.0 on the Richter scale has been conservatively selected for the MDE based on a review of regional tectonics and historical seismicity. Limited deformation of the tailings embankment is acceptable under seismic loading from the MDE, provided that the overall stability and integrity of the TSF is maintained and that there is no release of stored tailings or water (ICOLD 1995).

Stability Analysis

Embankment stability analyses were carried out for both static and seismic conditions under the following cases:

- static conditions during Operation and Post-Closure;
- earthquake loading from the Operating Basis Earthquake (OBE) and the Maximum Design Earthquake (MDE); and
- post-earthquake conditions using residual (post-liquefaction) tailings strengths.

The results of the stability analyses satisfy the requirements for factor of safety and indicate that the proposed design is acceptable to maintain both short-term (Operation phase) and long-term (Post-Closure) stability. The seismic analyses indicate that any embankment deformations during earthquake loading from the OBE or MDE will be minor and will not have a significant impact on embankment freeboard or result in any loss of embankment integrity. The results also indicate that the embankments are not dependent on tailings strength to maintain overall stability and integrity.

3.2.5 Ancillary Facilities

3.2.5.1 On-Site Buildings

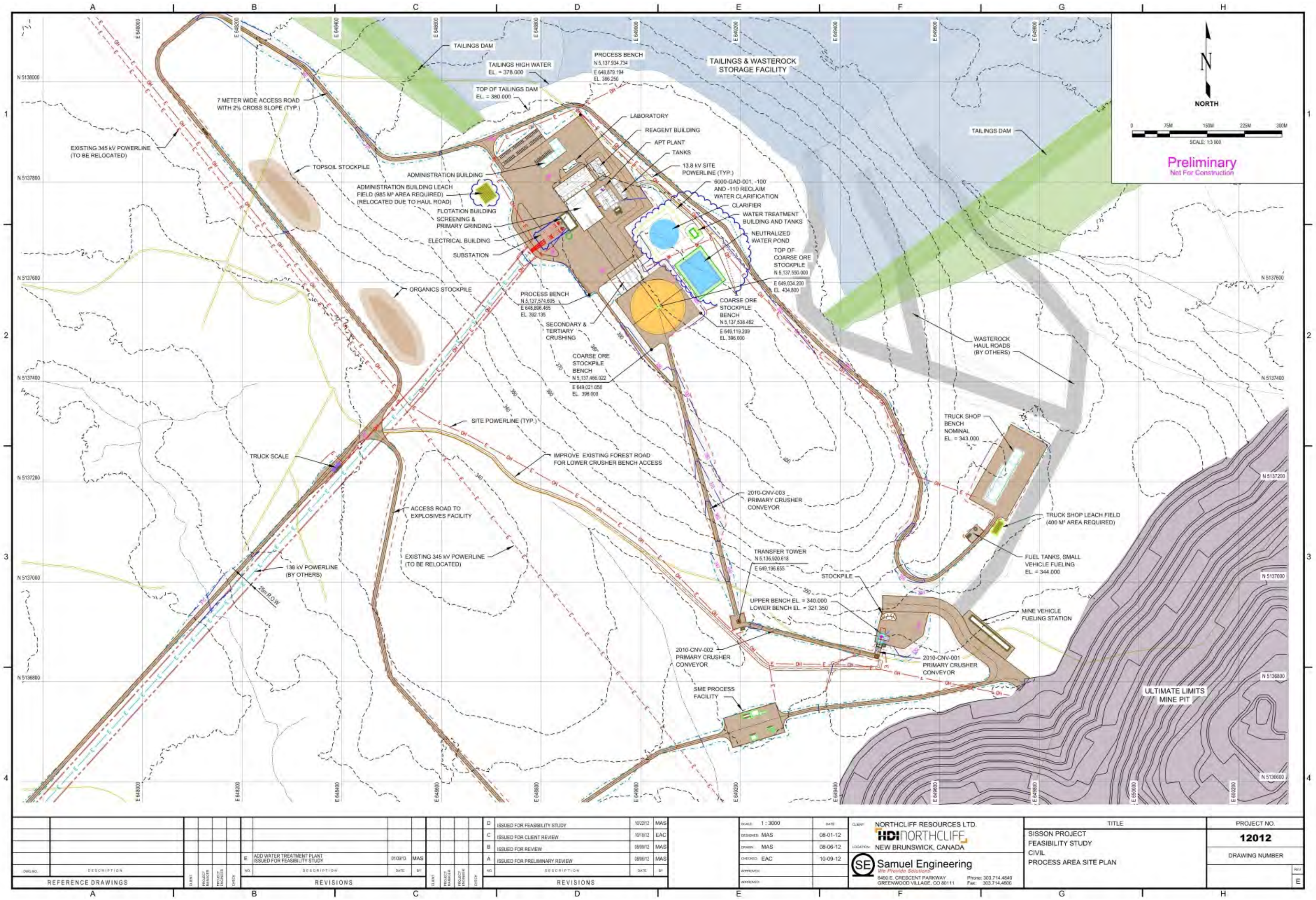
On-site buildings will include the process buildings, an administration building, a laboratory building, truck shop and warehouse, fuel storage, site mixed explosives (SME) plant, and explosives and detonator magazines. The general layout of the processing plant area and buildings and structures for the Project is shown in Figure 3.2.8.

3.2.5.1.1 Process Buildings

Secondary and tertiary crushing will be housed in a single crusher building with a total area of approximately 1,100 m^2.

The grinding circuit will be housed in a separate mill building with an area of approximately 3,400 m^2. The concentrator building measuring approximately 3,400 m^2 will house the molybdenum and tungsten bulk flotation and scavenger cells, and reagent preparation and storage area. This building will also house the mine main control room as well as all concentrator operating personnel offices and a maintenance shop. A reagent storage shed measuring about 250 m^2 will be erected outside the reagent preparation and storage area of the concentrator building.

The APT building will be a two story building covering approximately 1,100 m^2. This building will house APT processing equipment, an electrical room, APT control room, lab, and a small personnel office.



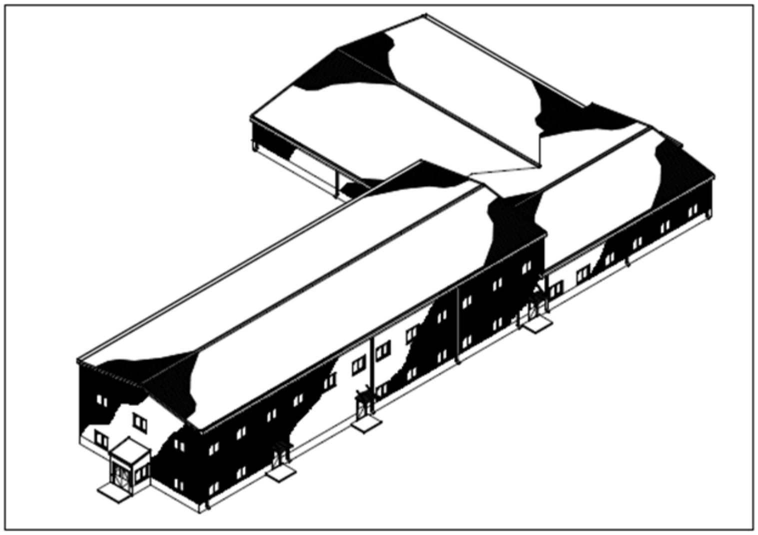
Source: Samuel Engineering (2013).

Figure 3.2.8 Process Plant Location, and Locations of Site Access Road and Internal Site Roads

3.2.5.1.2 Administration Building

The administration building will be a steel-framed, pre-fabricated, slab-on-grade building. The building footprint is L-shaped with a two-story segment covering approximately 560 m^2, and a single story segment covering approximately 680 m^2 (Figure 3.2.9).

The administration building will house space for site management, administration, mine management, engineering offices, conference rooms, archiving, building mechanical services, and washrooms. Dry change, and medical and safety offices will also be located in this facility. The building will be located north of the process plant.

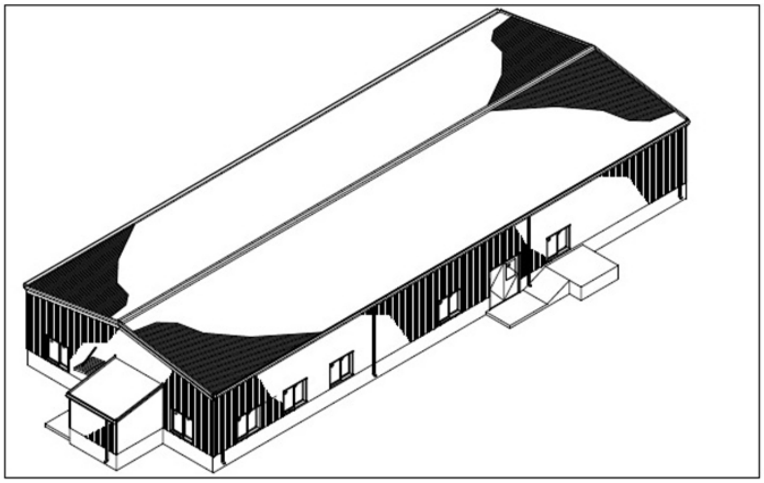


Note: Figure not to scale. Source: Samuel Engineering (2013).

Figure 3.2.9 Schematic of Administration Building

3.2.5.1.3 Laboratory Building

The laboratory building will be a single-story, steel-frame, prefabricated, slab-on-grade building covering approximately 360 m^2 (Figure 3.2.10). This building will house an analytical lab, metallurgical lab, sample preparation area, small office area, break room, and a washroom. The building will be located north of the process plant, adjacent to the administration building.



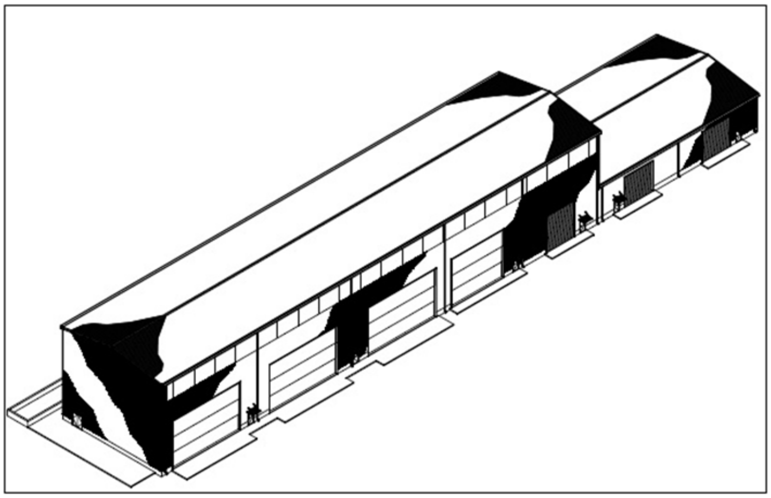
Note: Figure not to scale. Source: Samuel Engineering (2013).

Figure 3.2.10 Schematic of Laboratory Building

3.2.5.1.4 Truck Shop and Warehouse

The truck shop and warehouse building will be a single story, steel-framed, prefabricated, slab-on-grade building covering approximately 2,900 m^2 (Figure 3.2.11).

The building will house fleet repair facilities, wash bays, workshops, machine shop, a small office area, washrooms, and warehouse space for both mining and process facilities equipment. The building will be located approximately 800 m southeast of the process plant, close to the mine and mine haul roads.



Note: Figure not to scale. Source: Samuel Engineering (2013).

Figure 3.2.11 Schematic of Truck Shop and Warehouse

3.2.5.1.5 Fuel Storage and Distribution

Storage tanks will be used for storing diesel fuel and other petroleum products (*e.g.,* oils and lubricants) as well as reagents and other chemicals. The type, construction, capacity, and location of tanks will depend on their intended use and the materials stored.

All of the petroleum storage tanks will have secondary containment, as and required and will be designed and constructed in accordance with recognized industry standards and approved under the New Brunswick *Petroleum Product Storage and Handling Regulation – Clean Environment Act*. Chemical storage tanks will also be equipped with secondary containment.

A fuel storage depot and dispenser terminals will be located close to the truck shop. A storage shelter for a fire truck and mine rescue truck will be located adjacent to the truck shop.

A fuel oil tank located at the tank farm will be used to store and distribute fuel oil as required in a self-contained area which will be equipped with a sump pump for spill recovery.

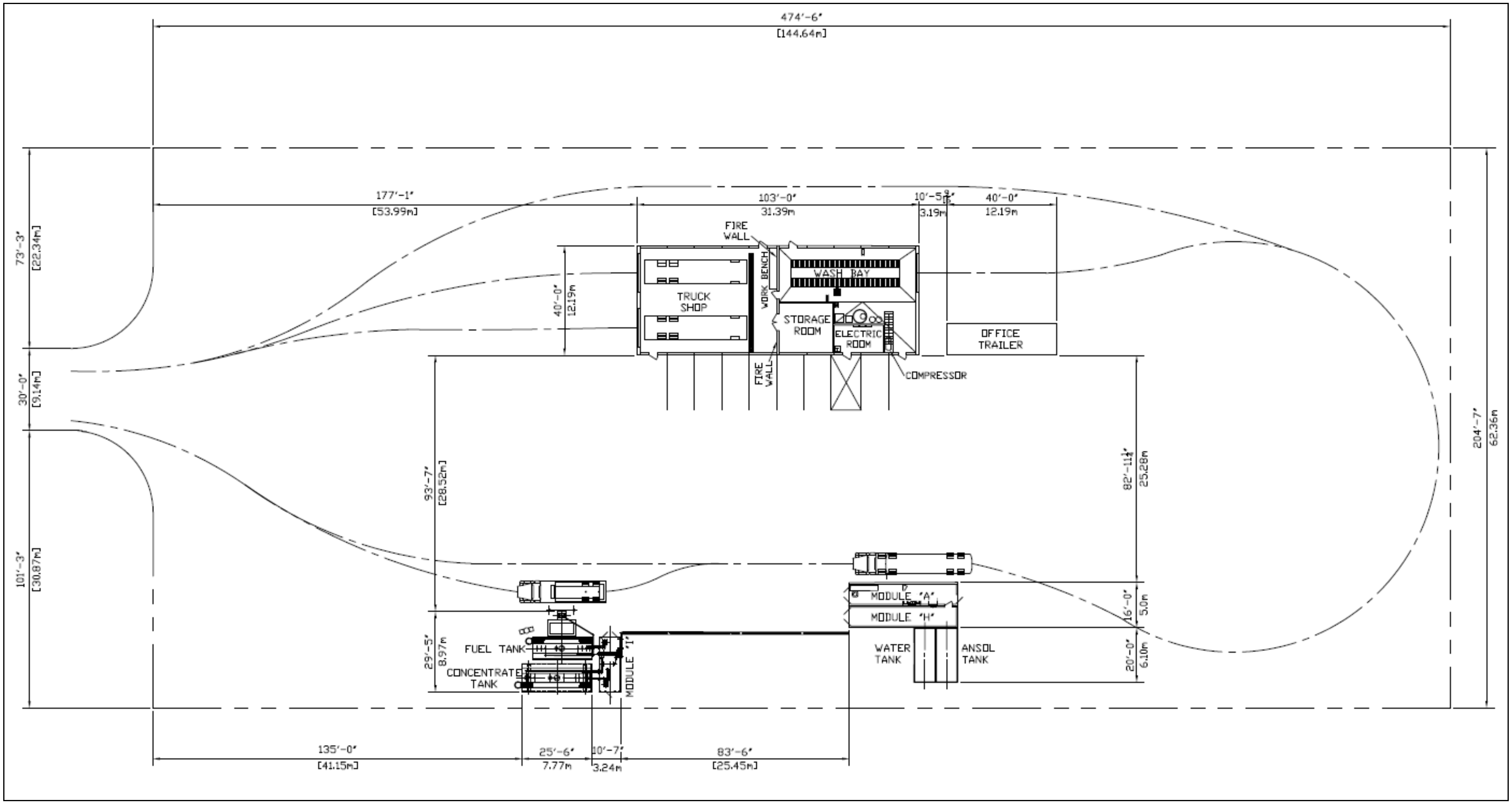
3.2.5.1.6 Site Mixed Explosives (SME) Plant and Storage

A site mixed explosives (SME) plant and explosives and detonator magazines will be located some distance west of the mine pit. The SME facility will store bulk ingredients required for producing the emulsion explosives used in the blast holes. It will also house all required pumps and tanks, truck wash bay and, blasting personnel offices and change rooms.

Specifications for blasting plant and explosives storage magazines and the locations of these facilities must adhere to the *Explosives Act* and regulations as published by the Explosives Regulatory Division of Natural Resources Canada (NRCan). The location of the blasting plant and the explosives magazines are determined by the table of distances that govern the manufacturing and storage of explosives and blasting agents. The contract explosives supplier will be responsible for proper placement of magazines and facilities.

Blasting accessories will be stored in the explosives and detonator magazines, with capacities of 32,000 kg of explosives and 124,500 detonators, respectively. The explosives magazine is located 730 m south of the SME plant, which houses the nearest inhabited building, and is in excess of 1 km from most other active site infrastructure. The nearest lightly travelled road is in excess of 265 m of the explosives magazine. The distance between the explosives and detonator magazine is a minimum of 50 m and includes effective barricades such as earthwork berms. Both the explosives magazine and detonator magazine meet or exceed all NRCan minimum distance requirements.

The SME facility will store bulk ingredients required for producing the emulsion explosive used in the blast holes. It will also house all required pumps and tanks, fuel storage, truck wash bay, and blasting personnel offices and change rooms. The location of both the SME facility and magazines, along with relative distances between each of the components of the SME facility, are shown in Figure 3.2.12.



Note: Figure not to scale.

Source: Samuel Engineering (2013).

Figure 3.2.12 Conceptual Site Mixed Explosives (SME) Facility Layout

The SME facility has capacity to store raw ingredients for the manufacture of approximately 87,000 kg of explosives. However, the manufacturing process is carried out at the blast holes and as such only the minimum NRCan distances of 270 m to the nearest inhabited building (in this case the primary crusher) and 30 m to the nearest lightly travelled road apply. Therefore, the SME facility meets or exceeds all NRCan distance requirements.

There are no temporary explosives facilities for storage or manufacturing of explosives used during pre-production or Project start-up.

3.2.5.2 Process Control System

The process control system (PCS) for the concentrator plant involves a microprocessor-based distributed control system (DCS) with components capable of being installed in separate locations and will incorporate APT plant wide digital process control communications. The control system will handle all process plant digital controls including motor control, interlocks, switches and all analog process control loops, process indicators and analog control devices. All concentrator data collection and plant operation will be operated from a single concentrator centralized control room located on the top floor between the flotation and grinding area with operator ability to view both areas from the control room. The primary crusher area, located away from the concentrator, will be operated from a primary crusher dedicated control room with operator ability to view the primary crusher and control primary crushing discharge and conveyor handling to coarse ore stockpile area. All data collection and APT plant operation will be from a single centralized control room located in a central location in the APT building near the digesters. The PCS level of automation will provide control room operators with the ability to perform all monitoring, direct control, regulatory, advanced control functions, supervisory control functions and data acquisition from any operator stations located in concentrator and APT plant areas. Any process equipment can be operated, started or stopped locally or remotely from the control room.

The PCS will use power supplies configured in a redundant format so that the failure of one power supply will not shut down the entire system. In addition, the PCS will have a dedicated uninterruptible power supplies (UPS) with batteries backup for the processors, communications, modules, and operator stations, so that these systems will remain operational for a specified time following a power outage.

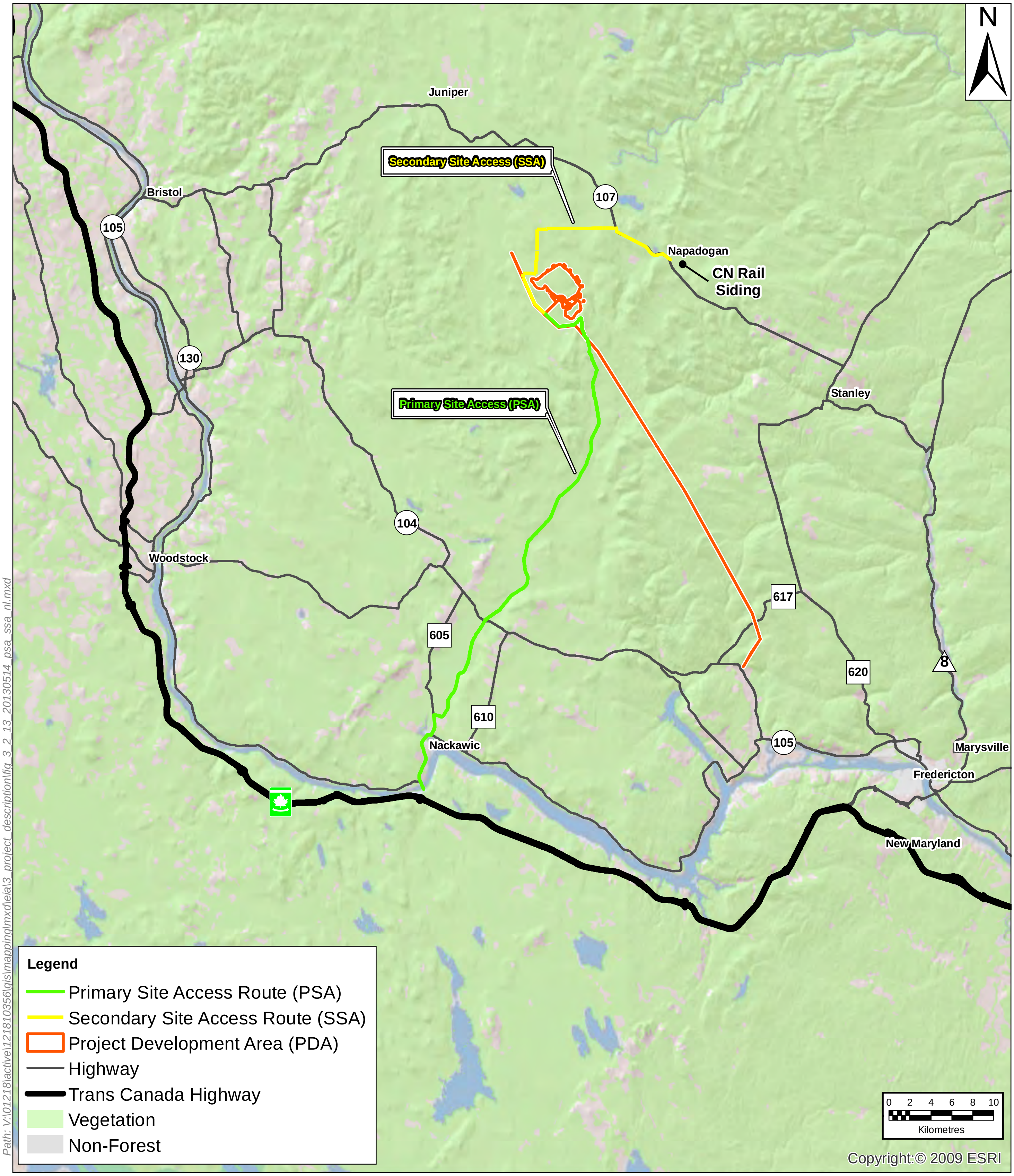
3.2.5.3 Access Roads

3.2.5.3.1 Existing Road Network

Existing forest resource roads will provide off paved highway access to the Project site. The two principal access routes to the Project are shown in Figure 3.2.13. They include the following.

- **Primary Site Access (PSA) route:** From the TransCanada Highway (Route 2), through Route 105 and Route 605, and finally through two forest resource roads, the Napadogan Road (also known as the Valley Forest Products Road) and the Fire Road, to the Project site.

- **Secondary Site Access (SSA) route:** From the CN Rail siding in Napadogan, through Route 107, and finally through two forest resource roads, the Four Mile Brook Road and the Fire Road, to the Project site.



Path: V:\01218\active\121810356\gis\mapping\mxd\eia\3 project description\fig 3 2 13 20130514 psa ssa nl.mxd

NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Primary Site Access (PSA) Route and Secondary Site Access (SSA) Route

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Sisson Mines Ltd.

Scale: 1:500,000

Project No.: 121810356

Data Sources:
NBDNR
ArcGIS Online

Fig. No.: 3.2.13

Date: (dd/mm/yyyy) 23/11/2014

Dwn. By: JAB

Appd. By: DLM

Stantec

Map: NAD83 CSRS NB Double Stereographic

The PSA route uses two forest resource roads, the Napadogan Road and the Fire Road, that extend approximately 45 km from Route 105 and Route 605 at the AV Nackawic Mill Woodyard entrance in Nackawic to the Project site. It has been designated by SML as the primary route of access to the Project from the provincial highway network. The Napadogan Road intersects Route 104, approximately 10 km north of the AV Nackawic Mill Woodyard. From Route 104, it continues north another 28 km to the Fire Road. The Project is located approximately another 7 km north of this intersection (Figure 3.2.13). The SSA route also uses two existing forest roads, Four Mile Brook Road and Fire Road, that extend westward then southward from Route 107 to the Project site, a length of approximately 17 km. These roads have been designated by SML as the secondary route of access from the provincial highway network north of the Project. The SSA route intersects Route 107 at the Four Mile Brook Road, approximately 5 km west of the community of Napadogan (Figure 3.2.13).

3.2.5.3.2 Realignment of the Fire Road

One forest resource road, the Fire Road, runs through the Project site. As a result, the Fire Road will be relocated for a linear distance of approximately 11 km around the southwest side of the site, in a common corridor with the realigned 345 kV transmission line as discussed in Section 3.2.5.7. The location of the realigned Fire Road in relation to its existing alignment is shown in Figure 3.2.14.

3.2.5.3.3 Site Access Road

A 3 km-long site access road will be established from the relocated Fire Road to the main process site area. Forest resource roads north to Route 107 and south to Route 105 will be renovated, as needed, to accommodate the increased traffic associated with Project.

Site access roads will be designed to current forest road standards outlined in the New Brunswick Forest Management Manual (NBDNR 2004a) in consultation with the Crown Timber Licence Holders and approved by NBDNR.

The site access road is depicted in Figure 3.2.8.

3.2.5.3.4 Internal Site Roads

Internal site access roads from the main access road will connect to the primary crusher, the site mixed explosives (SME) facility, the TSF, and mine pit. Ancillary roads from the site process area will connect to the truck shop and fuel storage facility. All mine access roads will be designed and constructed in consideration of standards for forest resource roads in New Brunswick (NBDNR 2004a). Internal site roads have been designed to provide safe and efficient movement of equipment and personnel throughout the site and have restricted access for all non-mine equipment and vehicles.

The internal site roads are depicted in Figure 3.2.8.

3.2.5.4 Water Supply and Distribution

The plant water systems will consist of process water, filtered process water, fresh water, potable water, soft water, de-ionized water, and recycled raw water.

3.2.5.4.1 Process Water

The process water system is supplied primarily by reclaim water from the TSF and with lower quantities of thickener overflow waters.

The water balance indicates that the Project will operate in a surplus condition over the 27-year mine life, and discharge of the excessive surplus (with treatment as necessary) will start in about Year 8. Prior to mill start-up, water will be impounded in the TSF for two freshet periods in order to collect an adequate volume of water for mill start-up. Water for processing will be pumped from the TSF supernatant pond to a head tank located at the mill via a floating reclaim pump barge and pipeline. The process water system will supply water to the secondary and tertiary screening plant, grinding circuit, flotation circuits, hoses, and filtered process water system.

The filtered process water will be stored in and distributed from a tank, the lower portion of which will hold a dedicated amount of water for fire protection. The filtered water tank will be located outside the grinding building along with the process water and fresh water tanks.

3.2.5.4.1.1 Reclaim Water Clarification Facility

The reclaim water clarification facility will be a single-story, engineered, concrete building of approximately 180 m^2. The building will contain flocculant and lime systems with mixing and dosing equipment, storage and mixing tanks, and associated piping, pumps and electrical components. Barge-mounted pumps located in the TSF will feed the plant. Treated water will flow, by gravity, to a neutralized water pond and from there will be fed by gravity to the process water tank located at the process plant, or discharged to the receiving environment with further treatment if in surplus. The treatment plant will be located on the southeast side of the process area.

3.2.5.4.2 Fresh Water

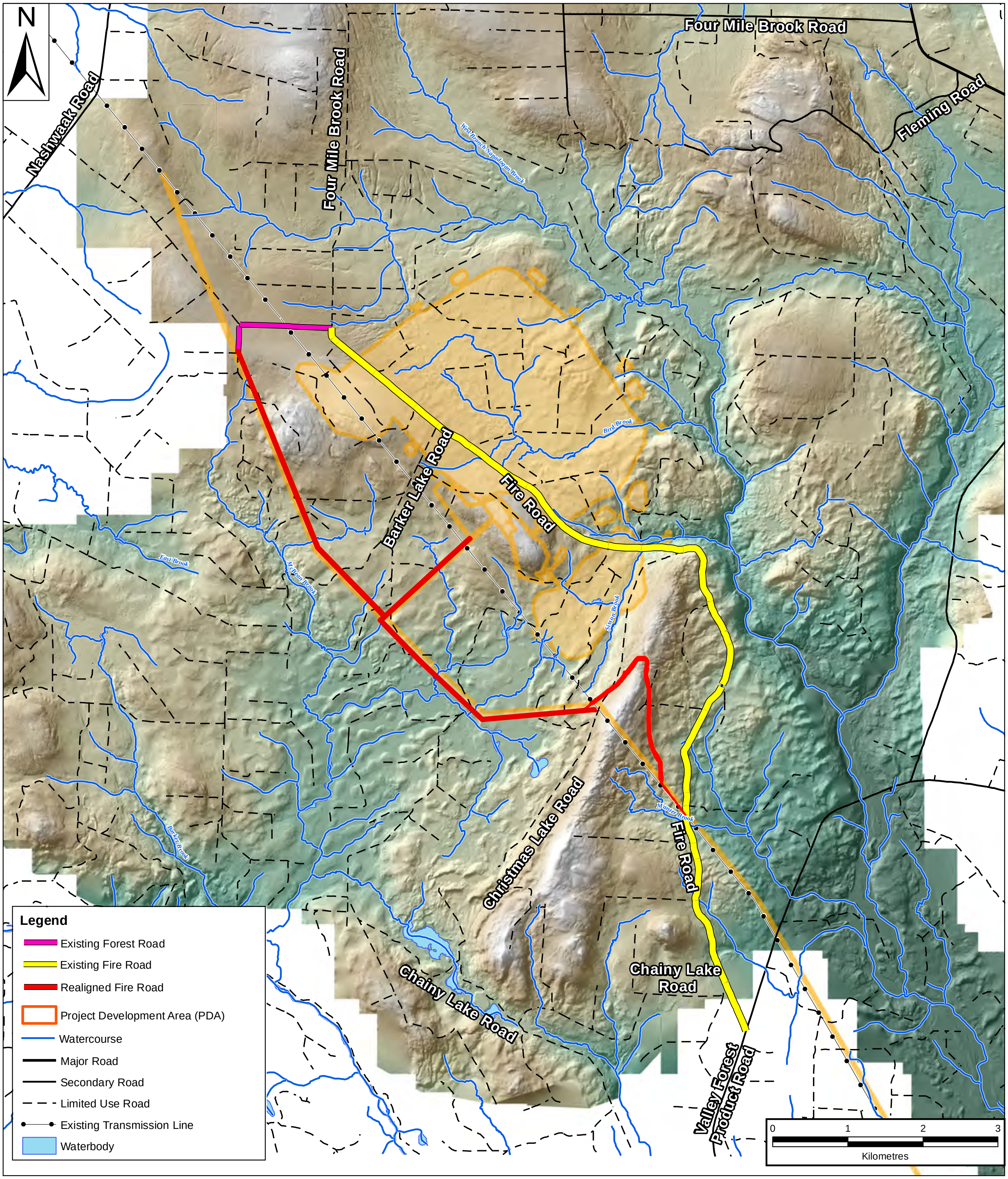
The fresh water system will be used to supply potable water system, APT plant, select reagent mixing and dust suppression. The fresh water will be obtained from a series of on-site groundwater wells. A fresh water supply pipeline from groundwater wells will supply Project fresh water requirements, estimated to be approximately 21 m^3/h.

Potable water for use in sanitary systems will be supplied by the groundwater wells. Drinking water will be treated as necessary, or delivered to site and used throughout the process plant and administration building areas, eye wash stations and showers, and dust suppression in selected areas.

De-ionized and soft water systems will be generated on site using fresh water supply. Both water systems will mainly serve the APT plant facility which will have its internal recycled water system.

3.2.5.4.3 Fire Protection

Fire water will be pumped from the filtered process water tank to the concentrator and APT plant fire water distribution system. Distribution will consist of a buried ring main around major facility buildings with hydrants and stand pipes connected to indoor hose stations. Allowances have been made for portable cart-type and handheld fire extinguishers for localized protection.



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NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Location of Realigned Fire Road

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Sisson Mines Ltd.

Scale: 1:70,000

Project No.: 121810356

Date: (dd/mm/yyyy) 23/11/2014

Dwn. By: JAB

Appd. By: DLM

Data Sources:
NBDNR
Leading Edge Geomatics Ltd.

Fig. No.: 3.2.14

Stantec

Map: NAD83 CSRS NB Double Stereographic

In addition to the hydrants and indoor stations, the APT building will employ a mist (fog) fire protection system at its solvent extraction area.

3.2.5.5 Sewage Treatment and Garbage Disposal

Sewage treatment for the process plant area, administration building, and laboratory will be by leach-bed system. Leach fields will be sized based on the personnel requirements at the ancillary facilities. The main leach field, approximately 1,000 m^2, will be located to the west of the main process area. In a failure event, the leach system will flow into the TSF. The truck shop and primary crusher leach field (approximately 400 m^2) will be located southeast of the truck shop.

No landfill will exist at site; rubbish will be hauled off-site for disposal at municipal landfills, recycling yards, and approved construction and demolition sites. APT waste and other process wastes will be stored in the TSF.

3.2.5.6 Security and Fencing

Security fencing will be installed around the substation and explosives storage area. No wildlife or security fencing is planned to encompass the entire PDA. A security gate and weigh scales used by delivery trucks, will be positioned on the site access road, remotely monitored and administered from the administration building.

The ore stockpile area and main process plant area will be large enough to accommodate laydown areas during Construction; no security is planned for these locations.

3.2.5.7 Power Supply

A 9-km-long section of an existing 345 kV transmission line (referred to by NB Power as Line 3011), which runs within the property boundary, will be re-routed a minimum of 500 m away from the open pit. This line is the main transmission grid line between New Brunswick and Québec, and is not intended to supply power directly to customers; thus, NB Power dismissed it as a Project supply option.

The Project requires approximately 50 MW of electrical power for its operation. A new 42-km-long, 138 kV transmission line from the NB Power Keswick terminal will supply power to the Project substation. This new line will be constructed by NB Power alongside the existing 345 kV transmission line, by expanding the existing 50 m-wide right-of-way by an additional 25 m to accommodate the new transmission line. Infrastructure at the Keswick terminal will be upgraded as necessary to accommodate the extension, though a vacant connection bay currently exists at the Keswick terminal to accommodate the new 138 kV transmission line. NB Power will own the line and the Keswick switchgear, but SML will own the mine site terminal station. The alignment of the new 138 kV transmission line and the realigned 345 kV transmission line is shown in Figure 3.2.15.

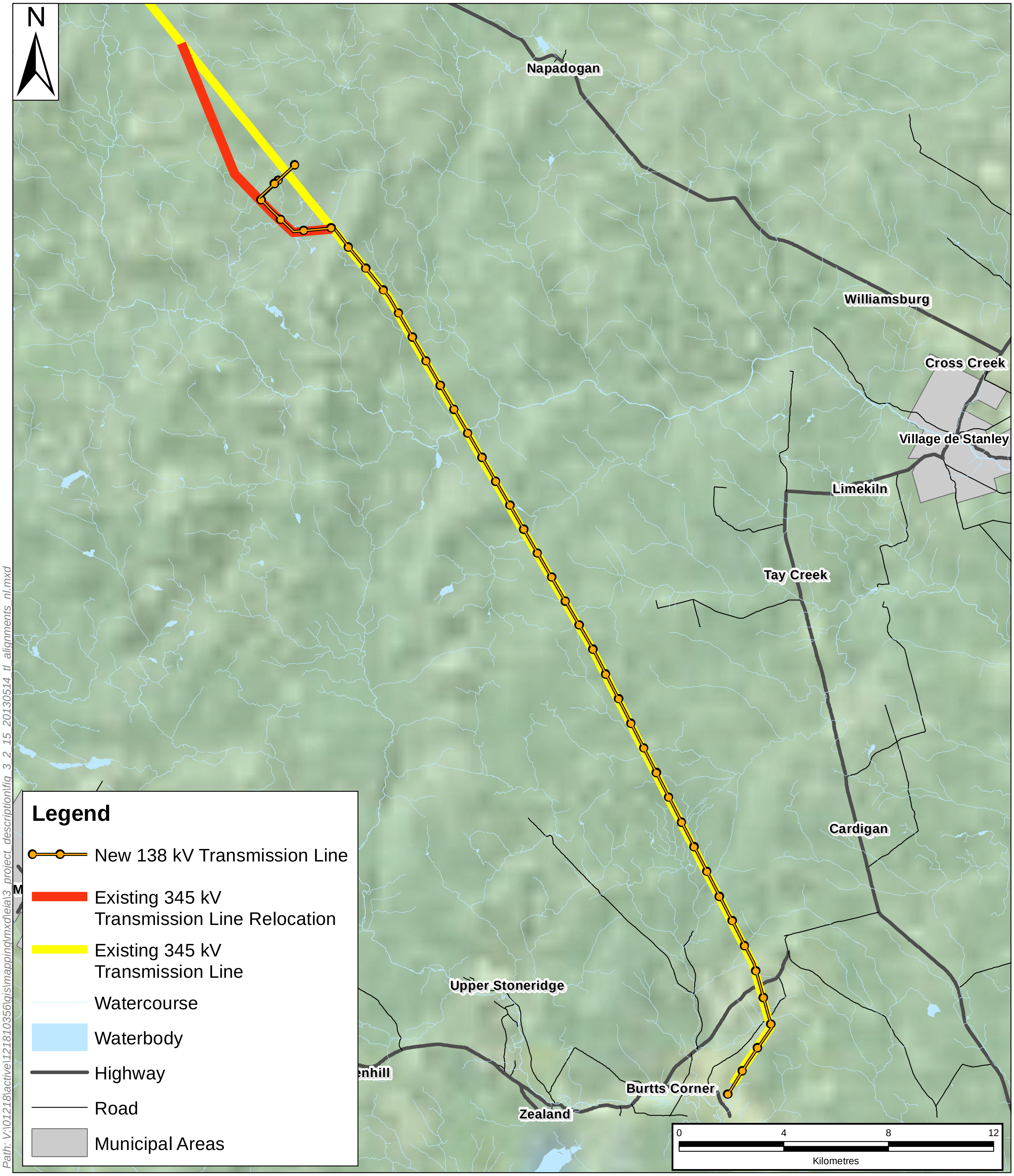
The relocated 345 kV transmission line will use steel poles, conductors (lines), insulators, guy wires, and concrete foundations. The new 138 kV transmission line will use a wood pole H-frame structure to support the conductors and insulators. A schematic of a typical wood pole H-frame structure is shown in Figure 3.2.16. These structures are safer, facilitate maintenance and minimize the environmental footprint along the right-of-way. Structures are also designed in accordance with a nationally recognized CSA standard to withstand known weather conditions and other related constraints.

The average height from ground to insulator of the wood pole H-frame structure will be approximately 18 m. The span between structures will be approximately 180 m, but could be as much as 213 m. Based on a preliminary line design, it is expected that approximately 200 structures will be required for the construction of the new transmission line. Three conductors will be suspended from the insulator strings (also two overhead ground wires for lightning protection). An easement interest will be acquired on all properties affected by the right-of-way to construct the new transmission line. The right-of-way is cleared to ensure safe electrical clearances and prevent trees from falling onto the line or coming into contact with the conductors.

The 138 kV transmission line will be terminated at a utility meter supplied by NB Power. The meter will be installed within a fenced substation located close to the site’s main electrical room and concentrator building. The substation will include the main 138 kV disconnect switch, two 138 kV-13.8 kV transformers, and a 13.8 kV bus with distribution switchgear; the facility will operate on both transformers. The location of the Sisson substation was shown in Figure 3.2.8.

Power will be distributed to the plant facilities at 13.8 kV. Distribution will be routed via duct banks to facilities adjacent to the main substation while the power supply to remote locations such as primary crushing, reclaim water system, quarry, truck shop, open pit, and SME facility will be routed via overhead lines.

An 800 kW diesel-powered emergency generator will be provided at the process plant to provide an alternate power supply for lighting, critical process loads and other process sensitive areas during scheduled or non-scheduled power outages. A smaller 350 kW diesel-powered emergency generator will also be provided at the primary crusher.



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NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Alignments for the New 138 kV Transmission Line and Relocated 345 kV Transmission Line

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Sisson Mines Ltd.

Scale: 1:200,000

Project No.: 121810356

Data Sources:
NBDNR
NRCAN, ESRI

Fig. No.: 3.2.15

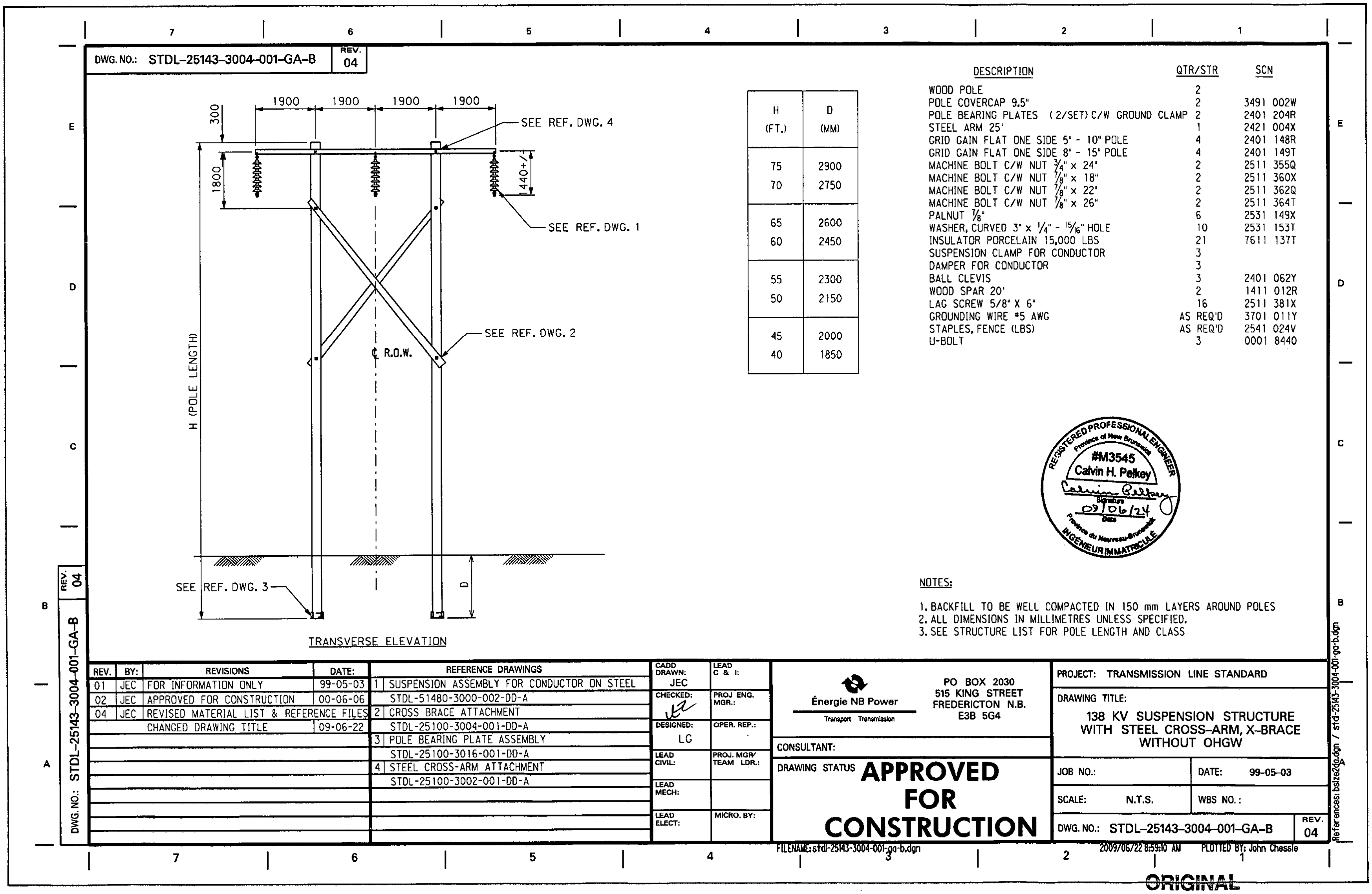
Date: (dd/mm/yyyy) 23/11/2014

Dwn. By: JAB

Appd. By: DLM

Stantec

Map: NAD83 CSRS NB Double Stereographic



DWG. NO.: STDL-25143-3004-001-GA-B REV. 04

H (FT.)	D (MM)
75	2900
70	2750
65	2600
60	2450
55	2300
50	2150
45	2000
40	1850

DESCRIPTION	QTR/STR	SCN
WOOD POLE	2	
POLE COVERCAP 9.5"	2	3491 002W
POLE BEARING PLATES (2/SET) C/W GROUND CLAMP	2	2401 204R
STEEL ARM 25'	1	2421 004X
GRID GAIN FLAT ONE SIDE 5" - 10" POLE	4	2401 148R
GRID GAIN FLAT ONE SIDE 8" - 15" POLE	4	2401 149T
MACHINE BOLT C/W NUT 3/4" x 24"	2	2511 355Q
MACHINE BOLT C/W NUT 7/8" x 18"	2	2511 360X
MACHINE BOLT C/W NUT 7/8" x 22"	2	2511 362Q
MACHINE BOLT C/W NUT 7/8" x 26"	2	2511 364T
PALNUT 7/8"	6	2531 149X
WASHER, CURVED 3" x 1/4" - 15/16" HOLE	10	2531 153T
INSULATOR PORCELAIN 15,000 LBS	21	7611 137T
SUSPENSION CLAMP FOR CONDUCTOR	3	
DAMPER FOR CONDUCTOR	3	
BALL CLEVIS	3	2401 062Y
WOOD SPAR 20'	2	1411 012R
LAG SCREW 5/8" X 6"	16	2511 381X
GROUNDING WIRE #5 AWG	AS REQ'D	3701 011Y
STAPLES, FENCE (LBS)	AS REQ'D	2541 024V
U-BOLT	3	0001 8440

#M3545
Calvin H. Pelkey
09/06/24

NOTES:

1. BACKFILL TO BE WELL COMPACTED IN 150 mm LAYERS AROUND POLES
2. ALL DIMENSIONS IN MILLIMETRES UNLESS SPECIFIED.
3. SEE STRUCTURE LIST FOR POLE LENGTH AND CLASS

REV.	BY:	REVISIONS	DATE:
01	JEC	FOR INFORMATION ONLY	99-05-03
02	JEC	APPROVED FOR CONSTRUCTION	00-06-06
04	JEC	REVISED MATERIAL LIST & REFERENCE FILES CHANGED DRAWING TITLE	09-06-22

	REFERENCE DRAWINGS
1	SUSPENSION ASSEMBLY FOR CONDUCTOR ON STEEL STDL-51480-3000-002-DD-A
2	CROSS BRACE ATTACHMENT STDL-25100-3004-001-DD-A
3	POLE BEARING PLATE ASSEMBLY STDL-25100-3016-001-DD-A
4	STEEL CROSS-ARM ATTACHMENT STDL-25100-3002-001-DD-A

CADD DRAWN: JEC	LEAD C & I:
CHECKED:	PROJ ENG. MGR.:
DESIGNED: LG	OPER. REP.:
LEAD CIVIL:	PROJ. MGR/ TEAM LDR.:
LEAD MECH:	
LEAD ELECT:	MICRO. BY:

Énergie NB Power
Transport Transmission

PO BOX 2030
515 KING STREET
FREDERICTON N.B.
E3B 5G4

CONSULTANT:

DRAWING STATUS APPROVED FOR CONSTRUCTION

PROJECT: TRANSMISSION LINE STANDARD

DRAWING TITLE:
138 KV SUSPENSION STRUCTURE
WITH STEEL CROSS-ARM, X-BRACE
WITHOUT OHGW

JOB NO.:	DATE: 99-05-03
SCALE: N.T.S.	WBS NO.:
DWG. NO.: STDL-25143-3004-001-GA-B	REV. 04

FILENAME: stdl-25143-3004-001-ga-b.dgn 2009/06/22 8:59:10 AM PLOTTED BY: John Chessie

Source: NB Power (2012).

Figure 3.2.16 Typical Wood Pole H-frame Structure

3.2.5.8 Quarry

Quarried rock for construction of Project facilities and the TSF embankments will be provided by an on-site rock quarry developed at the northwest corner of the TSF. Rock from the quarry has been classified as NPAG rock. The quarry will cover an area of approximately 118 ha at its ultimate extent.

3.2.5.9 Logistics and Transportation

No on-site housing is required for the Project. Construction personnel (whether employed by SML or by contractors), and employees during Operation, will reside in the surrounding communities.

Buses will be made available to transport employees to and from the Project site during Construction. Bussing will be arranged and managed by each individual contractor. For the purposes of the feasibility study and this EIA, it is assumed that parking lots will be established at Napadogan and Nackawic, where Construction personnel will catch the bus to the Project site. It is also assumed that personnel during Operation will use personal vehicles or car-pool to the site from surrounding communities.

Deliveries of equipment, materials and supplies to the Project site will be by truck. Products (molybdenum concentrate in bags and APT in drums) will be trucked from site to a rail siding at Napadogan for on-shipment by rail. Overseas shipments of mineral products will be handled through existing ports at Saint John or Belledune.

3.3 ALTERNATIVE MEANS OF CARRYING OUT THE PROJECT

This section discusses the various alternative means of carrying out the Project that are technically and economically feasible that have been considered and their environmental effects. These principally include the location of the main Project facilities such as the processing plant, waste rock storage, and tailings storage facility and include those identified in the Terms of Reference (Stantec 2012a). In general, it is desirable to locate these facilities as close as possible to each other in order to minimize the overall mine footprint and the cost of moving mined ore, waste rock and tailings. The currently preferred arrangement and size of these facilities is the most technically and economically feasible means of carrying out the Project. Some optimization will likely during detailed design and as environmental, engineering and cost factors are further refined.

3.3.1 Project Location and Mining Method

The Project location is fixed by the location of the ore body. The ore body at the Project site is near surface, with only 0.9 m to 4.0 m of overburden, so that underground mining is not a technically and economically feasible alternative. The only technically and economically feasible means of mining this ore body is by open pit.

Thus, in terms of location and method of mining, there are no technically and economically feasible alternative means of carrying out the Project.

3.3.2 Alternative Locations for Processing Plant

The principal factor that governs the location of the process plant is the distance between it and the open pit, and thus the cost of hauling or conveying ore to the plant. To minimize these costs, and other effects such as an expanded footprint and more truck travel, the processing plant will be located between the pit and the TSF location as was shown in Figure 3.2.8.

In terms of the location of the process plant, there are no technically and economically feasible alternative means of carrying out the Project.

3.3.3 Alternative Locations for Tailings Storage Facility

A thorough evaluation of potential options for locating and managing tailings, waste rock, and other waste materials arising from the Project was completed in support of the feasibility study. As part of this work, Knight Piésold and other consultants evaluated various TSF site locations, tailings technologies, and TSF embankment construction materials.

A TSF Site Alternatives Analysis was carried out following the general multi-criteria methodology described in Environment Canada’s “Guidelines for the Assessment of Alternatives for Mine Waste Disposal” (Environment Canada 2011a). The analysis examined the various locations considered by SML to construct the TSF, and indicated a preferred location for the TSF in consideration of known environmental (including socioeconomic), technical, and economic factors.

The TSF Site Alternatives Analysis was conducted using the current Project description and location of Project components, based on the feasibility-level engineering design of the Project at the time of completing the EIA Report. A summary of the methods and results of this analysis is provided below.

3.3.3.1 Tailings Management Objectives

The principal objectives when considering where and how to store tailings were as follows:

- the site and methods will ensure that the tailings are stored in a way that is, and will be, physically and chemically stable;
- potentially ML/ARD materials can be managed to minimize the potential for oxidation and subsequent release of low pH leachate;
- the design and construction methods are technically and economically feasible, and appropriate for the site conditions; and
- adverse environmental effects are minimized and not significant.

3.3.3.2 Site Selection Criteria

The principal site selection criteria and considerations were as follows, with the nature of the criteria indicated in brackets as technical, economic, or environmental:

a) there is sufficient volume within the topographic constraints for the anticipated quantity of tailings and waste rock over the life of the Project (technical);

b) there are minimal upslope catchment areas that will require diversion around the site (technical, environmental and economic);

c) there is favourable topography to minimize the size of the required confining embankments (economic);

d) there is favourable topography to minimize the footprint of the storage area (environmental);

e) the site is in the same catchment as the open pit for most effective, integrated and reliable overall Project site water management during Operation and Post-Closure. The open pit area naturally drains primarily via Sisson Brook to Napadogan Brook (minor drainage to McBean Brook), and will do so entirely (with treatment if necessary) once the pit fills during closure of the Project. Thus, TSF sites that drain to Napadogan Brook are preferred over sites that drain to the Upper Nashwaak River watershed (*i.e.,* above the Napadogan Brook confluence) (environmental);

f) if possible, it is only land-based (*i.e.,* contains no lakes or watercourses) (environmental);

g) it has no geotechnical challenges and/or geohazards (*e.g.,* no deep unconsolidated materials, unstable slopes, karst potential) that would be technically challenging to overcome (technical, economic);

h) it involves no special environmental sensitivities (*e.g.,* lakes, environmentally significant areas (ESAs), deer wintering areas (DWAs)) (environmental); and

i) it is close to the open pit and process plant for ease of operation, minimized roads and pipelines, and minimized costs and greenhouse gas emissions from trucking (economic, environmental).

As noted in the above points, the criteria are to varying degrees reflective of technical, economic and environmental considerations that were factors in considering the technical and economic feasibility of the TSF site alternatives, and their potential environmental effects.

3.3.3.3 Evaluation of Alternatives against Site Selection Criteria for Technical and Economic Feasibility and Environmental Effects

The main factors that govern the technical and economic desirability of the location of a TSF are the distance between it and the process plant, and the elevation difference between the two. Longer distances result in longer connecting infrastructure such as pipelines, power lines, and access roads, and thus more land disturbance and associated environmental effects, and higher capital and operating costs (*e.g.,* for truck hauling waste rock for storage in the TSF). Site water management is also technically simpler and more economical for more compact sites, and with less consequential environmental effects. It is generally preferred that the TSF be at a slightly lower elevation than the process plant to allow gravity flow of the tailings from the plant where possible, all contributing to improved technical and economic feasibility, and less consequential environmental effects.

As discussed in the *CEAA* Project Description (Stantec 2011), four main alternatives for locating the TSF were considered by Geodex (the previous Project owner) and subsequently by Northcliff/SML. The four main alternatives were identified and considered based on their technical and economic feasibility according to the site selection criteria listed in Section 3.3.3.2 above. The environmental effects of those alternatives were also considered. The following important features should be emphasized.

- The topography of the Project area is characterized by rolling hills separated by broad valleys. The surface elevation typically ranges from approximately 300 to 350 m above mean sea level, with some hills rising to over 400 m. The uplands are typically well-drained, stream density is high, and small lakes and wetlands are common in low-lying areas. Thus, TSF site alternatives were sought near or at the top of individual drainages to avoid the need to divert water around them (criterion “b” above), and to take advantage of the natural topography to minimize the need for engineered embankments (*i.e.,* criterion “c” in Section 3.3.3.2 above).

- Because of the high stream density in the Project area, none of the alternatives could be located to avoid covering at least one watercourse (*i.e.,* criterion “f” in Section 3.3.3.2 above).

- For reasons described elsewhere in the EIA Report, all waste rock will be stored sub-aqueously in the TSF.

- All TSF alternatives would be designed, built and operated to the same standards (see Section 3.2.4.3.3 of this EIA Report) so there are no technical factors that distinguish them in terms of their resistance to earthquakes or extreme rainfall events, and their seepage management features.

The four main alternatives are shown in Figure 3.3.1 and were the following. Note that all distances noted refer to the distance from the ore processing plant to the centre of each TSF alternative site.

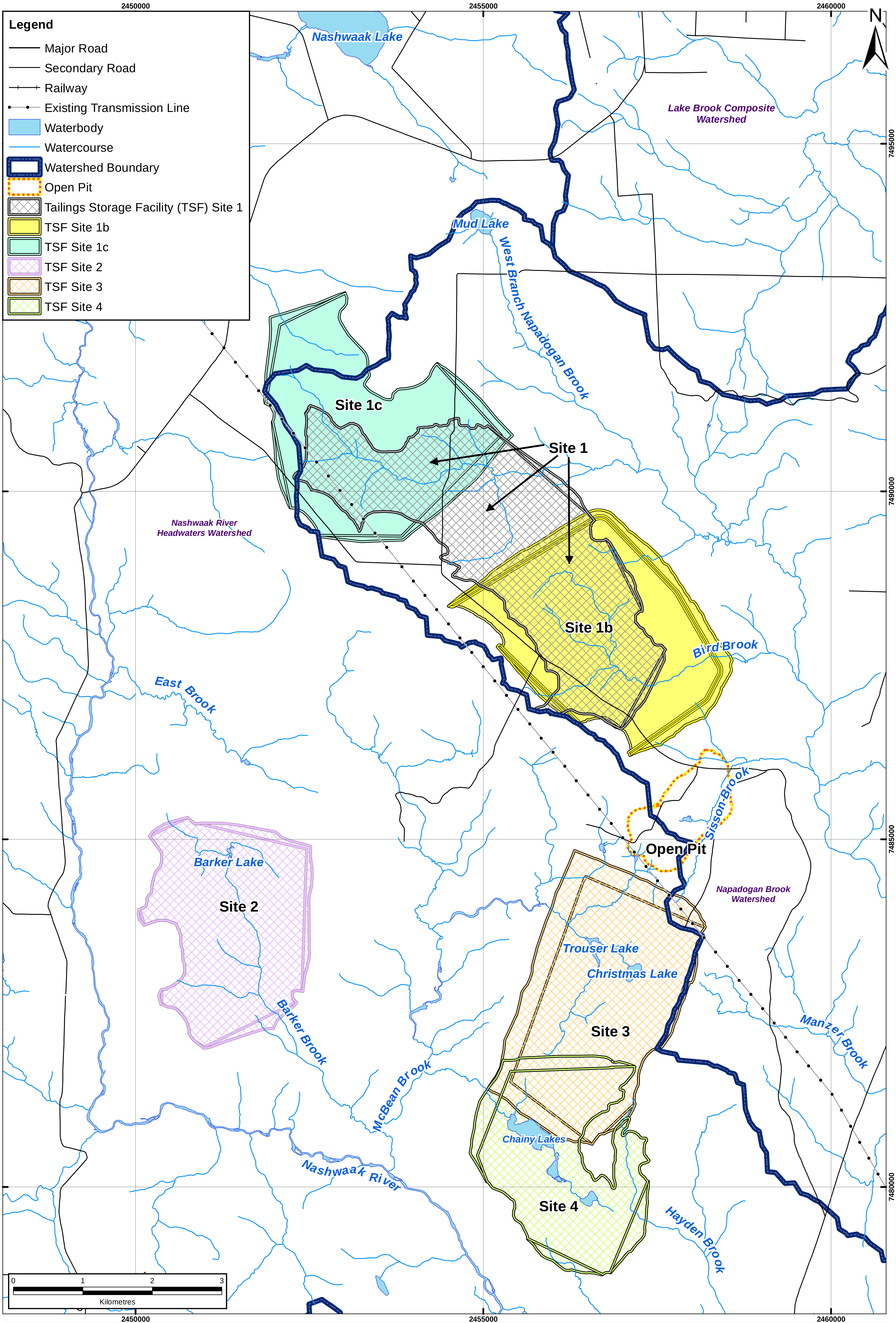
- **Bird Brook (Site 1)** is relatively close (3.3 km) to the proposed ore processing plant. Compared to the other alternatives, it has a relatively large “footprint” but does take good advantage of the natural topography (*i.e.,* criterion “c” in Section 3.3.3.2 above). It does not encroach on any lakes, and so meets criterion “h” in Section 3.3.3.2 above. It does cover much of the upper reaches of Bird Brook and one arm of West Branch Napadogan Brook, but does drain entirely to Napadogan Brook (criterion “e” in Section 3.3.3.2 above). Its proximity to the process plant means that the lengths of access roads, tailings and water pipelines, and power lines between the TSF and the plant site would be comparatively short.

- **Barker Lake (Site 2)**, located approximately 5.8 km to the southwest of the proposed ore processing plant location, has the advantage of constraining hills on its west side (*i.e.,* criterion “c” in Section 3.3.3.2 above). This alternative would be more costly to operate than Site 1 due to the distance from the process plant with the attendant additional environmental effects related to greater distances for trucking and infrastructure. More importantly, it would entail covering a lake and drains entirely to the Upper Nashwaak River watershed, so it would not meet criteria “h” and “e” in Section 3.3.3.2 above. Thus, Site 2 is undesirable relative to Site 1 due to greater environmental effects and higher costs.

- **Trouser Lake (Site 3)**, located approximately 4.1 km to the south of the proposed ore processing plant location, has the advantage of constraining hills on east side (*i.e.,* criterion “c” in Section 3.3.3.2 above). However, it would result in the elimination of lakes (known to support a recreational fishery) and drains entirely to the Upper Nashwaak River watershed, so it would not meet criteria “h” and “e” in Section 3.3.3.2 above. This alternative would be more costly to operate than Site 1 due to the distance from the process plant with the attendant additional environmental effects related to greater distances for trucking and infrastructure.   These environmental effects, coupled with the location in the Upper Nashwaak River watershed and the covering of lakes, make this alternative undesirable relative to Site 1 due to greater environmental effects and higher costs. Additionally, the route of the relocated transmission line and relocated Fire Road will need to pass through the site.

- **Chainy Lakes (Site 4)**, located approximately 6.1 km to the south of the proposed ore processing plant location, has the advantage of constraining hills on its northeast and southeast sides (*i.e.,* criterion “c” in Section 3.3.3.2 above). However, it would result in the elimination of lakes (known to support a recreational fishery) and drains entirely to the Upper Nashwaak River watershed, so would not meet criteria “h” and “e” in Section 3.3.3.2 above. This alternative would be more costly to operate than Site 1 due to the distance from the process plant with the attendant additional environmental effects related to a greater distances for trucking and infrastructure. These environmental effects, coupled with the location in the Upper Nashwaak River watershed and the covering of lakes, make this alternative undesirable relative to Site 1 due to greater environmental effects and higher costs.

The four alternatives are all technically feasible. Compared to Site 1, Sites 2, 3 and 4 present clear economic disadvantages due to the greater distances from the process plant, and thus to the higher infrastructure and operating costs for trucking and pumping. From an environmental perspective, Site 1 is preferred for several reasons – it covers no lakes, it drains entirely to the Napadogan Brook watershed, and it entails the minimum trucking distance and thus greenhouse gas emissions. For these reasons, Site 1 was considered the alternative of choice and was carried forward in the analysis of TSF site alternatives.



NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Location of Alternatives for the TSF Sisson Project: Environmental Impact Assessment (EIA) Report, Napadogan, N.B.	Scale: 1:50,000	Project No.: 121810356	Data Sources: NBDNR, SNB NHN, NB Aquatic Data Warehouse	Fig. No.: 3.3.1	Stantec
Client: Sisson Mines Ltd.	Date: (dd/mm/yyyy) 16/05/2013	Dwn. By: JAB Appd. By: DLM			

Map: NAD83 CSRS NB Double Stereographic

In early 2011, Northcliff refined Site 1 into two preferred site alternatives, Site 1b and Site 1c, in order to take up less land area than initially envisaged, and to thus avoid covering more watercourses than is absolutely necessary (Figure 3.3.1). This would further reduce the potential environmental effects of the preferred Site 1. Sites 1b and 1c are depicted in Figures 3.3.2 and 3.3.3, respectively. These two sites are considered to be technically and economically feasible, and are the two preferred alternatives that are evaluated in more detail in this document in terms of their relative environmental, technical and economic characteristics.

It should be noted that, during the feasibility and EIA studies, Site 1b was refined by Northcliff to situate its northwestern embankment to the southeast of an unnamed tributary to West Branch Napadogan Brook, thus preserving its environmental values. As well, the embankments were situated to avoid areas of elevated archaeological potential along that tributary and to the southeast of the TSF and north of the open pit. This resulting TSF Alternative 1b is shown in Figure 3.3.2.

3.3.3.4 Evaluation of TSF Site Alternatives

The selection of the preferred TSF Alternative 1b was made during the course of the feasibility study based on scoping level costing, professional experience and judgment. In late 2012, Northcliff undertook a thorough due diligence evaluation of that selection process to ensure that the results are robust and reasonable. To carry out that evaluation, a method known as multi-criteria analysis (MCA) was used. MCA is the method prescribed by Environment Canada in its “Guidelines for the Assessment of Alternatives for Mine Waste Disposal” (Environment Canada 2011a).

MCA is a well-developed and widely-used method in applications such as this one, and is described below. Because MCA is a quantitative method, and some of the factors used in the analysis can only be characterized qualitatively, the numerical results of an MCA can only be approximate. Moreover, MCA cannot possibly incorporate all the factors that might be applied in comparing various alternatives, and must necessarily focus on those factors that are most useful in distinguishing among the alternatives. As consequence, MCA results are indicative of the relative strength of the alternatives considered, and MCA is understood to be a decision-support tool and not a decision-making tool.

The MCA of the TSF site alternatives was undertaken in several steps which are described in detail in the sections below. Basically, MCA proceeds by identifying the factors to be used in comparing alternatives, and then giving each factor a numerical score for each alternative. MCA then identifies numerical weights to be used in evaluating the relative contribution that each factor should make to the analysis. The scores are then multiplied by the weights, the products are summed, and the overall totals for the various alternatives are compared. Finally, sensitivity analyses are performed by varying the weights to determine if giving more or less weight to, say, environmental factors, changes the overall results of the analysis.

3.3.3.5 Factors for Analyzing TSF Site Alternatives

Three categories of factors were established for comparing the TSF site alternatives: environmental, technical and economic. The factors in each category were selected for their importance ecologically, socially, and to regulators. They were also selected for their usefulness in distinguishing between the TSF alternatives. The selected factors are described below.

3.3.3.5.1 Environmental Factors

Footprint Area. The TSF footprint area is the total area covered by the embankments, tailings and water control works along the toe of the embankments. The footprint area (measured in ha) was used to assign the relative scores of each alternative. The alternative with the smallest footprint is desired, and thus received the maximum score. The other alternative received a proportionately lower score.

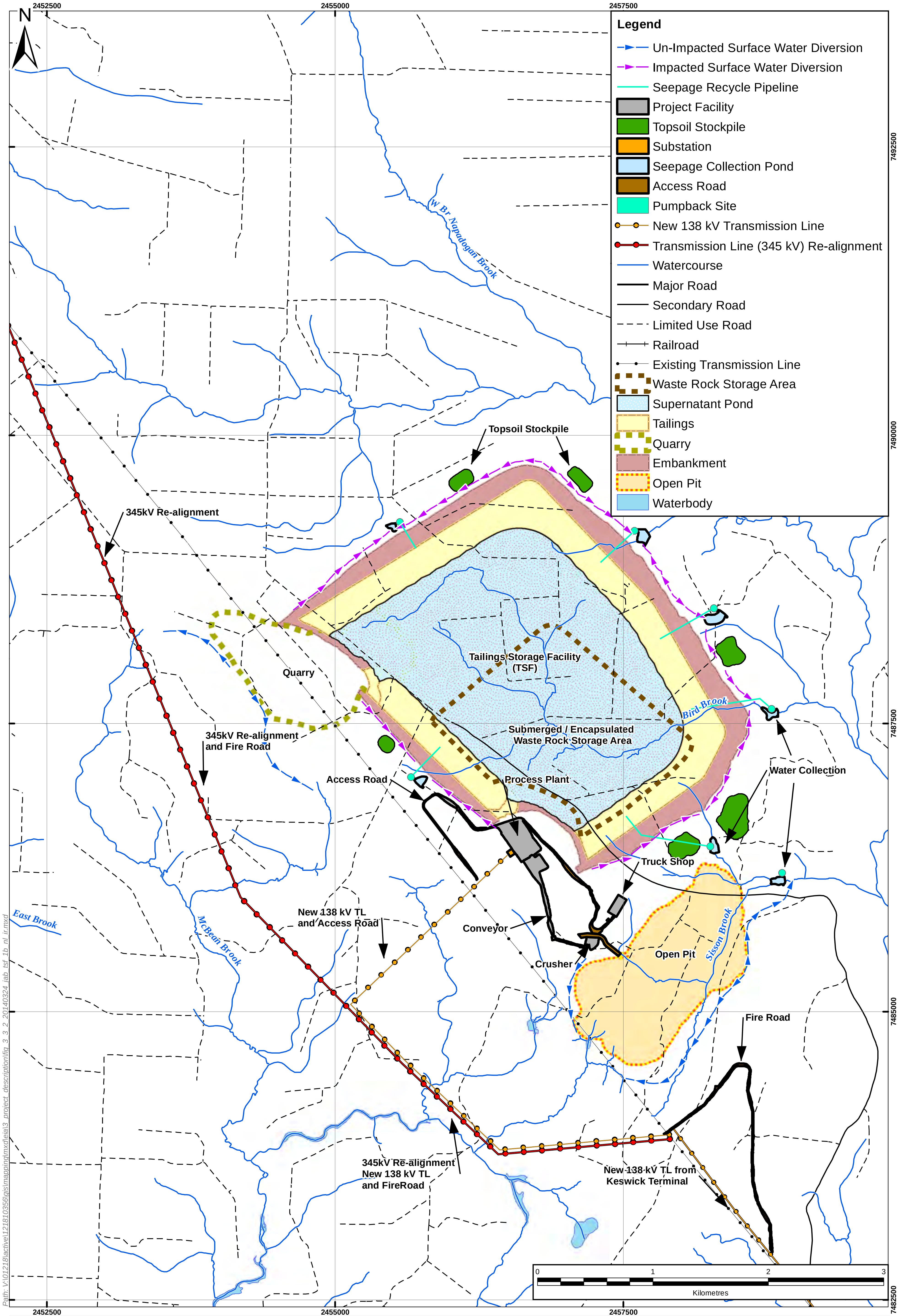
Area Within Napadogan Brook Watershed. The principal potential sources of contaminants to the aquatic environment are the TSF (from seepage) and the open pit, especially after closure of the mine, as well as releases of treated water from the water treatment plant. The open pit area naturally drains primarily via Sisson Brook to West Branch Napadogan Brook, and will do so entirely (with treatment if necessary) once the pit fills during Closure of the Project. For efficient and effective water management, and especially to minimize the number of drainages that might be affected by seepage, it is best if the TSF site also naturally drains to the same watershed. Thus, the TSF site with the largest proportion of its catchment area in the Napadogan Brook watershed received the maximum score, and the other alternative received a proportionately lower score.

Area of Permanent Aquatic Habitat Loss. The area of permanent aquatic habitat loss is the total area of aquatic habitat that will be covered by the TSF. The area of lost habitat (in m^2) was used to assign the relative scores. The alternative with the smallest habitat loss is most desired, and thus received the maximum score. The other alternative received a proportionately lower score.

The area of aquatic habitat in Site 1b was based on field measurements taken in 2011. Though some field surveys have been conducted within Site 1c, detailed aquatic surveys have not been conducted and the areas of aquatic habitat have not been field confirmed. The total length of watercourses within Site 1c is known based on digital elevation mapping (DEM) prepared for the Project. For the purposes of this MCA, the widths of watercourses in Site 1c were estimated based on stream order, as determined by aquatic scientists with field experience in the Project area. These widths multiplied by the known lengths (as obtained from a geographic information system) give the estimated amount of aquatic habitat in Site 1c.

Area of Permanent Wetland Loss. The area of permanent wetland loss is the total area of mapped wetland that will be covered by the TSF. The area of lost wetland (in ha) was used to assign the relative scores. The alternative with the smallest wetland loss is desired, and thus received the maximum score. The other alternative received a proportionately lower score.

As with aquatic habitat, detailed wetland field surveys have not been conducted in Site 1c, though they have been conducted in Site 1b. A wetland model was prepared for both TSF alternatives to predict areas that are likely wetland. This model was based on DEM data and depth to water table maps. Field verifications were conducted at Site 1b to ground truth the wetland areas predicted by the model; 74% of the modelled wetlands were confirmed to in fact be wetlands. As Site 1c is located within an area with similar conditions as Site 1b, it is considered to be a fair approximation that 74% of the modelled wetlands are actual wetlands. Accordingly, the modelled wetlands in Site 1c were reduced by 26% in order to estimate the area of permanent wetland loss.



NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

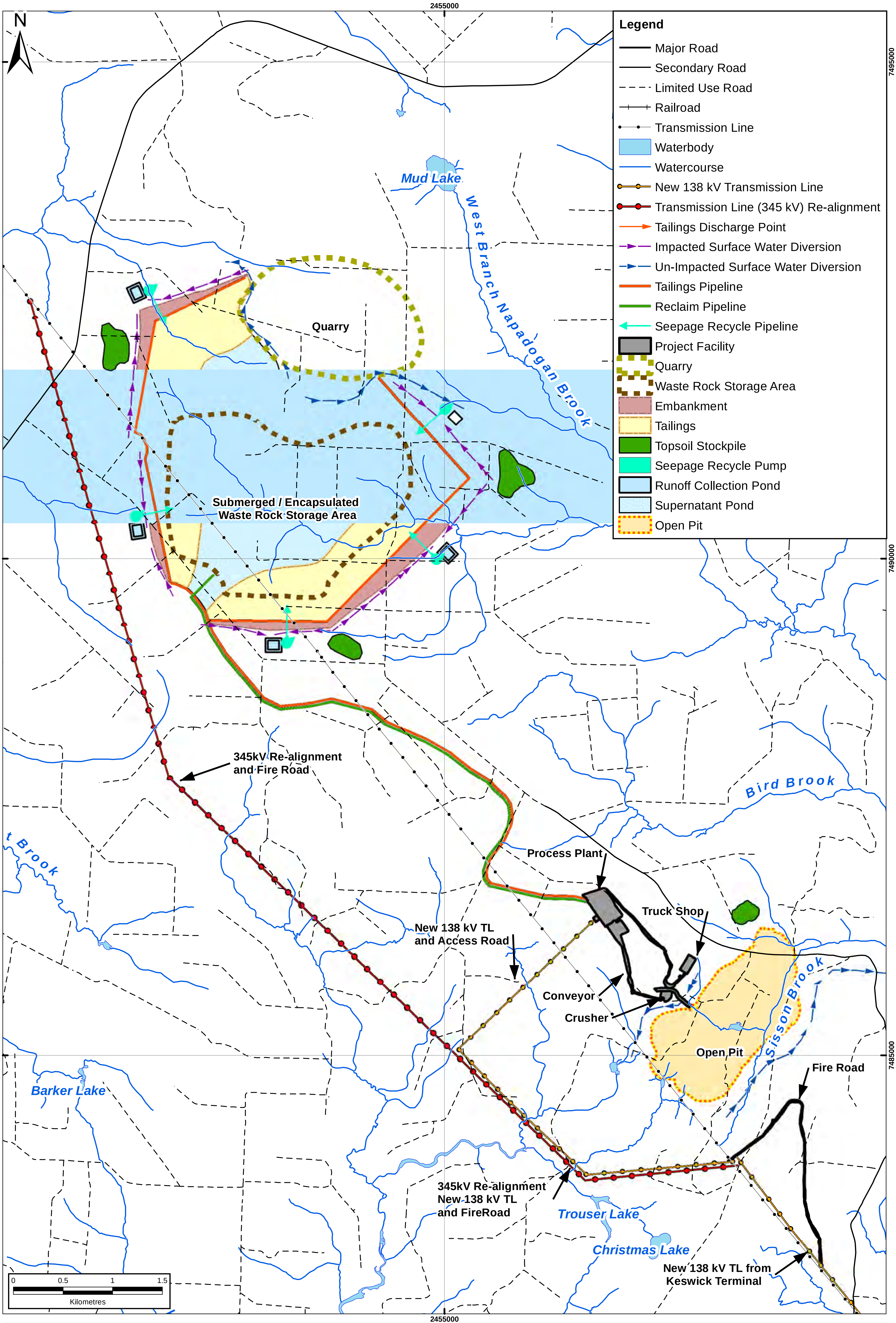
TSF Alternative 1b

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Sisson Mines Ltd.

Scale: 1:30,000	Project No.: 121810356	Data Sources: NBDNR	Fig. No.: 3.3.2
Date: (dd/mm/yyyy) 23/11/2014	Dwn. By: JAB	Appd. By: DLM	

Map: NAD83 CSRS NB Double Stereographic



NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

TSF Alternative 1c

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client:	Sisson Mines Ltd.
Scale:	1:35,000
Project No.:	121810356
Data Sources:	NBDNR, SNB
Fig. No.:	3.3.3
Date: (dd/mm/yyyy)	22/03/2014
Dwn. By:	JAB
Appd. By:	DLM

Stantec

Stantec Consulting Ltd. © 2014

Map: NAD83 CSRS NB Double Stereographic

Area of Permanent Loss of Interior Forest. Interior forest is an important wildlife habitat type. Interior forest is defined as continuous stands of mature forest greater than 10 ha that are free of edge effect. The area of permanent interior forest loss is the total area of interior forest that will be lost within the TSF either as a result of covering an interior forest stand, or reducing the total area of a stand to less than 10 ha such that it is no longer interior forest. The area of lost interior forest (ha) was used to assign the relative scores. The alternative with the smaller interior forest loss is desired, and thus received the maximum score. The other alternative received a proportionately lower score.

Greenhouse Gas Emissions. In response to comments from the Sustainability Working Group, a final environmental factor was added to the matrix to encompass emissions of greenhouse gases (as a surrogate for all air contaminant emissions) arising from one option over the other. The relative distance of the TSF from the ore processing plant results in emissions primarily associated with trucking waste rock from the open pit for storage within the TSF. The alternative with the lowest greenhouse gas (GHG) emissions is desired, and thus received the maximum score. The other alternative received a proportionately lower score.

Environment Factors Overall. It should be noted that including aquatic habitat and wetland losses as environmental factors in the alternatives analysis is inherently conservative since, in both cases, SML must agree to compensate for these losses before the Sisson Project can be approved. A plan to offset the lost aquatic habitat must be approved by the DFO, and a plan to compensate for lost wetlands must be approved by the NBDELG. Strictly speaking, an MCA should be based on the net effect on these factors which, with the required offsetting and compensation, will be nil and the factors should not be included in the MCA.

3.3.3.5.2 Technical Factors

Storage Efficiency. Storage efficiency is the ratio of available tailings storage volume to the embankment volume. Higher storage efficiency generally results in lower embankments and lower costs. The ratio was used to determine the score of each alternative. The alternative with the highest ratio received the maximum score, and the other alternative was scored proportionately less.

Ease of Operation. The relative ease of operation was qualitatively judged on a scale of low, medium, or high. Various factors were taken into account such as the number of personnel and the amount of mechanical equipment required, and susceptibility to difficulties caused by weather (*e.g.,* snow, wind, rain). An alternative that allows at least some gravity feed of tailings to the TSF is preferred over an alternative that does not. The alternative with the highest ease of operation was assigned the maximum score, and the other proportionately less.

It is expected that operation of a TSF at Site 1c will be slightly more difficult to operate than at Site 1b, largely because of the increased distance from the ore processing plant. TSF Site 1b and Site 1c were therefore assigned factor values of high and medium, respectively. Specific operational disadvantages associated with Site 1c include the following:

- longer roads between the ore processing plant and the TSF require proportionately more maintenance, including more manpower and materials;

- longer pipelines between the plant and TSF require proportionately higher pumping power, which often results in increased operating complexity; this is due in large part to the higher pressure pumps, pipelines, and fittings that are needed;
- longer pipelines between the ore processing plant and TSF, and a consequent greater susceptibility of pipe blockage due to freezing or sanding, require proportionately more maintenance, including more manpower and materials;
- ongoing construction of the TSF embankments and maintenance of mechanical equipment will be more difficult due to the relative remoteness of the site from the ore processing plant and open pit area where personnel and equipment are largely stationed; and
- the increased distance from the ore processing plant site means less timely mobilization of emergency response measures, should they be needed.

Ease of Closure. Closure refers to all post-mining activities including decommissioning of site infrastructure, reclamation of disturbed areas, and establishing long-term water management and site environmental monitoring and management. The relative ease of closure was qualitatively judged on a scale of low, medium or high. Various factors were taken into account such as:

- the number of personnel required;
- the availability of reclamation materials;
- ease of water management; and
- the effort required to ensure that the overall site is effectively stabilized for the long-term physically, biologically, and socially (*e.g.,* human safety).

The alternative with the highest ease of closure was assigned the maximum score, and the other alternative was scored proportionately less.

The two major aspects of closure of the TSF that were considered in this assessment are reclamation of the landforms and water management. Reclamation of the embankments and tailings beaches to provide a beneficial end land use will be similar at both sites though, being further from the ore processing plant site, Site 1c provides more of a closure challenge.

Water management was the major consideration in assigning Site 1c a ranking of medium when compared to Site 1b (high). Water management during Closure and Post-Closure is typically simpler when all the Project infrastructure is in close proximity. At the end of Operation for Site 1b, run-off from the TSF can be drained by gravity to the open pit to both accelerate filling of the pit and allow for a single water treatment plant and point of discharge. This will not be practical with Site 1c, where TSF run-off would need to be separately treated and discharged, or pumped through a long pipeline to the open pit. Thus, compared to TSF Site 1c, TSF Site 1b allows for a centralized approach to water treatment, and a single point of discharge for ease of managing and monitoring both water quality and potential environmental effects.

3.3.3.5.3 Economic Factors

Life of Mine Capital and Operating Costs. The Project costs that could vary the most between the two TSF site alternatives in order of expected magnitude are:

- initial and ongoing embankment construction earthworks;
- hauling of waste rock to the TSF for sub-aqueous storage;
- tailings and reclaim mechanical equipment; and
- ongoing power requirements for tailings delivery and water reclaim.

The construction of the TSF embankment will be similar for both alternatives since both will be constructed using locally quarried materials; Site 1c will require approximately 20% more fill material over the life of the Project due the lower storage efficiency. The cost of hauling waste rock to the Site 1c TSF will be significantly higher than for Site 1b due to the nearly four times longer haul distance from the open pit. The cost of mechanical equipment (pumps and pipelines) will be higher for Site 1c than Site 1b by approximately 50% because of the longer distance from the plant site. The ongoing power requirements for pumping tailings and reclaim water to and from Site 1c will be approximately 70% higher than for Site 1b.

The relative life-of-mine costs were qualitatively judged on a scale of low, medium, or high. The estimated overall life of mine comparative cost for Site 1c is in the order of two times the life of mine cost for Site 1b. The largest contributing factor is the haulage cost associated with transporting waste rock to the more remote Site 1c; this was the key consideration in assigning Site 1c a ranking of high when compared to Site 1b (medium).

3.3.3.5.4 Other Factors Considered

A number of other factors were considered for inclusion in the analysis, but were ultimately omitted for various reasons since they could not add value in distinguishing one site alternative from the other. The omitted factors were the following.

1. **Catchment Area:** Given the Project site and the location of both alternatives at the top of drainages, this area largely duplicates Footprint Area.

2. **Environmentally Sensitive Areas:** Neither site contains environmentally significant areas, or deer wintering areas, and there is no reason to expect the potential presence of species at risk to be different for the two sites.

3. **Water Quality**: Water discharged from the Project will be treated, as needed, to meet permit conditions that will be established by the Province of New Brunswick, so the quality of treated water released to the environment is not a distinguishing factor between the two alternatives. The only other potential source of environmental effects on water quality is seepage through the TSF embankments. Apart from embankment lengths, the main factors which affect seepage (*e.g.,* design of the TSF, depth to bedrock, permeability of the bedrock, characteristics of the

surficial material and overburden) are expected to be similar at the two sites. While Site 1c would have shorter embankments than Site 1b, Site 1c is higher in the Napadogan watershed where natural flows are lower and the effects of seepage on downstream water quality would thus be higher. Thus, neither site offers evident advantages in terms of seepage and downstream water quality management.

4. **Archaeological Potential:** Only Site 1b has been field surveyed to identify areas of elevated archaeological potential, and there was no meaningful way to estimate the size of these areas in Site 1c based only on the New Brunswick model for archaeological potential. Moreover, since the New Brunswick model for archaeological potential is based largely on proximity to watercourses, the environmental factor Area of Permanent Aquatic Habitat Loss is a reasonable proxy for archaeological potential.

5. **Current Use of Land and Resources for Traditional Purposes by Aboriginal Persons**: The two sites have essentially the same natural environment, as modified by forestry operations through cutting and building access roads over many years. There is thus no reason to expect a difference in the intensity of Aboriginal use between the two sites, and any real difference in use would be accounted for in the environmental factor Footprint Area. Further, the traditional use study (Moccasin Flower 2013) did not distinguish between use of land and resources in these areas, and SML has not been made aware (by First Nations or the Crown) of any additional information that might make such a distinction.

6. **Land and Resource Use**: The two sites have essentially the same natural environment, as modified by forestry operations through cutting and building access roads over many years. There is thus no reason to expect a difference in the intensity of forestry operations and recreational land use between the two sites, and any real difference in use would be accounted for in the environmental factor Footprint Area.

7. **Operational Emissions:** The potential for emissions of dust from the two TSF sites was considered to be equivalent.

8. **Metal Leaching and Acid Generation:** The same methods for the sub-aqueous storage of PAG tailings and both PAG and NPAG waste rock would be used at both sites. Thus, neither site offers advantages in terms of ML/ARD management.

9. **Stability of Embankments:** Site conditions and the availability of suitable construction materials were considered equivalent at the two sites, and the same design standards will apply to both. Thus, neither site offers advantages in terms of embankment stability under seismic loads greater than anticipated in the design.

10. **Ease of Construction:** Neither TSF site alternative had obvious significant advantages or disadvantages for construction. The only major difference between the sites is the distance from the ore processing plant site; however, both sites have similar access from existing roads and to sources of borrow or quarry materials.

3.3.3.6 Scoring and Weighting the Factors in Comparing the TSF Site Alternatives

In order to evaluate each TSF alternative, and then compare the two alternatives, each alternative was first “scored” against each factor on a scale of 1 to 9. For each factor, the score provided a relative value of each alternative with the “best” alternative receiving a score of 9 and the other receiving a proportionately lower score according to the available information.

Each factor was then assigned a relative weight to introduce a value bias in the individual factors, based on the relative subjective importance of one factor versus another. The relative weights indicate the relative value or importance of the factors. The sum of the weights across all factors was 100. First, each category of factors (environmental, technical and economic) was assigned a portion of the 100 weight “points”, then that portion was divided up among the factors in each category. The “base case” weights assumed approximately equal value of all categories of factors.

During the course of the alternatives analysis, the sensitivity of the analysis to various factor weights was tested by varying the weights to indicate how different sets of values affect the relative attractiveness of the TSF alternatives.

3.3.3.7 TSF Site Alternatives Analysis Results

As a final step, the comparison of TSF site alternatives was carried out by multiplying each factor score by its corresponding weight, and summing the products for each alternative. The alternative with the highest sum was considered the “best” TSF site. The results of the analysis are shown in Table 3.3.1 below.

Overall, the “base case” analysis resulted in Site 1b with an overall weighted score of 861 compared to a score of 706 for Site 1c. Thus, Site 1b is preferred over Site 1c. This preference held through the sensitivity analyses, even when environmental factors were weighted at 100% (Sensitivity Case 3 in Table 3.3.1).

Thus, the alternatives analysis confirmed the selection of TSF Alternative 1b (Site 1b) as the preferred location for the TSF.

Table 3.3.1 Results of TSF Site Alternatives Analysis

	Factor Value		Factor Score		Base Case			Sensitivity Case 1			Sensitivity Case 2			Sensitivity Case 3		
TSF Site Alternative	**1b**	**1c**	**1b**	**1c**	**Weight**	**1b**	**1c**	**Weight**	**1b**	**1c**	**Weight**	**1b**	**1c**	**Weight**	**1b**	**1c**
Environmental Factors																
Footprint Area (ha)	785	750	8.6	9.0	6	52	54	10	86	90	14	120	126	17	146	153
Area in Napadogan Brook Watershed (%)	100	80	9.0	7.2	6	54	43	10	90	72	13	117	94	17	153	122
Area of Permanent Aquatic Habitat Loss (m^2)	22,365	13,914	5.6	9.0	6	34	54	10	56	90	14	78	126	17	95	153
Area of Permanent Wetland Loss (ha)	161	202	9.0	7.2	6	54	43	10	90	72	13	117	94	17	153	122
Area of Permanent Loss of Interior Forest (ha)	109	70	5.8	9.0	5	29	45	10	58	90	13	75	117	16	93	144
GHG emissions (t CO2e/yr)	16,484	64,009	9.0	2.3	5	45	12	10	90	23	13	117	30	16	144	37
				Total	**34**	**267**	**251**	**60**	**470**	**437**	**80**	**625**	**586**	**100**	**784**	**732**
Technical Factors																
Storage Efficiency	11:1	9:1	9.0	7.4	11	99	81	7	63	52	4	36	30	0	0	0
Ease of Operation	High	Medium	9.0	7.0	11	99	77	7	63	49	3	27	21	0	0	0
Ease of Closure	High	Medium	9.0	6.0	11	99	66	6	54	36	3	27	18	0	0	0
				Total	**33**	**297**	**224**	**20**	**180**	**137**	**10**	**90**	**69**	**0**	**0**	**0**
Economic Factors																
Life of Mine Capital and Operating Costs	Medium	High	9.0	7.0	**33**	**297**	**231**	**20**	**180**	**140**	**10**	**90**	**70**	**0**	**0**	**0**
				Total	100	**861**	**706**	100	**830**	**714**	100	**805**	**725**	100	**784**	**732**

3.3.4 Alternative Tailings Management Technologies

As discussed in the Technical Report (Samuel Engineering 2013), a trade-off study was completed to evaluate the following tailings technologies:

- conventional (un-thickened) slurry tailings;
- thickened (paste) tailings; and
- filtered dry stack tailings.

The resulting recommendation was that an un-thickened tailings system, operating at approximately 35% solids content by weight, be used as the basis for Project development. This conclusion was based on several factors including the local climate, site water balance, overall system complexity, cost and ease of operation, and potential environmental effects and benefits.

Tailings management technologies include conventional slurry tailings, thickened/paste tailings, and filtered dry stack tailings. The preferred storage method for PAG tailings is sub-aqueous encapsulation within NPAG bulk tailings to preclude oxidation and acid generation, a very important environmental mitigation and consideration.

Thickened/paste or filtered tailings are placed within a tailings storage area at densities that are higher than typically achieved from the initial settling of conventional slurry tailings. However, tailings solids that are deposited as conventional slurries will also consolidate under their own weight over time; the ultimate tailings density in conventional tailings impoundments will tend to be comparable to the densities achieved with thickened/paste tailings. Thickened/paste tailings, and filtered dry stack tailings typically only make technical and economic sense where mines are developed in drier environments and the strict conservation of water resources is needed to avoid deficit situations.

A description of the three tailings management technologies considered, and a discussion of key issues which influence the selection of these technologies, follows.

3.3.4.1 Conventional Slurry Tailings

Conventional slurry tailings are typically discharged from the process plant at about 30% to 40% solids by total mass of slurry. These tailings may be pumped, flow by gravity, or some combination of both, depending on the available head and distance through pipelines from the plant to the TSF. The slurry is typically discharged through multiple off-takes from header pipes located around the periphery of the TSF confining embankments. The tailings solids settle and the resulting clear supernatant water is recovered from the TSF and pumped back for re-use in the process. The coarse fraction of the tailings typically settles rapidly and accumulates closer to the discharge points, forming a gentle “beach” with a slope of about 0.5 to 1%. Finer tailings particles tend to travel further and settle at a flatter slope to, and beneath, the supernatant pond. Selective tailings deposition is used to keep the supernatant pond away from the embankments, thereby reducing potential seepage losses, an important environmental mitigation and consideration.

This technology was selected for the Project because it has the advantage of being operationally simple, economical, of providing a stable water supply for use in the process and mine site, and of allowing for collection and treatment of all contact water streams associated with the mine site in one location, with one monitoring/treatment/discharge point. It also allows for the sub-aqueous storage and encapsulation of any PAG tailings and waste rock, an important environmental mitigation and consideration. The large buffering volume within the TSF pond is an important component of the site water management plan.

3.3.4.2 Thickened (Paste) Tailings Disposal

Thickened or paste tailings with higher slurry solids contents are produced in thickeners with the addition of flocculants to enhance liquid-solids separation. Therefore, a large proportion of the recoverable process water is reclaimed in the thickeners and the remaining thickened tailings are pumped to a TSF having similar embankments to those for conventional slurry tailings. Since thickened tailings are about the same density as the final settled density of slurry tailings, they require about the same size of TSF to accommodate tailings over the life of a mine. A thickened tailings TSF has no supernatant pond, so a separate, fully-lined water management pond is required for storage of stormwater run-off and snowmelt from the TSF surface, as well as for process water storage. Since a large volume of process water storage is required for start-up and winter operations, the water management pond needs to be correspondingly large resulting in an overall Project footprint, and consequent environmental effects, about the same as conventional slurry tailings.

As mentioned above, the advantage of employing thickened tailings is improved conservation of water, and especially the avoidance of evaporative losses from a TSF supernatant pond. Compared to conventional slurry tailings, the disadvantages include:

- higher processing costs for tailings thickening and thus higher energy use;
- higher pumping costs, and thus energy use, due to the thicker tailings as expensive and maintenance-intensive positive displacement pumps are typically required;
- high pressure tailings pipelines are more difficult to operate and maintain; and
- water management is complicated by the addition of a fully lined external pond.

The advantages of thickened tailings are typically more than offset by the disadvantages for a mine located in a cold winter climate with high net precipitation.

3.3.4.3 Filtered Dry Stack Tailings Disposal

Filtered tailings are produced using pressure or vacuum force in presses, drums, or belt filtration units, and are typically dewatered to a moist cake-like consistency. The materials are then transported by conveyors or trucks to a facility where they can be compacted in lifts (“dry stacked”) to improve density, traffic ability, and stability. The side slopes of the stack are supported by rock berms or buttresses and ultimately covered in a rock shell to prevent erosion. Like a thickened (paste) tailings facility, a filtered tailings stack has no supernatant pond, so a separate, water management pond is required for stormwater runoff, snowmelt and process water storage as described above for thickened (paste) tailings storage.

Compared to slurry or paste tailings, the advantages of filtered tailings are that they allow improved water conservation, and they are somewhat denser. The disadvantages of filtered dry stack tailings include:

- A water pond with a similar volume and storm capacity to the design described in Sections 3.2.4.3 and 3.4.2.3.1 would also be required, regardless of the tailings technology, in order to provide an equivalent level of environmental control of runoff from stormwater and snowmelt. In the case of a filtered tailings operation, this pond would need to be a separate facility contained by a water retaining dam, likely increasing the overall project footprint.
- They do not provide for effective isolation of PAG tailings and waste rock from oxygen diffusion and subsequent acid generation within a dry stack because a water cover is not possible.
- They require tailings filtering equipment that is expensive and complicated to build and operate, thus increasing operational complexity and energy use.
- The physical characteristics of tailings such as particle size distribution strongly influence the ability to dewater the tailings solids sufficiently so that they can be handled and placed in a compacted stack. The presence of excessive fines in the tailings may make it impractical to achieve a workable tailings product. The need to maintain the grind size in the mill within a very narrow range limits operational flexibility during ore processing.

Preventing snow or ice accumulations on a filtered tailings stack is a challenge in climates with cold, wet winters like New Brunswick. Adequate contingencies need to be provided for operations since placement of the tailings may be precluded by snow and ice on the surface of the stack, or by freezing of the tailings prior to placement:

- Wind-blown dust, and thus potential environmental effects, can worsen in winter months as freeze-drying and other frost processes can loosen the tailings.
- Wet months may cause problems as moisture addition can result in rapid degradation of surface traffic ability and prevent adequate compaction.
- The filtered tailings stack is susceptible to instability due to ice lenses or localized liquefaction if the pile becomes saturated due to rainfall, snow entrainment or percolation from run-off; and
- The operating cost, and thus energy, required to transport the large quantity of tailings to the dry stack is larger than for other tailings technologies.

No examples are known of filtered tailings management operations for comparable mining projects (*i.e.* similar climate, production rates, ore type, metallurgical process, project size) with similar waste and water management design needs, especially the need for subaqueous encapsulation of PAG tailings and waste rock. There are no known examples of a tungsten mine using paste or filtered tailings technology.

Several examples of filtered tailings management operations exist for northern mining projects north of the 60th parallel, but those have much smaller production rates (2,000 to 4,000 tpd, as compared to 30,000 tpd for the Sisson Project). Examples of small northern mining operations using filtered tailings management are: the Raglan Mine in Northern Québec, Minto Mine in the Yukon, Greens Creek Mine in Alaska, and the Pogo Mine in Alaska. An example of a larger production filtered tailings operation is La Coipa in northern Chile (approximately 17,000 tpd), which operates in an arid desert climate. Water conservation is critical for mining operations in an arid desert climate, or the far north where freezing and snow conditions are prevalent, and thus filtered tailings offer advantages in such climates. However, the relatively wet and temperate climate at the Sisson Project results in an overall water surplus at the site, negating the water conservation benefits of filtered tailings.

Filtered tailings technology can result in significant benefits where water conservation is paramount but, as discussed above, have many challenges that make this technology unfavorable in wetter climates, as at the Sisson Project site, where surplus water management is a key consideration. As well, the technology is not suited to safely encapsulating PAG tailings and waste rock so as to avoid acid generation since a water cover cannot be used, either during Operation or when the mine is closed. Effective surplus water management and avoidance of acid generation are key design, operational and closure imperatives for the Project, and thus filtered tailings are not a technically feasible technology at this site.

3.3.4.4 Summary

In consideration of the factors in the preceding sub-sections, the use of conventional slurry tailings disposal at the selected location represents the most technically and economically feasible means of carrying out the Project. Other options considered either carry technical challenges due to the Project location and climate, or are economically less desirable due largely to their energy requirements. Most importantly, slurry tailings provide for the storage of PAG tailings and waste rock sub-aqueously and encapsulated in NPAG tailings, and thus the most effective technology for effectively mitigating the potential for acid generation and consequent environmental effects. A complicated consideration of environmental effects of these or other alternatives is not warranted given these differences in environmental effects and benefits, and in consideration of other technical and economic factors.

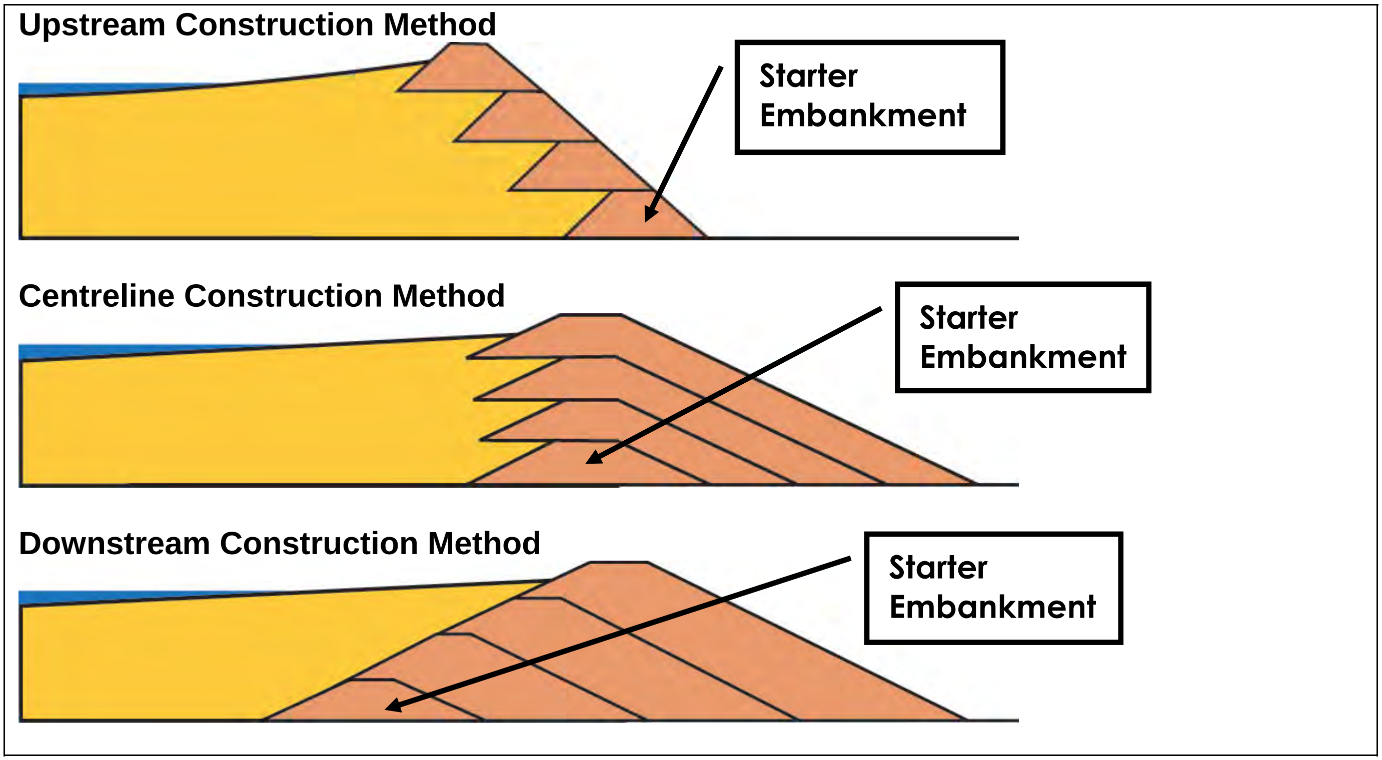
3.3.5 Alternative TSF Embankment Designs

The initial TSF embankment design assumed the use of waste rock from the open pit as a construction material for TSF embankments. Geochemical evaluation of the waste rock in early 2012 indicated that some of the waste rock may be PAG, will not be suitable for use as embankment fill material, and could not be practically mined separately from NPAG waste rock. The mitigation strategy is to place and submerge all waste rock within the TSF, and use quarried rock fill (characterized as NPAG and sourced from a quarry to be developed adjacent to the TSF) for embankment construction. There is no other technically or economically feasible alternative, and the proposed method affords appropriate mitigation for potential acid generation from PAG waste rock.

Knight Piésold further undertook a trade-off study in 2012 to compare the use of cycloned NPAG tailings sand vs. quarried rock fill as construction material alternatives for the TSF embankments. Both methods are technically feasible, though cycloned sand construction is rather more challenging due to the need to compact the deposited sand and to more complex water management requirements during embankment construction. Cycloned sand embankments are also more difficult to reclaim on Closure of the Project. At a feasibility level, one alternative was not evidently more economical than the other. For these operational reasons, and in view of the potential for regulatory and/or stakeholder concern with the use of cycloned sand which can be perceived to be less robust, quarried rock fill was selected as the preferred embankment fill material option.

The design of the TSF embankments was discussed in Section 3.2.4.3 and shown in Figure 3.2.7. The preferred design involves the progressive (staged) construction of the TSF embankments in a series of lifts that will be constructed over the life of the Project, the first of which is the initial starter embankment.

As illustrated in Figure 3.3.4, there are three principal methods of constructing the TSF embankments: upstream, centreline, and downstream that are described further below. All these methods involve sequentially raising the embankment as the TSF fills with tailings over the life of the Project; this is the typical approach for tailings embankment construction.



Source: Samuel Engineering (2013).

Figure 3.3.4 **TSF Construction Methods**

Upstream Construction. Of the three principal methods, the upstream construction method typically incorporates the smallest volume of compacted structural fill within the embankment. This method relies on hydraulically placed tailings as part of the foundation material for on-going embankment raises during staged expansion of the facility. Upstream construction has been used for many tailings embankments worldwide because of its lower costs. However, the seismic resistance of the upstream construction method is considered poor, and thus the great majority of embankment failures worldwide are in embankments of this type.

Centreline Construction. The centreline embankment construction method does not rely on hydraulically placed tailings for embankment stability during on-going staged expansion of the TSF. This type of embankment is inherently stable under static and seismic conditions, and is thus a construction method that is well-accepted and widely used.

Downstream Construction. The downstream construction method results in an embankment cross section that is similar to that of a conventional water retaining dam. It requires the largest volume of fill material as compared to the upstream and centreline construction methods. Downstream construction requires a greater footprint than centreline construction as each subsequent embankment stage extends the toe of the slope much further downstream of the TSF.

The upstream construction method is considered not technically feasible due to unacceptable geotechnical stability and is not considered further.

Both the centreline and downstream construction methods are technically feasible. Largely because of the additional rockfill material required, a tailings embankment constructed by the downstream method would cost in the order of $140 million more to build, over the life of the Project, than the proposed centreline embankment with no improvement in stability or other tangible technical benefit. The negative effect of this additional cost on the economics of the Project is not trivial. Apart from the cost disadvantage, compared to a centreline TSF embankment, a downstream embankment would:

- have a larger footprint due to the greater width of its base (by about 100 ha), and would need a larger quarry from which to obtain the rockfill material. Thus, the amount of aquatic, wetland and terrestrial habitat loss would be greater, as would be the compensation/offset required under the federal *Fisheries Act* (for lost fish habitat) and the New Brunswick *Clean Water Act* (for lost wetlands);

- provide no additional benefits in terms of seepage mitigation or collection and thus no additional benefits to downstream water quality management. Because of its larger base, the embankment drainage collection system under a downstream embankment would be more extensive than under a centreline embankment. However, the total amount of seepage from the TSF would not be substantially different, and the overall efficiency in capturing that total seepage through the larger embankment would not be expected to change;

- provide no additional resistance to extreme seismic events since the design basis for a downstream embankment is the same as for a centreline embankment (see Section 3.2.4.3.3.2); and

- provide no additional capacity to manage extreme storm events since, in both designs, the TSF would be designed and managed with sufficient capacity and freeboard to store the Probable Maximum Flood at all times during Operation (see Section 3.2.4.3.3.1).

In summary, both centreline and downstream embankment designs are technically feasible. However, compared to a centreline embankment, a downstream embankment would clearly cost substantially more and negatively affect the economics of the Project while offering no safety or environmental protection benefits. It would also result in a substantially increased environmental footprint with the associated adverse environmental effects. Thus, the results of the analysis of alternative embankment designs is that the Sisson TSF embankment will be constructed using the centreline construction method rather than the upstream or downstream method.

As shown in Figure 3.2.7, the centreline method will be slightly modified for the Sisson Project to incorporate compacted tailings on the upstream side of the embankments to reduce seepage. The modified centerline design provides the same level of security against slope failure as a centerline design, and meets or exceeds the factors of safety in the CDA Guidelines. In the case of the embankments for the Sisson Project, the target factors of safety are easily achieved or exceeded using a modified centerline design.

3.3.6 Alternatives for Low Grade Ore Storage and Waste Rock Storage

Low grade ore and waste rock storage was presented in the *CEAA* Project Description (Stantec 2011) as being stored in a designated storage area either north or west of the open pit. As detailed in Section 7.5 of this EIA Report and based on extensive ARD/ML characterization studies, waste rock generated by the Project is considered PAG and therefore not suitable for open waste rock storage or for use in building the TSF embankments. As a result, waste rock storage has been diverted to the TSF to effectively mitigate the potential for long-term ML/ARD issues consequent environmental effects on receiving water quality. The TSF as described in Section 3.2.4.4 will handle all tailings and waste rock, including the sub-aqueous disposal of PAG materials.

3.3.7 Alternative Means and Routes for Transporting Personnel, Equipment, Supplies, Materials, and Products

The Project is located in rural New Brunswick with a number of public highways and secondary roads that lead to the forest resource road network used to access the Project. To assist in the selection of Project routes and the assessment of potential environmental effects on road transportation as required by the Final Guidelines (NBENV 2009) and Terms of Reference (Stantec 2012a), SML retained exp Services Inc., a specialty engineering firm with considerable expertise in transportation planning and engineering, to carry out a Transportation Study for the Project. The Transportation Study (exp Services Inc. 2013a; 2013b) evaluated various means of accessing the Project site from major highways, with a focus on the transportation of Project personnel and the delivery of goods and materials to and from the Project site during the Construction, Operation, and Decommissioning, Reclamation and Closure phases of the Project.

The Transportation Study recommended the use of a Primary Site Access (PSA) route and a Secondary Site Access (SSA) route, as discussed in Section 3.2.5.3.1 and with their environmental effects evaluated in Section 8.15 (Transportation) of this EIA Report.

In terms of means of shipping mineral products from the Project, a combination of road and rail transportation will be used to ship mineral products from the Project site either directly to markets, or to port facilities in Saint John or Belledune. All such means of transportation will be considered and used through Operation of the Project, depending on the customer location, logistics, and economics.

In consideration of the Transportation Study, the residual environmental effects of the Project on Transportation, and planned mitigation, the selected means of transporting goods, materials and personnel to and from the Project site as discussed in this EIA Report represents the most technically and economically feasible means of carrying out the Project in this regard.

While most alternatives considered may have minor differences in the environmental effects experienced, since the Project will in all cases use existing public roads and forest resource roads with minimal increases in traffic levels (see Section 8.15), a complicated consideration of environmental effects of these or other alternatives is not warranted.

3.3.8 Alternative Electrical Transmission Line Routes

As discussed in Section 3.2.5.7, a new 138 kV electrical transmission line will be required to link the Project to the New Brunswick electrical grid. To assist in the planning and development of the Project, NB Power completed a Facilities Study (NB Power 2012) to identify potential options and routes for supplying electrical power to the Project. In its Facilities Study, NB Power identified five potential power supply options, including three distinct transmission line routes, for supplying the Project with electricity. The three routes, referred to herein as Potential Routes, were are analyzed in consideration of environmental, socioeconomic and engineering constraints trough a Route Alternatives Analysis, summarized briefly below.

3.3.8.1 Guiding Principles

A set of guiding principles was created to form the basis of constraint development and the approach and methodology to conduct the alternatives analysis. These guiding principles were to select a preferred route that:

- follows existing corridors to the extent possible;
- maximizes the use of public (Crown) land;
- avoids partitioning of large parcels of privately-owned land;
- minimizes its environmental footprint;
- minimizes watercourse crossings;
- avoids environmentally sensitive areas and features (*e.g.,* deer wintering areas (DWAs), ecologically significant areas (ESAs)) to the extent feasible; and
- is technically and economically feasible from an engineering and constructability perspective.

3.3.8.2 Route Evaluation Methods

3.3.8.2.1 Data Sources

The characteristics of the potential routes were determined by reviewing information collected from various information sources, including topographic maps, NBDNR wetland/hydrology maps land use mapping, land ownership mapping and associated records, and publications containing material of general and specific relevance to the area.

The Potential Routes were delineated using Geographic Information Systems (GIS) to allow for integration of multiple spatially referenced data sets and is a powerful tool in support of decision making. Information is easily combined and displayed in this format, allowing for easy interpretation and assessment of data.

3.3.8.2.2 Rankings

The Potential Routes were evaluated using three general categories of constraints: environmental, socioeconomic, and engineering. Each category was subdivided into smaller components. For each Potential Route, individual components within a category of constraints were evaluated and ranked using pre-determined criteria, according to the following methodology.

1. Components were ranked on a scale of 0 – 10. A ranking of 10 was given to the most favourable potential routes, whereas a ranking of 0 was given to potential routes of low favourability based on their respective criteria. Potential routes of equal favourability were ranked equally. No scores of less than 0 were assigned.

2. The ranking of each component within a category was then multiplied by its associated weighting factor to give a weighted component ranking.

3. All weighted component rankings were then summed to give an overall category ranking.

4. The overall category ranking was then multiplied by its weighting factor to give a weighted category ranking.

5. Weighted category rankings from each of the three categories were summed to give an overall ranking for each Potential Route. The overall rankings are displayed as a score out of 100, such that a score of 100 will be an ideal route, while a score of 0 signifies a very unfavourable route.

An example of the ranking system and calculation thereof is shown in Table 3.3.2.

Table 3.3.2 Potential Route Ranking Calculation Example

Constraints Category – Environmental (Weighting Factor 40%)									
Environmental Components	**Component Weighting Factor**		**Potential Route Ranking**		**Component Weighted Ranking**		**Category Weighting Factor**		**Category Weighted Ranking**
Watercourse Crossings	25%	x	4	=	1.0				
Wetlands	20%	x	9	=	1.8				
Ecologically Significant Areas	10%	x	8	=	0.8				
Deer Wintering Areas	10%	x	9	=	0.3				
Parallel to Existing Corridor	35%	x	10	=	3.5				
Category Ranking (sum)					**7.4**	**x**	**4 (40%)**	**=**	**29.6**

3.3.8.3 Constraints

A set of environmental, engineering, and socioeconomic constraints were developed based on the Guiding Principles detailed above. Each constraint was assigned a ranking criterion, against which each Potential Route was scored, and overall scores were totalled for each category of constraint and weighted to arrive at an overall score for each Potential Route.

Environmental Constraints: The following environmental constraints were considered:

- watercourse crossings;
- wetlands;
- ecologically significant areas (ESAs);
- deer wintering areas (DWAs); and
- parallel to existing corridor.

Adverse environmental effects, such as erosion, sedimentation, disturbance of ecologically significant areas, habitat disturbance and habitat fragmentation, are to be minimized. A route that is parallel to an existing corridor is preferred because no new fragmentation of habitat will be created.

Socioeconomic Constraints: The following socioeconomic constraints were considered:

- recreational areas; and
- bi-section of private property.

Adverse socioeconomic environmental effects, such as lost recreational area or disruption of trails and disturbance to private property, were also to be minimized.

Engineering Constraints: The following engineering constraints were chosen and considered:

- topography;
- length; and
- reliability of source.

Adverse environmental effects, such as excessive costs, were to be minimized while ensuring that a reliable electrical source can be provided to the Project.

3.3.8.4 Potential Routes

In its Facilities Study, NB Power identified potential transmission line routes by first identifying potential sources of electricity within the existing NB Power transmission system, based solely on engineering and constructability considerations. Four potential electrical sources that could be accessed to supply the electrical requirements for the Project were identified:

- the Keswick Terminal;
- Line 1126, a 138 kV line located to the west of the Sisson Project site, near Cloverdale;

- Line 3011, a 345 kV line that runs adjacent to and through the Sisson Project site; and
- Line 48, a 69 kV line located in Deersdale.

The Facilities Study identified the need to construct a new transmission line connected to one of the above noted potential sources in order to supply the electrical requirements for the Project. From this, three potential routes were identified, as follows.

Route A: Route A (Figure 3.3.5) originates at the Keswick Terminal and culminates at the Sisson Project site, running along the east side of an existing 345 kV transmission line (Line 3011). This route, approximately 42 km in length, parallels an existing linear corridor and is favourable due to facilitated access and reduced potential for habitat fragmentation concerns.

Route B: Route B (Figure 3.3.6) originates at the existing 138 kV transmission line (Line 1126) near Cloverdale, west of the Project, and culminates at the Sisson Project site. This route is approximately 23 km long and generally follows a straight path to the Project site. This entire route will require a new corridor to be developed between the Sisson Project site and the tie-in location to Line 1126.

Route C: Route C (Figure 3.3.7) originates at the 69 kV transmission line (Line 48) in Deersdale to the north of the Project, and culminates at the Sisson Project site. This route is approximately 13 km long and follows an essentially straight line path to the Project site. This route will require a new corridor to be developed between the Sisson Project site and the tie-in location to Line 48.

3.3.8.5 Route Alternatives Analysis Results

The complete quantitative evaluation and ranking of each Potential Route is shown in Table 3.3.3.

Table 3.3.3 Electrical Transmission Line Route Alternatives Analysis Results

Criteria		Weight (%)	Route A		Route B		Route C	
			Ranking	Score	Ranking	Score	Ranking	Score
A.	**Environmental Criteria**							
A.1	Watercourse Crossings	25%	4	1.0	7	1.8	8	2.0
A.2	Wetlands	20%	9	1.8	9	1.8	9	1.8
A.3	Ecologically Significant Areas	10%	8	0.8	5	0.5	8	0.8
A.4	Deer Wintering Areas	10%	3	0.3	7	0.7	10	1.0
A.5	Parallel to Existing Corridor	35%	10	3.5	0	0.0	2	0.7
	Score			**7.4**		**4.8**		**6.3**
	Weighted Score	**40%**		**29.6**		**19.0**		**25.2**
B.	**Socioeconomic Criteria**							
B.1	Recreational land use	45%	3	1.4	9	4.1	9	4.1
B.3	Bi-section of private property	55%	8	4.4	4	2.2	9	5.0
	Score			**5.8**		**6.3**		**9.0**
	Weighted Score	**20%**		**11.5**		**12.5**		**18.0**

Table 3.3.3 Electrical Transmission Line Route Alternatives Analysis Results

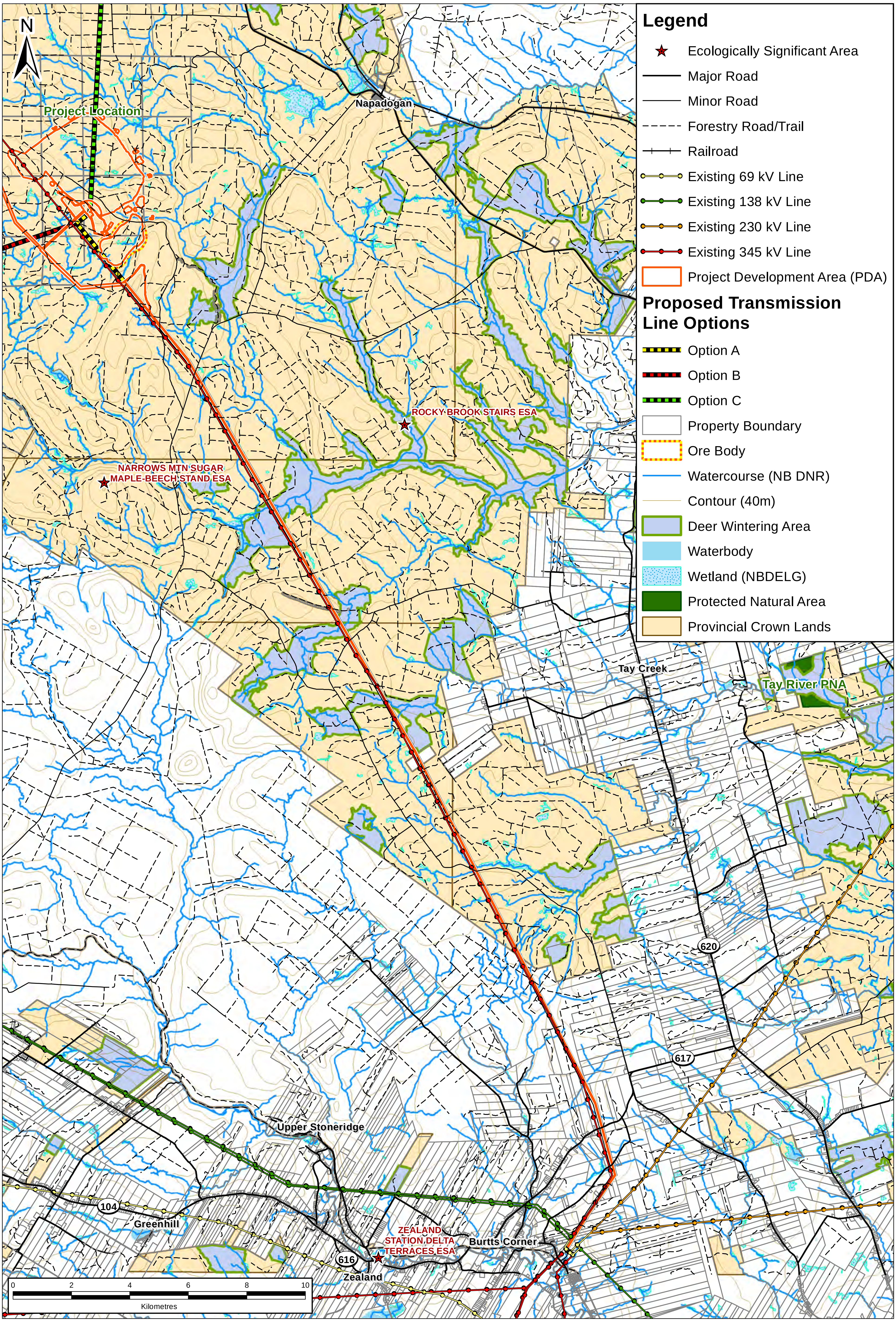
Criteria		Weight (%)	Route A		Route B		Route C	
			Ranking	Score	Ranking	Score	Ranking	Score
C.	**Engineering Criteria**							
C.1	Topography	10%	9	0.9	8	0.8	9	0.9
C.2	Length	25%	2	0.5	6	1.5	9	2.3
C.3	Reliability of source	65%	10	6.5	2	1.3	1	0.7
	Score			**7.9**		**3.6**		**3.8**
	Weighted Score	**40%**		**31.6**		**14.4**		**15.2**
	Total Weighted Score	**100%**		**72.7**		**45.9**		**58.4**

In each of the Potential Routes, the area is primarily Crown land, generally isolated, and rural, with only a few residential areas that are generally located at or near the source ends of the routes. Accordingly, a higher weighting was applied to environmental and engineering constraints than was applied to socioeconomic constraints.

Of the environmental constraint components, route location parallel to an existing corridor was assigned the highest weighting as compared to greenfield options. A parallel corridor will minimize habitat fragmentation and will use existing infrastructure (*e.g.,* access roads) reducing adverse environmental effects. The proposed transmission line design has the ability to span large areas and as a result the watercourse crossing component has been given a correspondingly lower weighting than for other constraints.

Of the engineering constraint components, reliability of source was assigned the highest weighting, as electrical supply problems could adversely affect both the Project itself as well as the stability and reliability of the New Brunswick electrical grid. The topography in the region surrounding the Project is favorable, and therefore this component was assigned a correspondingly lower weighting as compared to other constraints.

As a result of the analysis, Route A (Figure 3.3.5) received the highest overall weighted score (Table 3.3.3) and thus has been identified as the Preferred Route. Route A crosses several watercourses and wetlands; however, standard mitigation measures employed during the construction and operation of the electrical transmission line will minimize interactions with the surrounding environment and the potential for adverse environmental effects. For example, watercourses will be spanned by the electrical transmission line, and therefore no in-stream work will occur within 30 m of the watercourse. Cutting and clearing within the corridor of the Preferred Route will occur outside of the normal bird breeding season (May 1 – August 31) to minimize the potential for interaction with migratory birds and their nests. In locations where wetlands cannot be avoided, mitigation will be employed, including spanning the wetlands to avoid placing infrastructure within them. A wetland compensation plan will be developed and will consider any loss of wetland area or function that occurs as a result of the transmission line.



NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Potential Route A for an Electrical Transmission Line

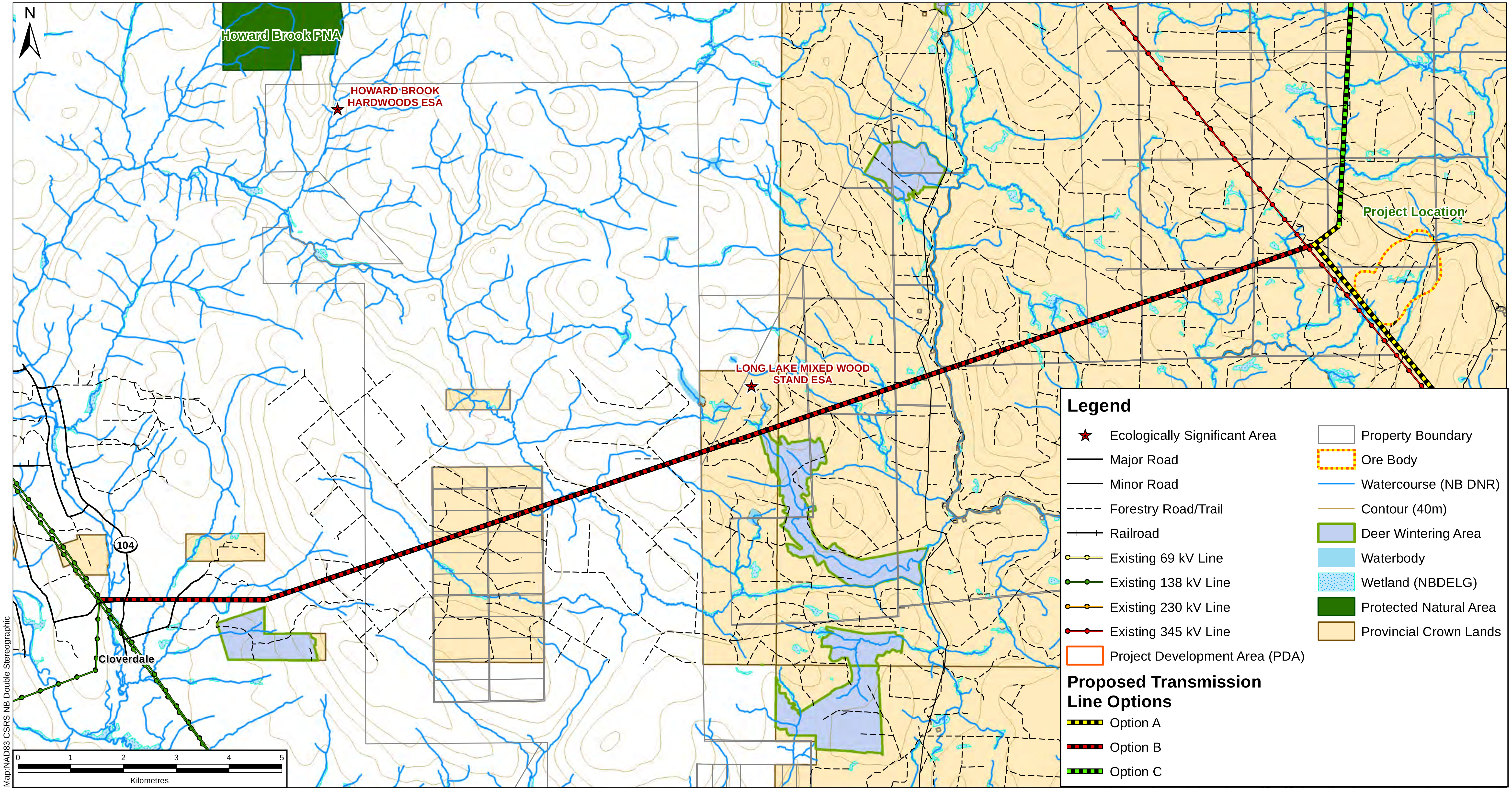
Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Sisson Mines Ltd.

Scale: 1:120,000	Project No.: 121810356		Data Sources: NB DNR NB DELG NRCAN	Fig. No.: 3.3.5
Date: (dd/mm/yyyy) 6/11/2013	Dwn. By: KR	Appd. By: DM		

Stantec

Map: NAD83 CSRS NB Double Stereographic



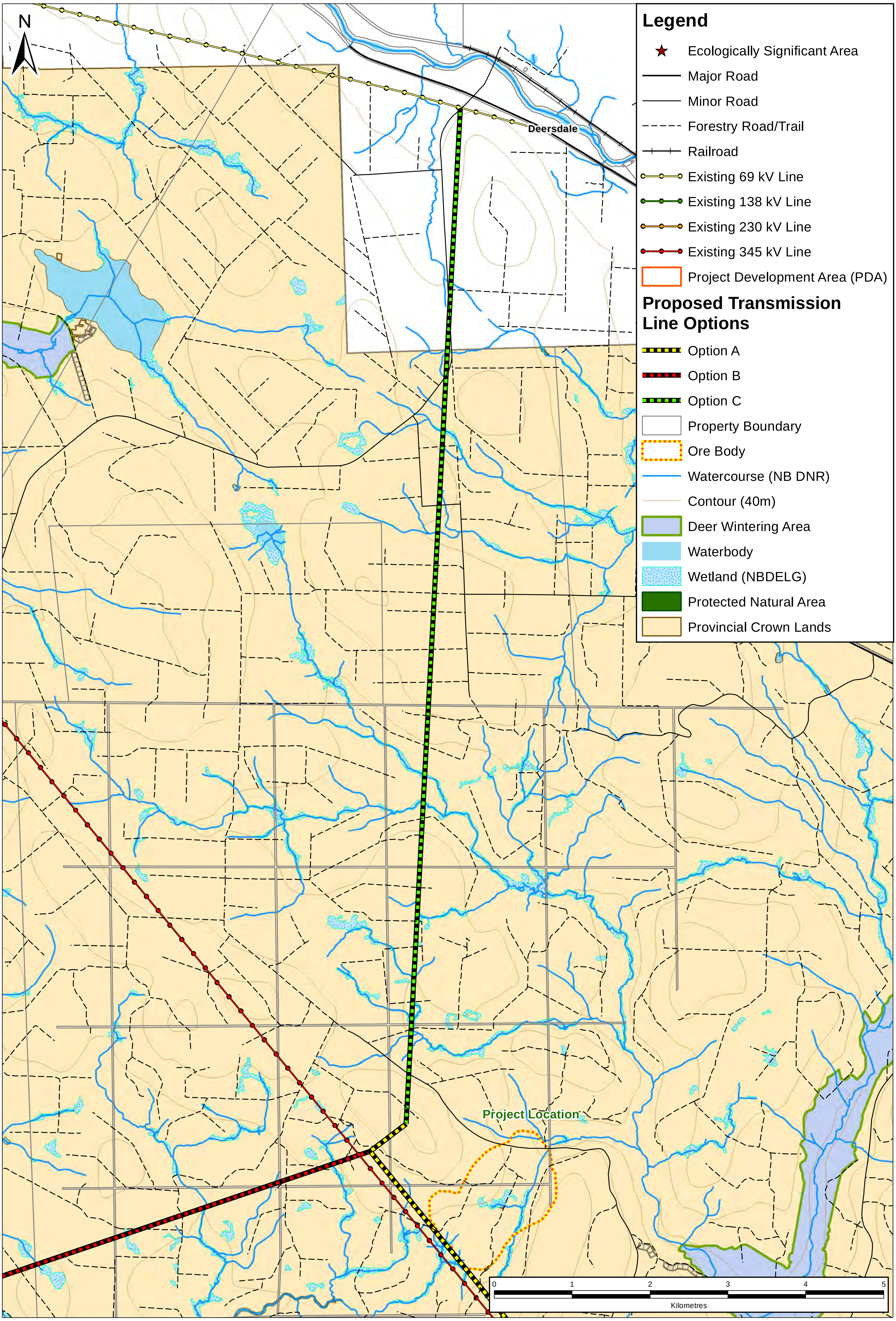
Potential Route B for an Electrical Transmission Line

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Sisson Mines Ltd.

Scale:	1:70,000
Project No.:	121810356
Data Sources:	NB DNR, NB DELG, NRCAN
Fig. No.:	3.3.6
Date: (dd/mm/yyyy):	6/11/2013
Fig. By:	KR
Appd. By:	DLM

Stantec



NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Potential Route C for an Electrical Transmission Line Sisson Project: Environmental Impact Assessment (EIA) Report, Napadogan, N.B.	Scale: 1:45,000	Project No.: 121810356	Data Sources: NB DNR NB DELG NRCAN	Fig. No.: 3.3.7	Stantec
Client: Sisson Mines Ltd.	Date: (dd/mm/yyyy) 6/11/2013	Dwn. By: KR Appd. By: DLM			

Map: NAD83 CSRS NB Double Stereographic

Route A was selected as the preferred route and alternative to supply electrical power to the Project. Other alternatives considered may be technically or economically feasible, but are not the preferred route in view of the technical and economic criteria employed in this analysis. While most alternatives considered may have minor differences in the environmental effects experienced, the facilities do not have substantive differences in footprints, emissions, discharges or wastes, and as such a complicated consideration of environmental effects of these or other alternatives is not warranted.

3.3.9 Alternative Options for Decommissioning, Reclamation and Closure

The *Mining Act* requires that a Mining and Reclamation Plan be developed for the Project as part of its approval under that Act.

SML has considered various options to achieve decommissioning, reclamation and closure of the Project site at the end of mine life. The Conceptual Reclamation and Closure Plan developed for SML (EvEco 2013) describes the conceptual approach to completing reclamation and closure of the Project as conceived in the feasibility study at this stage of Project development. This plan is described briefly in Section 2.6.3 of this EIA Report, and the activities that will be conducted during Decommissioning, Reclamation and Closure phase based on this plan are described in Section 3.4.3.

Monitoring and adaptive management will be carried out throughout the Project life, and invariably the conceptual plan to complete reclamation and closure will necessarily need to evolve as a result of potential changing requirements and features that cannot be anticipated at the onset of Project planning. The Reclamation and Closure Plan will thus be a dynamic document that will be updated throughout the mine life to reflect current plans and requirements to achieve successful reclamation and closure of the site.

Upon completion of mining activities, the plans for decommissioning, reclamation and closure that are developed and ultimately implemented by SML and subsequently approved by regulatory authorities will consist of the preferred (and only authorized) means of achieving these outcomes and the agreed-upon end land use objectives. In this light, there are no known technically or economically feasible alternatives to the current conceptual plans to complete decommissioning, reclamation and closure of the Project.

3.3.10 Alternative Options for Fish Habitat Offsetting

The Project will result in the loss of Sisson Brook, Bird Brook, and other small portions of watercourses to make way for Project facilities. The loss of fish habitat is considered to be “serious harm to fish” under the federal *Fisheries Act* that must be authorized under Sections 35(2) and 36 of the Act and offset to the satisfaction of the Department of Fisheries and Oceans Canada (DFO). As part of its evaluation of potential fish habitat offset opportunities for the Project, SML has identified four main options for consideration to offset the loss of Bird Brook and Sisson Brook as a result of the Project. These options, discussed briefly in Section 7.4 of this EIA Report, are:

- removal of the Campbell Creek Dam;
- removal of the Lower Lake Dam;

- provision of Atlantic salmon passage at the Dunbar Stream Falls; and
- replacing an old water-level control dam and road culvert on the Nashwaak River just below its exit from Nashwaak Lake with a woods road bridge.

Other opportunities are also being evaluated by SML for possible implementation, but the above four options represent what are believed to be the highest value options for offsetting the loss of fish habitat as a result of the Project such that no net loss of fish habitat will occur.

The evaluation of potential fish habitat offset alternatives was completed to compare the above-noted potential fish/fish habitat enhancement works and their potential suitability for fish habitat offset for the Project. The evaluation was undertaken in consideration of the following factors:

- consultation with federal and provincial regulators;
- hierarchy ranking within the framework in the former DFO Practitioners Guide (for HADD compensation opportunities) (DFO 2006);
- potential to offset the productivity of fish habitat in the brooks affected by the Project;
- engineering feasibility;
- value to brook trout and Atlantic salmon populations in the ecological unit;
- value to stakeholders and First Nations;
- heritage resource status (where applicable);
- other regulatory constraints (*e.g.,* presence of wetlands or Species at Risk);
- recognition of regulatory/stakeholder/public concerns; and
- estimated capital costs.

Further details on the evaluation process, considerations, and results are provided in Section 7.4. The evaluation resulted in the selection of the replacement of the old water-level control dam and road culvert on the Nashwaak River with a woods road bridge. Other alternatives considered did not meet all of the established criteria for selecting the preferred option, did not provide sufficient area available for compensation, and were less acceptable to regulatory agencies or stakeholders. As such, subject to regulatory approval, the Nashwaak Lake culvert replacement option has been brought forward to DFO as the most technically and economically feasible means of carrying out the Project in this regard. Since DFO will ultimately determine whether this preferred option is acceptable to offset the loss of fish habitat for the Project, consideration of environmental effects of this or other alternatives beyond that conducted in support of the evaluation presented in Section 7.4 of this EIA Report is not warranted.

3.4 DESCRIPTION OF PROJECT PHASES AND ACTIVITIES

Three Project phases are distinguished for this EIA Report. The **Construction** phase ends, and the **Operation** phase begins, at initial start-up of the ore processing plant. The **Decommissioning, Reclamation and Closure** phase begins when mining and ore processing are complete, and ends when the site is returned to a physically, chemically and biologically stable condition acceptable to the Province of New Brunswick. Within this third phase, "Closure" is defined as the time period between when mining operations cease and when the open pit has filled with water; "Post-Closure" begins when the open pit has been filled and starts discharging water, treated as required to meet water quality standards established by provincial approvals and permits.

Throughout this document, the Construction phase is identified as beginning in Year -2 and continues to completion in Year -1. The start of the Operation phase is in Year 1 and continues to Year 27 (the end of mine life). The Decommissioning, Reclamation and Closure phase begins in Year 28. It is important to note that there is no Year 0—the sequence is Year -2, Year -1, Year 1, Year 2, etc.

The key project phases, activities and physical works are identified in Table 3.4.1; these activities will be carried throughout the EIA of the Project. These key project phases and activities identify Project schedule milestones, characterize the physical works that will be carried out during an associated Project phase, and are representative of the activities that have the potential to result in a potential environmental effect as a result of the Project.

Table 3.4.1 Description of Project Phases, Activities, and Physical Works

Project Phase	Activity Category	Project Activities and Physical Works
Construction	Site Preparation of Open Pit, Tailings Storage Facility (TSF), and Buildings and Ancillary Facilities	The Project-related activities associated with preparing the open pit, TSF, and buildings site for physical construction, including: • surveying; • geotechnical investigations; • clearing; • grubbing; • removal and stockpiling of topsoil and overburden; and • grading/leveling.
	Physical Construction and Installation of Project Facilities	The physical construction of buildings and structures associated with the Project, and installation of equipment associated with its operation, including: • construction of surface facilities (*e.g.,* processing plants, electrical substation, primary crusher, ore conveyor, maintenance shop, explosives storage); • quarrying, aggregate crushing, and concrete batch plant; • development of starter pit and initial ore stockpile; • establishment of overburden and soil stockpiles; • construction of engineered drainage and diversion channels; • loss of Bird and Sisson brooks; • TSF preparation; • construction of TSF starter embankments, water management ponds, and ponding of start-up water; • establishment of water management system; and • equipment installation.
	Physical Construction of Transmission Lines and Associated Infrastructure	The physical construction of electrical transmission-related facilities associated with the Project, including: • site preparation (*e.g.,* clearing, development of access);

Table 3.4.1 Description of Project Phases, Activities, and Physical Works

Project Phase	Activity Category	Project Activities and Physical Works
		• relocation of existing 345 kV transmission line (*e.g.,* distribution of materials, foundation construction, erection of towers, stringing, reclamation); • construction of new 138 kV transmission line (*e.g.,* distribution of materials, foundation construction, erection of towers, stringing, reclamation); and • construction of electrical substation.
	Physical Construction of Realigned Fire Road, New Site Access Road, and Internal Site Roads	The physical construction of roads associated with the Project, including: • site preparation (*e.g.,* clearing, sedimentation and erosion control, grubbing, cutting and filling, grading); • relocation of Fire Road (*e.g.,* road bed preparation, ditching, finishing); • construction of site access road and internal site roads (*e.g.,* road bed preparation, ditching, finishing); and • construction of watercourse crossings.
	Implementation of Fish Habitat Offsetting/Compensation Plan	The physical construction and/or demolition activities associated with implementing various initiatives that form the basis of the Fish Habitat Offsetting program for the Project, including: • replacement of the Nashwaak Lake culvert with a woods road bridge (*e.g.,* clearing of access, heavy vehicle movement, physical removal of culvert and infrastructure, construction of a woods road bridge, site rehabilitation).
	Emissions and Wastes	Emissions and wastes arising from Construction activities, including: • air contaminant emissions (*e.g.,* fugitive dust from roadways and construction activities, emissions from vehicles and heavy equipment); • sound emissions (*e.g.,* from construction activities or from vehicle/equipment movements); • vibration; • surface run-off; and • solid waste disposal.
	Transportation	The activities associated with the transportation of goods, materials, and personnel to and from the Project site during Construction, including: • transportation of equipment, supplies and materials; and • transportation of personnel to and from the Project site using buses and personal vehicles.
	Employment and Expenditure	The activities associated with Project-related employment and expenditures associated with Construction of the Project, including: • purchase of equipment, supplies, and materials; and • employment and incomes.
Operation	Mining	The activities associated with open pit mining, including: • open pit mine operation (operation of explosives magazine, blasting, extraction of ore and waste rock, on-site transportation of ore to crusher, and, until last mining phase, on-site transportation of waste rock to TSF); • ore crushing and conveyance to processing plant; and • rock quarrying, trucking and crushing as needed.
	Ore Processing	The activities associated with the processing of ore in and production of products, including: • milling/grinding;

Table 3.4.1 Description of Project Phases, Activities, and Physical Works

Project Phase	Activity Category	Project Activities and Physical Works
		• flotation; • concentrate dewatering; • tungsten refining; and • packaging.
	Mine Waste and Water Management	The activities associated with the supply of water for the process operation, and the management and storage of surplus water and byproducts from the process operation including: • dewatering of open pit; • tailings storage in TSF; • construction of TSF embankments over life of mine; • waste rock storage in TSF; • collection and management of on-site mine contact water; and • surplus water treatment, release, and monitoring.
	Linear Facilities Presence, Operation, and Maintenance	The physical presence, and operation and maintenance, of Project-related linear facilities, including the 138 kV transmission line, substation, and site roads.
	Emissions and Wastes	Emissions and wastes arising from Operation activities, including: • air contaminant emissions (*e.g.,* fugitive dust from mining and on-site vehicle movements, emissions from ore processing plants, combustion gas emissions from vehicles and heavy equipment); • sound emissions (*e.g.,* blasting, equipment operation, and vehicle movements); • vibration; • treated surplus water release (assessed under Mine Waste and Water Treatment above); • mining waste disposal (*e.g.,* tailings and waste rock, assessed under Mine Waste and Water Treatment above); and • non-mining solid waste disposal.
	Transportation	The activities associated with the transportation of goods, materials, and personnel to and from the Project site during Operation, including: • transportation of equipment, supplies and materials; • transportation of products; and • transportation of personnel to and from the site.
	Employment and Expenditure	The activities associated with Project-related employment and expenditures associated with Operation of the Project, including: • purchase of equipment, supplies and materials; • employment and incomes; and • taxation and royalties.
Decommissioning, Reclamation and Closure	Decommissioning	The activities associated with the decommissioning of Project components and facilities at the end of mine life, including: • decommissioning and removal of equipment; and • removal of buildings and structures.
	Reclamation	The activities associated with reclamation of the Project site at the end of mine life.
	Closure	The activities associated with closure of the mine, including the filling of the open pit with water from the TSF and precipitation.
	Post-Closure	The existence of the former TSF and open pit, now filled with water, in perpetuity, and the ongoing treatment and release of surplus water, as applicable.

Table 3.4.1 Description of Project Phases, Activities, and Physical Works

Project Phase	Activity Category	Project Activities and Physical Works
	Emissions and Wastes	Emissions and wastes arising from Decommissioning, Reclamation and Closure activities, including: • surplus water management, treatment, and release.
	Transportation	The activities associated with the transportation of goods, materials, and personnel to and from the Project site during Decommissioning, Reclamation and Closure, including: • transportation of equipment, supplies and materials; and • transportation of personnel.
	Employment and Expenditure	The activities associated with Project-related employment and expenditures associated with Decommissioning, Reclamation and Closure of the Project, including: • purchase of equipment, supplies and materials; and • employment and incomes.

Further details on these phases and activities are provided in the sub-sections that follow.

3.4.1 Construction

The Construction phase will begin immediately following government approval of the EIA and the receipt of all government approvals, permits and authorizations required to begin construction of the Project, as well as Project financing and a SML Board decision to proceed. Construction is expected to take place over a period of about 24 months, and will be completed by the initial start-up of the ore processing plant—marking the beginning of the Operation phase.

The following is a brief description of Construction activities that are typical for an open pit mine and associated infrastructure. All Construction activities will be managed by the Environmental Protection Plan for Construction as described in Chapter 2.

In general terms, once EIA approvals, the Approval to Construct and other necessary permits are in place, Construction will start over the first fall/winter period. The planned Construction sequence is as follows.

- Construction will start over the first fall/winter period following receipt of all approvals, with tree clearing for the plant site and road infrastructure (*e.g.,* Fire Road relocation, site access road to the Project, and main site roads), the TSF starter dams and the associated initial pond areas within the tailings basin, and the water management ponds.

- Construction of the ore processing plant, TSF starter dams, water management ponds, and road infrastructure will begin as soon as site conditions allow the following spring/summer. Clearing for the new and relocated transmission lines, the initial open pit, and other facilities will take place over the second fall/winter period, and construction/relocation of the transmission lines will start during that second winter period.

- Development of the initial open pit and construction of other facilities (*e.g.,* primary crusher, ore conveyors, and explosives facility) will begin as soon as site conditions allow early in the second spring/summer of Construction.

The Project site layout at the end of Construction is shown in Figure 3.4.1. Clearing of the rest of the TSF will take place in stages during Operation over the fall/winter periods before each major extension of the TSF footprint and embankment raises the following summer. Similarly, clearing of the rest of the open pit area will occur in stages during Operation in the fall/winter periods before major pit extensions the following summer.

3.4.1.1 Site Preparation of Open Pit, Tailings Storage Facility (TSF), and Buildings and Ancillary Facilities

During Year -2 (first year of Construction), the site will be prepared for development of the open pit, TSF, buildings and ancillary facilities. Site preparation will include clearing, grading, and leveling of the site as required in preparation for foundations and equipment.

Erosion and sedimentation control techniques will be employed throughout the site preparation activities as required to minimize erosion of exposed areas and sedimentation in site surface water. Dust suppression and water containment will also be employed during site preparation to minimize the potential environmental effects of fugitive dust to offsite locations.

3.4.1.1.1 Surveying

The Project site will be surveyed to accurately determine actual elevations and contours in order to optimize cut and fill operations consistent with layout requirements of the site components.

3.4.1.1.2 Geotechnical Investigations

Drilling and geotechnical investigations will be completed to establish the requirements to achieve stable foundations for Project infrastructure and to finalize the design of the open pit slopes. Geotechnical/hydrogeological data collection during the detailed design and construction stages, will focus on bench mapping, borehole hydrogeological testing, and piezometer instrumentation and monitoring.

3.4.1.1.3 Clearing

Clearing of the areas for the open pit, primary crusher and ore conveyor, ore processing plants, stockpiles, TSF, site access road, internal site roads, and ancillary facilities will be completed using forest harvesting machinery. Clearing near watercourses will be conducted manually. Clearing activities will be conducted outside of bird breeding season (May 1-August 31) to the extent possible, to prevent the undue disturbance of migratory birds or their nests. Should clearing be required within this season, these areas will be surveyed to determine if nesting is occurring within these areas. All cleared merchantable timber will be sold, and except for the TSF area, any remaining cleared vegetation will be stockpiled. Non-merchantable timber in the TSF area will simply be flooded when water begins to be impounded in the TSF.

The TSF embankment areas will be locally sub-excavated to remove unsuitable material (*e.g.,* soft, loose, or excessively wet soils). This material will be used to the extent possible as fill within the starter embankment shell zones, and unneeded material will be stockpiled for future use. The TSF embankment foundation areas will be dewatered and any natural streams will be diverted in engineered channels.

3.4.1.1.4 Grubbing

Grubbing includes the removal and disposal of stumps and roots remaining after clearing. Grubbing will be conducted using a root rake or similar equipment that is able to remove the roots and stumps of cleared vegetation and leaves the topsoil for salvage. The areas associated with the ore processing plant, the TSF embankments, and other surface facilities (*e.g.,* roadways) will be grubbed, whereas the TSF area itself will not be prepared further beyond clearing and removal of merchantable timber.

3.4.1.1.5 Removal and Stockpiling of Topsoil and Overburden

The overburden in the open pit area generally consists of a veneer of organic matting and topsoil over till. The overburden thicknesses generally range from 0.90 to 4.0 m in depth below ground surface. Topsoil will be an organic material, while overburden will typically be till (*i.e.,* silty sand and gravel).

This material will be removed with excavators from the area of the starter open pit and in the area where foundations will be laid. Topsoil and overburden will be stockpiled in various areas surrounding the TSF and other facilities, for reuse during re-vegetation activities associated with progressive reclamation of the site and ultimate site reclamation at the end of mine life. The amount of materials to be collected, construction and operation considerations, space availability, and future intended uses will determine the exact location and size of these stockpiles. The material will be used at closure to provide a growth medium on the tailings beach, TSF embankments, and any other appropriate areas. Sediment control fencing will be installed and maintained at all stockpiles that are up-gradient of a watercourse to prevent the down-slope transport of sediment into watercourses.

3.4.1.1.6 Grading and Leveling

Once clearing is completed, the Project site (including ore storage areas, ore processing plant and the TSF embankment foundations) will be prepared by grading and leveling of the areas using heavy equipment such as graders, dozers and scrapers.

The ore storage pads will be graded to create the desired grade for drainage capture. The foundation zone will be prepared, and drainage collection works will be installed.

3.4.1.2 Physical Construction and Installation of Project Facilities

3.4.1.2.1 Construction of Surface Facilities

Footings and foundations will be poured for buildings and structures associated with the ore processing plant and other buildings and structures. Pre-packaged and field-erected ancillary facilities, including the buildings, fuelling and processing equipment, will be delivered to the site and installed.

All buildings and ancillary facilities will be constructed using standard methods and built to all applicable safety codes, with reference to public health, fire protection, and structural sufficiency. The primary purpose of the codes is the promotion of worker and public safety through the application of appropriate uniform building standards. Equipment will be set up in their appropriate locations, electrical and mechanical connections will be established.

3.4.1.2.2 Quarrying, Aggregate Crushing, and Concrete Batch Plant

A quarry will be developed as shown in Figure 3.2.1 to supply coarse rock to be used in Project construction, particularly for the construction of the TSF embankments. Material from the quarry will be crushed as required using an aggregate crusher and used to develop the TSF starter embankments. Aggregate from the quarry will also be used to supply the on-site concrete batch plant during Construction.

3.4.1.2.3 Development of Starter Pit and Initial Ore Stockpile

Construction of the haul roads in the open pit will begin in Year -1 of Construction and will evolve as the pit is extended during each year of Operation. Following the removal of overburden, topsoil and waste rock in the pit, some initial ore will be blasted, excavated and stockpiled to prepare for operation of the ore processing plant.

3.4.1.2.4 Establishment of Stockpiles and Storage Areas

Stockpiles of cleared and grubbed soil, overburden and vegetation will be established at various locations around the open pit and TSF to store materials for use during re-vegetation activities at various times during the Project, and for use during reclamation activities. Stockpiles will not be located within 30 m of a watercourse or wetland within the Project site to minimize environmental effects through erosion and sedimentation. As an erosion and sedimentation control measure, stockpiles will be seeded after initial construction.

Storage areas for equipment, petroleum products (*e.g.,* petroleum, oils and lubricants) and explosives will be established. Proper storage and handling of petroleum products and explosives will prevent the chance of accidental spill or discharge. Temporary storage typically includes above-ground storage tanks and the use of portable tanks and containers for refueling and on-site maintenance activities. Permanent storage, including the establishment of above-ground storage tank systems, may be established within the Truck Maintenance facility for refueling and other maintenance activities.

All petroleum storage tank systems established for the Project will have an annual Petroleum Storage Site License and will be registered in compliance with the *Petroleum Product Storage and Handling Regulation – Clean Environment Act*. Petroleum storage areas will be inspected regularly and tanks will be inspected for stress or leaks. Storage areas will be sloped and will be directed to drain any spilled material to a safe collection area for clean-up. Storage areas and fuelling areas will not be located within 100 m of a watercourse, wetland, or groundwater supply well.

3.4.1.2.5 Construction of Engineered Drainage and Diversion Channels

Engineered drainage and diversion channels will be constructed to divert non-contact surface water and precipitation away from the Project site wherever possible. Water management during this phase will consist of establishing collection ponds, coffer dams, pumping systems, run-off collection ditches, and diversion channels. Some of the temporary works such as coffer dams and by pass diversion channels will be removed once the initial starter embankments have been constructed. Sediment collection ponds and collection ditches will remain in place throughout the life of the Project.

3.4.1.2.6 Loss of Bird and Sisson Brooks

Development of the Sisson Project will involve the creation of a TSF which will gradually inundate sections of Bird Brook, Sisson Brook, and an unnamed tributary (Tributary "A") to West Branch Napadogan Brook, thus eliminating them as fish habitat. Sisson Brook is located atop the Sisson ore deposit, and Bird Brook and its tributaries pass directly through the location of the TSF. Since they cannot be diverted due to their position within the Project site, these brooks and associated fish habitat will be lost. Habitat loss will be authorized by DFO under the *Fisheries Act* and will be compensated accordingly.

3.4.1.2.7 TSF Preparation

In order to avoid the possibility of harming fish currently resident in the brook sections referred to above, SML intends to explore and, if possible, implement a program for removing fish from these brook sections before any tailings are deposited in them. Implementation of such a program depends upon the timing of EIA approvals, and the issuance of relevant permits and authorizations, since some of the required activities are seasonally restricted. Clearing activities are generally restricted to September through April, and electrofishing is limited to when weather and hydrological conditions allow for the safe and effective operation of the equipment. From a practical standpoint, implementation will also depend upon SML being able to accommodate such a program within the overall Project construction plan and schedule.

3.4.1.2.7.1 Overview of TSF Construction

Construction of the TSF will begin with the construction of small starter dams to collect the water required for the start of Operation. These dams will become encapsulated within the TSF embankments, and the embankments as well as the area inundated by water (and then tailings when operations begin) will grow over the life of the Project.

Construction of the TSF cannot begin before creating access to and clearing the dam construction sites. Coffer dams will then be installed just upstream of the starter dam locations, and stream flows from above the coffer dams will be pumped around the construction site for discharge downstream. The coffer dams will be sized to ensure that sediment generated upstream will settle out before the water is pumped around the construction sites. Construction of the starter dams, the downstream water management ponds, and then the initial TSF starter embankments, will follow. Within the TSF footprint, timber that is merchantable will be harvested and removed; timber that is not merchantable will be felled and gradually covered with water and then tailings. Other than for the construction of starter dams and embankments, no grubbing or other earth moving within the TSF footprint is required.

3.4.1.2.7.2 Fish Removal Strategy

Removal of fish from the relevant brook sections will be undertaken when weather and hydrological conditions allow for safe and effective operation of the equipment while avoiding peak salmonid spawning periods—likely over the June through September period. Captured fish will be released downstream of the starter dam and water management pond sites. To prevent fish from returning upstream, and if the coffer dams are not in place by late September, barrier nets or other suitable means will be established just downstream of the locations of the water management ponds. Once the coffer dams are in place and the upstream brooks are fish-free, the upstream brook beds within the TSF footprint will be filled in with non-deleterious materials such as local borrow or quarried material where access permits. Suitable means will be employed to allow groundwater discharge along the brook beds (*e.g.,* the bottom layer of fill will be coarse material and/or a drainage pipe will be laid in the bed). A detailed fish removal plan will be submitted for regulatory review and approval prior to the removal of fish.

3.4.1.2.7.3 Conceptual Fish Removal Plan

Preparatory Activities

Fish removal will likely be undertaken June through September and be preceded by a number of preparatory activities. These include primarily:

- during the year before fish removal, completion of test pitting in already identified areas of elevated archaeological potential wherever removal-related activities (*e.g.,* development of access roads) will disturb the ground surface;
- removal of beavers and beaver dams;
- clearing for, and development of, access roads to various points along the brooks; and
- clearing of woody debris and overhanging vegetation from the brook channels.

Various permits and authorizations will also be required before fish removal can be undertaken, the principal ones being the following.

- EIA approval of the Project under *CEAA* and the New Brunswick *Clean Environment Act* before any clearing or ground-breaking works can be initiated.
- A scientific collection permit for fish from DFO. Consultation with DFO and NBDNR will be required to determine suitable release locations for captured fish.
- Since the fish removal is in preparation for development of the TSF and consequent serious harm to fish, authorization of the serious harm to fish by DFO will be required under the *Fisheries Act*. That authorization will be contingent upon DFO approving a fish habitat offsetting plan.
- Provincially, an Approval to Construct will be required from NBDELG that will encompass specific permits (*e.g.,* Watercourse and Wetland Alteration (WAWA) permit).

Fish Removal

The following fish removal approach assumes that the coffer dams will not be in place at the time of initiating fish removal activities. Should these be in place, the fish removal process will follow the same general approach but the execution will be considerably simpler as fish will not be able to ascend past the coffer dams. Fish removal will be required in the TSF area, and to a lesser extent in the open pit area.

Fish removal will start in the headwaters of each watercourse and move in a downstream direction. Fish removal will entail isolating sections of watercourse using porous barriers (*e.g.,* dams made of sand bags and fitted with a screened PVC pipe) to allow for continuous flow of water and to prevent fish returning to areas already fished out. These porous barriers, and fish removal, will move sequentially downstream until each watercourse is determined to be free of fish.

It is anticipated that a minimum of three electrofishing passes will be required to remove fish from within each stretch of watercourse. Agreement will be required with DFO on what will be considered an acceptable “end point” (*i.e.,* after what type and level of effort a section of watercourse will be deemed to be “fish-free”). In fish-bearing waters where electrofishing is not possible (*e.g.,* flooded wetland), alternate methods of capture such as fyke nets and minnow traps will be used.

Captured fish will be placed in buckets of water for transfer to oxygenated tanks of water mounted on transport vehicles stationed at access points nearby. These vehicles will convey the captured fish to approved discharge points below the construction sites for release downstream.

Electrofishing will be conducted by crews consisting of a lead biologist, electrofishing technicians, and “porters” to carry fish in buckets to vehicle access points. Other crews will be responsible for porous barrier placement, for verifying that watercourse sections are free of fish, and for transporting captured fish to the discharge locations and releasing them.

The fish removal activities outlined above will be resourced and scheduled to be complete by the end of September. The porous barriers, barrier nets, or other suitable measures, may need to be kept in place until the coffer dams are installed to ensure that fish cannot return to the stretches of watercourses from which they have been removed. It is expected that installation of the coffer dams will be completed over the October-December period, and that the upstream, fish-free watercourses will be filled in during the winter months when flows are at a minimum and the ground is frozen enough that equipment can readily move around.

3.4.1.2.7.4 Alternatives

As an alternative to electrofishing, or as a complementary method, the use of an acoustic pressure cannon will be explored. This device releases a sonic boom to frighten fish from an area, and deters them from returning. It can be used in concert with electrical and/or physical barriers as approved by DFO and NBDNR. The currently available acoustic cannon requires a minimum of 1 m of water depth, is intended for use in large and deep waterbodies, and appears to be a relatively successful method. There is the potential to develop a smaller version of the acoustic cannon for use in the small watercourses found on the Sisson site.

If fish removal is not practical before construction of the coffer and starter dams, it may be possible to carry out such activities afterwards using the methods outlined above in the remaining upstream brooks, and various trap methods in the pond behind the dams.

Finally, since fish removal is a fish rescue activity that is generally permitted by DFO to be conducted at any time of year, it may be possible to carry out fish removals during the winter low flow period.

3.4.1.2.8 Construction of TSF Embankments, Water Management Ponds, and Ponding of Start-up Water

The land in the Project area is relatively low lying with gentle topography, which allows the TSF design to be relatively low and shallow given the storage capacity. Minimizing the depth of the TSF and the height of the embankments has several benefits, including:

- increased geotechnical stability,
- reduced seepage potential,
- operational efficiency, and
- advantages during reclamation and closure.

The TSF embankment foundation areas will be locally sub-excavated to remove unsuitable material (*e.g.,* soft, loose, or excessively wet). This material will be used to the extent possible as fill within the embankments. The foundation areas will be dewatered and any natural streams will be diverted away from the area using engineered channels. TSF filter sections will be developed using sand and/or crushed material produced from quarried rock. The TSF starter embankments will be lined so as to accumulate water from run-off and precipitation over one or two freshet periods prior to the start of mine operations to provide sufficient water for process start-up.

3.4.1.2.8.1 TSF Construction Methodology

The construction of the TSF is divided into the stages shown in Table 3.4.2.

Table 3.4.2 TSF Staging

TSF Stage	Embankment Crest Elevation (m above sea level)	End Year	Primary Construction By
Stage 1	318	-2	Contractor
Stage 2	338	7	Mine Fleet
Stage 3	362	19	Mine Fleet
Stage 4	376	27	Mine Fleet

The TSF starter embankments will be constructed by a contractor and ongoing embankment raises will be built by the mine fleet. Construction of the TSF has been divided into three phases, described below:

1. Site Establishment;
2. Starter Embankment Construction; and
3. Ongoing Embankment Construction.

Site Establishment

Site establishment consists of the activities required prior to beginning construction of the starter embankments:

- clearing the construction areas;
- upgrading existing forest resource roads to an access road sufficient for the contractor's equipment;
- establishing any maintenance shops, or other infrastructure that the contractor may require;
- preparing suitable laydown areas for equipment and cleared timber;
- construction of temporary by pass channels, or coffer dams (depending on contractor strategy); and
- best management practices for silt and sediment control (*e.g.,* sediment control ponds, silt fences, straw bales).

Starter Embankment Construction (Stage 1)

The Stage 1 starter embankments will be constructed by a contractor two years preceding mill start-up. The Stage 1 elevation was selected to provide sufficient capacity to store water for mill start-up and the first year of tailings storage. The major construction activities are:

- clearing and grubbing of the starter embankment footprints;
- excavation and re-compaction of overburden material for the Stage 1 embankment footprints;
- installation and operation of construction dewatering equipment (where required);
- overburden and topsoil stockpile development;
- development of local borrow sources; and
- coffer dam construction upstream of the embankments and installation and operation of dewatering systems (if required).

Construction of the Stage 1 embankments will require:

- installation of high density polyethylene (HDPE) upstream face liner (to prevent seepage and allow the collection of plant start-up water within the TSF starter pond) and placement of ice protection layer;
- removal of dewatering equipment;
- installation of tailings and reclaim pipework; and

- construction of water management ponds and pumping systems.

Ongoing Embankment Construction (Stage 2 and Onward)

Ongoing construction will include staged embankment raises and the installation of additional tailings and reclaim pipelines. Embankment raises will be completed using rock fill from the quarry located at the northwest corner of the TSF. The mine fleet will deliver quarried rock to the embankments, including processed filter and transition zone materials. A contractor may be used to spread and compact the filter and transition zones as they may be too narrow for the mine equipment to operate on efficiently. The major Stage 2 (and later stages) construction activities are:

- continued clearing of the impoundment, as required;
- continued grubbing, stripping, and excavation of unsuitable overburden beneath the expanded embankment footprints;
- modified centerline embankment raises using quarried rock fill delivered by the mine fleet;
- placement of processed filter and transition zones upstream of the coarse rock fill zone;
- hydraulic placement and compaction of deposited tailings in cells on the upstream side of the embankment; and
- installation of additional tailings pipelines to reach the full extent of the embankments.

3.4.1.2.9 Establishment of Water Management System

Overall, the water management system facilities to be installed during Construction include:

- diversion channels to divert clean (non-contact) water away from the site, with the objective of keeping clean water clean;
- the starter dams to establish the TSF as a collection point for all mine contact water, including from dewatering of the open pit, during Operation;
- lined water management ponds (WMPs) and pump-back equipment at the topographic low points downstream of the TSF embankments;
- groundwater monitoring wells below the WMPs; and
- tailings and reclaim water pipelines between the ore processing plant and the TSF.

3.4.1.2.10 Equipment Installation

Following the completion of physical construction of buildings and structures at the Project site, equipment for use in the ore processing plant and related facilities will be delivered to the site and installed at their intended location. The physical installation will be completed by anchoring the process units to the foundations at the appropriate location, and by completing all mechanical and electrical installations as required. Since most of these components are fabricated elsewhere and delivered to the site, the equipment installation will be relatively straightforward and result in minimal to no environmental effects.

3.4.1.3 Physical Construction of Transmission Lines and Associated Infrastructure

Relocation of the existing 345 kV transmission line, and construction of the new 138 kV transmission line, substation, and associated infrastructure will consist of activities described below. The transmission lines will be constructed and operated by NB Power, and the substation by SML.

Centreline Survey. A centerline survey will be conducted, consisting of a 1.2 m wide line cut, where required, to allow for a “line of sight” to obtain the necessary field information to finalize the design of the transmission lines. The vegetation is cut using chain saws and left on the ground parallel to the centerline. Data collected during the centerline survey includes, ground elevation, location of features such as roads, trails, stream crossings and wetlands, and other information which is vital to produce the plan and profile maps and to establish structure locations. The centerline survey may lead to minor modifications to the right-of-way as a result of previously unidentified constraints.

Access and Staging. Access is required to allow transportation of clearing and construction equipment, materials and personnel to the right-of-way. Access to the new transmission line will largely be provided through the adjacent existing 345 kV transmission line corridor. Access may be required along the right-of-way and deviate off right-of-way where watercourses and wetlands cannot be crossed with equipment. In all cases, use of existing access roads will be maximized. Temporary staging areas will be established for storage of equipment and material during Construction. These sites will be selected in close proximity to the new transmission line and away from developed areas in order to prevent noise and dust problems. Preferred new sites will be brownfield sites, such as forestry landings or abandoned quarries requiring little or no modification. An agreement will be signed with any landowners. Following Construction, the sites will be returned to their original condition.

Vegetation Clearing. Clearing will be conducted to remove from the right-of-way vegetation that may prohibit the construction and safe operation of transmission line. Clearing of vegetation will be conducted by mechanical means, except within 30 m of a watercourse or wetland where manual methods (*e.g.*, chain saws and other hand held equipment) will be used, leaving the under growth and duff layer undisturbed to prevent erosion. Trees will be felled, de-limbed, and piled at the edge of the right-of-way, and merchantable timber will be sold. The remaining slash and debris will be windrowed a few metres from the edge of the right-of-way and compacted to a height no greater than 0.5 m. The windrows will be broken (left open) at all roads or access trails, along property lines, and along watercourses, to provide access across the windrow for any wildlife not capable of crossing the low vegetation pile. The windrows will be allowed to decompose naturally. Burning of vegetation will not be undertaken. To the extent possible, clearing will be conducted outside of breeding bird season (May 1 – August 31). Should clearing be required within this season, these areas will be surveyed to determine if nesting is occurring within these areas.

Excavation and Structure Assembly. The assembly of structures involves the transportation of construction materials, the excavation for pole placement and the backfilling of excavated material. Excavations will be augured where possible. Excavation with backhoes and/or blasting will be used for larger foundations or in soils that cannot be efficiently augured. The assembly of structures will take place on-site at the structure locations. Depending on soil conditions, compacted native soil or imported backfill material will be used to fill the sides of the excavations and secure the poles in place. Guy wires will be used as necessary.

Conductors Stringing. Large reels of wire (conductor) will be delivered to selected areas along the right-of-way. The wire will be subsequently strung using a tension-pulling machine and attached to the insulators by hand while pulling lines between structures. Once the conductors are in place, they will be correctly sagged and tensioned, then permanently clipped into the clamps at each structure. Hardware such as marking, vibration damping devices, or air flow spoilers may also be installed, as required. In areas where the transmission lines cross a road, rider poles will be installed on either side of the roadway to support conductors and prevent the conductor from sagging.

Inspection and Energization. Upon completion of construction, ground and air acceptance patrols will be conducted by staff to ensure that the lines are ready for service. Any deficiencies discovered during these patrols will be corrected prior to energizing the line. NB Power will complete the connection of the new transmission line at the Keswick Terminal.

Clean-up and Re-vegetation. Site clean-up and re-vegetation to stabilize disturbed areas will complete the construction of the transmission lines. In areas where the disturbance of soil may cause erosion, measures will be taken to stabilize the affected area. Such measures include trimming and back-blading, mulching, seeding and fabric placement. Erosion control used during construction will be maintained until such time the disturbed ground has been adequately stabilized with vegetation, and will then be removed.

Construction of Sisson Electrical Substation. SML will construct the new electrical substation at the Sisson mine site. This will involve clearing, pouring of concrete foundations for switchgear and transformers, installation of equipment, inspection, energization, erection of a fence surrounding the substation for security purposes, and clean-up and landscaping of the area following construction.

Removal of By-passed 345 kV Transmission Line. NB Power will be responsible for removal of the former line and by-passed line towers and conductors, and for reclaiming the abandoned right-of-way.

3.4.1.4 Physical Construction of Realigned Fire Road, New Site Access Road, and Internal Site Roads

Construction will be conducted of the realigned Fire Road, a new site access road to access the Project site from the Fire Road, and internal site roads within the PDA to connect the Project facilities. All roads will be unpaved.

Road construction requires the creation of a continuous right-of-way through clearing and grubbing of existing forested areas (as shown in Figure 3.2.14), and cutting, filling and grading to overcome geographic obstacles and provide grades low enough to permit vehicle travel. Right-of-ways will be cleared as required in accordance with guidelines, standards and best practices for developing forest resource roads. Leveling and excavation will be conducted as necessary. Some blasting may be required. The completed roadways will be finished by preparing a stabilized sub-grade with a gravel surface. Fill, gravel, and rock will also be sourced as needed from local sources or the site quarry.

Erosion control and dust suppression measures will be implemented to reduce the potential environmental effects of activities on neighbouring watercourses and surrounding properties.

All site access and internal site roads will be designed based on loadings, vehicle dimensions, travel speeds, sight distances, and traffic densities that are required during the life of the road according to forest resource road specifications. All site access roads and site roads will be refurbished or constructed in accordance with the Forest Management Manual (NBDNR 2004a, Section 4.4 “Roads and Watercourse Crossings”) and have approval from NBDNR. Best management practices for the use of forest roads in New Brunswick will be implemented and a Traffic Plan developed in consultation with the Crown Timber Licence Holders and NBDNR.

3.4.1.4.1 Construction of Watercourse Crossings

No watercourse crossings on the existing forest resource road network require refurbishment or replacement to access the Project.

Within the planned realignment of the Fire Road, six new watercourse crossings (including wetlands) are required. All new watercourse crossings structures installed as part of the Project will be designed, installed, and maintained to support design loadings, and will be presented to NBDNR for approval prior to construction. These watercourse crossings will be pre-constructed single-span bridges that avoid construction activity in the watercourse bed and disturbance of its embankments. The bridges will span the width of the watercourse from bank to bank, such that no disturbance of the stream bed or its banks (up to the ordinary high water mark) is required. Concrete culverts may be used in place of bridges for small watercourse crossings.

The construction activities conducted within 30 m of a watercourse or wetland will require a permit under the New Brunswick *Watercourse and Wetland Alteration Regulation–Clean Water Act* (WAWA Regulation). However, with the construction methods identified, it is not expected that any further approvals, permits, or other forms of authorization (*e.g.*, *Fisheries Act* authorization) will be required.

3.4.1.5 Implementation of Fish Habitat Offsetting/Compensation Plan

Subject to regulatory approval, the implementation of fish habitat offsetting/compensation plan will involve replacing an old water-level control dam and road culvert on the Nashwaak River just below its exit from Nashwaak Lake with a woods road bridge (see Section 7.4 for details).

Construction will be carried out during the low-flow summer period. A coffer dam will be installed upstream of the site, and flow pumped around the site, to provide a dry working area. Any fish in the working area will be moved downstream. The existing timber box culvert and abutments will be removed and disposed of offsite. Once the existing structure is removed, the stream bed will be inspected for barriers to fish passage and modifications will be made as required to allow for suitable flow conditions under the new bridge. The new bridge abutments and deck will then be built, and rip rap or other armouring will be installed to prevent erosion. Once construction is complete, the coffer dam will be removed and disturbed areas will be reclaimed as required to ensure bank and shoreline stability.

3.4.1.6 Emissions and Wastes

3.4.1.6.1 Air Contaminant Emissions

Air contaminant emissions during Construction will not be substantial. Emissions will consist mainly of combustion gas emissions from heavy equipment on-site and the heavy-duty trucks used to deliver equipment to the site, as well as fugitive dust emissions resulting from on-site activities. The only sources of greenhouse gas (GHG) emissions will be from fuel combustion in heavy equipment and trucks. During Construction, air contaminants may be released from the following activities:

- fuel combustion in heavy equipment during clearing and site preparation (*e.g.*, excavators, dozers);
- fuel combustion in passenger vehicles moving to and from the site, as well as on-site;
- fuel combustion in trucks transporting equipment and material;
- dust from site preparation activities (*e.g.*, land clearing);
- dust from vehicle and equipment movements on unpaved roads;
- combustion emissions from detonated explosives in the quarry;
- dust from drilling and blasting events in the quarry;
- dust from loading and unloading of overburden, topsoil, and quarry rock; and
- dust from stockpiling of overburden and topsoil.

Emissions inventories for air contaminant and GHG emissions for Construction were developed based on information provided by Northcliff, published emission factors, and engineering judgment, as detailed below.

Emissions of air contaminants and GHGs from diesel fuel combustion in typical construction equipment were estimated using emission factors from the USEPA NONROAD program (USEPA 2008), with assumed horsepower and operating hours of each unit. The equipment types are provided in Table 3.4.3.

Table 3.4.3 Heavy Equipment Used – Construction

Equipment	Number of Units	Horsepower (hp)	Operating Hours (h/d)
Scraper	2	300	12
Excavator	2	300	12
Crane	1	300	6
Bulldozer	2	300	12
Generators	5	175	12
Dump Truck	5	475	12
Concrete Truck	1	475	12

The estimated emissions of air contaminants and GHGs during Construction are provided in Tables 3.4.4 and 3.4.5, respectively.

Table 3.4.4 Criteria Air Contaminant (CAC) Emissions – Fuel Combustion in On-site Construction Equipment – Construction

Equipment	Emissions (t/a)				
	Carbon Monoxide (CO)	Nitrogen Oxides (NO_X)	Sulphur Dioxide (SO_2)	Volatile Organic Compounds (VOCs)	Total Particulate Matter (PM)
Scraper	3.22	6.80	0.01	0.50	0.59
Excavator	3.27	6.81	0.01	0.50	0.62
Crane	0.57	1.63	0.00	0.11	0.08
Bulldozer	3.22	6.80	0.01	0.50	0.59
Generators	3.37	9.47	0.02	0.68	0.70
Dump Truck	14.63	26.95	0.05	1.78	2.46
Concrete Truck	2.93	5.39	0.01	0.36	0.49
Total	**31.20**	**63.85**	**0.12**	**4.43**	**5.54**

Notes:
t/a = tonnes per year.
1) Numbers may not add up due to rounding.

Table 3.4.5 Greenhouse Gas (GHG) Emissions – Fuel Combustion in On-site Construction Equipment – Construction

Equipment	Emissions (t/a) [a]
	Carbon Dioxide (CO_2)
Scraper	1,391
Excavator	1,391
Crane	344
Bulldozer	1,391
Generators	2,007
Dump Truck	5,507
Concrete Truck	1,101
Total	**13,133**

Notes:
[a] Emission CH_4 and N_2O were not estimated as these are minor contributions to total GHG emissions.
t/a = tonnes per year.
1) Numbers may not add up due to rounding.

Fuel combustion emissions were estimated for passenger vehicles and vehicles used to transport materials and equipment to and from the Project site as well as on-site vehicle traffic. Northcliff provided some information on vehicle movements; conservative assumptions were made for the remainder, including distances travelled. Emission factors and default fuel efficiency values from the Transport Canada Urban Transportation Emissions Calculator (Transport Canada 2012) were used. Air contaminant and GHG emissions from vehicle operation during Construction are provided in Tables 3.4.6 and 3.4.7, respectively.

Table 3.4.6 Criteria Air Contaminant (CAC) Emissions – Vehicle Fuel Combustion – Construction

	Emissions (t/a)						
	Carbon Monoxide (CO)	Nitrogen Oxides (NO_X)	Sulphur Dioxide (SO_2)	Volatile Organic Compounds (VOCs)	Total Particulate Matter (PM)	Particulate Matter less than 10 µm (PM_{10})	Particulate Matter less than 2.5 µm ($PM_{2.5}$)
Personal vehicles (includes on-site traffic)	7.06	0.56	0.004	0.35	0.02	0.02	0.01
Equipment and Materials	0.22	1.11	0.004	0.05	0.03	0.03	0.02
Total	**7.28**	**1.67**	**0.01**	**0.40**	**0.05**	**0.05**	**0.03**

Assumptions:

- Personnel travel by bus (6 roundtrips/day) and by light duty passenger trucks (50 roundtrips per day), 6 days per week.
- Buses travel from Nackawic assumed to be 2/3 of the trips, and from Napadogan 1/3 of the trips.
- Light duty passenger trucks travel equally from Nackawic and Napadogan.

Notes:

t/a = tonnes per year.

1) Numbers may not add up due to rounding.

Table 3.4.7 Greenhouse Gas (GHG) Emissions – Vehicles Fuel Combustion – Construction

	Emissions (t/a)			
	Carbon Dioxide (CO_2)	Methane (CH_4)	Nitrous Oxide (N_2O)	Total Greenhouse Gases (CO_2e)
Personnel (includes on-site traffic)	290	0.003	0.03	300
Equipment and Materials	213	0.01	0.01	215
Total	**503**	**0.01**	**0.04**	**515**

Assumptions:

- Personnel travel by bus (6 round trips/day) and by light duty passenger trucks (50 round trips per day), 6 days per week.
- Buses travel from Nackawic assumed to be 2/3 of the trips, and from Napadogan 1/3 of the trips.
- Light duty passenger trucks travel equally from Nackawic and Napadogan.

Notes:

t/a = tonnes per year.

CO_2e = carbon dioxide equivalent.

1) Numbers may not add up due to rounding.

Dust emissions from site preparation were estimated using a United States Environmental Protection Agency (USEPA) emission factor (USEPA 1995a) and a conservative estimate of the area of site disturbance (1,253 ha). Application of water sprays during site preparation will reduce dust emissions by approximately 70% (NIOSH 2012). Particulate matter emissions for site preparation activities are estimated to be approximately 13.2 tonnes, 2.49 tonnes, and 1.39 tonnes for PM, PM_{10}, and $PM_{2.5}$, respectively, for the Project (estimate covers total site preparation which is spread over the life of the Project).

Dust lifted by blasting activities in the quarry during Construction may be estimated using a USEPA emission factor (USEPA 1998) and the area of land subjected to the blast. Blasting in the quarry is anticipated to occur once per week for 3 months of the year. An average blast area of 2,150 m^2 per blast was used to estimate fugitive dust emissions (NIOSH 2012). Particulate matter emissions (PM) from blasting were estimated to be approximately 0.07 tonnes per year.

The movement of vehicles and equipment on unpaved roads during Construction may cause particulate matter emission (PM, PM_{10}, $PM_{2.5}$). The USEPA methodology to estimate emissions is based on silt content of the road material and vehicle tonnage. Northcliff provided information on vehicle and equipment movements, and Stantec made conservative assumptions regarding the silt content and vehicle tonnage. It was assumed that the site access road and internal site roads are watered for dust suppression, and this gives a 80% reduction in dust generation; no dust suppression was assumed for the unpaved forest resource roads (*i.e.,* the PSA Route via Nackawic and the SSA Route via Napadogan). The estimated fugitive emissions from vehicles movements on unpaved roads are provided in Table 3.4.8.

Table 3.4.8 Particulate Matter from Unpaved Roads – Construction

	Emissions (t/a)		
	Total Particulate Matter (PM)	**Particulate Matter less than 10 µm (PM_{10})**	**Particulate Matter less than 2.5 µm ($PM_{2.5}$)**
Forest Resource Roads (PSA and SSA Routes, for transporting materials, equipment, and personnel)	515	136	13.6
Site access road and internal site roads (on-site heavy equipment and passenger vehicles)	93.1	24.7	2.47
Total	**608**	**161**	**16.1**

Notes:
t/a = Tonnes per year.
1) Numbers may not add up due to rounding.

Topsoil and overburden stockpiled during Construction will be seeded and re-vegetated periodically. Emissions of dust from these sources are therefore considered to be negligible (essentially zero).

Stantec estimated fugitive dust emissions for material transfer activities during Construction. Topsoil and overburden are transferred by trucks to stockpiles. While material handling may generate dust, it is assumed that the material is wet and that minimal dust is generated.

A concrete plant will be used during Construction to provide concrete for foundations. Stantec estimated particulate matter emissions from the concrete plant using the total anticipated concrete production and emission factors from USEPA (2006c). The analysis assumed the use of best practice dust control. The estimated emissions of PM and PM_{10} per year are 3.3 tonnes and 0.98 tonnes, respectively, over the entire period of Construction.

3.4.1.6.2 Sound and Vibration Emissions

Some noise will be generated during Construction and is expected to be typical of that associated with construction projects involving the movement of heavy equipment.

To estimate emissions of sound, Stantec developed an inventory of sound emission sources from heavy equipment during Construction activities. The number and types of equipment, as well as hours of operation, were estimated based on experience and professional judgment. Equipment sound power levels for each equipment type were assigned based on information for the various equipment in the United States Federal Highway Administration's "Roadway Construction Noise Model User's Guide" (FHWA 2006).

The activity data and sound power levels associated with Construction are presented in Table 3.4.9.

Table 3.4.9 Sound Inventory – Construction

Equipment Type	Number of Equipment	Operation Hours per Day	Sound Pressure Level (dB_A) at 15 m	Sound Power Level (dB_A)
Scraper	2	12	84	115
Excavator	2	12	81	112
Crane	1	6	81	112
Wheeled Bulldozer	2	12	82	113
Generators	5	12	81	112
Dump Truck	5	12	76	107
Concrete Truck	1	12	76	107
Crusher	1	12	84	116

The contribution of the movement from on-site light duty truck traffic is assumed to be negligible in comparison with heavy equipment operation on-site (only on-site roads were not included in the noise model). There will be sound emissions from transportation vehicles on Project access roads. The number and types of transportation vehicles accessing the site on a daily basis were provided by Northcliff, based on the planned activities. The traffic information entered into the acoustic model is provided in Table 3.4.10.

Table 3.4.10 Project Traffic – Construction

Vehicle Type	Vehicles per Hour	Starting Point
Buses	6	Through Nackawic
Heavy trucks	1	Through Napadogan
Passenger trucks/vehicles	19	Through Napadogan

Notes:
For modelling of traffic noise the change through Napadogan was the focus as this represents the largest change from existing traffic. 19 vehicles through Napadogan based on estimate of 76 per day from Route 8 to SSA, with 4 peak hours per day assumed (shift changes). Buses all assumed to originate in Nackawic.

A review of available literature on vibration emitted from construction activities was conducted to assess the distance from the PDA that vibration may be perceptible. In the US Federal Transit Administration (FTA) document "Noise and Vibration Manual" (FTA 2006), average peak particle velocities (PPVs) at 7.6 m (25 feet) for various equipment types and activities are presented. Reference PPVs for common construction equipment types are provided in Table 3.4.11.

Table 3.4.11 Typical Equipment Vibration (Peak Particle Velocity) – Construction

Equipment	Reference Peak Particle Velocity (PPV) at 7.6 m (mm/s)
Pile Driver (impact)	16.4
Vibratory roller	5.3
Caisson drilling rig	2.3
Large bulldozer	2.3
Loaded trucks	1.9
Jackhammer	0.9
Small bulldozer	0.1

Source: FTA (2006).

The largest piece of mobile construction equipment on-site is likely to be a large bulldozer.

Some blasting and crushing of rocky material may occur in the quarry area during Construction, and blasting will also be required during leveling and preparation of the PDA for building construction.

3.4.1.6.3 Surface Run-Off

Site run-off from precipitation events will be carefully managed, and there are no other activities during Construction of the Project that will result in the generation of wastewater. Engineered drainage diversion channels constructed early in the Construction period will limit the amount of off-site surface run-off from entering the site.

Watercourse and wetland alteration mitigation measures (*e.g.,* erosion and sedimentation control measures) will be employed during Construction, and ground disturbance will be held to a minimum outside the required construction zones. Management of site run-off will employ best practices such as containment ditches, sediment settling ponds and silt curtains to avoid or mitigate potential environmental effects to watercourses.

Any liquid hazardous materials (*e.g.*, waste oils and lubricants) generated by contractors on-site will be collected and disposed of using approved hazardous materials collectors.

3.4.1.6.4 Solid Waste Disposal

During Construction, there will be a need to dispose of some general construction wastes such as wood, steel, cardboard or other packaging, and other construction wastes. All merchantable timber from site clearing will be sold, and remaining brush will be stockpiled or be covered by fill or Project facilities (*e.g.,* by water and then tailings in the TSF area). No burning will be carried out during Construction. Soil and overburden will be stockpiled for future use in reclamation activities. SML or its contractors will re-use or recycle waste materials where possible, and dispose of other wastes at approved facilities.

3.4.1.7 Transportation

Construction and trucking activities will vary from month to month during Construction, depending on what components are being constructed and the stage of construction. During Construction, contractors will be encouraged to bus their crews to the Project site. For the purpose of this EIA, it is assumed that Project workers will be collected at two parking lots, one located near Route 2 at Nackawic and the other located near the Napadogan rail siding, and travel by bus from those parking lots to the Project location. The precise location of the parking lots to be used for such purposes will be confirmed as further Project planning and contracting is conducted.

Road traffic generated during Construction will comprise:

- passenger vehicles (construction workers' automobiles, SUVs, vans and pick-ups);
- buses (construction workers); and
- trucks (for transport of construction equipment and materials, and various services).

The traffic generated by the Project during Construction will accumulate as it approaches the Project site. All Project generated traffic volumes were converted to one-way daily (ADT) volumes. A summary of the average daily traffic that will be generated by the construction activities associated with the Project is presented in Table 3.4.12.

Table 3.4.12 Average Daily Traffic (ADT) Generated During Construction

Traffic Components	Round Trips Per Day	Average Daily Traffic (ADT) (one-way)
Vehicles to/from Project Site		
Trucks (at highest month of Project construction activity to Site)	12	24
Construction Workers' Buses (75% of workers, between parking lots and Site)	6	12
Construction Workers' Autos (25% of total workers, direct to Site, two per vehicle)	50	100
Total	**68**	**136**

Source: exp Services Inc. (2013a, 2013b).

The Project-generated traffic volumes reflect the maximum volumes expected during the highest month of construction activity. The additional traffic volumes predicted to be generated by the Project total 136 ADT.

3.4.1.8 Employment and Expenditure

A variety of construction personnel will be required to complete various construction activities, including but not limited to heavy equipment operators, millwrights, welders, and other specialized trades. It is expected that the Project will generate direct employment for up to approximately 500 workers at the peak of Construction activity. These workers may be working for New Brunswick based construction firms, working for firms from outside the province coming to deal with specific aspects of the construction or provide engineering supervision, or employees of the mine owner or engineering firms associated with the Project but working outside New Brunswick.

Total capital expenditures (construction costs) for the Project are expected to reach $578.8 million over an estimated 24 month construction period. About 38% of the expenditures will occur during the first year of construction, with most of the remainder spent during the second year. Table 3.4.13 provides a summary of expenditures during Construction.

Table 3.4.13 Construction Expenditures

Description	Construction Expenditures (Millions of Canadian dollars)						
	Mine (including SME Facility)	Concentrator (including Clarification Plant)	APT Plant	TSF and Environmental	Infrastructure	Owner's Cost	Total
Earthwork	$8.3	$6.2	$0.1	$14.1	$3.5	-	$32.1
Buildings	$1.2	$32.2	$2.7	-	$6.9	-	$43.0
Concrete	-	$14.6	$1.9	-	$3.7	-	$20.2
Steel	-	$20.7	$0.5	-	$0.2	-	$21.4
Equipment	$24.5	$105.5	$21.0	$11.2	$0.9	-	$163.2
Piping	-	$13.5	$4.9	-	$0.2	-	$18.6
Electrical	-	$13.4	$1.1	-	$14.2	-	$28.6
Instrumentation	-	$7.3	$2.6	-	$0.4	-	$10.4
Direct Cost	$34.0	$213.3	$34.6	$25.3	$30.1	-	$337.4

Table 3.4.13 Construction Expenditures

Description	Construction Expenditures (Millions of Canadian dollars)						
	Mine (including SME Facility)	Concentrator (including Clarification Plant)	APT Plant	TSF and Environmental	Infrastructure	Owner's Cost	Total
Contractor Indirects	$1.2	$43.8	$8.3	$2.0	$4.9	-	$60.2
Contracted Indirects	-	$36.6	$6.0	$0.8	$4.1	-	$47.4
Spares	$0.7	$1.3	$0.2	-	-	-	$2.2
Initial Fills	-	$4.1	$0.9	-	-	-	$5.0
Owner's Cost	-	-	-	-	-	$36.0	$36.0
Indirect Cost	$1.9	$85.9	$15.3	$2.8	$8.9	$36.0	$150.8
Other Expenditures and Contingency	$3.2	$58.6	$11.9	$3.4	$7.1	$6.4	$90.6
Total Cost (millions, CAD$)	**$39.1**	**$357.8**	**$61.9**	**$31.5**	**$46.1**	**$42.4**	**$578.8**

Source: Samuel Engineering (2013)

3.4.2 Operation

Operation begins at Year 1 with the commissioning of the ore processing plants and extends to completion of mining and ore processing at approximately Year 27. Details of activities to be conducted during Operation are provided below. The site layout will evolve as the Project proceeds through various stages of Operation with the most substantive evolution occurring in the extent of the open pit and the TSF.

In addition to the routine inspections carried out by mine personnel on a shift/daily/weekly/monthly basis, the Project and facilities will be audited regularly by a suitably qualified professional engineer to ensure it is operating in a safe and efficient manner. A dam safety review will be conducted every five years by a qualified geotechnical engineer.

The following is a brief description of activities that will be carried out during Operation of the Project.

3.4.2.1 Mining

3.4.2.1.1 Open Pit Mine Operation

Operation of the open pit mine will involve drilling, blasting, loading and hauling of ore and waste rock, primary crushing, and conveyance to the ore processing plant.

Open pit mining will be carried out year-round on a 24 hour per day, seven day per week schedule, for approximately 360 days per year. Following clearing, and removal and stockpiling of overburden in the pit area during Project construction, the pit will be excavated by drilling and blasting successive benches and removing the broken rock with a hydraulic shovel and/or wheeled loaders. Blasting will occur approximately every two days using emulsion explosives. The broken rock will be hauled out of the pit by truck, and run-of-mine (ROM) ore will be delivered to the primary crusher or to the temporary ore stockpile nearby. Waste rock will be trucked to the TSF and stored under water in the TSF. As the pit expands over time, there will be successive “push backs” of the pit rim with associated vegetative clearing and overburden removal and storage. Further details on the operation of the open pit are provided below.

3.4.2.1.2 Drilling

In-situ rock will require drilling and blasting to create suitable fragmentation for efficient loading and hauling of both ore and waste rock. Ore limits will be defined in the blasted muck pile through blast hole, assays and grade control technicians. Support personnel and equipment will be required to maintain the mining area, ensuring the operation runs safely and efficiently.

Primary production drilling at the Sisson Project uses diesel hydraulic rotary drills outfitted with high precision drill positioning or GPS systems for efficient and accurate positioning, and superior data collection from each drill unit and drill hole.

Areas will be prepared on the bench floor for blast patterns in the *in-situ* rock. The spacing and burden between blast holes will be varied as required to meet the specified powder factor for the various rock types. The drill operators will be responsible for blast hole sampling for the ore control system (OCS).

Controlled blasting techniques will be used for high wall rows, pioneering drilling during pre-production, and development of initial upper benches. Where required, dozers will be used to establish initial drilling benches for the upper portions of each phase.

3.4.2.1.2.1 Blasting

A contract explosives supplier will provide the blasting materials and technology for the mine, as well as manufacture bulk emulsion-type explosives on-site at the site mixed explosives (SME) plant. The nature of the business relationship between the explosives supplier and the mining operator will determine who is responsible for obtaining the various manufacture, storage and transportation permits, as well as any necessary licenses for blasting operations. This will be established during commercial negotiations. For the feasibility study, the explosives contractor delivers the prescribed explosives to the blast holes and supplies all blasting accessories. Different contractors have various explosives products and specifications. The chosen contractor will be responsible for providing all material safety data sheets (MSDS) and product fact sheets as applicable. For the feasibility study, all contract explosives providers recommended 100% emulsion products.

Loading of the explosives will be done with bulk explosives loading trucks provided by the explosives supplier. The trucks will be equipped with global positioning system (GPS) guidance or otherwise tied into the in-pit data network, and will be able to receive automatic loading instructions for each hole from the engineering office.

The blast holes will be stemmed to avoid fly-rock and excessive air blasts. Any crushed rock required for blast hole stemming will be provided by the onsite rock crusher specified for mine roads and quarrying operations.

The SME facility will be equipped to deal with spills of hazardous materials, coming under the responsibility of the explosives contractor operating the SME facility. The spill prevention and contingency plan typically developed for such facilities is as follows.

Prevention

- Double-walled diesel and fuel phase tanks.
- Ammonium nitrate solution tank containment system.
- Trace chemicals stored in sea-can containers.
- Closed systems in emulsion plant and parking garage.
- Drip trays at transfer points.
- Water recycling system in ammonium nitrate solution.

Contingency

- Spills recovery and clean-up procedures.
- Standard operating procedures for waste and wastewater management.
- Off-site disposal of sanitary waste and hazardous wastes.
- Internal HSE audit program and inspections.
- Emergency plan for transportation incidents off-site.

The SME facility will be a zero discharge plant. The wastewater from SME plant will be treated (through settling, oil separation and filtration) and will be re-introduced into the process. Wastewater will also be treated and re-introduced into the water injection systems of the trucks.

3.4.2.1.3 Loading

Production loading will be performed by electric hydraulic shovel units, sized according to the feed rate and waste rock volume per day or per year. Using 30,000 t/d mill feed and 30,000 t/d waste rock, the 16.5 m^3 class of hydraulic shovel paired with the 136 t haul truck is the most cost effective combination. Using this match, and with the addition of the quarry and machine availability, three shovel units are specified, with one shovel being under-used. The 136 t truck is the largest payload to efficiently match the shovel production rate with four-pass loading.

A 433 kW dozer will be stationed in the pit. This dozer is larger than others on-site and is included for heavy ripping and in-pit ramp and road cuts. A 372 kW wheel dozer is included for cleaning up spilled rock at the shovel face.

Bench widths are designed to ensure operating room is suitable for efficient double-sided loading of trucks at the shovels. Where double-sided loading is not possible, *i.e.,* the upper benches of the pit phases where the end of the bench meets topography, ancillary equipment will be deployed in non-productive operating areas, to prepare the digging areas for higher shovel productivity.

After mill start-up, there will be a requirement each year to mine a given quantity of quarried rock. The intention is to campaign mine the required quarry tonnes for one or two months each year. During these months, it is intended to relocate a single shovel and matching truck fleet to the quarry area for the required length of time.

3.4.2.1.3.1 Hauling

The hauler selected to match the 16.5 m^3 shovels is the 136 t payload class diesel haul truck. The size of the haul fleet is determined by the production schedule and required truck operating hours to meet the scheduled tonnage over the haul road network for each operating period. The life-of-mine (LOM) maximum haul fleet is 14 units. All haul trucks are fitted with fleet management systems, state-of-the-art data centres that report on all facets of machine health.

Pit maintenance activities include haul road maintenance, mine dewatering, transporting operating supplies, relocating equipment, snow removal, and pit floor clean-up.

3.4.2.1.3.2 Ore Crushing and Conveyance

To minimize dust, the blasted ore is wetted down as it passes through the primary crusher and conveyor to the ore processing plant. The primary crusher will be a gyratory cone crusher and process approximately 30,000 t per day of ore. The ore will be crushed to approximately 150 mm, conveyed and deposited into the crushed ore stockpile at the plant site. The stockpile will have approximately 30,000 t storage capacity.

Potential noise and dust generating parts of the primary crusher are below ground with water sprays are applied as needed to control dust. The conveyor from the primary crusher to the coarse ore stockpile at the ore processing plant is enclosed from weather as the damp ore will produce very little dust (though the conveyor is not air tight or does not provide a full enclosure for dust control).

At the plant, the coarse ore stockpile is uncovered. Water sprays can be used as needed to wet the ore stockpile in dry conditions.

3.4.2.1.3.3 Rock Quarrying, Trucking and Crushing

Throughout Operation of the Project, the quarry will be used to provide NPAG rock for construction of the TSF embankments and internal haul roads. The location of the quarry is shown in Figure 3.2.1. Rock will be quarried and trucked from the quarry to locations surrounding the TSF as required. The rock will be crushed using the on-site mobile aggregate crusher and placed using mobile mining equipment.

3.4.2.1.4 Mining Schedule

The overall mine production is scheduled by pit phase and bench on an annual basis. The activities in the pre-production periods are mainly related to construction of the facilities and the TSF dams. The first pit phase provides continuous mill feed after start-up with minimal pre-stripping in the last half of Year -1. Full mill feed production capacity is expected in Year 2. The production schedule specifies:

- pre-production (Construction) in Years -2 and -1;

- pre-stripping in second half of Year -1; and
- life-of-mine (LOM) operations starting in Year 1 and onward.

The general schedule of mining by pit phase, year, and kilotonnes (kt) mined, is summarized in Table 3.4.14.

Table 3.4.14 Mining Schedule by Phase and Year, and Total Kilotonnes (kt) Mined

Year	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Total
	kt	kt	kt	kt	kt	kt	kt
-1	2,648	-	-	-	-	-	2,648
1	19,505	-	-	-	-	-	19,505
2	12,398	8,959	-	-	-	-	21,358
3	911	17,329	3,896	-	-	-	22,136
4	379	13,072	8,296	-	-	-	21,747
5	-	9,148	12,410	-	-	-	21,557
6	-	828	22,102	-	-	-	22,929
7	-	770	20,188	-	-	-	20,957
8	-	-	17,196	3,002	-	-	20,198
9	-	-	11,923	8,275	-	-	20,198
10	-	-	2,096	21,214	-	-	23,310
11	-	-	1,574	23,787	-	-	25,360
12	-	-	457	23,458	-	-	23,915
13	-	-	-	20,646	-	-	20,646
14	-	-	-	19,301	-	-	19,301
15	-	-	-	19,635	-	-	19,635
16	-	-	-	18,523	-	-	18,523
17	-	-	-	17,293	1,203	-	18,496
18	-	-	-	14,244	4,438	314	18,996
19	-	-	-	12,553	3,649	2,538	18,741
20	-	-	-	12,963	-	5,053	18,016
21	-	-	-	2,603	19,960	-	22,563
22	-	-	-	-	18,027	1,143	19,170
23	-	-	-	-	8,297	17,175	25,472
24	-	-	-	-	4,703	21,628	26,332
25	-	-	-	-	-	23,740	23,740
26	-	-	-	-	-	18,067	18,067
27	-	-	-	-	-	15,130	15,130
Total Life-of-Mine (LOM) (kt)	**35,840**	**50,105**	**100,137**	**217,498**	**60,278**	**104,789**	**568,647**

Source: Samuel Engineering (2013).

3.4.2.1.5 Detailed Mine Plan

The description of the detailed mine plan, for both the open pit and quarry operation, is based on the production schedule. End of period (EoP) maps were generated from the production schedule, to depict what the Project site may look like at the end of the year listed. EoP maps were generated for pre-production (Year -1) and production years 1, 5, 10, 20, and 27, where Year 27 represents the life-of-mine (LOM). EoP maps are shown in Figures 3.4.1 to 3.4.6, starting at mill start-up (Year -1) and culminating at end of life-of mine (Year 27).

3.4.2.2 Ore Processing

The ore processing will take the mined ore produce final products of dried molybdenum concentrate and 96.7% pure ammonium paratungstate (APT) in crystallized form.

A simplified flowsheet for the ore concentrator process is provided in Figure 3.4.7. The operation of the major processes is described below.

3.4.2.2.1 Milling/Grinding

From the coarse ore stock pile, the ore is transported via covered apron feeders and conveyors to the secondary screening process. These conveyors have a dust collector. All dust collectors in the ore processing plant will discharge collected particles into bags and will not discharge to atmosphere.

The secondary screens separate the ore stream based on size, with larger particles being conveyed to the secondary crusher and smaller particles being conveyed to the tertiary (high pressure grinding roll or HPGR) crusher for further size reduction. Material out of the secondary crusher is then conveyed back to the secondary screens for rescreening and sorting to the secondary and tertiary crusher.

Following tertiary HPGR crushing, the ore is screened again with particles larger than 4 mm being conveyed back to the tertiary crusher for additional size reduction. Dust is controlled through the secondary and tertiary screening process via a dust collector, with dust being routed back to the secondary screens surge bin and minimal emissions of dust to atmosphere via the air exhaust fan. A process water fed scrubber will also be used to control atmospheric emissions from the secondary and tertiary crushers.

Particles less than 4 mm will pass through the screens and into the primary cyclone feed pump box where filtered water is added to the ore particles to allow pumping into the primary cyclones for further size classification. Larger particles exit the cyclone and into the primary ball mill for further size reduction, while smaller particles are transported to the flotation process tanks. The slurry exiting the ball mill is pumped back through the cyclones.

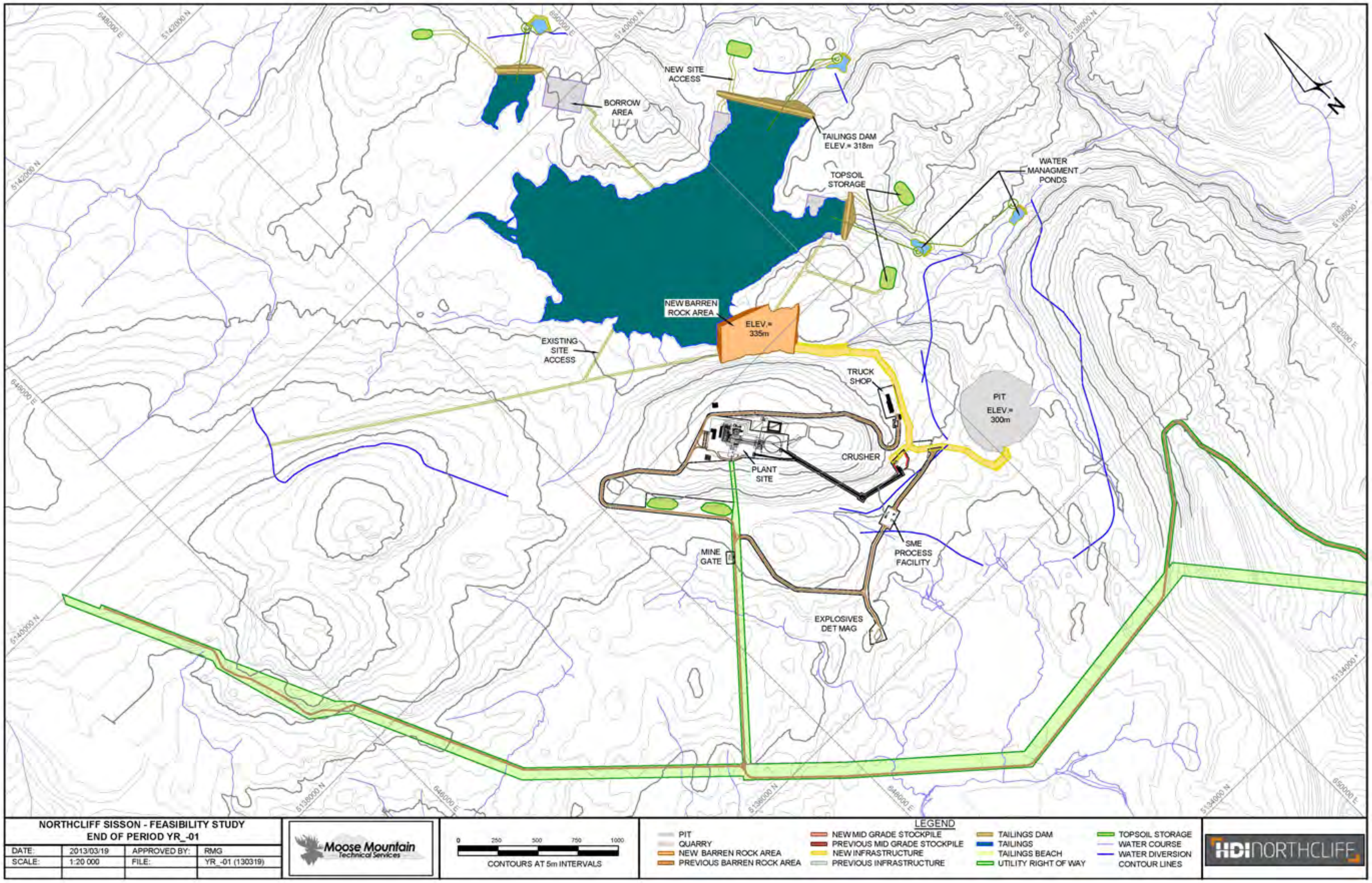


Figure 3.4.1 End of Period (EoP) Map, Pre-production Year -1 (Mill Start-up)

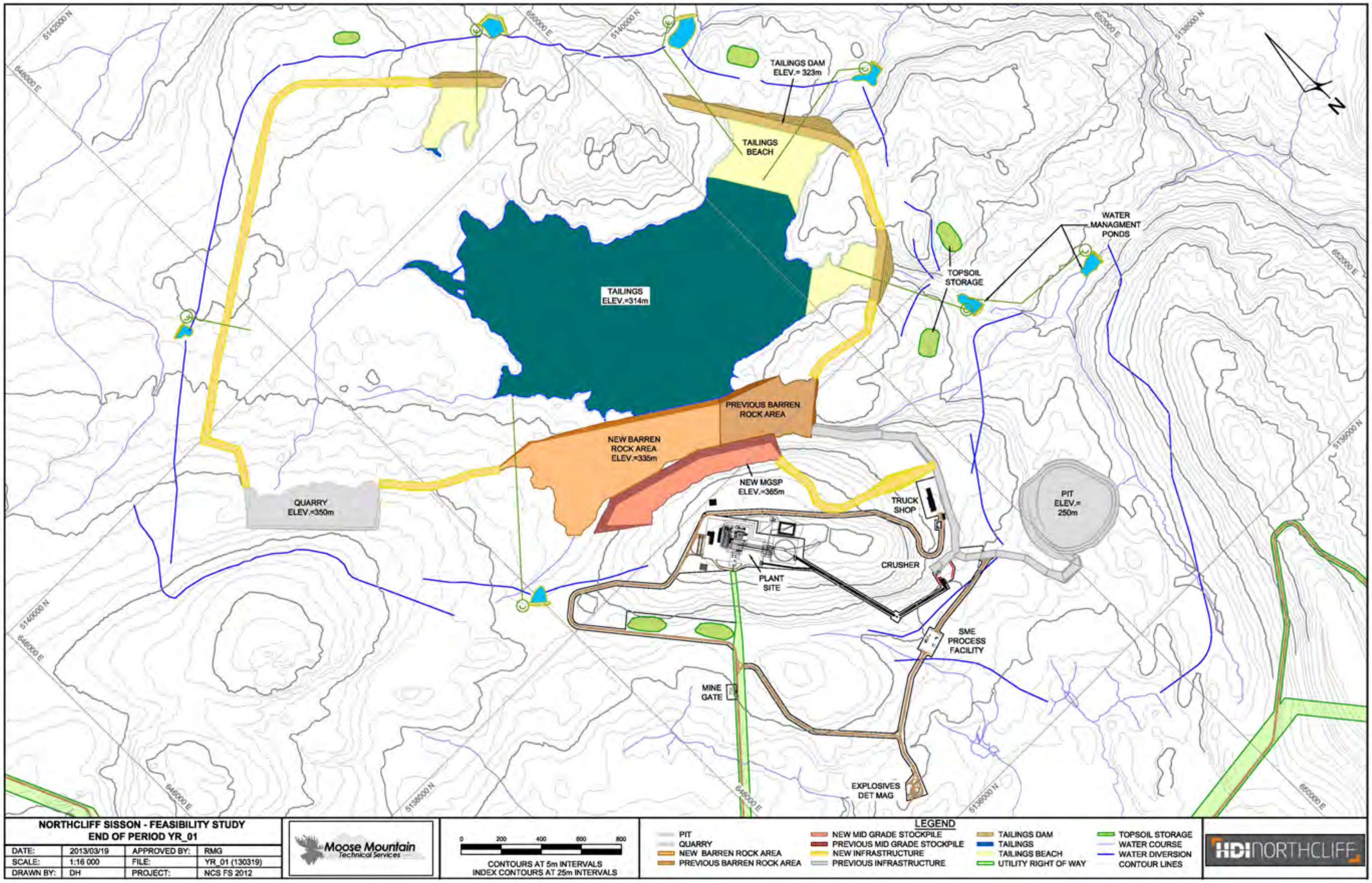


Figure 3.4.2 End of Period (EoP) Map, Production Year 1

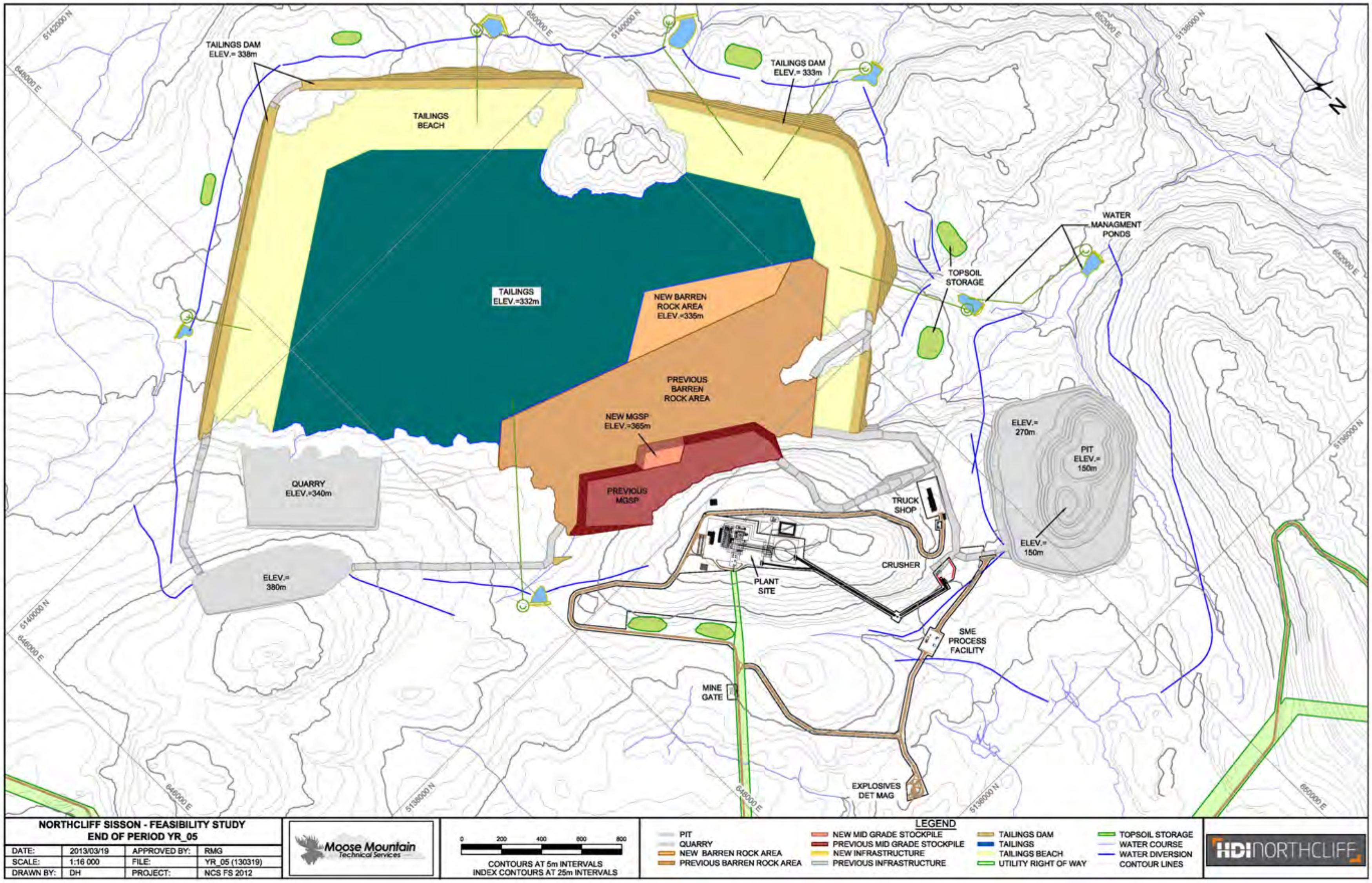


Figure 3.4.3 End of Period (EoP) Map, Production Year 5

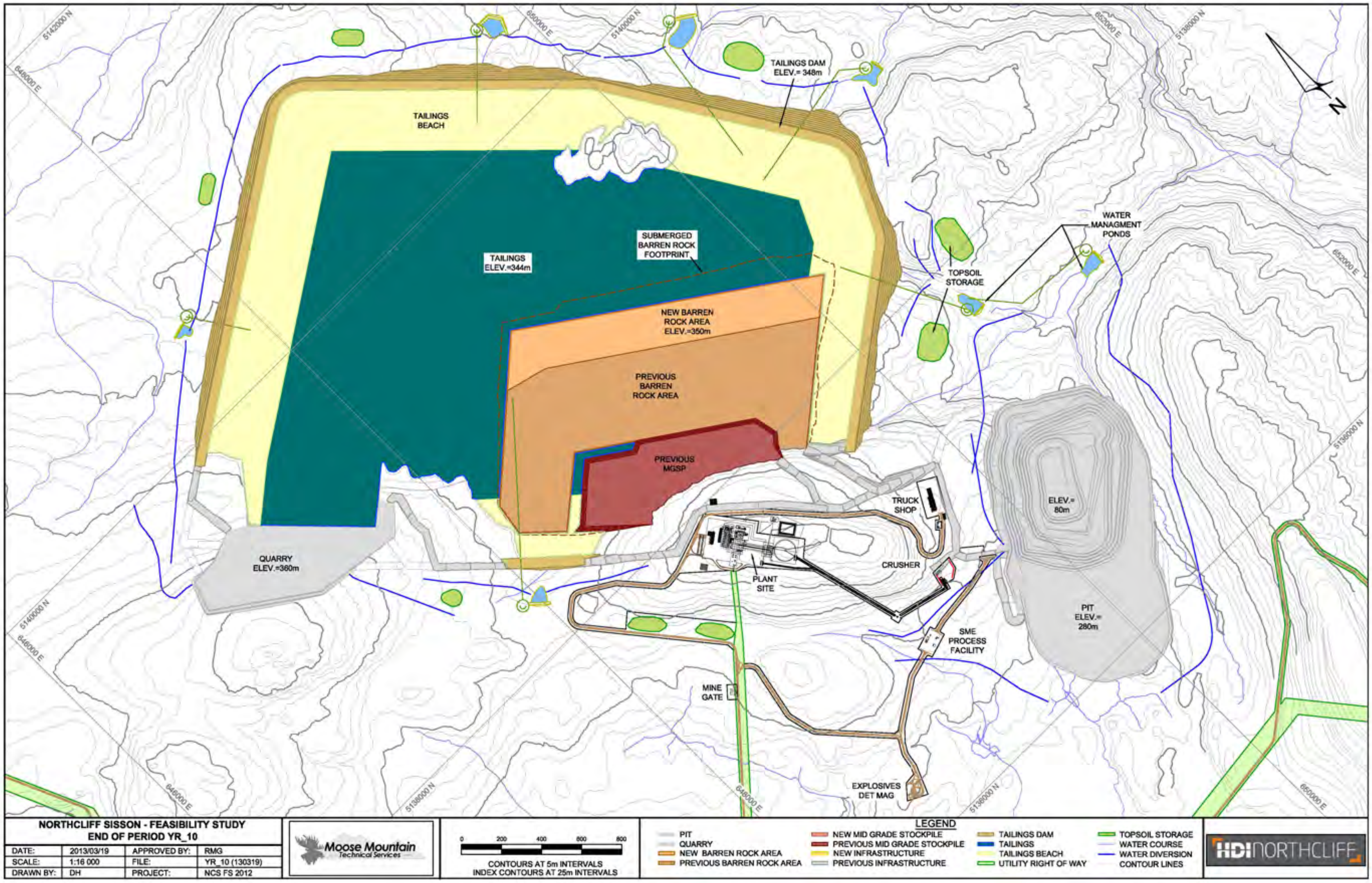


Figure 3.4.4 End of Period (EoP) Map, Production Year 10

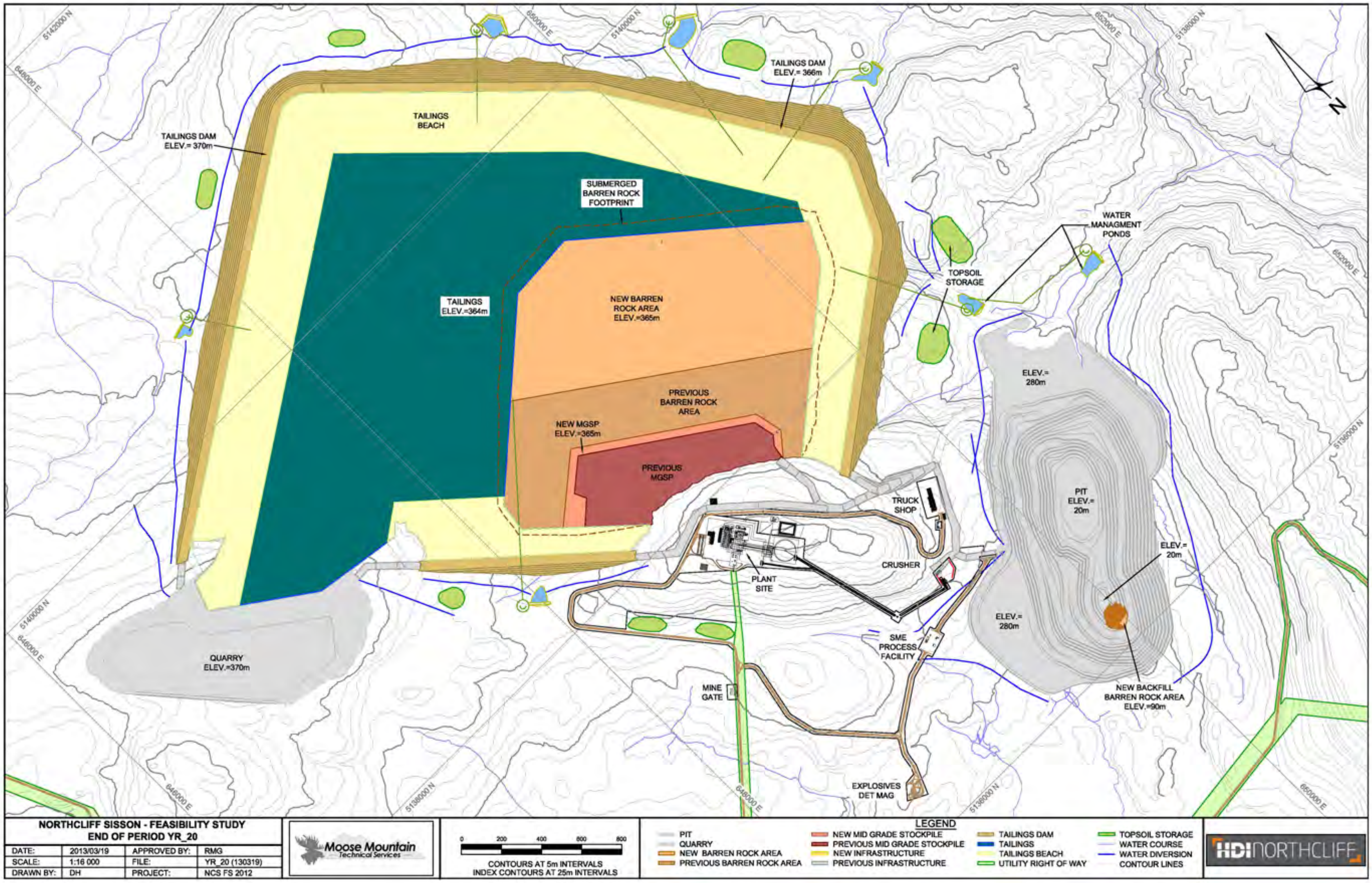


Figure 3.4.5 End of Period (EoP) Map, Production Year 20

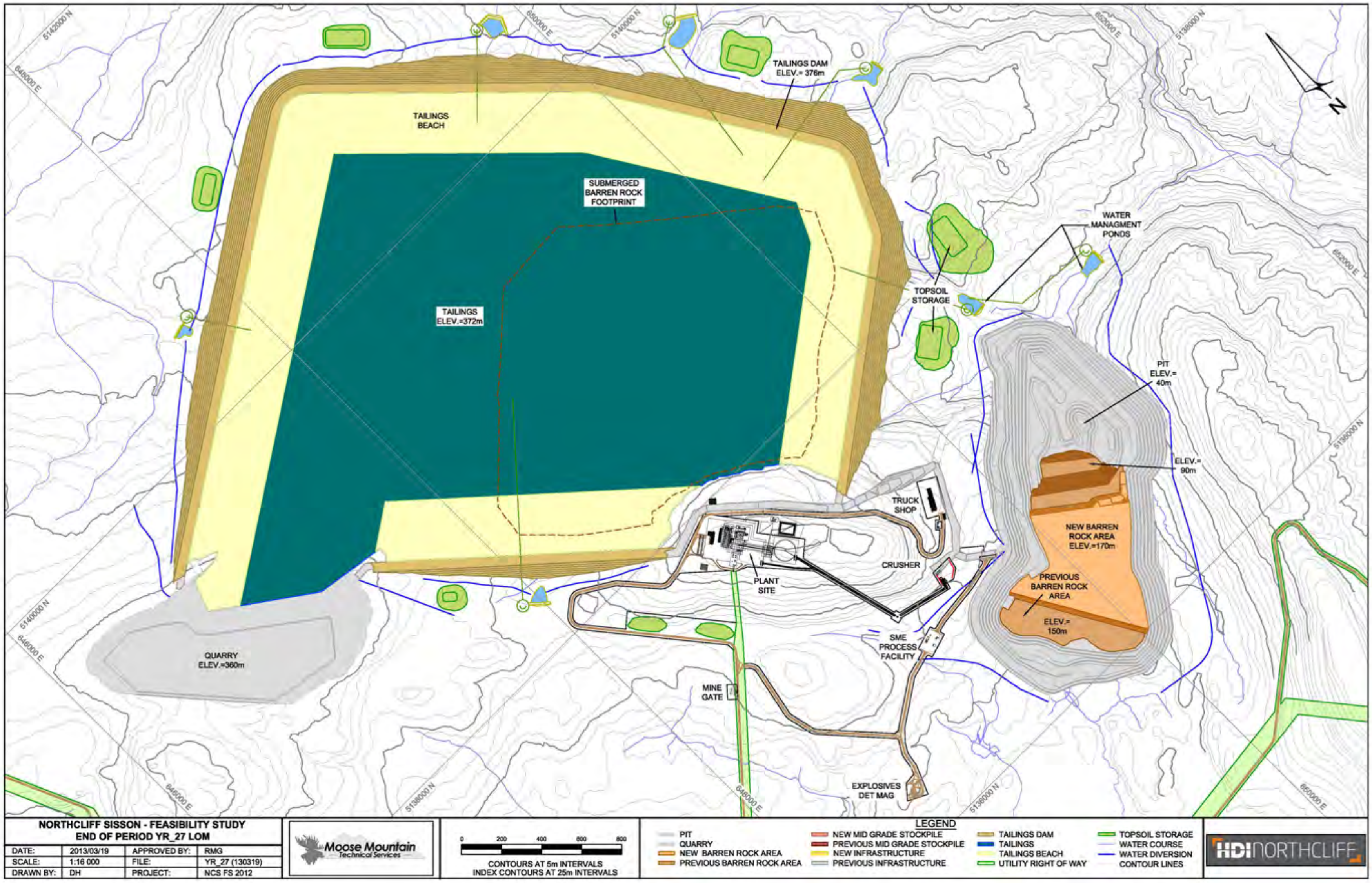
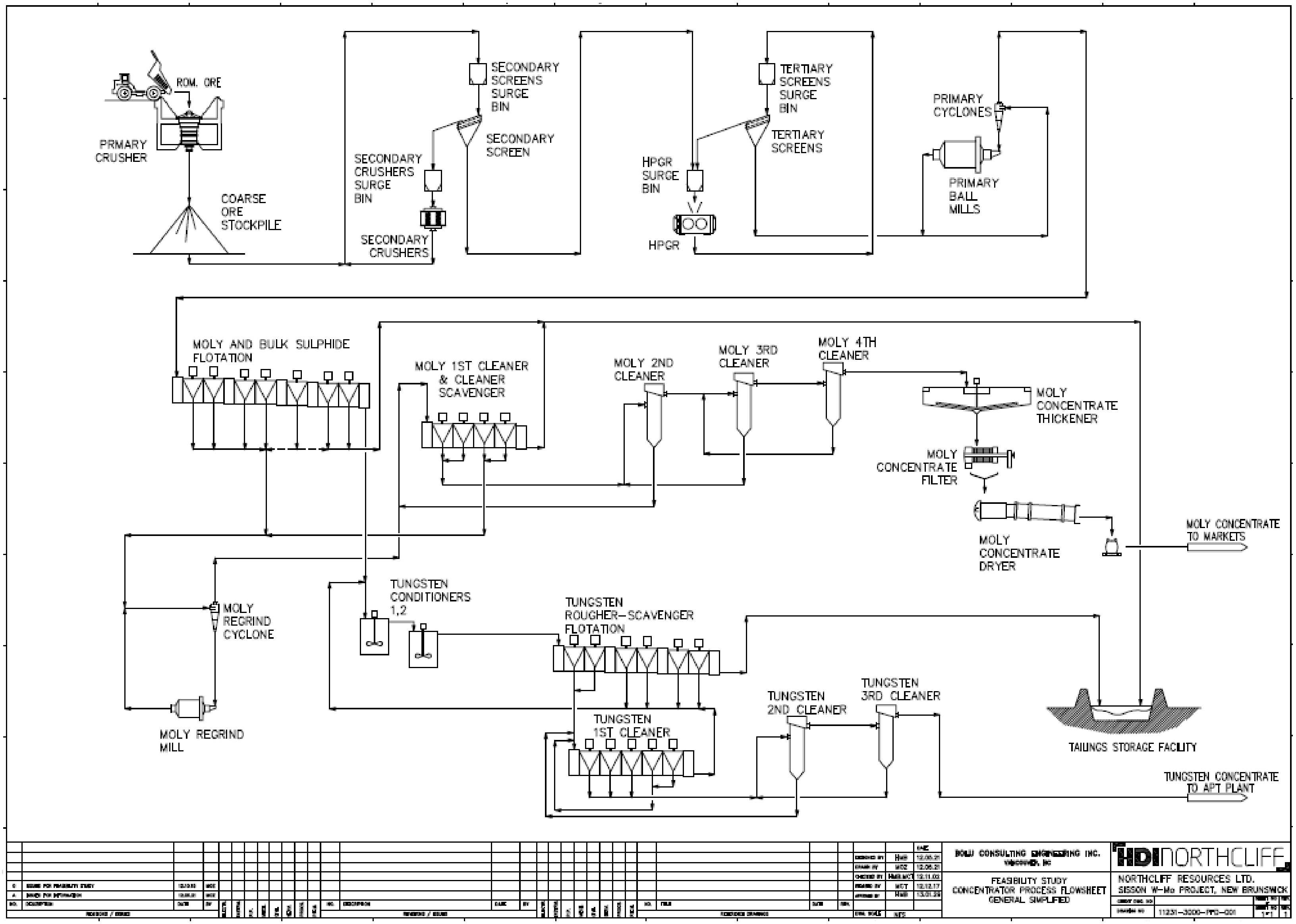


Figure 3.4.6 **End of Period (EoP) Map, Production Year 27 (Life-of-Mine)**



Source: Samuel Engineering (2013).

Figure 3.4.7 **Simplified Concentrator Process Flowsheet**

3.4.2.2.2 Flotation

The flotation process consists of a series of cells to allow for multiple stages of separation of the various ore constituents. The use of a multistage circuit for froth flotation allows for flexibility as the concentrates (and tailings wastes) can be monitored at the various tank outlets and the amount of recirculation of material between cells can be adjusted accordingly to optimize recoveries of the overall process.

Molybdenum and Bulk Sulphide Rougher Flotation

The molybdenum and bulk sulphide flotation circuit comprises seven 250 m^3 tank cells in series, of which the first four cells will float a molybdenite rougher concentrate and the remaining three a bulk sulphide concentrate. The molybdenite rougher concentrate will be sent to a regrind circuit for further liberation and upgraded in four stages as described below. The Bulk Sulphide Flotation (BSF) concentrate stream will join the molybdenum cleaner scavenger tailings and will be discharged for disposal to the TSF through a dedicated submerged pipeline. The BSF tailings stream will proceed to the tungsten flotation circuit.

Reagent addition will include fuel oil, pine oil and methyl isobutyl carbinol (MIBC) frother for the molybdenum circuit, and a sulphide collector PAX (potassium amyl xanthate) and MIBC frother to aggressively float the remaining sulphides in the BSF circuit.

Molybdenum Cleaner Flotation

The molybdenum cleaner circuit is based on single stage cleaner and cleaner scavenger flotation using tank cells, and three subsequent stages of cleaners using industry standard column flotation cells resulting in a total of four stage of cleaning plus a cleaner scavenger stage for recycling of oversize material back to regrinding. The regrinding and the four-stage cleaner and cleaner scavenger flotation circuit is designed to operate in counter current configuration.

The rougher molybdenite concentrate flows to a regrind cyclone feed pump which pumps the combined regrind mill discharge and rougher concentrate to regrind cyclones. Regrinding is accomplished in a ball mill operating in closed circuit with the cyclone pack. The cyclone underflow discharges to the regrind mill feed inlet accompanied with iron sulphide depressants and sodium sulphide.

The regrind circuit finished product, the cyclone overflow, flows by gravity to a bank of four cleaner and cleaner scavenger flotation tank cells for upgrading. Fuel oil is added to the tank cells to facilitate flotation. A cleaner concentrate is collected from the first two cells and a cleaner scavenger concentrate from the remaining two cells. The cleaner scavenger concentrate is returned to the molybdenite regrind circuit, and the cleaner scavenger tailings (which are PAG) are pumped to the TSF for storage.

The first cleaner concentrate is further upgraded in the subsequent cleaner flotation stages employing column cells.

Molybdenum Concentrate Dewatering

The concentrated slurry from the molybdenum cleaner circuit is pumped to a concentrate thickener where flocculant is added to assist in settling out the heavier particles (including the molybdenum). The thickened underflow is pumped through a pressure filter to further dewater, and then to a concentrate dryer. Removed water is recycled, and the dried molybdenum concentrate is bagged for shipment.

Tungsten Rougher-Scavenger Flotation

The tungsten flotation is accomplished by conventional techniques involving conditioning, rougher and scavenger flotation, and three stages of cleaning to produce a final tungsten concentrate.

A series of two agitated conditioning tanks will sequentially adjust the pH of the incoming slurry, and progressively condition the feed with dispersants, gangue depressants, collectors, and frothers. These will include sodium hydroxide, sodium carbonate, sodium silicate, quebracho, and fatty acids. The overflow from the second conditioner will report to the rougher flotation bank.

Six tank cells will be used to recover the tungsten. The first two cells will float a rougher concentrate which will be sent to cleaning. The remaining four cells will produce a scavenger concentrate which is pumped back to the second conditioner. Supplementary collector and frother are added to the scavenger cells.

The tungsten scavenger tailings will be discharged to the TSF through a dedicated pipeline as NPAG tailings.

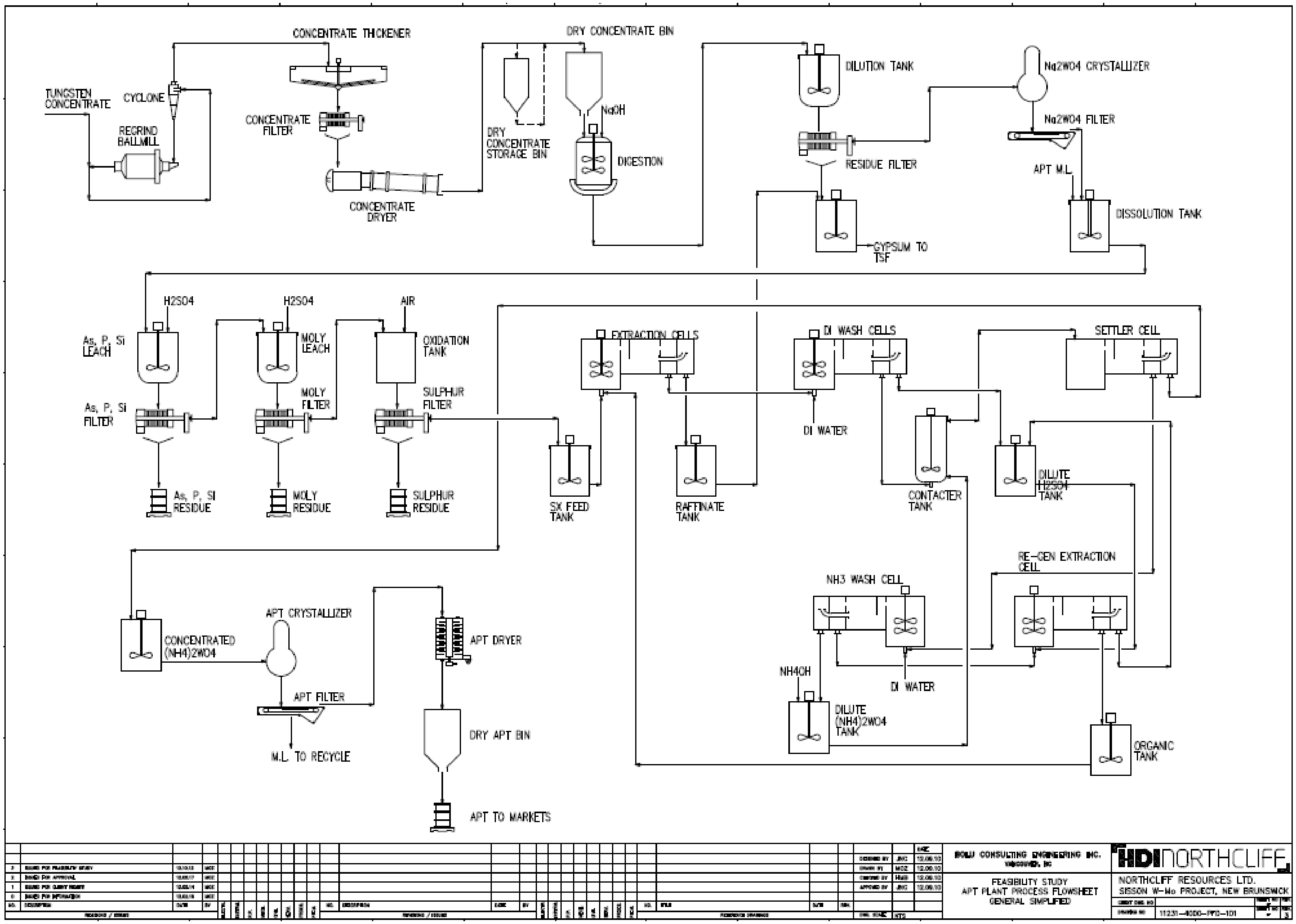
Tungsten Cleaner Flotation

The rougher concentrate is cleaned in three stages. The first stage consists of five tank cells. The first two cells produce Cleaner 1 concentrate, and the remaining three cells produce a cleaner scavenger concentrate which is recycled to the head end of the cleaner circuit. Supplementary frothers and depressants are added as needed to the first stage of cleaning. The Cleaner 1 concentrate is cleaned two more times using two column cells in series operating on forced air. The final concentrate of approximately 30% tungsten trioxide (WO_3) is thickened, filtered, and dried. The final tungsten concentrate is then pumped to the APT plant for further refining.

3.4.2.2.3 Tungsten Concentrate Refining to APT

The tungsten concentrate produced in the flotation process is thickened, dewatered and further refined in the ammonium paratungstate (APT) plant. The APT plant will operate year-round, with two 12-hour shifts per day, processing approximately 2 to 3 tonnes per hour of WO_3 concentrate. A simplified process flowsheet for the APT plant is provided in Figure 3.4.8. The process in the APT plant consists of the following major steps:

- feed preparation;
- digestion and residue filtration;



Source: Samuel Engineering (2013).

Figure 3.4.8 **Simplified Ammonium Paratungstate (APT) Plant Flowsheet**

- alkali recovery and solution purification;
- conversion to ammonium tungstate;
- APT crystallization;
- APT drying and packaging; and
- reagent preparation and utilities.

Tungsten concentrates will first be reground and dewatered in the feed preparation circuit in order to allow a uniform feed ahead of digestion. Tungsten in the concentrates will be digested using an alkali leach system and the sodium tungstate solution will be filtered from the undigested leach residue. The gypsum residue will be stored in a lined containment pond within the TSF, while the sodium tungstate solution will be processed through an alkali recovery and purification process. Common impurities will be removed and stored for disposal at an approved off-site facility. The resulting sodium tungstate solution will be converted to ammonium tungstate and subsequently to APT crystals.

The aqueous solution effluent from the ammonium tungstate conversion will be stored in a lined containment pond within the TSF after pH adjustment. The dried and screened APT will be packaged for markets. Vapours from the crystallizer and other process vessels and processes in the plant will be sent to their respective scrubbers and stripping systems for reclaim and re-use before release to atmosphere. The main reagents used in the process are sodium hydroxide, sulphuric acid, anhydrous ammonia, ammonium hydroxide, sodium sulphahydrate, lime, and organic exchange media.

Feed Preparation

Tungsten concentrate slurry from the concentrator plant will be processed through a wet grinding mill to facilitate size reduction and further exposure of tungsten mineral grains. The mill will operate in closed circuit with a hydrocyclone and the finished product, the cyclone overflow, is fed to a thickener for dewatering and density adjustment prior to filtering. The filter cake discharge is fed to continuous dryer to further reduce moisture. The ground and dried concentrate is stored in a hopper for feed to the digesters.

Digestion and Residue Filtration

The digestion section of the plant consists of digesters, dilution tanks, filter presses, residue processing equipment, and storage tanks.

The three digesters are nickel-lined jacketed vessels, and will process seven digestions per day using an alkali solution. After digestion, the digested slurry is transferred for filtration of the gangue from the sodium tungsten solution to agitated steel vessels. After transfer, the slurry is diluted with raw and recovered condensate water and then filtered to separate the sodium tungstate solution from the residue. The undigested residue is washed with recovered condensate for maximum tungsten recovery. The sodium tungstate solution and wash are pumped to steel storage tanks before further processing. Filter cake, the undigested residue, is hauled for storage in a lined containment pond within the TSF (separate from tailings).

Alkali Recovery and Solution Purification

The sodium tungstate solution is next processed through a purification process where impurities are removed from the solution. The first step is alkali recovery where the products are alkali and sodium tungstate crystals. This is accomplished in an evaporator crystallizer which yields sodium tungstate crystals, alkali, the bottoms and condensate (pure water) vapours. The bottoms are separated using a horizontal belt vacuum filter, the alkali is reused in the digestion step, and the recovered condensate is recycled within the plant.

The sodium tungstate crystals are then re-dissolved in condensate to remove impurities such as aluminum (Al), molybdenum (Mo), and silicon (Si). This is accomplished by pH adjustment of the re-dissolved crystal solution and addition of ammonium hydroxide and magnesium sulphate to precipitate aluminum and silicon. This solution is then agitated, settled and filtered to remove the impurities. The solution from the Al/Si removal step is then treated with sodium sulphahydrate and pH adjusted to precipitate the molybdenum, agitated, settled and filtered. The hydrogen sulphide generated in this step is scrubbed with sodium hydroxide and converted to sodium sulphide for reuse in the process. The resulting solution is oxidized with air to convert the excess sulphide to sulphur, and filtered to remove the sulphur as it is transferred to the solvent extraction section. At this point, the solution is ready for conversion to ammonium tungstate.

Conversion to Ammonium Tungstate

The conversion of sodium tungstate to ammonium tungstate is accomplished in a continuous solvent extraction process. The feeds to the solvent extraction process are the sodium tungstate solution, an amine organic solution, sulphuric acid, ammonia, and deionized water. There are three extraction cells, two low pH wash cells, a product separation cell, a high pH wash cell, and an organic regeneration cell, plus supporting feed and storage tanks used in the conversion process.

The extraction cells produce a sodium sulphate waste solution (raffinate) that is mixed with lime and pH adjusted in an agitated treatment tank to stabilize the calcium sulphate. The resulting slurry is stored with the earlier gypsum waste in a lined containment cell within the TSF, separate from tailings. Sulphuric acid, ammonium hydroxide and an organic solvent are used in the extraction, and these reagents are recovered and recycled in the process.

Ammonium Paratungstate (APT) Crystallization and Drying

The APT is crystallized in a continuous evaporator crystallizer. The concentrated ammonium tungstate solution is pumped to the crystallizer and, as formed, the crystals are continuously removed from the mother liquor by use of a belt filter. Mother liquor is returned to the crystallizer. The crystals are then washed on the belt filter, dried and stored for packaging.

Ammonia (NH_3) Scrubber and Stripper

The ammonia scrubber will consist of a scrubber, a steam stripper and an ammonia absorption tower. Fumes containing ammonia will be scrubbed using sulphuric acid from the solvent extraction circuit and concentrated sulphuric acid. The resulting ammonium sulphate will be sent to the steam stripper, and then the resulting ammonia and water vapour will be absorbed in the absorption tower for reuse as ammonium hydroxide in the solvent extraction circuit.

3.4.2.2.4 Packaging

The dried molybdenum concentrate will be placed in bags for shipment off-site. The design capacity for production of molybdenum concentrate is 1 tonne per hour.

The dried APT is stored in dry APT bins prior to being packaged in drums for shipment. Standard packaging is 150 kg of APT in polyethylene bags inside 60 litre drums. The design capacity for production of the APT crystals is 1.7 tonnes per hour.

3.4.2.2.5 Reagents

Reagents and chemicals for the process plants will be used in flotation, dewatering, reclaim water clarification and APT conversion circuits. Reagents will be delivered in bulk or by specific container and stored onsite in separate, secure, designated areas near or attached to process plant buildings. Covered and open storage areas for all reagents will be self-contained and equipped with spill recovery sump pumps as needed. Reagents will be mixed with filtered process water where necessary and pumped to day-tanks for use. Some select reagents such as flocculants will use fresh water for mixing.

A listing of reagents used in the ore processing plant and APT plant is provided in Table 3.4.15.

Table 3.4.15 Ore Processing Reagents

Reagent	For Use In
Fuel Oil	Molybdenum Flotation
Pine Oil	
Sodium Hydrosulphide (NaHS)	Molybdenum Cleaner Flotation, APT Plant
Potassium Amyl Xanthate (PAX)	Bulk Sulphide Flotation
Methyl Isobutyl Carbinol (MIBC)	Molybdenum and Bulk Sulphide Flotation
Sodium Hydroxide	Tungsten Flotation, APT Plant
Sodium Silicate	
Sodium Carbonate	Tungsten Flotation
Quebracho	
Fatty Acid	
Frother	
Lime	Water Clarification, APT Plant
Liquid Carbon Dioxide	Water Clarification
Flocculant	Concentrate Thickening, Water Clarification
Ammonium Hydroxide	
Sulphuric Acid	
Liquid Nitrogen	APT Plant
Magnesium Chloride	
Ammonia	
Amine	

Fuel oil, pine oil, MIBC, fatty acid, and tungsten flotation frother will be shipped to site in tanker trucks and stored in environmentally-safe tanks where they will be transferred, as required, into day tanks for use. PAX, quebracho and flocculant will be shipped to site in dry solid flakes or pellet form in bags or drums. These will be stored in the reagent storage area next to the reagent preparation building. Bulk reagents such as sodium hydroxide, sodium carbonate, and lime will be shipped to site in tanker trucks and pneumatically unloaded into their dedicated on-site storage bins. Sodium silicate and sodium hydrosulphide will be delivered to the site in liquid form to their storage tanks.

3.4.2.3 Mine Waste and Water Management

Mine waste will include tailings (*i.e.,* residual rock after mineral processing which is fine sand and silt material in a slurry with process liquids) and waste rock (*i.e.,* rock mined from the pit that is uneconomical to process). Mine contact water (*i.e.,* precipitation, groundwater, or surface water that comes in contact with site activities) and water that will accumulate in the open pit will also need to be managed throughout the life of the mine. The primary waste and water management system component is the TSF, where tailings, waste rock, all mine contact water, and process water will be stored and managed. Water within the TSF will be reclaimed, treated, and used in the ore processing plant, then discharged back to the TSF in a closed loop. At approximately Year 8, water will be in surplus within the TSF, thereby necessitating the treatment of water to meet water quality discharge standards (to be defined by permit requirements) before being released to the environment.

Further details on the mine waste and water management activities associated with the Project are provided below.

3.4.2.3.1 Tailings Storage Facility

The TSF is designed to contain approximately 282 Mt of tailings, 17 Mt of mid-grade ore, 270 Mt of waste rock from the open pit, water contained within the tailings and waste rock voids, as well as mine contact water from the entire Project site. Approximately 650 kt of APT process residue will also be stored in lined cells within the TSF over the mine life.

Tailings from the ore processing plant will be pumped to the TSF and stored there in perpetuity, as will be the waste rock trucked from the open pit (until Year 21). Reclaim water will be recycled back to the ore processing plant from a floating barge and pipeline for use as process water.

The TSF inflows are:

- tailings slurry pumped to the TSF from the ore processing plant;
- open pit dewatering;
- pump-back water from the water management ponds (WMPs) around the TSF;
- direct precipitation into the TSF; and
- other mine contact water collected throughout the PDA.

The TSF outflows and losses are:

- water retained within in the tailings and waste rock voids;
- water recycled back to the ore processing plant;
- seepage under and through the embankments; and
- evaporation.

The majority of the process water for the ore processing operation will be supplied by the TSF reclaim water system. This will be supplemented by a fresh water make-up for the processing plants supplied from groundwater wells on the Project site.

The TSF will be designed and operated to prevent fugitive dust emissions. Rotational deposition of tailings will keep exposed tailings beaches wet during operations to prevent dusting.

The TSF embankments will be constructed as required through the life of the mine to maintain containment of the contents of the TSF. The evolution of the TSF embankments throughout the various Operation stages was shown in Figures 3.4.1 to 3.4.6.

SML plans to use the centerline construction method for tailings embankments at the Sisson Project because of its superior seismic resistance, reduced foundation footprint when compared to downstream construction, and efficient use of non-mineralized mine rock for construction. The TSF embankments and foundations will be designed to minimize the seepage of water, and collection systems and monitoring wells designed to gather run-off and seepage from the embankments for recycle into the TSF.

The embankments will be engineered for stability and containment. As embankment construction will continue throughout the active life of the mine, experience gained from ongoing monitoring and analysis will allow for changes and improvements in the design if required.

3.4.2.3.2 Tailings Storage in TSF

Tailings from the ore processing plant will be pumped as a slurry to the TSF and stored there in perpetuity. Tungsten tailings are NPAG and will be discharged via a pipeline that will surround the perimeter of the TSF; molybdenum tailings are considered PAG and will be discharged to the TSF subaqueously using a separate pipeline. The NPAG slurry (approximately 30% solids) pumped into the TSF will discharge from the top of the TSF embankments, with larger solid particles settling out by gravity closer to the embankment and finer particles travelling further toward the centre of the TSF. The solids will settle to form a solid beach type surface. The water from the TSF supernatant pond will be reclaimed by the moveable barge and pumped back to the ore processing plant. Water levels in the TSF will be managed to keep water away from embankments as well as to ensure sub-aqueous disposal of PAG tailings and waste rock.

3.4.2.3.3 Waste Rock Storage in TSF

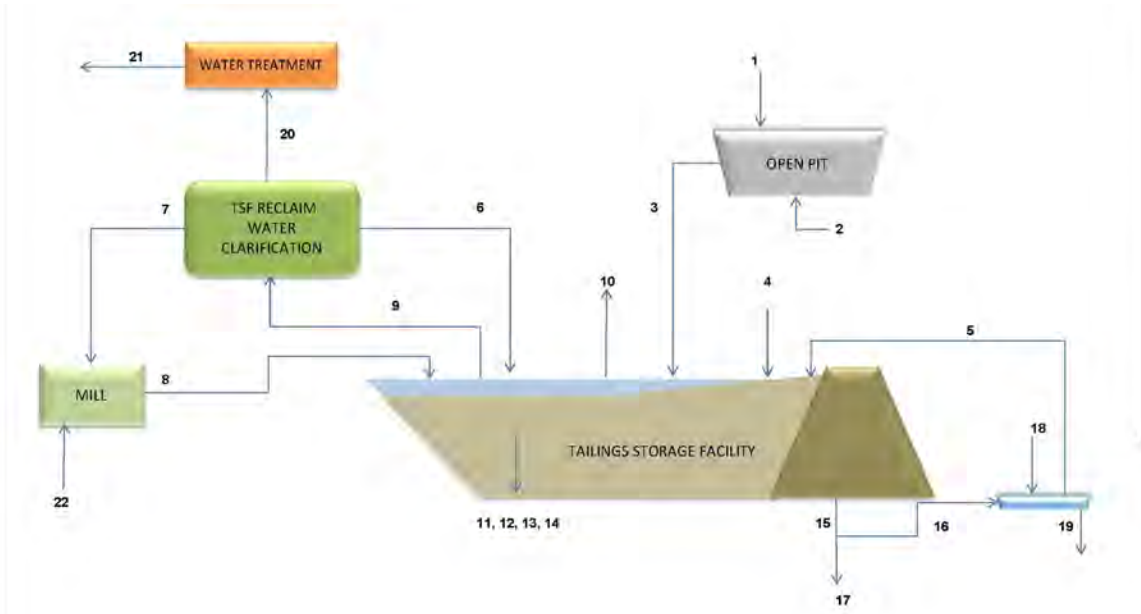
All waste rock from the open pit will be stored under water and NPAG tailings in the TSF. By containing all waste rock within the TSF as opposed to a separate storage pad, environmental benefits are achieved by avoidance of ML/ARD generation, despite the increased short-term cost of waste disposal due to hauling of waste rock to the TSF as opposed to storing it near the pit.

Waste rock will be hauled from the open pit to the TSF. At approximately Year 21, waste rock will remain stored in an inactive area of the open pit, to be later flooded by water during Closure.

3.4.2.3.4 Water Management in the TSF

The operational water balance model for the Project is discussed in Section 7.6 of this EIA Report, and is shown schematically in Figure 3.4.9. The operational water management plan for the TSF includes the following.

- All un-diverted run-off from within the TSF catchment will report to the TSF.
- Process slurry water contained in the tungsten and molybdenum tailings streams will be discharged into the TSF with the tailings solids at an average rate of approximately 2,022 m^3/h at full production.
- Tailings supernatant pond water will be reclaimed and pumped back to the process plant to meet the average process water requirement of approximately 2,003 m^3/h at full production.
- The TSF will have approximately 6 million m^3/year of surplus water (including surplus precipitation from the TSF area as well as water from dewatering of the open pit) starting at about Year 8. After treatment in the clarifier and water treatment plant at the ore processing plant to meet water quality discharge standards, this surplus will be discharged to Sisson Brook in order to maintain an acceptable operating pond volume in the TSF and to supplement the downstream flows affected by the Project. The reclaim barge has been sized to accommodate this additional flow rate.
- NPAG tailings will be selectively deposited from along the top of the embankments to develop stable beaches around the inside of the embankments. The operational supernatant pond volume will be managed to ensure that sufficient storage exists for operational flexibility and storm inflow storage.
- Engineered drainage diversion channels will divert non-contact water away from the TSF and quarry, to the extent possible.
- Water management ponds (WMPs) at low points around the TSF embankment perimeter will collect seepage and run-off from the TSF embankments. This water will be pumped back to the TSF unless the water quality is suitable for direct release to the environment.
- Groundwater monitoring wells will be located below the WMPs to monitor water quality. Groundwater pump-back wells will be developed as necessary if the groundwater quality may jeopardize downstream water quality; this groundwater will be pumped to the WMPs.



Number	Description
1	Open Pit direct precipitation and catchment runoff
2	Open Pit groundwater inflows
3	Open Pit dewatering to TSF
4	TSF catchment & beach runoff; direct precipitation on pond
5	Water Management Pond recycle
6	Water from Clarification Plant to TSF pond
7	Water from Clarification Plant to Mill
8	Water in tailings to TSF
9	TSF reclaim water to Clarification Plant
10	TSF pond evaporation
11	Water retained in tailings void spaces
12	Water retained in clarification slurry void spaces
13	Water retained in barren rock void spaces
14	Water retained in mid-grade stockpile void spaces
15	TSF embankment seepage - total
16	TSF embankment seepage - captured by seepage collection system / WMPs
17	TSF embankment seepage - lost
18	Water Management Pond embankment and catchment runoff
19	Water Management Pond seepage
20	Excess clarified water to treatment
21	Treated water discharged to environment
22	Fresh water make-up to mill

NOTES:
1. WATER BALANCE SCHEMATIC IS NOT DRAWN TO SCALE.
2. SOLID LINE DENOTES WATER ROUTING ASSUMPTION →

NORTHCLIFF RESOURCES LTD.
SISSON PROJECT

OPERATIONAL WATER BALANCE SCHEMATIC

Knight Piésold
CONSULTING

P/A NO.
VA101-447/2
REF NO.
7
REV
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0	27MAR'13	ISSUED WITH REPORT	ER	DF	KJB
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

Source: Samuel Engineering (2013).

Figure 3.4.9 Schematic of Mine Operational Water Balance

- Water from the open pit will be pumped to a WMP near the pit rim and then to the TSF.

The water balance model results were used to estimate the likelihood of having a surplus or deficit of water in the TSF. The TSF pond is predicted to be in a surplus condition for the entire operating life of the mine, indicating that the system (including the TSF and contributing catchments) is able to supply more than enough water to meet the mill process water requirements, even under dry conditions. This surplus will accumulate in the TSF until it is excessive (starting about Year 8 as noted above) and needs to be discharged.

3.4.2.3.5 Dewatering of the Open Pit

The water pumped from the open pit by the dewatering system includes direct precipitation onto the pit, undisturbed pit catchment surface run-off entering the pit, and groundwater inflows. Water collected in the open pit will be periodically pumped from a pit sump and report to the TSF via an intermediary WMP.

3.4.2.3.6 Collection and Management of Mine Contact Water

Precipitation and surface water run-off onto the site will be directed away from Project facilities with engineered diversion channels wherever possible to minimize the creation of mine-contact water. Mine- contact water from throughout the PDA will be sent to the TSF for storage and use.

Water management ponds constructed at the topographic low points downstream of the embankments will collect water that may seep through the TSF embankment as well as run-off from the embankments. Embankment foundation drains will be piped to these ponds and water from the ponds will be pumped back to the TSF for containment and use.

3.4.2.3.7 Surplus Water Treatment, Release and Monitoring

The conceptual water treatment process for the Project is described in Appendix I of SRK (2013). *Sisson Project: Metal Leaching and Acid Rock Drainage Characterization. August 2013.* The process is conceptual since it was developed for feasibility study purposes. This is normal practice at the environmental assessment stage of a project, which is intended to be a planning process rather than a detailed engineering review for the purposes of permitting. Further refinement of the water treatment process will be carried out during Basic Engineering, with input from regulatory agencies regarding expected effluent standards, and will be described fully in subsequent permit applications for the Project.

Table 3.4.16 presents the predicted TSF water quality data for Operation, as well as any water quality discharge limits set by the federal *Metal Mining Effluent Regulations* (*MMER*). It is the TSF water that is treated for use in the ore concentrator. Starting about Year 8, water surplus to Project requirements will need to be discharged to Sisson Brook.

Table 3.4.16 TSF Water Quality Predictions - Operation

Parameter	Average Concentration in TSF Water (mg/L)	Maximum Concentration in TSF Water (mg/L)	Discharge Limits (maximum authorized monthly mean concentration, column 2) (mg/L)
Aluminum (dissolved)	0.6	0.9	---
Antimony (total)	0.012	0.019	---
Arsenic (total)	0.08	0.13	0.5
Cadmium (total)	0.00058	0.00084	---
Chromium (total)	0.012	0.017	---
Copper (total)	0.026	0.036	0.3
Cyanide	N/A	N/A	1.00
Lead (total)	0.0016	0.0022	0.2
Manganese (total)	0.64	0.94	---
Molybdenum (total)	0.081	0.13	---
Nickel (total)	0.0079	0.012	0.50
Selenium (total)	0.0026	0.0034	---
Zinc (total)	0.044	0.068	0.50

During the feasibility study, the water quality predictions presented in Table 3.4.16, and the preliminary environmental effects assessments based on them, indicated that water treatment for arsenic (and antimony) was likely to be required before the surplus TSF water can be discharged to Sisson Brook. Thus, this capability was added to the conceptual design of the water treatment process.

During Operation, water recycled from the TSF pond will be clarified with lime and then carbon dioxide to settle fine tailings solids and silica minerals before the water is used in the concentrator plant. The solids from the clarifier will comprise two streams: a lime underflow at approximately 28 tonnes per hour; and a calcium carbonate precipitate (from the CO_2 treatment) at approximately 67 tonnes per hour. These two streams will be pumped into the TSF for permanent storage. For the purposes of the TSF capacity calculations, both these waste streams are assumed to settle to a final dry density of 0.5 tonnes/m^3. However, to be conservative, the predictive water quality modelling assumed that the elements in these solids would re-mobilize in the tailings water; this assumption is currently being refined through additional test work.

Starting in about Year 8 of Operation, water surplus to Project needs will be released (following treatment as necessary) into Sisson Brook at between about 5,000 and 55,000 m^3/day (average of 16,500 m^3/day) to mimic the Napadogan Brook hydrograph as close as possible. Before discharge, and after it is clarified with lime and carbon dioxide, the water will be treated in a ferric co-precipitation process[1] (shown in Figure 3.4.10 targeted to remove arsenic and antimony; the process is expected to beneficially remove the other elements listed in Table 3.4.16 but, to be conservative, these benefits have not been assumed at this stage of Project planning. This treatment entails feed water entering Reactor 1 where ferric sulphate and sulphuric acid are added and the pH drops to approximately 5 or 6. In the reactor, ferric hydroxide precipitates are formed, which adsorb and co-precipitate arsenic,

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[1] The USEPA (United States Environmental Protection Agency. 2005. Treatment Technologies for Arsenic Removal. Cincinatti (OH). Reference No.: EPA/600/S-5/006) recognizes ferric treatment as an effective method for arsenic and antimony removal.

antimony and other metals. A second reaction tank (Reactor 2 in Figure 3.4.10) extends the retention/reaction time to ensure that the adsorption reaction is complete. The ferric sludge produced in the process will be collected and removed in a clarifier. A portion of the produced solids from the clarifier underflow will be recycled back to the reactor tanks to provide seed for the ongoing precipitation process. The balance of the ferric sludge, approximately 650 tonnes/year of solids, will be pumped for disposal in the TSF. This sludge is expected to be stable (*i.e.*, will not dissolve) and to thus not affect TSF water quality.

The final effluent will flow from the clarifier overflow to a sand filtration unit before it is released to Sisson Brook. The predicted quality of water discharged to Sisson Brook is given in Table 3.4.17 below.

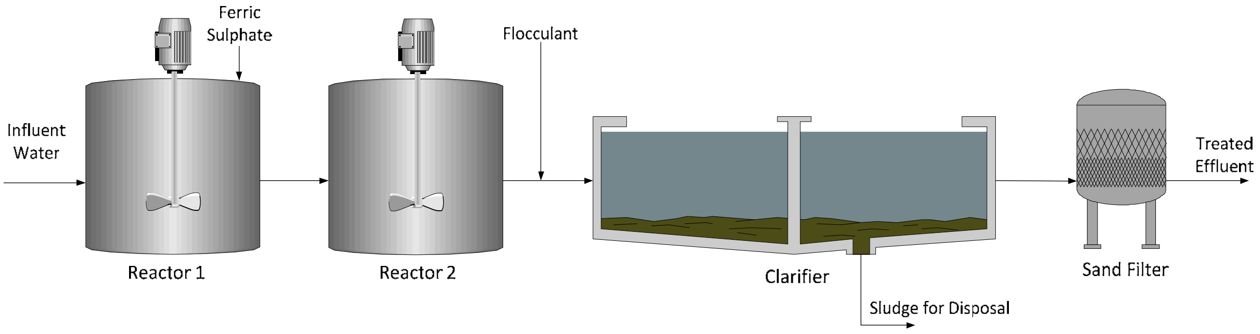

Figure 3.4.10 Ferric Co-precipitation Process Flow Diagram

Table 3.4.17 Predicted Discharge Water Quality to Sisson Brook for Treated Parameters – Operation

Parameter	Average Expected Final Effluent Water Quality-Concentration of Trace Metal in Water (mg/L)	Maximum Expected Final Effluent Water Quality – Concentration of Trace Metal in Water (mg/L)	*MMER* Discharge Limits (maximum authorized monthly mean concentration, column 2) (mg/L)
Aluminum (dissolved)	0.2	0.2	---
Antimony (total)	0.01	0.01	---
Arsenic (total)	0.01	0.01	0.50
Cadmium (total)	*0.0004 (0.0005)*	0.0005	---
Chromium (total)	0.01	0.01	---
Copper (total)	0.002	0.002	0.30
Cyanide	N/A	N/A	1.00
Lead (total)	0.0005	0.0005	0.20
Manganese (total)	0.1	0.1	---
Molybdenum (total)	0.05	0.05	---
Nickel (total)[2]	0.0084	0.012	0.50
Selenium (total)	*0.0027 (0.015)*	*0.0034 (0.015)*	---
Zinc (total)[2]	0.047	0.068	0.50
TSS	< 15.00	< 15.00	15.00

Notes:

1. The numbers in *underlined italics* indicate that concentration is lower than the WTP threshold removal. The threshold values are given in brackets.
2. Nickel and Zinc are not targeted for removal in the WTP, but are shown for comparison with *MMER* Discharge Limits.

3.4.2.3.8 Fresh Water Supply

Fresh water for the Project will be pumped from the fresh water wells developed for the Project. This will include water for use as drinking water (treated as necessary to ensure potability), for sanitary facilities, for fire protection, for dust suppression, and as fresh water make-up for the ore processing plant. The requirement is about 21 m^3/h of fresh water for all uses.

3.4.2.4 Linear Facilities Presence, Operation and Maintenance

Linear facilities, including the transmission lines and access roads, will be operated and maintained throughout the Project life.

3.4.2.4.1 Operation and Maintenance of the Transmission Lines

NB Power will conduct the required maintenance of the transmission line so that it operates in a safe and reliable manner according to the Canadian Electrical Code. The electrical code clearances were developed for safe and reliable operation of high-voltage lines. NB Power will also be responsible for maintaining the right-of-way for vegetation control and to permit suitable access to the transmission line during emergencies and for regularly scheduled inspections and maintenance. Routine inspections will be conducted to facilitate the safe and reliable operation of the transmission line, and to minimize the risk of potential hazards such as fires or electrocution caused when trees grow too close to energized power lines.

In order to avoid interruptions to electric service caused by overgrown or fallen vegetation, NB Power restricts the growth of trees and brush along the lines through its vegetation management program. Manual and mechanical methods will be used to control vegetation along right-of-way. The frequency of vegetation management depends upon the growth rate, but is normally carried out every five to seven years.

3.4.2.4.2 Operation and Maintenance of Site Access Road and Internal Site Roads

The forest resource roads will be used by personnel and for delivery and product vehicles as well as by existing users (mainly for forestry operations). General forest road maintenance activities will be carried out by third parties (*e.g.,* the Crown timber license holder or contractors) during the summer months, with the assistance of SML. The site access road and internal site roads will be maintained by SML.

Detailed maintenance procedures will be developed during later planning stages; however, maintenance of the roads may include:

- bridge or culvert maintenance;
- litter pick-up;
- road repairs;
- snow removal and ice control;

- traffic sign installation and repairs;
- traffic signal maintenance; and
- vegetation control.

Periodic maintenance of roadway drainage systems may be required, including the replacement or repair of culverts, re-establishment of the drainage ditches and clearing of brush and trimming of overhanging vegetation to re-establish sight lines. Repairs will be conducted as necessary and may involve occasional excavation or removal of the existing cover and subgrade, leveling, grading, and gravelling. Traffic disruption from these repairs will be temporary and infrequent in nature.

Winter operation activities generally involve snow removal and ice control to reduce traffic disruptions and safety hazards. Snow removal will be accomplished by plow. Road ice will be managed through the application of sand to icy or snow-packed road surfaces, to provide traction.

Growth of vegetation may interfere with the lines of sight required for safe use of the roads. Clearing and trimming along the roadways will be necessary and will part of regular maintenance routines for access roads and may involve both manual and mechanized cutting. There will be no herbicide application for the control of vegetation.

3.4.2.5 Emissions and Wastes

3.4.2.5.1 Air Contaminant Emissions

During Operation, emissions of air contaminants may be released from the following activities:

- fuel combustion in mobile mining equipment;
- fuel combustion in passenger vehicles to and from the site, as well as on-site;
- fuel combustion in trucks bringing in materials and transporting products out;
- dust from drilling and blasting events;
- combustion emissions from detonated explosives;
- dust from loading and unloading of run-of-mine ore;
- dust from the operation of the primary crusher;
- dust from the conveying of crushed ore to the ore processing plant (at material transfer points);
- dust from the movement of vehicles and equipment on unpaved roads;

- dust from wind erosion of the crushed ore stockpile;
- dust from wind erosion of the TSF beaches; and
- air contaminants and odourous compounds from the ore concentrator building and the APT plant.

Emissions inventories for air contaminant and GHG emissions for Operation were developed based on information provided by Northcliff, published emission factors, and engineering judgment, as detailed below.

Emissions of air contaminants and GHGs from the combustion of diesel in heavy mining equipment during Operation were estimated using USEPA NONROAD program (USEPA 2008) based on the list of equipment provided by Northcliff. Indirect emissions of GHGs from electric equipment were estimated using the New Brunswick grid emission factor from the most recent National Inventory Report (Environment Canada 2012d). A list of mining and support equipment for Operation is provided in Table 3.4.18.

Table 3.4.18 Heavy Equipment Used – Operation

Equipment	Number of Units	Horsepower (hp)	Fuel
Electric Drill	2	700	Electric
Blasthole Loader	1	110	Diesel
Hydraulic Shovel	3	1,200	Electric
Bulldozer	1	580	Diesel
Wheeled Bulldozer	1	500	Diesel
Haul Truck	11	1,450	Diesel
Water Truck	1	1,000	Diesel
Bulldozer	3	410	Diesel
Grader	1	300	Diesel
Multi-tool	1	390	Diesel
Excavator	1	380	Diesel
Mobile Screening Plant	1	100	Diesel
Light Plant	4	30	Diesel
Forklift – 10 t	1	150	Diesel
Forklift – 30 t	1	230	Diesel
Fuel/Lube Truck	1	375	Diesel
Jaw Crusher	1	400	Diesel
Warehouse Truck	1	375	Diesel
Mine Rescue Truck	1	375	Diesel
Service Truck	2	375	Diesel
Welding Truck	1	375	Diesel
Picker Truck	1	375	Diesel

In addition to the equipment in Table 3.4.18, it is estimated that there are 8 personnel gasoline vehicles on-site. Emissions from these equipment are included in the estimates of on-site vehicles (below).

The releases of criteria air contaminants (CAC) and greenhouse gases (GHG) are shown in Tables 3.4.19 and 3.4.20.

Table 3.4.19 Criteria Air Contaminant (CAC) Emissions – Fuel Combustion in Mining and Support Equipment – Operation

	Average Annual Emissions (t/a)						
	Carbon Monoxide (CO)	Nitrogen Oxides (NO_X)	Sulphur Dioxide (SO_2)	Volatile Organic Compounds (VOCs)	Total Particulate Matter (PM)	Particulate Matter less than 10 µm (PM_{10})	Particulate Matter less than 2.5 µm ($PM_{2.5}$)
Mining and Support Equipment	104	318	0.29	32.8	20.2	20.2	20.2

Notes:
t/a = tonnes per year.

Table 3.4.20 Greenhouse Gas (GHG) Emissions – Fuel Combustion in Mining and Support Equipment – Operation

	Average Annual Emissions (t/a)			
	Carbon Dioxide (CO_2)	Methane (CH_4)	Nitrous Oxide (N_2O)	Total Greenhouse Gases (CO_2e)
Mining and Support Equipment	30,867	1.72	12.7	34,852

Notes:
t/a = tonnes per year.
CO_2e = carbon dioxide equivalent.

Indirect GHG emissions from the use of electricity in mobile mining equipment and facility operations are estimated to be 183,600 t CO_2e per year.

Fuel combustion emissions were estimated for passenger vehicles and vehicles transporting materials, equipment, and product. Northcliff provided some information on vehicle movements and Stantec made conservative assumptions for the remainder, including distances travelled. It is assumed that heavy trucks transport the product from the site to the rail siding in Napadogan; from there, the product is transported to port(s) by rail and loaded onto existing trains. Stantec assumed the train transporting product is travelling regardless of whether the Project existed due to existing transportation needs in New Brunswick; therefore emissions from locomotive transportation have not been estimated.

For vehicles, emission factors and default fuel efficiency values from the Transport Canada Urban Transportation Emissions Calculator (Transport Canada 2012) were used to estimate emissions.

The estimated emissions from vehicle travel during Operation are presented in Tables 3.4.21 and 3.4.22.

Table 3.4.21 Criteria Air Contaminant (CAC) Emissions – Vehicle Fuel Combustion – Operation

	Average Annual Emissions (t/a)						
	Carbon Monoxide (CO)	Volatile Organic Compounds (VOCs)	Nitrogen Oxides (NO_X)	Sulphur Dioxide (SO_2)	Total Particulate Matter (PM)	Particulate Matter less than 10 µm (PM_{10})	Particulate Matter less than 2.5 µm ($PM_{2.5}$)
Personnel	17.8	0.86	0.92	0.01	0.03	0.03	0.01
Deliveries	0.30	0.08	1.31	0.01	0.04	0.04	0.03
Total	**18.1**	**0.94**	**2.23**	**0.02**	**0.07**	**0.07**	**0.04**

Assumptions:

- Personnel travel by light duty passenger trucks (100) for 30 days per month. Personnel category includes 8 on-site gasoline vehicles.
- Light duty passenger trucks travel from Napadogan and Nackawic (50:50 split).

Notes:

t/a = tonnes per year.

Table 3.4.22 Greenhouse Gas (GHG) Emissions – Vehicle Fuel Combustion – Operation

	Average Annual Emissions (t/a)			
	Carbon Dioxide (CO_2)	Methane (CH_4)	Nitrous Oxide (N_2O)	Total Greenhouse Gases (CO_2e)
Personnel (includes on-site traffic)	580	0.04	0.08	605
Deliveries	401	0.02	0.01	405
Total	**981**	**0.06**	**0.09**	**1,010**

Assumptions:

- Personnel travel by light duty passenger trucks (100) for 30 days per month. Personnel category includes 8 on-site gasoline vehicles.
- Light duty passenger trucks travel from Napadogan and Nackawic (50:50 split).

Notes:

t/a = tonnes per year.
CO_2e = carbon dioxide equivalent.

Stationary point sources of air contaminants include the exhaust of the primary crusher, as well as exhaust points from the ore concentrator building and APT plant.

Emissions from the crusher were estimated using the anticipated throughput of material and USEPA emission factors (USEPA 1995b). A dust collector and wet sprays will minimize emissions of dust from Operation; a control efficiency of 95% was applied to account for these controls. The estimated particulate matter emissions from the primary crusher are presented in Table 3.4.23.

Table 3.4.23 Particulate Matter Emissions – Primary Crusher – Operation

	Average Annual Emissions t/a)		
	Total Particulate Matter (PM)	Particulate Matter less than 10 µm (PM_{10})	Particulate Matter less than 2.5 µm ($PM_{2.5}$)
Primary Crusher	32.0	3.24	0.49

Notes:

t/a = tonnes per year.

There are exhaust vents equipped with dust collectors on the ore concentrator plant building to collect particulate matter from exhaust air streams and from building ventilation. Each dust collector releases exhaust gases and a negligible amount of particulate matter into the atmosphere. No emissions were therefore estimated from this source.

There are three exhaust points at the APT plant: the H_2S scrubber exhaust, the NH_3 scrubber exhaust, and the package boiler exhaust. The air contaminants released from these exhaust points include combustion gases, H_2S, NH_3, decane, ethylbenzene, naphthalene, tri-isooctylamine (TIA), and particulate matter. Northcliff provided the concentrations of the air contaminants for the H_2S and NH_3 scrubbers. Stantec estimated air contaminant emissions from the combustion of diesel fuel in the package boiler.

The estimated emissions from the H_2S and NH_3 scrubber are provided in Table 3.4.24.

Table 3.4.24 Point Source Emissions – APT Plant – Operation

	Average Annual Emissions (t/a)					
	Hydrogen Sulphide (H_2S)	**Ammonia (NH_3)**	**Decane**	**Ethylbenzene**	**Naphthalene**	**Tri-isooctylamine (TIA)**
H_2S Scrubber	1.65	-	42.6	33.8	0.26	0.95
NH_3 Scrubber	-	0.64	42.6	33.8	0.26	0.95

Notes:
t/a = tonnes per year.
- = not released from this source.

The estimated emissions of CACs and selected trace metals from the diesel package boiler are presented in Tables 3.4.25 and 3.4.26, respectively.

Table 3.4.25 Point Source Criteria Air Contaminant (CAC) Emissions – Package Boiler - Operation

	Average Annual Emissions (t/a)						
	Carbon Monoxide (CO)	**Volatile Organic Compounds (VOCs)**	**Nitrogen Oxides (NO_X)**	**Sulphur Dioxide (SO_2)**	**Total Particulate Matter (PM)**	**Particulate Matter less than 10 µm (PM_{10})**	**Particulate Matter less than 2.5 µm ($PM_{2.5}$)**
Package Boiler (Diesel Fuelled)	2.52	0.13	10.1	0.11	1.0	0.65	0.65

Notes:
t/a = tonnes per year.

Table 3.4.26 Point Source Metals Emissions – Package Boiler – Operation

	Average Annual Emissions (kg/a)							
	Arsenic (As)	**Cadmium (Cd)**	**Chromium (Cr)**	**Copper (Cu)**	**Lead (Pb)**	**Mercury (Hg)**	**Nickel (Ni)**	**Selenium (Se)**
Package Boiler (Diesel Fuelled)	0.28	0.21	0.21	0.42	0.64	0.21	0.21	1.1

Notes:
kg/a = kilograms per year.

The estimated emissions of GHGs from the diesel package boiler are presented in Table 3.4.27.

Table 3.4.27 Point Source Greenhouse Gas (GHG) Emissions – Package Boiler – Operation

	Average Annual Emissions (t/a)			
	Carbon Dioxide (CO_2)	Methane (CH_4)	Nitrous Oxide (N_2O)	Total Greenhouse Gases (CO_2e)
Package Boiler (Diesel Fuelled)	11,296	0.56	1.68	11,829

Notes:
t/a = tonnes per year.
CO_2e = carbon dioxide equivalent.

Prior to blasting, holes are drilled into the rock to place explosive charges. The drilling may generate some dust; however, based on the number of holes drilled per blast (estimated at 40), an estimated density of the rock, and controls by wet drilling, the amount of dust that may be generated is less than 1 kg per year for all blasting events. Therefore, a negligible amount of dust is generated from drilling activities in the quarry and open pit.

Fugitive particulate matter caused by blasting activities during Operation was estimated using an USEPA emission factor (USEPA 1998) and the area of land subjected to a blast. Blasting in the open pit is expected to occur approximately every two days throughout the year (approximately 178 events per year), and blasting in the quarry is expected to occur once per week for three weeks in a year (three events per year). Stantec used the average blast area of 2,150 m^2 per blast to estimate fugitive dust emissions. Particulate matter (PM) emissions from blasting were estimated to be approximately 3.89 tonnes per year. Emissions of PM_{10} and $PM_{2.5}$ were estimated to be approximately 2.02 tonnes per year and 0.12 tonnes per year, respectively.

The detonation of explosives during blasting releases combustion gases into the atmosphere. The releases of these gases based on the amount of explosive, the number of blast events per year, and USEPA emission factors (USEPA 1980). The estimated air contaminant emissions are presented in Table 3.4.28.

Table 3.4.28 Criteria Air Contaminant (CAC) Emissions – Explosive Detonation – Operation

	Average Annual Emissions (t/a)		
	Carbon Monoxide (CO)	Nitrogen Oxides (NO_X)	Sulphur Dioxide (SO_2)
Explosives Detonation	35.1	8.26	1.03

Notes:
t/a = tonnes per year.

During Operation, run-of-mine material is transferred from the pit to the primary crusher and crushed ore is transferred with a conveyor belt onto the crushed ore stockpile. Points in the process where material is transferred are known as transfer points. Fugitive emissions from material handling were estimated based on emission factors and equations from USEPA (USEPA 2006b; 2004; 1995b), and using average wind speed and material moisture content. The estimated emissions are presented in Table 3.4.29.

Table 3.4.29 Particulate Matter Emissions – Material Handling and Transfer Points – Operation

	Average Annual Emissions (t/a)		
	Total Particulate Matter (PM)	Particulate Matter less than 10 µm (PM_{10})	Particulate Matter less than 2.5 µm ($PM_{2.5}$)
Loading in Pit	0.32	0.15	0.02
Unloading at Crusher	0.32	0.15	0.02
Loading onto Stockpile	16.3	7.72	1.17
Total	**16.9**	**8.02**	**1.21**

Notes:
t/a = tonnes per year.

The movements of vehicles and equipment on unpaved roads during Operation cause emissions of fugitive particulate matter (PM, PM_{10}, $PM_{2.5}$). The USEPA methodology to estimate emissions is based on silt content of the road material and vehicle tonnage. Northcliff provided information on vehicle and equipment movements, and Stantec made conservative assumptions regarding the silt content and vehicle tonnage. It was assumed that the site access road and internal site roads are watered for dust suppression, and this gives a 80% reduction in dust generation (NIOSH 2012); no dust suppression was assumed for the unpaved forest resource roads (*i.e.,* PSA Route via Nackawic or SSA Route via Napadogan). The estimated fugitive emissions from vehicle activity on unpaved roads are provided in Table 3.4.30.

Table 3.4.30 Particulate Matter from Unpaved Roads – Operation

Operation	Average Annual Emissions (t/a)		
	Total Particulate Matter (PM)	Particulate Matter less than 10 µm (PM_{10})	Particulate Matter less than 2.5 µm ($PM_{2.5}$)
Forest Resource Roads (PSA and SSA Routes)	986	261	26.1
Site Access Road and Internal Site Roads	412	109	10.9
Total	**1,397**	**370**	**37.0**

Assumptions:

- On-site roads have a silt content of 8.3% and access roads have a silt content of 10% (default values from USEPA 2006a).
- Heavy mobile equipment is assumed to have a mass of 263 tonnes (290 tons) (upper range from USEPA 2006a).
- Passenger vehicles are conservatively assumed to have a mass of 1.8 tonnes (2 tons) (lower range from USEPA 2006a).
- Water is applied to site roads to control fugitive emissions. An 80% reduction was applied to emissions (NIOSH 2012).
- It is assumed that fugitive emissions will not occur during days with precipitation or snow cover. Based on local weather data, Stantec assumed that 176 days per year will not be capable of generating dust.

Notes:
t/a = tonnes per year.

Topsoil and overburden will be stockpiled periodically throughout Operation as land is cleared for the open pit and quarry. To minimize dust emissions, each pile will be seeded and re-vegetated periodically. Emissions of dust from these sources are therefore considered to be negligible.

During Operation, crushed run-of-mine ore is stockpiled near the ore processing building. As addition of material to the stockpile and reclaiming ore from the stockpile will be frequent, there is potential for dust generation from wind erosion. Stantec estimated hourly particulate matter emissions using wind speed and precipitation data for six years from the Fredericton weather station (Environment Canada 2012c). The steady-state dimensions of the pile were provided by Northcliff. The yearly average emission rates of particulate matter, considering hours with precipitation (with no emissions during precipitation events), are provided in Table 3.4.31.

Table 3.4.31 Particulate Matter Emissions – Crushed Ore Stockpile – Operation

	Average Annual Emissions (t/a)		
	Total Particulate Matter (PM)	Particulate Matter less than 10 µm (PM_{10})	Particulate Matter less than 2.5 µm ($PM_{2.5}$)
Crushed Ore Stockpile	0.013	0.012	0.002

Notes:
t/a = tonnes per year.

Fugitive emissions of particulate matter from the TSF beaches may be generated from wind erosion of dry surfaces, on dry windy days. Stantec estimated hourly particulate matter emissions using wind speed and precipitation data for six years from the Fredericton weather station and the area of the TSF beaches. It was assumed that of the total area of the beaches (20 km^2), approximately 1/3 of the beach is active (*i.e.*, wetted by new material addition). The yearly average emission rates of particulate matter, considering hours with precipitation (with no emissions during precipitation events), are provided in Table 3.4.32.

Table 3.4.32 Particulate Matter Emissions – TSF Beaches – Operation

	Average Annual Emissions (t/a)		
	Total Particulate Matter (PM)	Particulate Matter less than 10 µm (PM_{10})	Particulate Matter less than 2.5 µm ($PM_{2.5}$)
TSF Beaches	89.7	1.35E-4	2.02E-5

Notes:
t/a = tonnes per year.

Stantec applied the metal concentrations in the ore to estimate fugitive emissions of specific metals from truck unloading at the crusher, primary crusher operation, material transfer onto the conveyor, material transfer onto the crushed ore stockpile, and stockpile wind erosion fugitive dust. An adjusted breakdown was applied to wind erosion fugitive dust emissions from the TSF beaches; for these, it was assumed that the tailings will not contain any molybdenum or tungsten. The average concentration of trace metals in the ore as supplied by SRK Consulting is provided in Table 3.4.33.

Table 3.4.33 Average Trace Metals Concentration in the Ore

Metal	Units	Value (Average)
Aluminium (Al)	%	1.8
Arsenic (As)	mg/kg	41
Boron (B)	mg/kg	<20
Cadmium (Cd)	mg/kg	1
Cobalt (Co)	mg/kg	13
Total Chromium (Cr)	mg/kg	67
Copper (Cu)	mg/kg	180
Lead (Pb)	mg/kg	45
Lithium (Li)	mg/kg	43
Manganese (Mn)	mg/kg	720
Total Mercury (Hg)	mg/kg	0.01
Molybdenum (Mo)	mg/kg	300
Nickel (Ni)	mg/kg	20

Table 3.4.33 Average Trace Metals Concentration in the Ore

Metal	Units	Value (Average)
Selenium (Se)	mg/kg	0.8
Thallium (Tl)	mg/kg	0.97
Tungsten (W)	mg/kg	530
Uranium (U)	mg/kg	2.8
Vanadium (V)	mg/kg	80
Zinc (Zn)	mg/kg	150

3.4.2.5.2 Sound and Vibration Emissions

To estimate emissions of sound during Operation, Stantec developed a sound emissions inventory for based on the Project activities. The sources of sound included in the inventory are:

- operation of heavy mining equipment;
- transportation of personnel, material, and product;
- crushing/processing equipment; and
- intermittent drilling and blasting activities.

Similar to Construction, Stantec estimated sound emissions from heavy equipment and drilling activities based on publically available literature (FHWA 2006).

The activity data and sound power levels associated with Operation are presented in Table 3.4.34.

Table 3.4.34 Sound Inventory – Operation

Equipment Type	Number of Units	Sound Pressure Level (dB_A) at 15 m	Sound Power Level (dB_A)
Electric Drill	2	81	112
Blasthole Loader	1	79	110
Hydraulic Shovel	3	79	110
Bulldozer (580 hp)	1	82	113
Wheeled Bulldozer	1	82	113
Haul Truck	11	76	107
Water Truck	1	75	106
Bulldozer (410 hp)	3	82	113
Grader	1	85	116
Multi-tool	1	74	105
Excavator	1	81	112
Mobile Screening Plant	1	87	118
Light Plant	4	81	112
Forklift – 10 t	1	75	106
Forklift – 30 t	1	75	106
Fuel/Lube Truck	1	75	106

Primary crushing equipment is located within a three-sided structure to reduce noise. Rock is dumped into the crushing equipment by haul trucks. Northcliff provided sound measurements for the operation of a similar crusher at the Gibraltar Mine in British Columbia; the maximum measured sound pressure level was 85 dB_A at 15 m while a haul truck was dumping ore.

The sound power level associated with the conveyor belt was calculated from the maximum measured sound pressure level for a similar conveyor belt at the Gibraltar Mine in British Columbia. The measured sound pressure level was 70 dB_A at 15 m.

The ore processing plant is enclosed to protect the equipment from the weather. Northcliff provided sound measurements for the operation of a similar ore processing facility at the Gibraltar Mine in British Columbia; the maximum measured sound pressure level was 74 dB_A at 15 m.

The contribution of the movement of on-site light duty truck traffic is assumed to be negligible in comparison with heavy equipment operation on-site. There will be sound emissions from transportation vehicles on the site access road and internal site roads. The number and types of transportation vehicles accessing the site on a daily basis was provided by Northcliff, based on the planned activities. The traffic information entered into the model is provided in Table 3.4.35.

Table 3.4.35 Project Traffic – Operation

Vehicle Type	Vehicles per Hour	Starting Point
Heavy Trucks	2	Through Napadogan
Passenger Trucks/Vehicles	15	Through Napadogan

Notes:
For modelling of traffic noise the change through Napadogan was the focus as this represents the largest change from existing traffic. 15 vehicles through Napadogan based on estimate of 60 per day from Route 8 to SSA, with 4 peak hours per day assumed (shift changes).

The main sources of vibration during Operation are the movement of the loaded trucks from the pit to the crushing equipment and the crushing equipment itself. Similar to the assessment of vibration from construction equipment, reference PPVs from loaded trucks were found and are provided in Table 3.4.11 (above).

3.4.2.5.3 Treated Surplus Water Release

As discussed in Section 3.4.2.3.4, all non-contact water will be diverted away from the Project site, and all mine contact water within the PDA will be collected in the TSF. Starting in approximately Year 8 of Operation, and as discussed in Section 3.4.2.3.7 above, surplus water from the TSF will be treated as necessary, and monitored, to ensure acceptable water quality, and released to the former Sisson Brook channel. In the remainder of this EIA Report, this surplus water treatment and release during Operation is assessed under the activity “Mine Waste and Water Management”, to avoid duplication.

Liquid wastes (containing suspended solids) from the ore processing will be minimized by recycling reagents and water wherever feasible. Sumps in each process area are fed back into the process where feasible or directed to the TSF for settling and reuse of water. Liquids and slurries that cannot be reasonably recycled back into the process will be safely stored in the TSF with pond water being recirculated to the ore processing plant.

3.4.2.5.4 Mining Waste Disposal

As discussed in Sections 3.4.2.3.2 and 3.4.3.2.3, tailings and waste rock from the Operation of the Project will be stored permanently in the TSF, as previously described. PAG waste rock (and tailings) will be stored subaqueously to effectively inhibit the potential generation of acid and metal leaching. This avoids the potential for ML/ARD from the waste rock if stored in land-based piles. In the remainder of this EIA Report, the disposal of tailings and waste rock in the TSF during Operation is assessed under the activity "Mine Waste and Water Management", to avoid duplication.

The process of refining tungsten concentrate to ammonium paratungstate (APT) is summarized above in Section 3.4.2.2.3 and in Figure 3.4.8. This process generates two waste streams that will be disposed of within the TSF:

1. The first waste stream is undigested residue from the concentrate digestion process. It is generated as a filter cake (about 25% water, by weight), containing calcium hydroxide with trace minerals and oxides, at a rate of approximately 68 tonnes/day.

2. The second waste stream is raffinate[2] generated during the solvent extraction process that converts sodium tungstate to ammonium tungstate. The raffinate consists of 10% to 15% sodium sulfate in a sulphuric acid solution with minor concentrations of molybdenum, silicates and aluminum, and likely some trace metals. The raffinate will be mixed with lime and pH adjusted in an agitation tank, and will then be passed through a crystallizer to remove the metals and other constituents as a dry product at a rate of approximately 0.8 tonnes per day. The product is primarily sodium sulphate, with minor components of calcium sulphate (gypsum) and trace metals.

These two waste streams cannot be stored directly in the TSF because their effects on TSF water quality would reduce the ore concentrator efficiency (*e.g.*, calcium ions would adversely affect tungsten flotation recoveries) and seepage water quality (notably regarding sodium and sulphate). Therefore, they will be placed in storage cells within the TSF basin, but above the active TSF pond level during Operation. The cells will be double-lined with HDPE, and also equipped with a leak detection and recovery system, to ensure they will not leak to the TSF during Operation. During Operation, precipitation recovered from an open cell will be pumped to treatment before reuse or discharge. Fences or other suitable safety measures will be used as needed to limit access by people or animals to the cells during Operation.

Over the life of the Project, there may be up to six of these cells, staged consecutively from the northwest to the northeast of the plant site between the elevations of approximately 335 masl and 370 masl within the TSF. Only three cells are required to contain the estimated volume of solids described above: 400,000 m^3, 300,000 m^3 and 650,000 m^3 for Cells 1, 2 and 3, respectively. Figures 3.4.11 through 3.4.13 below depict the cells at the end of each period. Additional cells have been considered as a contingency measure in the event that the actual quantity or density of the wastes varies from the current estimate.

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[2] In solvent extraction, a "raffinate" is the liquid stream which remains after solutes from the original liquid are removed through contact with an immiscible liquid.

Cell 1 will be built and operated first (Figure 3.4.11) and, as it fills and the level of tailings, waste rock and water rises in the TSF, it will be capped and closed and Cell 2 will go into operation at a higher elevation (Figure 3.4.12). Similarly, Cell 2 will be operated, closed and superseded by Cell 3 at a higher elevation (Figure 3.4.13). The crest elevation of the Cell 3 embankments will be about 370 masl; at Closure the TSF pond elevation is at about 376 masl, so Cell 3 will be submerged under about 6 m of tailings and water.

The solids stored in each cell will be allowed to consolidate to the extent possible prior to closure of the cell. Methods that may be used to enhance consolidation include allowing the solids to air dry during the dry summer months prior to closure, or the use of wick drains and strip drains. Closure of a cell will involve capping it with a HDPE top liner before it becomes encapsulated by tailings within the TSF.

Once the cells are encapsulated within the TSF, it is highly unlikely that pore water in the tailings would interact with the material in the cells. The HDPE top and bottom liners present a very low permeability barrier to groundwater flow; therefore, seepage between the TSF and the groundwater beneath it would flow preferentially around the cells, rather than through them. Furthermore, when the cells are closed and encapsulated, the groundwater conditions within the TSF will be such that seepage into or out of the cells is improbable.

The size, number and location of the cells will be confirmed during the Basic and Detailed Engineering design phases of the Project.

The cells will be designed to be stable, self-contained structures within the TSF, and gradually covered with tailings, so that their contents are securely isolated. Thus, in the highly unlikely event of a failure of TSF containment, the cells and their contents would remain intact.

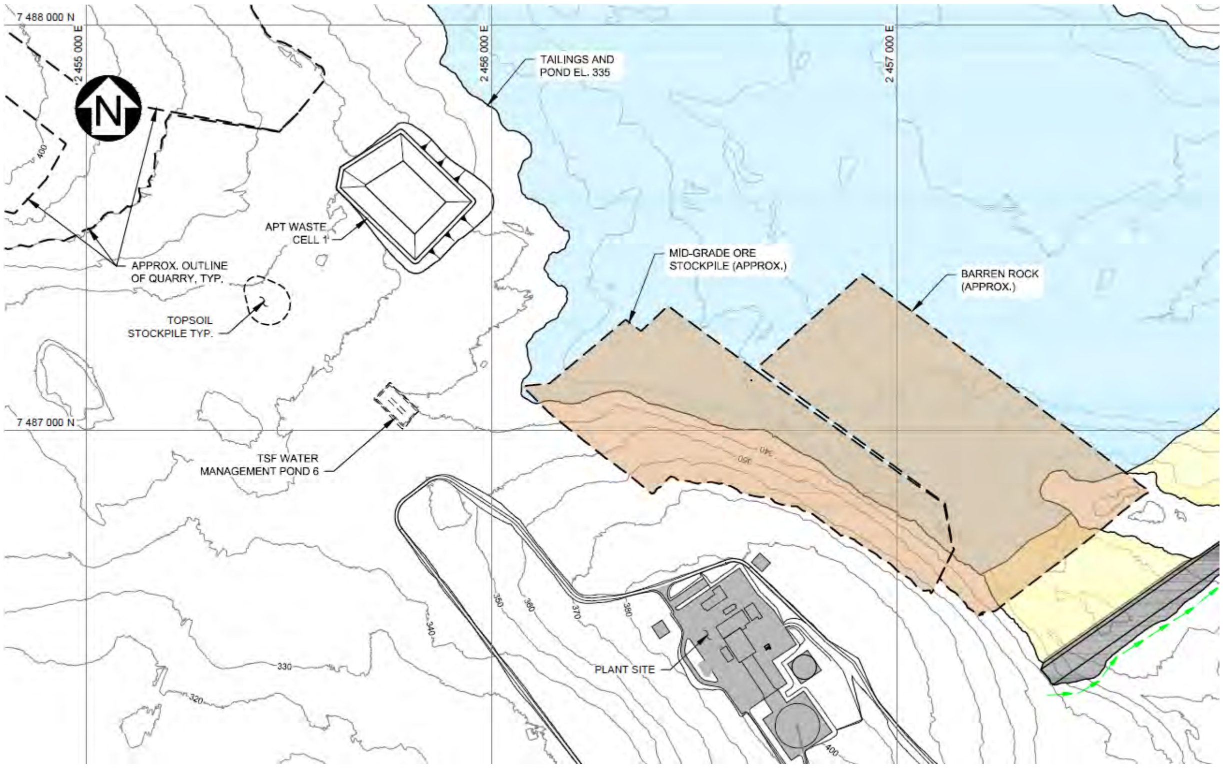


Figure 3.4.11 APT Waste Cell 1 – Years 1 to 8

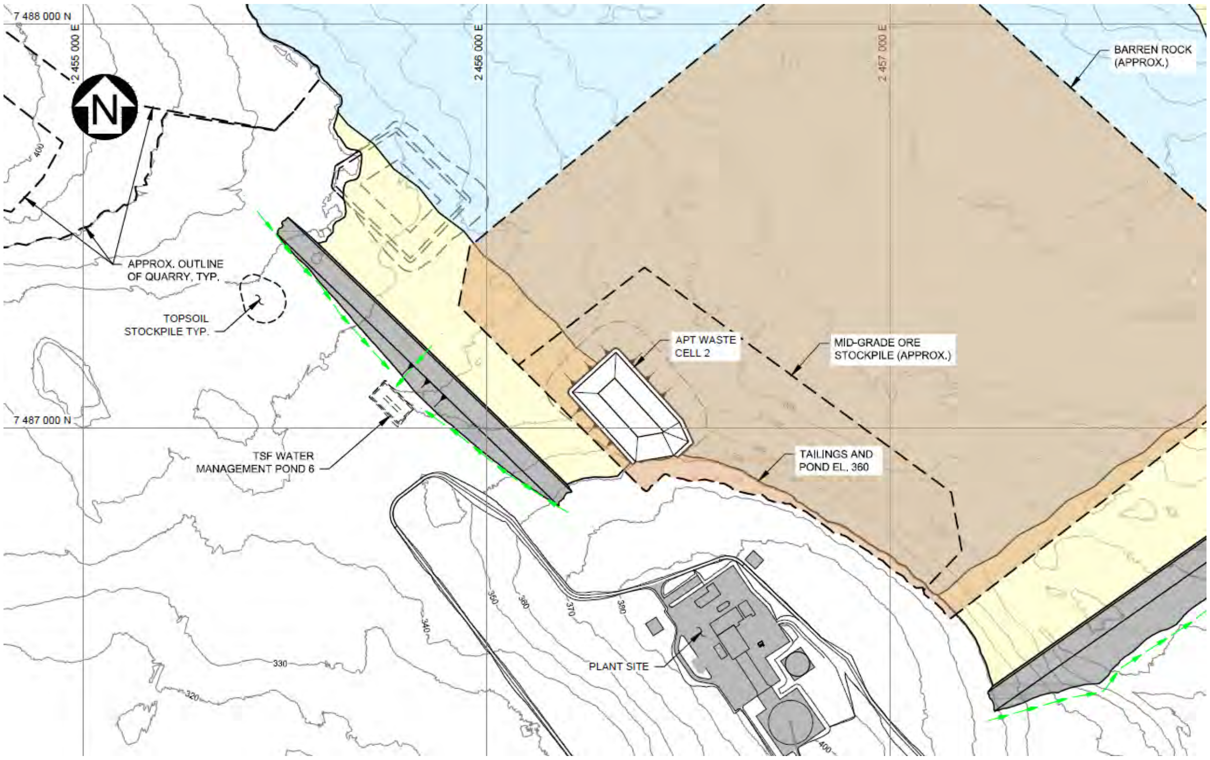


Figure 3.4.12 APT Waste Cell 2 – Years 9 to 14

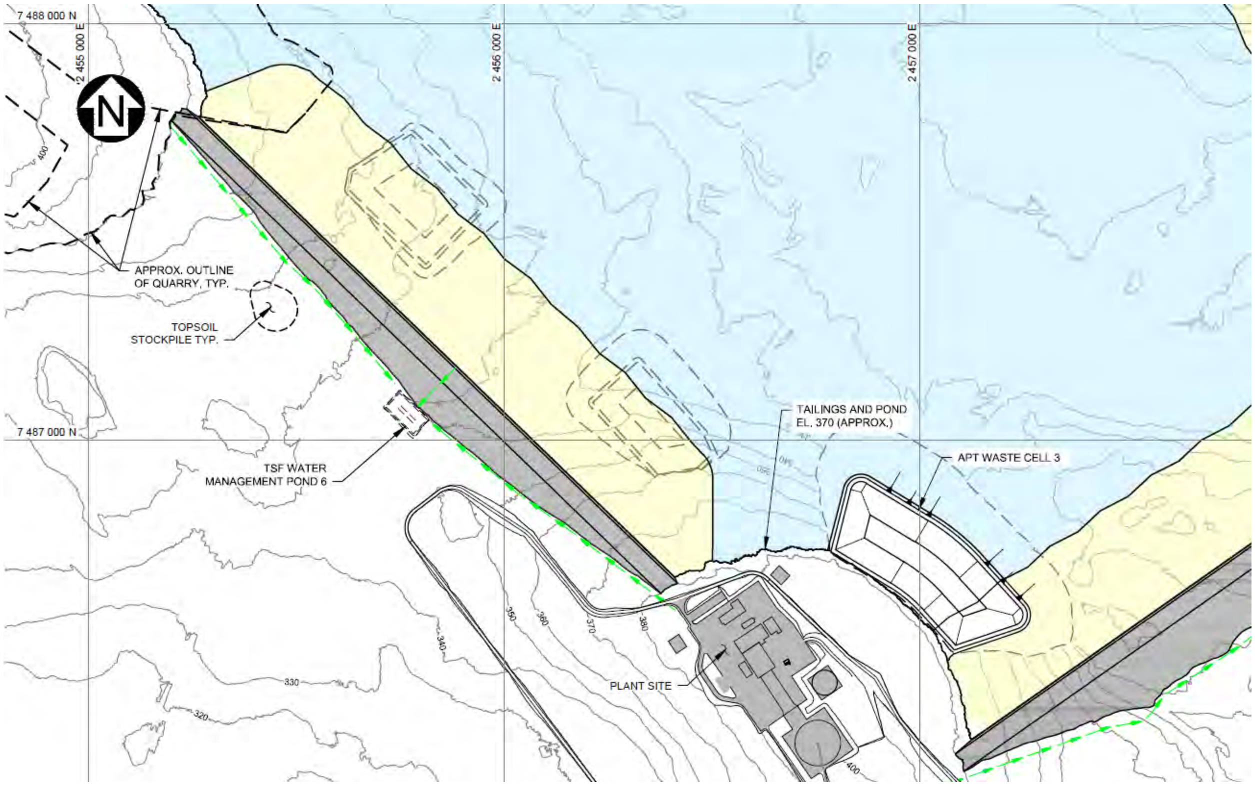


Figure 3.4.13 APT Waste Cell 3 – Years 15 to 27

3.4.2.5.5 Non-Mining Solid Waste Disposal

Non-mining waste refers to wastes generated beyond the open pit mining operation including in the ore processing plant (concentration and APT processes) as well as other site buildings (such as the administration and maintenance buildings). SML will re-use or recycle waste materials where possible, and dispose of other wastes at approved facilities.

3.4.2.6 Transportation

Once commissioning activities are completed, the Project Operation and the traffic generated will be fairly uniform. Estimates of the truck trips per month have been broken down by inbound shipments of production input materials and outbound product, as well as various services used during the Operation phase. The estimated daily average number of mine workers that will be employed in the Project Operation will drive into the site in their own vehicles.

Road traffic generated during the Operation phase of the Project will be comprised of:

- Passenger vehicles (mine workers' automobiles, SUVs, vans and pick-ups); and
- Trucks (for transport of inbound shipments of production input materials and outbound product, and various services for mine operations).

Truck traffic generated by the Project during its Operation will travel over segments of the public Provincial highway network and PSA/SSA Routes within the Project area to the site access road.

The Operation phase traffic generated by the Project will accumulate as it approaches the Project site. All Project generated traffic volumes were converted to one-way daily (ADT) volumes to correspond with the existing AADT traffic. A summary of the average daily traffic that will be generated during Operation of the Project is presented in Table 3.4.36.

Table 3.4.36 Average Daily Traffic (ADT) Generated During Operation

Traffic Components	Round Trips per day	Average Daily Traffic (ADT) (one-way)
Vehicles To/From Project Site		
Trucks (at highest month of Project Operation activity to site)	14	28
Mine Workers' Autos (direct to site, two per vehicle)	100	200
Total	**114**	**228**

Source: exp Services Inc. (2013a; 2013b).

The Project-generated traffic volumes reflect the maximum volumes generated at the site once the mining operation is at its full level of activity, and a steady state mining operation will continue from that point forward at this average daily traffic generation level. The additional traffic volumes predicted to be generated by the Project operation total 228 ADT.

3.4.2.7 Employment and Expenditure

Mining operations will require various types of workers on-site, including but not limited to management personnel, heavy equipment operators, contractors, process operators, and maintenance personnel. It is expected that the Project will generate direct employment for up to 300 workers during the Operation phase of the Project, generally split between two 12-hour shifts per day.

Table 3.4.37 shows the total operating expenditures by main component of the Project over its life. At present, the projected expenditures for the Operation phase total $4.09 billion, including $3.9 billion in operating expenditures and $195.8 million in sustaining capital, over the life of the Project.

Table 3.4.37 Total Operating Expenditures

Component	Total Operating Expenditures	
	Millions of Canadian dollars	% of total expenditure
Milling	$2,001.3	48.9%
Mining	$1,168.1	28.5%
APT Plant	$428.3	10.5%
Tailings	$167.1	4.1%
Administration	$132.3	3.2%
Sustaining Capital	$195.8	4.8%
Total (millions, CAD$)	**$4,092.9**	**100.0%**

Source: EcoTec (2013).

Table 3.4.38 shows the expected breakdown of expenditures by year.

Table 3.4.38 Operating Expenditures by Year

Year during Operation Phase	Annual Operating Expenditures (Millions of Canadian dollars)	Year during Operation Phase	Annual Operating Expenditures (Millions of Canadian dollars)
1	$152.9	15	$159.6
2	$157.0	16	$161.5
3	$147.1	17	$151.4
4	$149.0	18	$155.3
5	$152.8	19	$155.1
6	$152.7	20	$153.4
7	$152.1	21	$162.2
8	$150.8	22	$149.8
9	$150.4	23	$148.1
10	$164.0	24	$147.6
11	$159.3	25	$142.9
12	$155.3	26	$138.5
13	$151.1	27	$126.5
14	$146.6		
Total			**$4,092.9**

Source: EcoTec (2013).

3.4.3 Decommissioning, Reclamation and Closure

The Decommissioning, Reclamation and Closure phase extends from completion of mining and ore processing activities during Operation to Post-Closure of the facilities. Activities in this phase will be focused on the decommissioning, land reclamation, and closure of the Project site. All mining facilities not needed post-Operation will be decommissioned at the end of the Project Operation, and the mine site will be restored to meet desired end land uses and as required under provincial and federal legislation and regulations.

In general, all facilities, buildings and other infrastructure will be removed and the sites reclaimed except for those that will be used for ongoing care and maintenance of the site (*e.g.,* water treatment, TSF inspections). The water management system will be reconfigured as needed to ensure the long-term stability of the site. The TSF embankments and beaches will be capped and re-vegetated, and a spillway will direct run-off to the open pit. The open pit is estimate to take approximately 12 years to fill during Closure, between Years 28-39. Once the pit is completely full (at approximately Year 40), Post-Closure begins and water (treated, if necessary, until it meets regulatory requirements) will discharge to the former Sisson Brook channel.

A description of the current plans for Decommissioning, Reclamation and Closure of the Project is provided in the document entitled “Sisson Project: Conceptual Decommissioning, Reclamation, and Closure Plan” (EvEco 2013) prepared for SML. These Plans are based on best professional judgment regarding the desired end land uses of the site as conceived at this time. These end land uses will need to be discussed and confirmed by the Government of New Brunswick in consultation with stakeholders, First Nations, and other interested parties, at the appropriate time over the life of the Project. Further reclamation information is presented in Section 3.4.3.6 and Appendix H.

3.4.3.1 Site Description at Closure

The site will include the following elements at Closure:

- the open pit will be flooded to create an aquatic feature;
- permanent submersion of waste rock within the TSF and at the bottom of the open pit;
- TSF embankments and beaches will be undergoing re-vegetation with suitable species to provide forested, wetland, and open water habitats suitable for wildlife;
- engineered channels connecting the quarry to the TSF pond, and the TSF pond to the open pit to manage the collection, treatment if necessary, and discharge of on-site water to the environment;
- disturbed areas around the open pit, TSF, the former ore processing plant area, and most of the plant site will be decommissioned and reclaimed to forested, wetland and shrub-riparian habitats primarily suitable for wildlife use with potential for traditional, recreational and commercial forestry use;
- appropriate surface and groundwater drainages from the site and the ongoing restoration of constructed drainages to open water will be established, with shrub-riparian and aquatic habitats suitable for use by wildlife and fish; and
- site buildings, equipment, roads and power supply needed for care and maintenance of the site after operations cease.

The general strategies for Decommissioning, Reclamation and Closure are to:

- decommission and remove all buildings, equipment and infrastructure not required for future care and maintenance of the site;
- stabilize terrestrial and aquatic environments;
- remediate disturbed areas using passive natural systems;
- recreate a natural environment dominated by native vegetation;
- restore visual aesthetics; and
- restore land use potential and possibly create new opportunities.

3.4.3.2 Activities during Decommissioning, Reclamation and Closure

In the short-term and conceptually, Reclamation and Closure activities will focus on site restoration (*i.e.,* beginning the process of re-establishing existing vegetation communities) as much as rehabilitation (*i.e.,* re-establishing ecosystem processes and capability). The short-term objective will be to establish a stable growing medium to support pioneer vegetative species as soon as possible.

Activities will include removing buildings, equipment and unneeded roads, preparing new landforms and covering them with overburden and soil, ensuring stable site drainage, and planting prepared areas with native plant species. New channels to direct run-off from the quarry and TSF into the open pit to accelerate its filling will also be constructed at this time.

3.4.3.2.1 Decommissioning

Most of the site infrastructure will be decommissioned and removed. Plant site buildings and equipment no longer required include the primary ore crusher, ore concentrator, APT plant, the SME process facility, conveyors, warehouse, truck service bays, the laboratory and the vehicle fueling stations. The administration office and its fresh water supply and sanitation system, the site water management and treatment system, and one or two small buildings for housing equipment or supplies will be retained until no longer needed. All of the removable assets, which include everything except the buildings, will be removed and sold or disposed of prior to or concurrent with their dismantling.

All access roads, power supplies, sanitation infrastructure, fresh water supplies, water management structures, and other utilities, will be decommissioned unless required for care and maintenance of the site during Closure and Post-Closure. All on-site power supplies and utility poles no longer needed will be decommissioned and removed from the site to approved off-site facilities. The main electrical transmission line supplying power to the site will be retained until the site is fully reclaimed, capability goals for each end land use objective have been achieved, and water resources have been restored to sustainable levels. At this point, this line may also be decommissioned and reclaimed. The electrical transmission line will remain the property of NB Power who will be responsible for planning and executing any decommissioning and subsequent reclamation activities of all aspects of the electrical transmission line.

Sanitation infrastructure and fresh water supplies not required for post-Operation work will be decommissioned. Above-ground structures, pumps, and pipes will be removed, sold or recycled to an approved off-site facility. All below-ground structures will remain in place and reclaimed as part of the plant site reclamation.

Following removal of the assets, most buildings will be either dismantled for re-use at another site or cut into pieces and sold or recycled as steel scrap. Foundations will be broken or blasted down to or below ground level, where possible, and then backfilled to create natural-looking landforms. Other surplus materials (*e.g.,* sheet metal, insulation, roofing material, and other waste industrial construction materials) will be recycled or disposed of at an approved off-site facility. Chemicals, waste products and potentially hazardous materials will be disposed of according to local requirements.

During the decommissioning work, an investigation will be conducted to determine the presence, if any, of contamination from accidental spills and long-term use of hazardous materials. Any incidents identified will be remediated according to practices approved by NBDELG.

3.4.3.2.2 Reclamation

Reclamation will involve the restoration of the Project site to as near natural conditions as possible. In general, disturbed areas of the site including the former ore processing plant areas and other active areas of the site will be graded and shaped. Slopes will be graded to merge naturally into adjacent undisturbed areas. Grading may include decommissioning ditches and other water management structures that are no longer needed, or enhancing them to provide natural swales for channelling surface water into nearby watercourses. Former building sites, foundations and laydown areas will be capped with overburden.

It will not be possible to reclaim the open pit other than as an open-water landscape feature once a pit lake with acceptable water quality has been established Post-Closure. There are no reclamation options for the bare rock faces that will not require intensive intervention and the potential benefits likely outweigh the level of effort given safety concerns and that success will be uncertain. The benches that may remain exposed above the pit lake level will likely be subject to wide temporal and spatial variability in moisture availability, depending on run-off from surrounding slopes, seepages from surrounding pit walls, and seasonal changes. The focus for reclamation will therefore be to encourage natural re-vegetation, with limited intervention. Over time, some natural habitats will emerge, such as rock outcrop on the pit rim and walls, possibly wetland habitat on shallow, submerged rock terraces, and upland forest in areas surrounding the pit. The main end land use objectives for the open pit will thus be open water feature with some use by terrestrial wildlife such as birds, waterfowl, amphibians, reptiles and small mammals. Large mammals will be excluded from the pit rim by security fencing.

Specifically for the TSF embankments and exposed TSF beaches, reclamation may include the following.

- The open water of the TSF pond will be an aquatic feature, used for resting and escape terrain by waterfowl.
- The beaches adjacent to the open water will be flat to gently sloping shorelines, reclaimed as shrub-riparian or open water wetland to provide forage, cover and nesting habitat for waterfowl and shorebirds.
- The top of the TSF embankment will be maintained as an access road.
- The downstream slopes of the TSF embankments may be reclaimed to grassland and forest cover of varying composition depending on aspect and moisture regime. Upper and south-facing slopes of the embankments will likely be subject to summer drought, so may be reclaimed to an upland forest habitat such as tolerant hardwood or intolerant hardwood habitats. The lower and north-facing slopes may be wetter, so may be reclaimed to spruce-balsam fir or rich softwood habitats. Areas subject to surface erosion may need to be treated with coarse quarry rock, and thus remain exposed as rock outcrop.

Although reclamation of the TSF will focus on forested habitats, the end land use objective will remain primarily wildlife use by mammals, birds, reptiles, amphibians and insects. Commercial forestry use will be discouraged because the TSF is an engineered facility unsuited to logging activity. Over the long term, some of the reclaimed footprint may become suitable for traditional or recreational end land uses.

Exposed areas will be re-vegetated in accordance with the end land use objectives for upland and wetland forests. Areas will be hydroseeded to help accelerate the establishment of a vegetative cover. Hydroseed mixes should include species that are tolerant of drought and infertile conditions, with an emphasis on native species. Although this type of seed blend may not be appropriate to wetter areas, wetter areas can be expected to naturally re-vegetate to full cover within approximately three years.

Once the areas are stable, native shrubs and trees such as speckled alder, grey birch, trembling aspen, and pin cherry will quickly invade within two decades. Except for the area of the TSF within which commercial forestry will be discouraged, spot planting of black spruce, balsam fir, hardwoods or other locally occurring commercial tree species may be appropriate on sites where adequate moisture and mineral soil is present. Where commercial forestry is agreed as an end land use objective in the final, approved Decommissioning, Reclamation and Closure Plan, reforestation of the PDA for future commercial forestry will be undertaken.

3.4.3.2.3 Closure

During Closure, the non-contact surface water diversion channels outside the PDA will be maintained. Engineered channels will be established between the quarry and the TSF, and between the TSF and the open pit, to direct run-off to the open pit and accelerate its filling with water.

The water management ponds around the TSF will be maintained to collect TSF embankment run-off and seepage, and to pump it to the TSF until it becomes of sufficient quality to allow its discharge into downstream drainages.

The open pit will take up to about 12 years to fill (approximately Years 28-39), and until it does there will be no discharge of mine contact water from the site, with the possible exception of water within the water management ponds as just discussed. The open pit will be allowed to fill to an elevation that ensures it is a groundwater sink (*i.e.,* groundwater around the pit will only flow into it); this elevation will be maintained by pumping the lake water to a reactivated or new water treatment plant. Filling of the open pit to this elevation will mark the end of the Closure period and the beginning of Post-Closure.

The Site will include the following elements at Closure:

- the open pit that will be flooded to create an aquatic feature;
- permanent submersion of barren rock and mid-grade ore within the TSF and at the bottom of the open pit;
- TSF embankments and beaches that will be undergoing re-vegetation with suitable species to provide forested, wetland, and open water habitats suitable for wildlife;
- engineered channels connecting the quarry to the tailings pond and the tailings pond to the open pit, to manage the collection, treatment and discharge, as necessary, of on-site water;
- disturbed areas around the open pit, TSF, the former ore processing area (*i.e.*, primary crusher), and most of the plant site that will be decommissioned and reclaimed to forested, wetland and/or shrub-riparian habitats primarily suitable for wildlife use with potential for traditional, recreational and commercial forestry use;

- appropriate surface and groundwater drainages in and around the site and the ongoing restoration of all surrounding watercourses to open water, shrub-riparian and aquatic habitats suitable for use by wildlife and fish; and

- site buildings, equipment, roads and power supply needed for care and maintenance of the site after Operations cease.

The conceptual closure and reclamation plan that would be implemented at various stages of the mine development is presented on Figure 3.4.14 to Figure 3.4.17. The plan has been divided into the following areas:

- TSF Reclamation;
- Open Pit Reclamation;
- Barren Rock and Mid-Grade Ore Reclamation;
- Decommissioning of Mine Site Infrastructure; and
- Ongoing Post-Closure Monitoring and Reclamation.

A description of the scope of work for each of the areas is presented below.

TSF Reclamation

- Selective discharge of tailings around the TSF during the final years of plant operations to establish a final tailings beach that will facilitate surface water management and reclamation. A surface pond will be maintained at the centre of the TSF.

- Tailings beaches will be capped with a layer of barren rock and topsoil from the topsoil stockpiles.

- Swales will be excavated in the beaches to make the grade less uniform and promote drainage. The beaches will then be hydroseeded and planted with appropriate vegetation.

- Downstream tailings embankment slopes will be capped with a layer of topsoil and hydroseeded, wherever possible.

- Removal of surface water diversion channels and access roads not required for long term monitoring.

- Construction of a permanent outlet channel and spillway from the TSF to the open pit. The TSF and surface pond will be designed to attenuate storm inflows to minimize the magnitude of spillway discharge flows and hence the size of the outlet channel.

- Removal of the water management ponds and collection systems at such time that suitable water quality for direct release is achieved.

Open Pit Reclamation

- A perimeter fence will be installed around the open pit.
- The pit will fill naturally with groundwater, precipitation and TSF discharge.
- Construction of a permanent outlet channel and spillway from the open pit to Sisson Brook.
- Open pit discharge will require water treatment prior to downstream release.

Barren Rock and Mid-Grade Ore Reclamation

- Re-grading of the barren rock dump and mid-grade ore stockpile within the TSF to ensure permanent submersion below the final TSF elevation to mitigate potential onset of acid generation.

Decommissioning of Mine Site Infrastructure

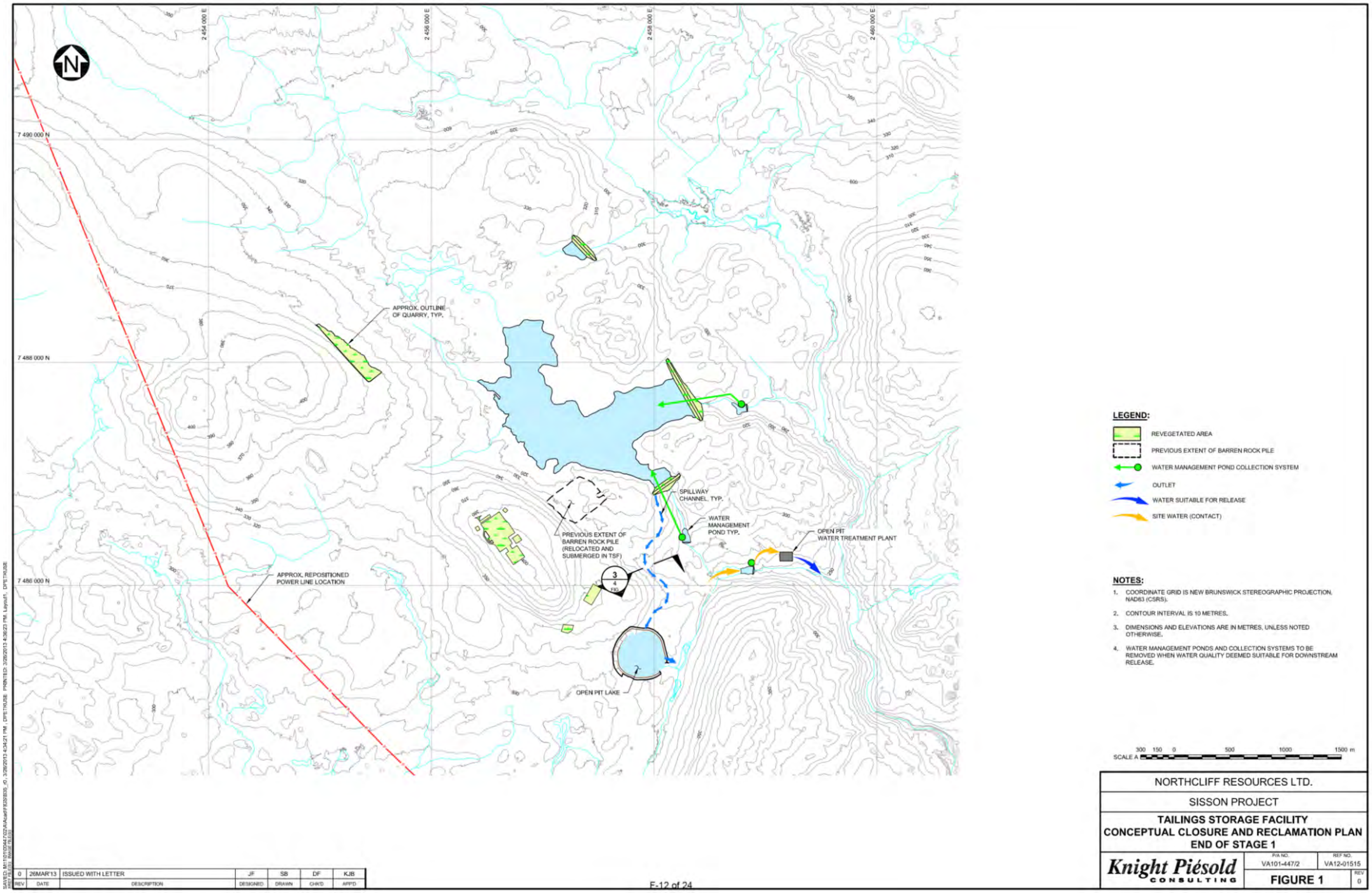
- Decommissioning and removal of all surface facilities and buildings.
- Building materials, pipelines, pumps, electrical equipment, septic systems, and machinery will be trucked to the nearest acceptable disposal facility and/or will be sold (if possible).
- Concrete foundations will be demolished and buried on site.

Ongoing Post-Closure Monitoring and Reclamation

Certain aspects of the Reclamation Plan will require an ongoing commitment beyond the initial closure and active reclamation period. This generally includes engineering support, reclamation and water quality monitoring, and site maintenance.

Specific activities for the Site will include:

- maintenance of electrical infrastructure to ensure available power for needed Site equipment;
- maintenance of geotechnical instrumentation for long-term monitoring of the stability of the TSF;
- operation of the water treatment facility, as needed, to treat all surplus site water for discharge to ensure it will meet the Project’s permit conditions for discharge water quality;
- upkeep of water management infrastructure as needed, including ditches, engineered channels, WMPs, and groundwater monitoring and pump-back wells, to monitor, capture and pump runoff and seepage, if any, back to the TSF;



NOTES:

1. COORDINATE GRID IS NEW BRUNSWICK STEREOGRAPHIC PROJECTION, NAD83 (CSRS).
2. CONTOUR INTERVAL IS 10 METRES.
3. DIMENSIONS AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.
4. WATER MANAGEMENT PONDS AND COLLECTION SYSTEMS TO BE REMOVED WHEN WATER QUALITY DEEMED SUITABLE FOR DOWNSTREAM RELEASE.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	26MAR'13	ISSUED WITH LETTER	JF	SB	DF	KJB

Figure 3.4.14 Conceptual Closure and Reclamation Plan - End of Stage 1

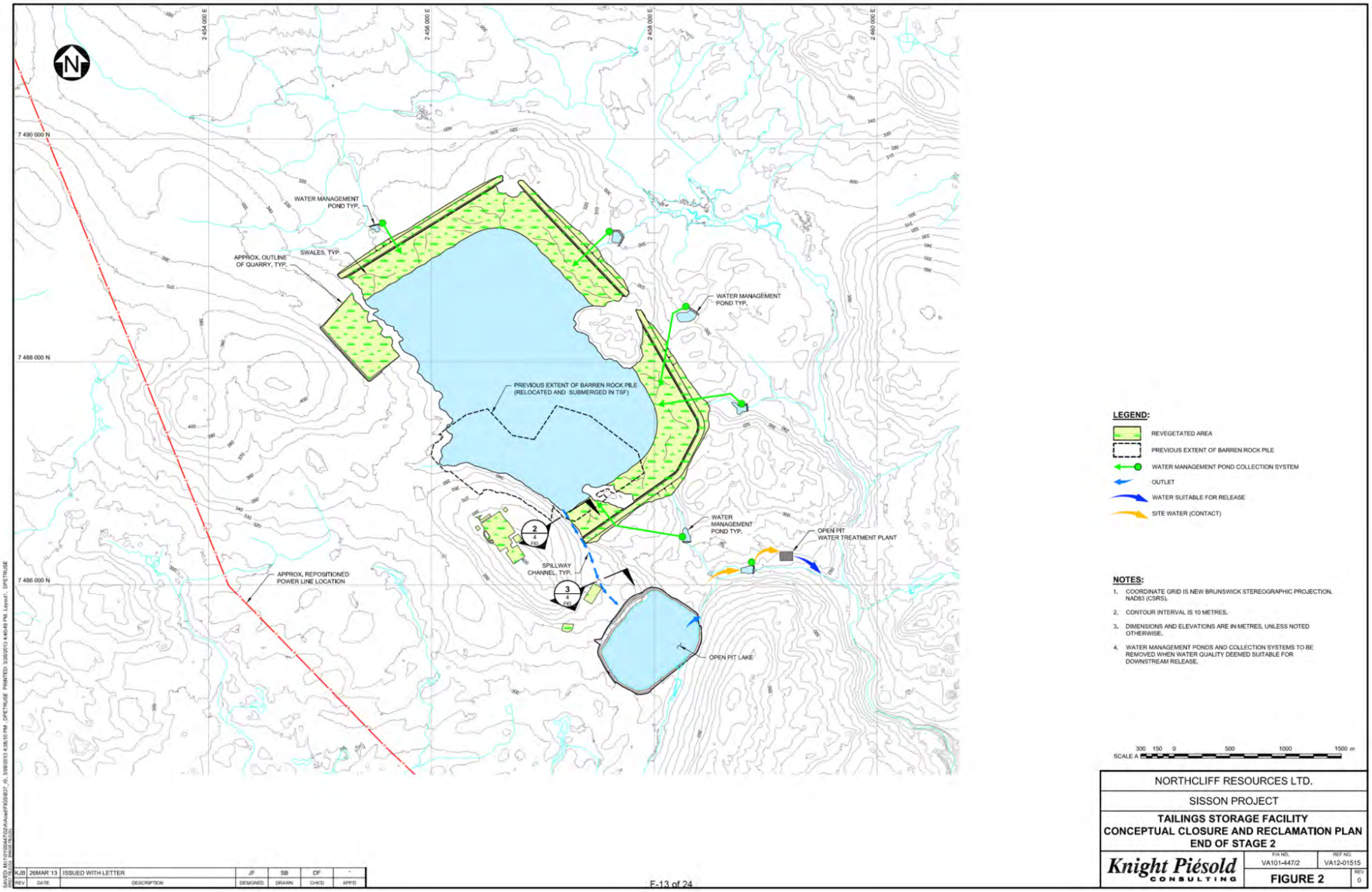
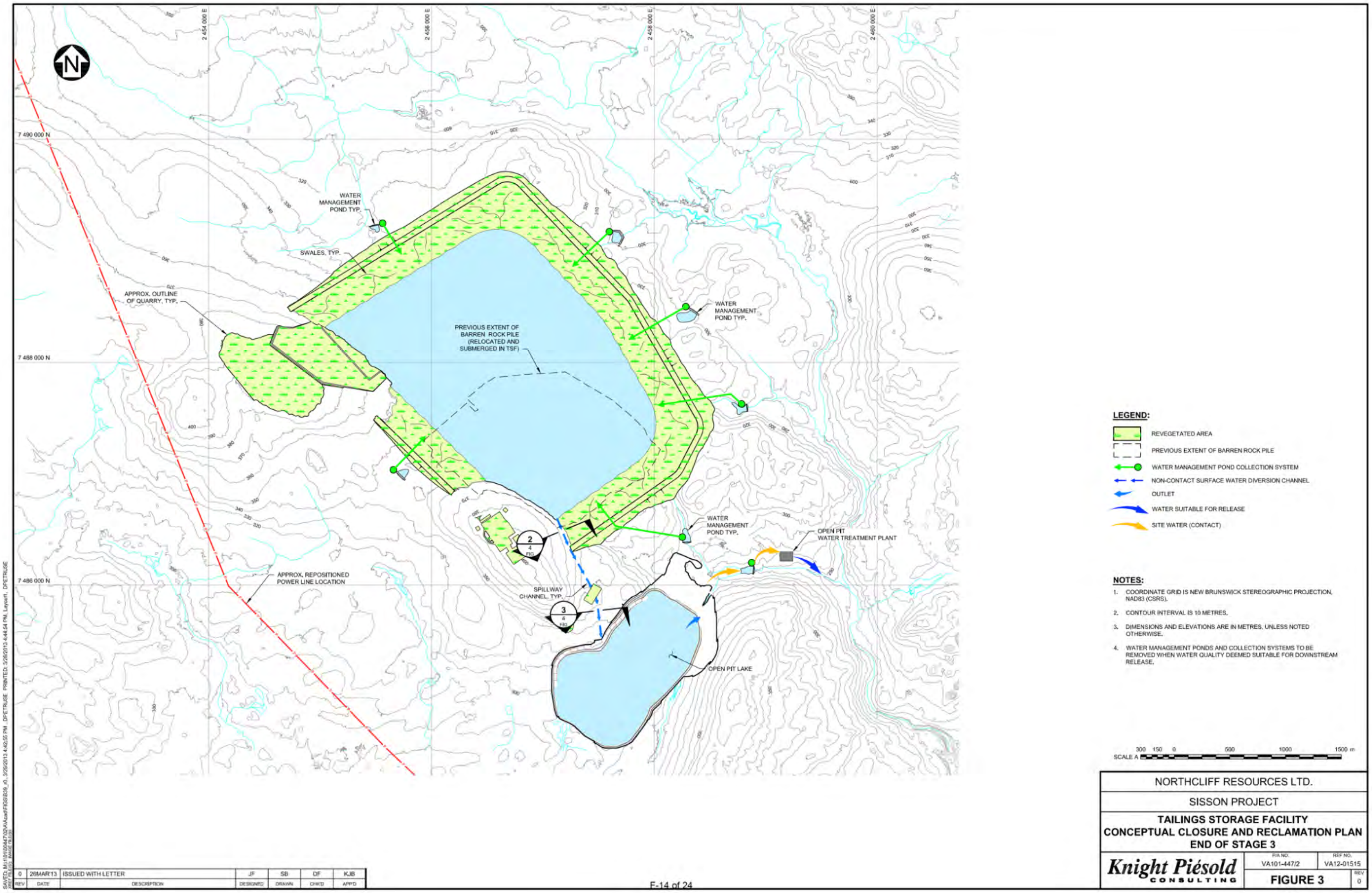


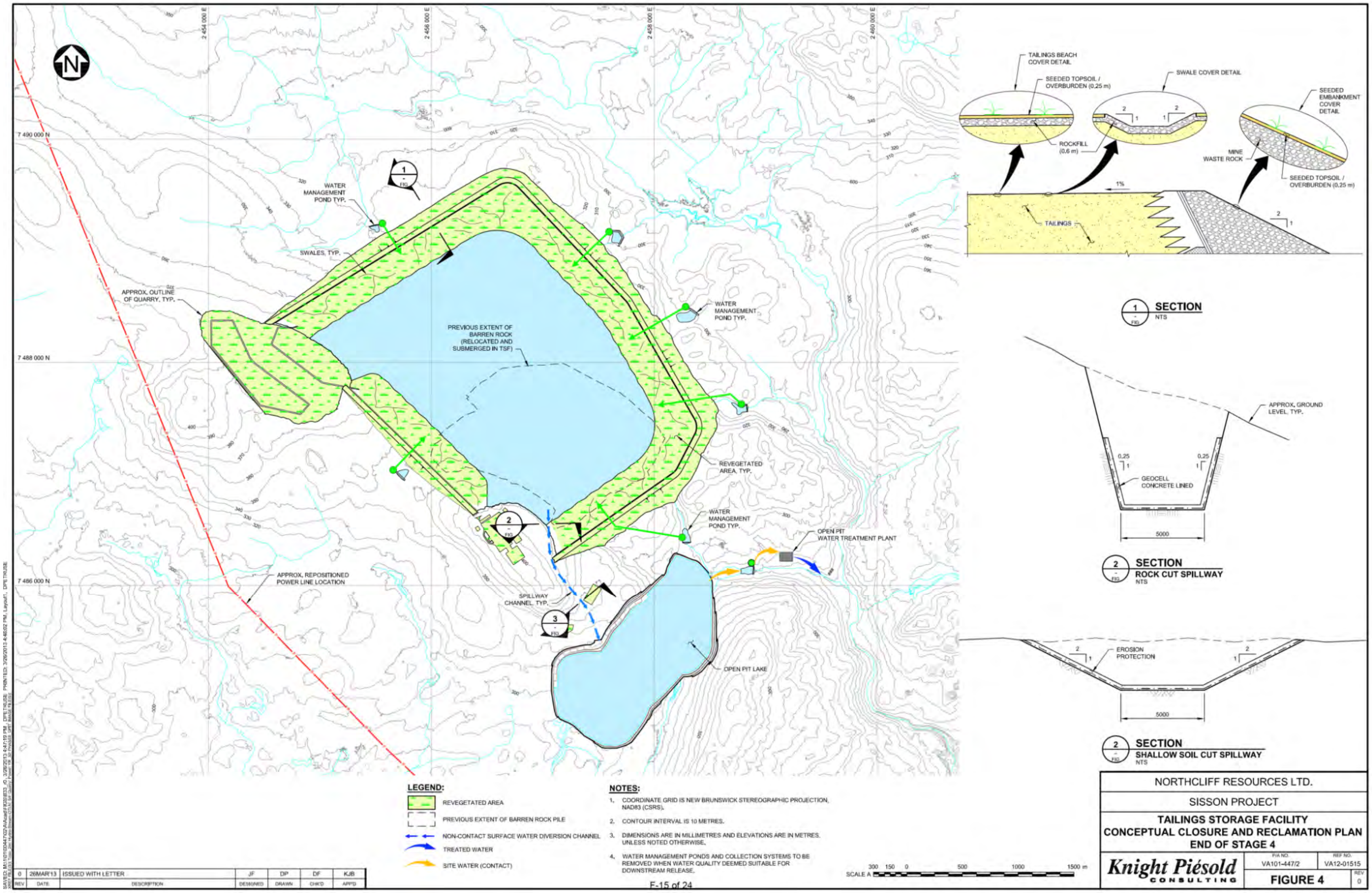
Figure 3.4.15 Conceptual Closure and Reclamation Plan - End of Stage 2



NOTES:

1. COORDINATE GRID IS NEW BRUNSWICK STEREOGRAPHIC PROJECTION, NAD83 (CSRS).
2. CONTOUR INTERVAL IS 10 METRES.
3. DIMENSIONS AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.
4. WATER MANAGEMENT PONDS AND COLLECTION SYSTEMS TO BE REMOVED WHEN WATER QUALITY DEEMED SUITABLE FOR DOWNSTREAM RELEASE.

Figure 3.4.16 **Conceptual Closure and Reclamation Plan - End of Stage 3**



NOTES:

1. COORDINATE GRID IS NEW BRUNSWICK STEREOGRAPHIC PROJECTION, NAD83 (CSRS).
2. CONTOUR INTERVAL IS 10 METRES.
3. DIMENSIONS ARE IN MILLIMETRES AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.
4. WATER MANAGEMENT PONDS AND COLLECTION SYSTEMS TO BE REMOVED WHEN WATER QUALITY DEEMED SUITABLE FOR DOWNSTREAM RELEASE.

Figure 3.4.17 Conceptual Closure and Reclamation Plan - End of Stage 4

- water quality monitoring around the Site to support the effective collection and treatment of water, as required, before discharge to nearby watercourses; and
- upkeep of site roads and buildings that are kept active to support ongoing inspection, monitoring, and maintenance.

3.4.3.2.4 Post-Closure

Post-Closure (starting when the open pit is completely full, estimated to be about Year 40), all contact water that needs to be discharged will be treated for as long as is necessary to meet discharge permit conditions, as described above during the Closure period. When the pit lake water quality becomes of sufficient quality to allow its discharge into downstream drainages, it will be allowed to fill and discharge to the former Sisson Brook channel through an engineered channel.

During Closure and Post-Closure, all on-site and downgradient water management features will be reclaimed as open water features, wetlands and/or other appropriate end land uses when no longer needed.

During Post-Closure, when the pit has been filled, the combined water from the TSF and open pit will be treated before discharge to Sisson Brook. Tailings will no longer be deposited in the TSF and it is expected that the water quality in the TSF pond will gradually improve. However, for the purpose of assessing treatment needs Post-Closure, it was conservatively assumed that TSF water quality would remain the same as during Operation (see Section 3.4.2.3.7).

Water treatment will occur during the open water season at between about 12,000 and 97,000 m^3/day (average of 30,000 m^3/day), and it is expected that treatment for arsenic, antimony and dissolved metals will be required. Treatment is planned to include in-pit ferric co-precipitation followed, if required, by in-plant lime treatment for pH adjustment and dissolved metals removal.

In-pit water treatment will be implemented after the spring melt each year. Pit water will be pumped to a mixing tank onshore where ferric sulphate will be added. After reacting with ferric sulphate, the process water will flow to a section of the pit lake that is enclosed with an open-bottom floating baffle curtain made of impermeable liner material (*e.g.*, HDPE). The enclosed section of the pit lake will allow ferric solids to settle to the bottom for permanent disposal. A photograph of such a floating baffle system in a pit lake at a Canadian mine is shown in Photo 3.4.1 below.

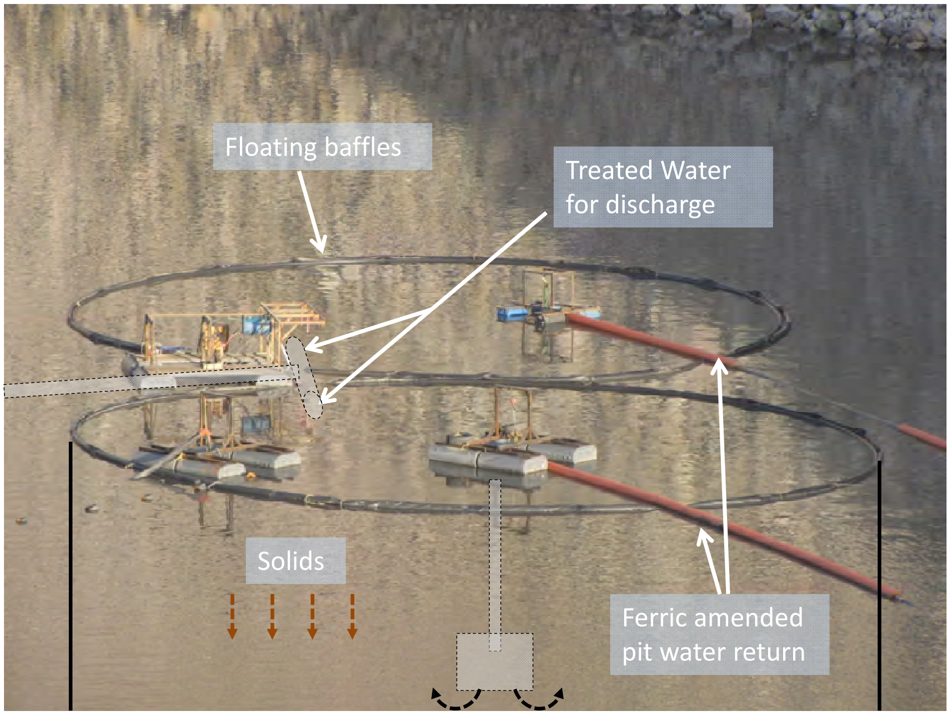


Photo 3.4.1 Example of in-pit floating baffle for water treatment.

If required, lime treatment will consist of pumping metal-depleted water from within the in-pit floating baffle curtain to a pair of reactor vessels onshore. Lime will be added to the first of the reactors in order to raise the pH to a level suitable for discharge. The elevated pH will also cause dissolved metals (such as iron and copper) to precipitate as hydroxide solids. The precipitates will be recovered as lime sludge in the clarifier, and then pumped for disposal in a purpose-built storage cell on-site.

The predicted Post-Closure discharge water quality is provided in Table 3.4.39. The post-water treatment plant (post-WTP) discharge values assume that lime treatment will be implemented.

Table 3.4.39 Predicted Post-Closure Water Quality for Treated Parameters

Parameter	Pit Lake		Post-Ferric Treatment (baffled section of lake)		Post-WTP Discharge		Water Treatment Threshold (mg/L)	*MMER* Discharge Limit (maximum authorized monthly mean concentration, column 2) (mg/L)
	Seasonal Average (mg/L)	Seasonal Maximum (mg/L)	Seasonal Average (mg/L)	Seasonal Maximum (mg/L)	Seasonal Average (mg/L)	Seasonal Maximum (mg/L)		
Aluminum (dissolved)	0.16	0.20	0.16	0.20	*0.16*	0.2	0.2	-
Antimony (total)	0.011	0.011	0.01	0.01	0.01	0.01	0.01	-
Arsenic (total)	0.078	0.079	0.01	0.01	0.01	0.01	0.01	0.50
Cadmium (total)	0.00018	0.00020	0.00018	0.00020	*0.00018*	*0.00020*	0.0005	-

Table 3.4.39 Predicted Post-Closure Water Quality for Treated Parameters

Parameter	Pit Lake		Post-Ferric Treatment (baffled section of lake)		Post-WTP Discharge		Water Treatment Threshold (mg/L)	*MMER* Discharge Limit (maximum authorized monthly mean concentration, column 2) (mg/L)
	Seasonal Average (mg/L)	Seasonal Maximum (mg/L)	Seasonal Average (mg/L)	Seasonal Maximum (mg/L)	Seasonal Average (mg/L)	Seasonal Maximum (mg/L)		
Chromium (total)	0.0069	0.0076	0.0069	0.0076	*0.0069*	*0.0076*	0.01	-
Copper (total)	0.022	0.022	0.022	0.022	0.002	0.002	0.002	0.30
Lead (total)	0.0015	0.0015	0.0015	0.0015	0.0005	0.0005	0.0005	0.20
Manganese (total)	0.16	0.19	0.16	0.19	0.1	0.1	0.1	-
Molybdenum (total)	0.081	0.081	0.05	0.05	0.05	0.05	0.05	-
Nickel (total)[2]	0.0032	0.0036	0.0032	0.0036	0.0032	0.0036	-	0.50
Selenium (total)	0.0009	0.0011	0.0009	0.0011	*0.0009*	*0.0011*	0.015	-
Zinc (total)[2]	0.022	0.023	0.022	0.023	0.022	0.023	-	0.50

Notes:

1. The numbers in *underlined italics* indicate that concentration is lower than the WTP threshold removal.
2. Nickel and Zinc are not targeted for removal in the WTP, but are shown for comparison with *MMER* Discharge Limits.

3.4.3.3 Emissions and Wastes

Emissions and wastes during Decommissioning, Reclamation and Closure are expected to be relatively modest in comparison to those that will occur during Construction or Operation of the Project. Emissions of air contaminants and noise may occur during Decommissioning and Reclamation activities from the movement of heavy equipment and vehicles on-site as demolition occurs and as materials are hauled to and from the Project site, as well as from reshaping of the landscape. These are not expected to be substantive. There are no known solid waste materials expected from the Decommissioning, Reclamation and Closure phase beyond disposal of decommissioning materials as discussed above.

As discussed above in Section 3.4.3.2.3, no water will be discharged from the Project during Closure with the possible exception of water in the water management ponds (WMPs) if it is of suitable quality for direct discharge; water from the WMPs will otherwise be pumped to the TSF. During Post-Closure, and as discussed above in Section 3.4.3.2.4, water from the pit lake will be treated before discharge until it is of suitable quality for direct discharge.

3.4.3.4 Transportation

Transportation needs during Decommissioning, Reclamation and Closure will be modest and will vary depending on the activity being carried out at the time. Although specific details of the Decommissioning phase and associated transportation requirements are not fully defined at this time, it is expected Project activities and requirements during this phase will be similar to or less than those during the Construction phase. This is a conservative assumption.

3.4.3.5 Employment and Expenditure

Employment and expenditure during Decommissioning, Reclamation and Closure will be modest and will vary depending on the activity being carried out at the time. Decommissioning will require limited contractor and project personnel to dismantle all equipment and facilities associated with the Project. Reclamation will see limited contractor and project personnel to restore areas of the site to near pre-Project conditions. Closure will involve limited Project personnel to carry out care, maintenance and monitoring activities, and to maintain and operate the limited equipment remaining on-site (*e.g.,* water treatment plant). Expenditure associated with all these activities will be relatively limited in comparison to that occurring annually during Operation. Once surplus water no longer needs to be treated to meet discharge standards at Post-Closure, employment and expenditure activities will cease.

3.4.3.6 Estimated Decommissioning, Reclamation and Closure Costs

3.4.3.6.1 Capital Construction Costs, Long-Term Maintenance, Monitoring and Water Treatment

A cost estimate for the conceptual closure and reclamation plan for the Project was developed based on a plan to achieve the following objectives:

- minimize or eliminate residual environmental effects following closure;
- establish conditions that allow the natural environment to recover from mining activities; and
- establish long-term physical, chemical, and ecological stability in the disturbed area.

A number of assumptions were made about the end-use plan for the Site, including:

- flooding of the open pit to create a lake;
- permanent encapsulation of barren rock within the TSF;
- TSF embankments will be vegetated with suitable species;
- TSF impoundment area will include wildlife habitat such as littoral, wetland, and a lake area; and
- appropriate drainage for surface and groundwater from the new landforms will be ensured.

Closure is defined as the time period between when the mine ceases operation and when the open pit has filled with water. The Post-Closure period is defined as the time after which the open pit has been flooded and begins discharging water, which is estimated to occur approximately 10 years after Closure.

The closure and reclamation plans will be updated throughout design, construction, and operation of the Project to help ensure that the objectives can be successfully achieved; the cost estimate and subsequent bonding requirements may also require adjustment as the Project evolves through the EIA process, permitting, and operations.

3.4.3.6.2 Ongoing Post-Closure Expenses

Certain aspects of the closure and reclamation plan will require ongoing commitment beyond the initial closure and active reclamation period. These generally include environmental monitoring, engineering support, and site maintenance; specific Post-Closure activities included in the cost estimate are:

- upkeep of water management ponds and recycle pumps being used to collect seepage and embankment runoff, which will be retained until monitoring results indicate that runoff and seepage from the TSF is of suitable quality for untreated discharge;
- groundwater monitoring wells and geotechnical instrumentation will be retained for long-term monitoring. Water quality will be assessed on a schedule defined in the detailed closure plan;
- annual inspection of the TSF and an ongoing evaluation of water quality, flow rates, and instrumentation records will be performed;
- maintenance of site roads that are kept active beyond closure to support ongoing monitoring and inspection requirements;
- maintenance of electrical infrastructure to ensure that power is available for pumps where applicable; and
- water treatment at the open pit discharge point to Sisson Brook until water quality is deemed acceptable for direct release.

3.4.3.6.3 Cost Estimate Methodology

The reclamation cost estimate was developed by identifying the tasks required to achieve the defined closure and reclamation objectives. The quantities used for the cost estimate were based on neat-line take-offs from the design figures with allowances for construction variances. Lump sum or provisional sum allowances were based on similar projects and estimates where sufficient detail did not exist to develop quantities for a particular line item.

The unit rates were developed using production rates, material costs, and contractor equipment rentals rates from the following sources:

- Caterpillar Performance Handbook (Edition 40);
- 2011-2012 BC Blue Book - Equipment Rental Rate Guide - BC Road Builders and Heavy Construction Association (July 2011); and
- 2010 RS Means Heavy Construction Cost Data (2010).

Assumptions

The following assumptions were used to develop the reclamation cost estimate.

- The work would be performed by a contractor using contractor equipment. The cost estimate assumes a worst case scenario that the mine equipment is not available to perform the closure and reclamation work.
- Surface reclamation areas as shown on Figures 13.4.14 to 13.4.17.
- Tailings beaches capped with a 60 cm thick layer of rockfill from the quarry to provide a trafficable surface for topsoil and overburden placement.
- Disturbed areas will first be shaped, resurfaced with an average topsoil and overburden layer 25 cm thick, and then re-vegetated.
- Topsoil and overburden for resurfacing will be located in a stockpile within 2 km of the final destination.
- The open pit will fill naturally with precipitation, groundwater inflow, and TSF discharge (*i.e*. no pumping required).
- Demolished concrete can be disposed of on-site (*i.e*. buried).
- Salvage value of materials transported to a disposal site will cover any disposal fees (*i.e*. net zero disposal fees).
- The TSF spillway will be constructed as a rock cut in the south abutment of the TSF embankment near the plant site.
- An open pit spillway to Sisson Brook will be constructed as a rock cut at the northeast side of the open pit.
- Water treatment will be bonded for assuming that it is required in perpetuity.
- Operating expenditures for water treatment can be scaled based on plant design flow (reduced operating expenditures if the mine closes prematurely, due to a smaller catchment area of the facilities and hence leading to lower design flows).
- Infrastructure from the plant clarification system used during mine operations can be partially utilized for the post-closure water treatment plant. A 50% reduction for the water treatment plant capital cost was assumed. This assumption for costing is based upon determination that the process water clarifier will be large enough to handle the mill reclaim flow rate combined with the surplus water sent to the Water Treatment Plant during operations, and should therefore be suitable for use Post-Closure when only surplus water needs treatment. The design of the clarifier and Water Treatment Plant will be reviewed during Basic Engineering to determine their suitability for both Operation and Post-Closure. If necessary, the cost estimate for Post-Closure water treatment equipment and operation can be revised for bonding

calculation purposes. At Closure, as the actual environmental conditions become more clear, a water treatment plant may need to be custom built for flow sizing, water quality objectives, power requirements, *etc*. and any pre-existing equipment should not be assumed to be suitable for use, at least not for bonding calculation purposes. This rationale can be integrated into the 5 year bond review process as the Project advances.

Exclusions

The closure and reclamation cost estimate currently excludes costs for dump disposal fees for structures, pipelines, pumps, and foundations.

3.4.3.6.4 Estimate Breakdown

The closure and reclamation cost estimate is divided into the following sections:

- Direct Costs;
- Indirect Costs;
- Ongoing Post-Closure Expenses; and
- Allowances and Contingency.

Direct Costs

The direct costs include:

- TSF Reclamation;
- Open Pit Reclamation;
- Barren Rock and Mid-Grade Ore Reclamation;
- Decommissioning of Mine Site Infrastructure; and
- Miscellaneous Allowances (Environmental Monitoring and Best Management Practices).

Indirect Costs

The indirect costs were estimated as a fixed percentage of the direct costs. Materials, services, and engineering/specialist input were estimated as lump sums.

The indirect costs included in the estimate are:

- Contractor mobilization and demobilization at 5% of estimated direct costs;
- Construction management and indirects at 12% of estimated direct costs;

- Materials and services such as power and insurance; and
- Engineering and specialist input.

Ongoing Post-Closure Expenses

Annual Post-Closure expenses will be incurred beyond the active reclamation period. A bond will need to be posted such that interest gained on the initial investment will cover the estimated annual expenses in perpetuity. The on-going Post-Closure expenses are attributed to water treatment, and monitoring and maintenance of equipment.

The water treatment costs (SRK 2013) include capital costs and fixed and variable operating costs.

The costs represent Post-Closure water treatment at full mine development (*i.e.,* at the end of the projected mine life at 27 years). Water treatment costs for premature mine closure will be estimated using a water treatment design flow factor, which is based on the catchment area reporting to the TSF that cannot be practically diverted around the facility and the approximate size of the open pit at each stage of the mine life.

The capital costs (SRK 2013) are for a standalone, newly constructed water treatment plant. However, based on the current mine design and feasibility study results, cost savings may be available by utilizing the clarification plant that would be built as part of the processing facilities. The closure and reclamation cost estimate assumes that 50% of the estimated capital cost of the water treatment plant will be required to upgrade the clarification plant for use as the Post-Closure water treatment plant. In addition to the clarification plant, a stand-alone water treatment plant will be required for Operations in Year 8; it is assumed that this plant can be used as the post-closure treatment plant at no additional cost.

For simplicity, no interest rate was utilized for estimating the bonding requirements, and hence no interest is gained on the bonding investments nor was any bond credit applied in subsequent years once the water treatment plant is built.

Allowances and Contingency

The following allowances will be included in the direct costs for items with limited design information:

- A $500,000 allowance to cover best management practices during the active reclamation period; and
- A $1,000,000 allowance for monitoring (environmental and geotechnical).

A contingency of 25% was allotted for the direct costs.

3.4.3.6.5 Description of Bonds

Based on input from the New Brunswick Department of Energy and Mines (NBDEM) and the New Brunswick Department of the Environment and Local Government (NBDELG), there are three, distinct bonds that will be posted and maintained over the 27 year life of the Project to mitigate liability to the Province for:

- Reclamation;
- Environmental Protection; and
- Post-Closure Water Treatment.

Reclamation Bonding

Reclamation bonding will be initiated at the onset of construction and will cover a period of three years (Year -2 to Year +1, inclusive), which will span the two-year construction period plus the initial year for commissioning and start-up. Potential reclamation efforts over this period would be the least significant during the mine life as construction of the Project will have been completed and commissioning of the plant will have been fully achieved such that it can operate at 100% of its capacity.

For this period, there will be fresh water (from precipitation) stored behind the tailings embankment (up to 8 million m^3), a minimum amount of tailings discharges into the TSF from commissioning activities (up to approximately 4 million m^3 or 1% of the total tailings volume), overburden piles developed from pre-stripping activities in the open pit (5.3 million tonnes or 2% of the total waste tonnes), and quantities of waste rock stored in the TSF basin (up to 13.0 million tones or 5% of the total waste tonnes) from initial mining activities.

The bond for this period has been calculated based on an initial bond amount, which would increase in value over the three years to a fully matured amount based on a 0% net interest rate for simplicity in presenting the calculations. This bond would be posted to NBDEM when construction of the Project begins at the beginning of Year -2.

After this initial, three year period, a second bond would be posted for a five year period (Year 2 to 6, inclusive) at the beginning of Year 2. Since the Project will be in full operation by this time, the value of the new bond will be substantially greater than the previous bond to cover the reclamation cost associated with significantly more tailings and waste rock stored in the TSF as well as more process water mixed with fresh water in the TSF pond. For calculation simplicity, it has been assumed that the original bond will continue to be reinvested at the nominal interest rate (assumed to be 0% for simplicity), and a new, second bond to be made at the beginning of Year 2 will be provided to NBDEM for the difference.

Subsequently, a third bond would be posted for another five year period (Year 7 to 11, inclusive) at the beginning of Year 7.

After this period, there will be sufficient bond value to cover the next five year period's liability amount based on the gain in the accumulated interest on the three bonds. In fact, all periods after this will be fully covered with these bonds.

The bond values will vary based on the effective interest rate at the time of the bond placements. For simplicity, the values presented assume a 0% interest rate; however, the interest rate at the time of bond placement will change the bond values as interest will allow the bonds to grow in value over time while they are held by the regulatory agency.

Environment Protection Bonding

The environment protection bonding would be established in a progressive manner starting prior to construction and continuing for three years (i.e. two years of construction plus a year for commissioning and startup) up to the end of the commissioning period. An initial contribution at the commencement of construction would be provided. An annual contribution for the three year period of construction would be provided to ensure sufficient bond prior to the start of full production at the mine at the beginning of Year 2.

This bond would be established to accommodate the cost of monitoring during the active reclamation period (one year) and for a subsequent two-year mine Closure period. The value of the bond account at the end of the 27 year mine life would be calculated using the same interest rate (assumed to be 0% for simplicity) for the other bonding instruments.

Post Closure Water Treatment Bonding

The period of Post Closure water treatment would commence once the open pit has filled, approximately 12 years after the end of Operation. This bonding would be in place at the commencement of the Post Closure period to cover the cost of water treatment in perpetuity.

Bond contributions would be made at the beginning of Year 2, once full production has started, and would be placed as a separate capital cost (CAPEX) amount and an operating cost (OPEX) amount. As per the bonding placement procedure described for reclamation bonding, subsequent bonds for CAPEX and OPEX would be posted for each five year period thereafter at the beginning of each of these periods to cover the liability associated with each period. However, the CAPEX bond placement would end at Year 7 as the total CAPEX bond value would match the CAPEX value for the water treatment plant that would be built and operating by Year 10; hence no further bonding contributions to CAPEX would be necessary. Similarly, the OPEX bond placement would end at Year 17 as the total OPEX bond value would match the OPEX value for water treatment throughout the remaining 27 years of the mine life.

The bond values will vary based on the effective interest rate at the time of the bond placements. For simplicity, the values presented assume a 0% interest rate; however, the interest rate at the time of bond placement will change the bond values as interest will allow the bonds to grow in value over time while they are held by the regulatory agency.

Summary of Bonding Requirements

The estimated costs for closure and reclamation throughout the mine life will increase over time. It is proposed that the bonding requirement shall be reviewed on a five-year “look forward” basis once the mill reaches full production and adjusted as required. The estimated maximum bonding requirement is presented in Table 3.4.40 below at the start of construction, at the commencement of full production (beginning of Year 2) and at the end of the estimated life of the mine after 27 years.

Table 3.4.40 Bonding Summary

No.	Bond Description	Estimated Bond Requirement Start of Construction (Year -2)	Estimated Bond Requirement Full Production (Year 2)	Estimated Bond Requirement End of Life of Mine (Year 27)
1.	Reclamation	$7,500,000	$24,000,000	$41,800,000
2.	Environmental Protection	$1,500,000	$1,500,000	$1,500,000
3.	Post-Closure Water Treatment			
3a.	CAPEX Bond value	Nil	$4,600,000	Nil
3b.	OPEX Bond Value	Nil	$19,700,000	$22,000,000
	Totals	**$9,000,000**	**$49,800,000**	**$65,300,000**

Note:
No discount or interest rate was utilized for estimating the bonding requirements for each of these periods. This table assumes that the CAPEX bond for Post-Closure Water Treatment has been withdrawn once the water treatment plant has been built (Year 8), and hence this amount is shown as “Nil” at the End of Life of Mine (Year 27).

The closure bonding requirement generally increases over the mine life as additional development takes place and the Project footprint expands, which requires additional reclamation work and greater water treatment capacity.

The closure plan has been developed to a conceptual level and the cost estimate will require adjustment to account for changes in the scope, design, and permitting requirements as the Project is developed further. Studies carried out as part of the EIA process and information received from this process will solidify decisions about the preferred end-use for the site after Closure. For example, ongoing soil and vegetation studies will better define the soil replacement and re-vegetation strategy.

Further details of the reclamation plan for the Project can be found in Appendix H.

3.4.3.7 Site Safety and Security

Because the open pit and quarry at Closure will remain as open water features with abrupt, steep, and sometimes unstable edges, they will present potential safety issues and liabilities. They thus warrant exclusion of both people and terrestrial wildlife, and will be fenced around the edges to prevent access. No other continuous fencing is planned.

Much of the remaining area will be accessible (particularly during the winter), so fencing, berms, rock barriers, or warning signs discouraging public access may be employed in target areas to prevent accidents and minimize exposure to potentially harmful conditions. Warning signs will be posted at regular intervals along fenced areas and along the base of the TSF, on posts of sufficient height so the signs will be visible during winter conditions.

The main access to the site and the on-site access roads to the open pit and quarry will be restricted with locked gates. Locked gates will be accessible to mine personnel and contractors only. Any remaining buildings will be secured.

On-site roads required for Closure and Post-Closure maintenance will not be secured. Those required for water quality monitoring or vegetation surveys will be partially decommissioned with water bars and berms to discourage all traffic use, except by ATV or snow machines. All other on-site roads no longer required will be permanently decommissioned.

4.0 REGULATORY FRAMEWORK, SCOPING, AND CONSULTATION AND ENGAGEMENT

The Project requires an environmental impact assessment (EIA) pursuant to Section 5(1) of the New Brunswick *Environmental Impact Assessment Regulation* (EIA Regulation). Additionally, several federal regulatory agencies (termed "Responsible Authorities" or "RAs") have determined that an environmental assessment (EA) is required under Section 5(1)(d) of *the Canadian Environmental Assessment Act (CEAA).*

This chapter:

- summarizes the regulatory framework applicable to the Project, including a discussion of the federal EA or provincial EIA requirements, a description of the harmonized approach adopted by both levels of government to conduct the EIA/EA for the Project, as well as the identification of other applicable approvals, permits, and authorizations that may be required to enable the Project to be carried out;

- describes the scope of the EIA/EA as determined by the federal and provincial regulatory agencies responsible under their respective scoping processes;

- summarizes the issues and comments received by SML from the public, stakeholders, and Aboriginal persons during public, stakeholder and Aboriginal engagement activities carried out for the Project to date;

- identifies the valued environmental components (VECs) that have been selected for the EIA/EA to address the requirements of the Final Guidelines (NBENV 2009), the Terms of Reference (Stantec 2012a), and in consideration of public/stakeholder/Aboriginal issues and comments received by SML; and

- identifies the other past, present, or reasonably foreseeable future projects or activities (*i.e., "other projects or activities that have been or will be carried out"* as required by *CEAA*) with potential environmental effects that might overlap those of the Project, to assist in carrying out the assessment of cumulative environmental effects for each VEC.

4.1 REGULATORY FRAMEWORK

The Project is subject to a variety of federal and provincial environmental regulatory requirements, including EIA requirements as well as compliance with several federal and provincial acts and regulations. A summary of the applicable environmental regulatory framework for the Project is provided below.

4.1.1 Environmental Impact Assessment

4.1.1.1 *Canadian Environmental Assessment Act*

Federal EA is regulated under the former *Canadian Environmental Assessment Act* (*CEAA)*. While the EIA of the Project commenced under *CEAA* (described below), that act has since been repealed and replaced in July 2012 by the *Canadian Environmental Assessment Act, 2012* (*CEAA, 2012*). The transition provisions in *CEAA, 2012* provide that an EA review already commenced under *CEAA* will be continued under that former act. Therefore, the federal EA process for the Sisson Project is being conducted under the former *CEAA*, and this EIA Report has been written to comply with its provisions. For complete clarity in this regard, "*Canadian Environmental Assessment Act*" and "*CEAA*" in this EIA Report means the former Act prior to it being superseded by *CEAA, 2012.*

The requirements for federal EA are defined by *CEAA* for projects or activities under federal jurisdiction. For *CEAA* to apply there must first be a "project" as defined under the *Act*. There must also be a "trigger". Thus, an EA is not automatically required for a project; rather, *CEAA* does not require an EA unless there is a "project" as defined in the Act and there are one or more "triggers" in respect of the Project.

The requirement for an EA is triggered under Section 5(1) of *CEAA* when a federal authority:

- proposes a project (Section 5(1)(a));
- provides financial assistance to a proponent to enable a project to be carried out (Section 5(1)(b));
- sells, leases, or otherwise transfers control or administration of federal land to enable a project to be carried out (Section 5(1)(c)); and/or
- provides a license, permit, approval, or authorization that is listed in the *Law List Regulations* under *CEAA* that enables a project to be carried out (Section 5(1)(d)).

All EAs under *CEAA* are screenings, unless they are on the former *Comprehensive Study List Regulations* or have been referred to mediation or a review panel.

The Project requires an EA under Section 5(1)(d) of *CEAA* as it is a "project" as defined in *CEAA*, and because it requires authorizations that are "triggers" under the *Law List Regulations* of *CEAA*. The regulatory triggers under the *Law List Regulations* of *CEAA* that are applicable to the Project are outlined in Table 4.1.1 below.

Table 4.1.1 *Law List Regulations* Triggers for the Project

Legislation and Section	Nature of Authorization	Relevance to Project	Responsible Authority (RA)
Fisheries Act, Section 32	Destruction of fish (mortality) by means other than fishing.	To address fish mortality for any in-water works during construction that may result in the killing of fish by means other than fishing (*e.g.,* as a result of open pit and tailings storage facility (TSF) construction), thereby requiring authorization under Section 32 of the *Fisheries Act*. A fish relocation program from portions of watercourses affected by the Project and is being considered.	Department of Fisheries and Oceans Canada (DFO)

Table 4.1.1 *Law List Regulations* Triggers for the Project

Legislation and Section	Nature of Authorization	Relevance to Project	Responsible Authority (RA)
Fisheries Act, Sub-section 35(2)	Serious harm to fish that are part of a commercial, recreational, or Aboriginal (CRA) fishery.	Loss of most of Sisson Brook and Bird Brook, and the partial loss of portions of McBean Brook and an unnamed tributary to West Branch Napadogan Brook due to the presence of the open pit and TSF, must be authorized under Section 35(2) of the *Fisheries Act*. May also be required related to serious harm adjacent to, at, or downstream of these and other facilities.	Department of Fisheries and Oceans Canada (DFO)
Explosives Act, Sub-section 7(1)(a)	Issuance of a license for factories and magazines.	A magazine is required for the Project for the storage or manufacture of explosives, thereby requiring authorization under Section 7(1)(a) of the *Explosives Act*.	Natural Resources Canada (NRCan)

Since they must exercise a power, duty or function in respect of issuing the above authorizations to in order to enable the Project to be carried out, the Department of Fisheries and Oceans Canada (DFO) and Natural Resources Canada (NRCan) are responsible authorities (RAs) for the EIA under *CEAA*. Though initially thought to be an RA, Transport Canada has confirmed that it is not an RA as there is no need to issue an authorization for the Project under the former *Navigable Waters Protection Act* (now superseded by the *Navigation Protection Act*), as the potentially affected watercourses are considered to be minor waters. The Canadian Environmental Assessment Agency (CEA Agency) has administered the federal EA under *CEAA* on behalf of the federal government since the EA was initiated, and it will continue to do so until the Project is referred by the Minister to the RAs under Section 23 of *CEAA* so that they may exercise their respective powers, duties, or functions pursuant to Section 37 of *CEAA*. Health Canada, Environment Canada, and Transport Canada are federal authorities (FAs) for this EIA and may be in possession of specialist or expert information or knowledge with respect to the Project. Upon request, Health Canada or Environment Canada may make available that information or knowledge to the CEA Agency. The role of these FAs, as well as their areas of expertise, is noted in the Project Agreement at http://mpmo.gc.ca/projects/31.

Section 5(2) of *CEAA* requires that an EA must be conducted if the Government of Canada must amend provisions of certain Acts or regulations so as to enable a project to be carried out. The Project need for a tailings storage facility (TSF) could precipitate the need for the Governor-in-Council to amend Schedule 2 of the *Metal Mining Effluent Regulations* (*MMER*) under the *Fisheries Act.* If such a regulatory amendment is ultimately determined to be required in order to allow tailings to be deposited in waters currently frequented by fish, an EA is required prior to the Government of Canada exercising this power, duty, or function to amend Schedule 2 of *MMER*. This EIA Report fulfills the requirement of Section 5(2) of *CEAA* in this regard, as applicable.

The anticipated daily production rate for the mine exceeds the threshold for metal mines and metal mills under Part V, Section 16(a) of the former *Comprehensive Study List Regulations* under *CEAA.* Therefore, the EA under *CEAA* is a comprehensive study.

4.1.1.2 New Brunswick *Environmental Impact Assessment Regulation*

The *Environmental Impact Assessment Regulation* (EIA Regulation), administered by the New Brunswick Department of Environment and Local Government (NBDELG), was enacted in 1987 under the New Brunswick *Clean Environment Act*. The EIA Regulation requires that the construction, operation, modification, extension, abandonment, demolition or rehabilitation of certain projects or activities (called "undertakings") described in Schedule A of the Regulation must be registered. Schedule A identifies 24 categories of undertakings requiring registration, one of which is *"(a) all commercial extraction or processing of a mineral as defined in the Mining Act*". Thus, the Project had to be registered under Section 5(1) of the EIA Regulation, since it is listed under item (a) of Schedule A.

Once it is registered, the registration document submitted by the proponent is reviewed by a technical review committee (TRC) to identify and understand potential environmental effects of the project and proposed mitigation. Questions of the TRC are provided to the proponent for response. When all questions have been answered (iterative process), the TRC provides its recommendations to the New Brunswick Minister of Environment and Local Government (the Minister), who will determine if the project may proceed directly with conditions (Determination Review) or if a more detailed EIA is required (Comprehensive Review).

If the Minister determines, on advice of the TRC, that a Comprehensive Review is required, the following key process elements are undertaken:

- development of Draft Guidelines for the EIA by the Minister;
- public input to Draft Guidelines;
- issuance of Final Guidelines for the EIA by the Minister;
- development of Terms of Reference by the proponent to meet the Final Guidelines;
- development of an EIA Report (also referred to as an Environmental Impact Statement or EIS) by the proponent, and subsequent review of the EIA Report by the TRC (iterative process) and associated revision of the EIA Report;
- following revision and answering of all questions, acceptance of the EIA Report by the Minister
- release of the EIA Report to the public for review and comment;
- preparation of a summary report and General Review Statement regarding the EIA by the Minister;
- public meeting;
- preparation of a report and recommendation by the Minister for consideration by the Lieutenant-Governor-in-Council; and
- decision by Lieutenant-Governor-in-Council.

Other procedural steps may be required in addition to the above, including the requirement for public, stakeholder and Aboriginal input to the EIA throughout its conduct. The specific requirements and procedural steps to be undertaken by a proponent are normally specified in the Final Guidelines.

For the Project, the Project Registration document (Rescan 2008) was submitted to the New Brunswick Department of Environment (NBENV, now the NBDELG) on September 5, 2008. The Minister determined on October 24, 2008 that an EIA (Comprehensive Review) of the Project was required. Final Guidelines for the EIA of the Sisson Project (NBENV 2009) were issued on March 1, 2009, following public consultation on them.

4.1.1.3 Harmonized Environmental Impact Assessment

The Governments of New Brunswick and Canada implemented a harmonized environmental impact assessment process for the Sisson Project. Under this approach, both levels of government have agreed to cooperate in the carrying out of the EIA to meet the requirements of their respective legislation, beginning with Terms of Reference being issued jointly to define the scope of the EIA federally and how SML will meet the Final Guidelines provincially. They have also agreed that a single EIA Report prepared by the Proponent would meet the requirements of the Terms of Reference, with revisions to produce a Final EIA Report as required under the provincial EIA process to address comments arising from the provincial TRC’s review of the draft report. The CEA Agency will prepare its comprehensive study report (CSR), relying upon the EIA Report and the results of the review process.

Both levels of government have worked together extensively in carrying out Aboriginal consultation activities to fulfill their respective “duty to consult” responsibilities for the Project, and along with SML have also collaborated in respect of public and stakeholder consultation and Aboriginal engagement activities for the EIA.

4.1.1.4 Terms of Reference

Section 10(1) of the EIA Regulation requires that the proponent *“…prepare terms of reference for an environmental impact assessment, setting out his proposals for the carrying out of an assessment in accordance with the final guidelines”*. The specific requirements for the Terms of Reference are outlined in Section 2.8 of the Final Guidelines issued on March 1, 2009. To meet the New Brunswick requirements, the Terms of Reference (Stantec 2012a) were prepared in accordance with Section 2.8 of the Final Guidelines to describe the methods used by SML to conduct the EIA of the Project, and the means by which SML will consult with the public during the course of the EIA, to meet the requirements of Sections 10(1) and 10(2) of the EIA Regulation. The Terms of Reference were also prepared to outline the requirements for the federal EA under Sections 15 and 16 of *CEAA*.

The Terms of Reference were issued on April 16, 2012 by the CEA Agency on behalf of the federal government as its EIS Guidelines for the EA under *CEAA*, thereby defining the scope of the EA, including scope of project, factors to be considered, and scope of factors to be considered. Following consultation on them, the Terms of Reference were approved by the Minister of NBDELG on April 16, 2012. The Terms of Reference were also adopted as the scope of the federal EA under Sections 15(1) and 16(3) of *CEAA* on April 16, 2012.

The Terms of Reference will support the preparation of a comprehensive study report (CSR) by the CEA Agency. The CEA Agency will exercise the powers, and perform the duties and functions, of the RAs until such time as the federal Minister of Environment is provided with the CSR, following the completion of the EIA.

Following acceptance of the Terms of Reference, SML set out to develop this EIA Report to meet the requirements of the Final Guidelines using the methods identified in the Terms of Reference. This EIA Report provides the necessary details as set out by the Terms of Reference and serves as the basis for public comment in respect of regulatory decision-making regarding the Project.

4.1.2 Other Legislation Applicable to the Project

The key federal and provincial environmental legislation that may apply to the Project is outlined below. Other acts and regulations may apply.

4.1.2.1 Federal

4.1.2.1.1 *Fisheries Act*

The *Fisheries Act,* as amended in 2012, is administered by Fisheries and Oceans Canada (DFO) and is the main legislation protecting fish and fisheries in Canada. Section 35 of the *Fisheries Act* prohibits the carrying out of a work, undertaking or activity that results in “serious harm to fish that are part of a commercial, recreational or Aboriginal fishery” (hereinafter referred to as “CRA fisheries”) without first obtaining an Authorization from Fisheries and Oceans Canada (DFO). “Serious harm to fish” is defined in the *Fisheries Act* as “the death of fish or any permanent alteration to, or destruction of, fish habitat”. Authorization under the Act requires that the proponent must offset any serious harm to fish that were part of, or supported, CRA fisheries such that the productivity of the fisheries is maintained or improved. An Offsetting Plan must accompany the application for authorization, and is evaluated by DFO following the “Fisheries Productivity Investment Policy: A Proponent’s Guide to Offsetting” (DFO 2013a).” Temporary alterations to fish habitat (*e.g.*, construction of road culverts or reductions in mean annual flow less than about 10%) are no longer subject to the provisions of Section 35 and therefore no longer require a *Fisheries Act* authorization.

Additionally, under Section 36 of the *Fisheries Act*, “no person shall deposit or permit the deposit of a deleterious substance of any type in water frequented by fish” without authorization. For mines, the requirements of Section 36 of the *Fisheries Act* are further defined and regulated by the *Metal Mining Effluent Regulations* (*MMER*). The depositing of deleterious substances produced by mines (*e.g.*, tailings, waste rock) into waters frequented by fish is authorized through a regulatory amendment to Schedule 2 of *MMER*, with associated compensation/offsetting.

It is also possible that an authorization under Section 32 for the destruction of fish may be required, depending on Project specifics and methods of construction.

4.1.2.1.1.1 *Fisheries Act – Metal Mining Effluent Regulations*

The *Metal Mining Effluent Regulations* (*MMER*) of the *Fisheries Act* apply to the Project. *MMER* requires that a tailings impoundment area must be added to Schedule 2 of those regulations for depositing deleterious substances (*e.g.,* waste rock, tailings or effluent) into those areas. Furthermore, the *MMER* establishes monitoring requirements and discharge limits for various parameters, requires effluent to be non-acutely lethal to rainbow trout and *Daphnia magna*, and requires environmental effects monitoring (EEM) to be conducted including the submittal of study designs and the requirement for evaluating sub-lethal effects on aquatic communities.

4.1.2.1.2 *Explosives Act*

The *Explosives Act,* administered by Natural Resources Canada (NRCan), regulates the manufacturing, testing, sale, storage, transportation and importation of explosives. Explosives required for blasting will be stored and handled on-site, which will result in the requirement of an on-site explosives magazine. Accordingly, a licence under the *Explosives Act* is required to enable the Project to proceed*.*

4.1.2.2 Provincial

4.1.2.2.1 New Brunswick *Clean Air Act – Air Quality Regulation*

The New Brunswick *Clean Air Act – Air Quality Regulation* requires, among other requirements, that a stationary “source” that releases air contaminants to the environment must obtain approvals to release those air contaminants. Accordingly, an Approval to Construct and an Approval to Operate pursuant to this regulation are anticipated to be required by the Project, as the Project will be a source.

4.1.2.2.2 New Brunswick *Clean Environment Act – Water Quality Regulation*

The New Brunswick *Clean Environment Act – Water Quality Regulation* prohibits the release of a contaminant that may result in water pollution without an approval under the regulation, among other requirements. As such, an Approval to Construct and an Approval to Operate pursuant to this regulation will be required for the Project.

4.1.2.2.3 New Brunswick *Clean Water Act – Watercourse and Wetland Alteration Regulation*

All work within 30 m of a watercourse or wetland requires a permit under the New Brunswick *Clean Water Act – Watercourse and Wetland Alteration Regulation.* As several wetlands and watercourses are located within the Project Development Area (PDA; Figure 1.2.1), a permit under this regulation will be required for the Project before work can begin in these areas.

4.1.3 Other Approvals, Permits, and Authorizations

Following the completion of the EIA and upon obtaining approval from the respective federal and provincial regulatory agencies in respect of the EIA, the Project will require a number of approvals, permits, or authorizations prior to Project initiation. In addition, throughout Construction and Operation, compliance with various standards contained within provincial or federal legislation, regulations and guidelines will be required, in addition to specific terms and conditions that may be mandated as part of various approvals, permits and other forms of authorization required for the Project.

Table 4.1.2 provides a summary of the anticipated permits, approvals or authorizations that may be required, the enabling legislation, the regulatory agency responsible, and the aspects of the Project they may apply to. This listing is based on the best knowledge of SML according to information it has received at the time writing, but is not necessarily intended to be all-inclusive. Other permits, approvals or authorizations may be determined by regulatory agencies to apply to the Project. SML will work with regulatory agencies to confirm these requirements and identify any additional legislation or authorizations that may apply to the Project. It is important to note that following the completion of the EIA process, the Province is expected to issue an Approval to Construct under the New Brunswick *Clean Air Act* and/or the New Brunswick *Clean Water Act*. These Approvals often package a number of permit requirements, including watercourse and wetland alteration, air quality, sound quality, and vibration. Following Construction, it is expected that Approvals to Operate will be issued under the same two acts.

Table 4.1.2 Potential Legislation and Permits, Approvals, and Authorizations That May Apply to the Project

Permit, Approval, or Authorization	Legislation	Department or Agency	Activity or Component
Federal			
Permit, Licence or Certificate for the Manufacturing, Testing, Sale, Storage, Transportation and Importation of Explosives	*Explosives Act* R.S.C., 1985, c. E-17 (Section 7) and attendant regulations	Natural Resources Canada	Manufacture, testing, sale, storage, transportation and importation of explosives and the use of fireworks.
Permit to Import, Export, or Transport Hazardous Waste or Hazardous Recyclable Materials	*Canadian Environmental Protection Act*, 1999 (S.C. 1999, c. 33) (Section 185(1)(b)) and *Export and Import of Hazardous Waste and Hazardous Recyclable Materials Regulation*	Environment Canada	Import, export or convey in transit a hazardous waste or hazardous recyclable material, or prescribed nonhazardous waste for final disposal.
Authorization for the Destruction of Fish by Means Other than Fishing	*Fisheries Act*, c. F-14, Section 32	Fisheries and Oceans Canada	All project activities that may involve the destruction of fish (Construction phase).
Authorization for Harmful Alteration, Disruption or Destruction (HADD) of Fish Habitat	*Fisheries Act*, c. F-14, Section 35(2)	Fisheries and Oceans Canada	All project activities that may involve the alteration, disruption or destruction of fish habitat (Construction phase mainly).
Scientific Collection Permit	*Fisheries (General) Regulations* 93-53 under the *Fisheries Act* (Section 52)	Fisheries and Oceans Canada	Electrofishing, seining, netting or other non-lethal means of fishing for scientific purposes.
Designation of a Waterbody as a Tailings Impoundment	*Metal Mining Effluent Regulations* 2002-222 (*MMER*) under the *Fisheries Act*	Environment Canada	Designation of a waterbody as a tailings impoundment - Requires tailings impoundment to be added via regulatory amendment to Schedule 2 of the *MMER.*
Species At Risk Permit	*Species at Risk Act c.29* (Section 73(1))	Environment Canada	Any project activity affecting a listed species at risk or their habitats.
Provincial			
Approval to Construct, Modify, or Operate a Source	*Air Quality Regulation 97-133 – Clean Air Act*	Environment and Local Government	Approval for the release of air contaminants from a designated source of air contaminants.
Open Burning Permit	*Air Quality Regulation 97-133 – Clean Air Act*	Environment and Local Government	Open burning activities.
Approval to Construct, Modify, or Operate a Source	*Water Quality Regulation 82-126 - Clean Environment Act*	Environment and Local Government	Approval for the release of wastewater from a designated source.

Table 4.1.2 Potential Legislation and Permits, Approvals, and Authorizations That May Apply to the Project

Permit, Approval, or Authorization	Legislation	Department or Agency	Activity or Component
Approval of the Discharge Point	*Water Quality Regulation 82-126 - Clean Environment Act*	Environment and Local Government	Approval of the discharge point.
Approval of any Source, Wastewater Work, or Waterworks	*Water Quality Regulation 82-126 - Clean Environment Act*	Environment and Local Government	Approval of any source, wastewater work, or waterworks.
Written permission to cease operation of a wastewater work or waterworks	*Water Quality Regulation 82-126 - Clean Environment Act*	Environment and Local Government	All releases of wastewater from the Project.
Site Approval	*Petroleum Product Storage and Handling Regulation 87-97 - Clean Environment Act*	Environment and Local Government	Approval of a petroleum storage site.
Environmental Approval	*Petroleum Product Storage and Handling Regulation 87-97 - Clean Environment Act*	Environment and Local Government	Approval of environmental protection and mitigation measures for tankage, and tanks themselves, storing petroleum products as defined in the Regulation.
Storage licence	*Petroleum Product Storage and Handling Regulation 87-97 - Clean Environment Act*	Environment and Local Government	License for petroleum storage systems (greater than 2000 L per site).
Watercourse and Wetland Alteration (WAWA) Permit	*Wetland and Watercourse Alteration Regulation 90-80*	Environment and Local Government / Health	All Project phases, but largely focused on Construction activities. Lesser impact for other phases (*e.g.,* decommissioning).
Well Driller's Permit	*Water Well Regulation 90-79 - Clean Water Act*	Environment and Local Government/Health	Project phases and activities that require the drilling of a potable water well.
Licence or Permit Authorizing the Holder to Hunt, Trap or Snare any Species of Wildlife or to Angle for any Species of Fish	*Fish and Wildlife Act F-14.1*	Agriculture, Aquaculture and Fisheries/Natural Resources	Hunt, trap or snare any species of wildlife or to angle for any species of fish (*e.g.,* fish or wildlife rescue prior to or during construction).
Work Permit to Conduct an Industrial Operation Upon Forest Land	*Forest Fires Act F-20*	Natural Resources	Operation of Project.
Burn Permit	*Forest Fires Act General Regulation 84-204*	Natural Resources	Open burning activities.
Archaeological Field Research Permit	*Heritage Conservation Act H-4.05*	Culture, Tourism and Healthy Living	Archaeological investigations on the project site (background research, walkover, shovel test pitting (STP), excavation or mitigation).
Special Permit - restricted highway access by weight	*Highway Act H-5*	Transportation and Infrastructure	All Project phases requiring transportation of oversize or overweight loads.
Mining Lease	*Mining Act M-14.,* Section 67	Energy and Mines	Lease for "production" of a mineral. Required for entire mining development. Lease must be obtained prior to construction.
Quarry Lease	*Quarriable Substances Act Q-1.1*	Energy and Mines, Natural Resources, Finance	Quarrying of a quarriable substance on Crown land.

Table 4.1.2 Potential Legislation and Permits, Approvals, and Authorizations That May Apply to the Project

Permit, Approval, or Authorization	Legislation	Department or Agency	Activity or Component
Permit to Carry Out Activities in a Protected Area	*Protected Natural Areas Act P-19.01*	Natural Resources	Permit to carry out activities in a protected area for scientific research, educational, rehabilitation/restoration purposes, if the Project affects a Protected Natural Area. New Protected Natural Areas proposed by Minister of Natural Resources in October 2012.
Permit to Possess a Species at Risk	*Species at Risk 2012 C.6, Section 34(1)*	Natural Resources	The Minister may issue a permit to a person to kill an individual of a wildlife species that is listed as an extirpated species, an endangered species, or a threatened species, or to possess such an individual.
Permit to Engage in Activities	*Species at Risk 2012 C.6, Section 35(1)*	Natural Resources	The Minister may issue a permit to engage in activities that could kill, harm, or harass a species that is extirpated, endangered, or threatened.
TDG Permit	*Transportation of Dangerous Goods 2011, C.232 Regulation 89-67*	Public Safety	Not specified.
License of Occupation	*Crown Lands and Forests C-38.1 (Section 26)*	Natural Resources	Lease for the occupation of Crown Lands.
Topsoil Removal Permit	*Topsoil Preservation 2011, c.230*	Environment and Local Government	Removal of topsoil during construction activities.
Operating Permit	*Elevators and Lifts Act E-6*	Public Safety	Construction and operation of a lifting device.
Development and Building Permits	*Community Planning Act C-12*	Environment and Local Government/Rural District Planning Commission	Development of an area of land, or building of a structure.
Boiler and Pressure Vessel Certificate	*Boiler and Pressure Vessel Act c.122* (Section 13(1))	Training and Employment Development/Public Safety	Approval of boiler or pressure vessel.

4.2 SCOPE OF ASSESSMENT

The scope of the EIA of the Project to meet the requirements of the Final Guidelines (NBENV 2009), the Terms of Reference (Stantec 2012a), and Sections 15 and 16 of *CEAA* is defined in this section.

4.2.1 Scope of the Project

As outlined in Section 2.2.1 of the Terms of Reference (Stantec 2012a), the scope of the Project to be assessed under the EIA Regulation and under *CEAA* includes the Construction, Operation, and Decommissioning, Reclamation and Closure phases (including post-closure activities as appropriate) of the open pit mine; ore processing facility; tailings and ore storage areas; and all associated infrastructure. The specific processes, components and activities that form the scope of Project are outlined below. This list of Project elements encompasses those elements identified in Section 3.1 of the Final Guidelines (NBENV 2009).

The scope of the Project, and its main elements and activities, is comprised of but it not limited to, the following:

- a conventional open pit mine including blasting and movement of waste rock and ore;
- storage areas for ore, and the storage of ore in these areas;
- stockpiling of organics and overburden for future reclamation use;
- ore processing facilities (*e.g.,* crushing, grinding, flotation), and the on-site processing of ore to produce molybdenum concentrate and ammonium paratungstate (APT), and the management of waste rock and tailings;
- a tailings storage facility (TSF) for storage of tailings from the process and waste rock, and the associated operation of the TSF;
- diversion of clean surface water away from Project facilities (*i.e.,* open pit, TSF);
- collection of run-off and precipitation on the Project site, and groundwater flows into the open pit (collectively referred to as mine contact water), to prevent their escape to the environment and for use as process water in operations, and the discharge of surplus water as required (with treatment as needed to meet permit conditions);
- ancillary facilities, including on-site buildings, an explosives magazine for on-site storage and manufacture of explosives, a concrete batch plant during Construction, a quarry for supplying rock for construction of the TSF embankments and aggregate, fuel storage and distribution systems, potable water supply systems, and sanitary facilities;
- linear facilities to the Project site comprised of a new 138 kV electrical transmission line, a re-aligned 345 kV electrical transmission line, and use of existing public and forest resource roads, refurbished as needed to accommodate Project needs;
- transportation of the equipment, materials and supplies to the Project site, and of mineral products to off-site buyers;
- decommissioning of facilities, and reclamation and closure of the site at the end of the mine life; and
- care and maintenance of the site Post-Closure.

4.2.2 Factors to be Considered

The factors to be considered in the assessment of environmental effects of the Project were described in Section 2.2.2 of the Terms of Reference (Stantec 2012a). A summary of these factors is provided below.

4.2.2.1 Federal Environmental Assessment

All environmental assessments conducted under *CEAA* require specific factors to be considered. Sections 16(1)(a) to 16(1)(d) of *CEAA* detail the mandatory factors to be considered within the scope of an EA conducted under *CEAA*, as follows:

> *(a) "the environmental effects of the project, including the environmental effects of malfunctions or accidents that may occur in connection with the project and any cumulative environmental effects that are likely to result from the project in combination with other projects or activities that have been or will be carried out;*
>
> *(b) the significance of the effects referred to in paragraph (a);*
>
> *(c) comments from the public that are received in accordance with this Act and the regulations;*
>
> *(d) measures that are technically and economically feasible and that would mitigate any significant adverse environmental effects of the project."*

Section 16(1)(e) of *CEAA* establishes that additional factors can be considered if determined to be relevant by the federal RAs:

> *(e) "any other matter relevant to the screening, comprehensive study, mediation or assessment by a review panel, such as the need for the project and alternatives to the project, that the responsible authority or, except in the case of a screening, the Minister after consulting with the responsible authority, may require to be considered."*

As an additional factor to be considered under Section 16(1)(e) of *CEAA*, the CEA Agency requires that the EIA consider the need for and alternatives to the Project, in accordance with the CEA Agency's Operational Policy Statement entitled "Addressing "Need for", "Purpose of", "Alternatives to" and "Alternative Means" under the *Canadian Environmental Assessment Act*" (CEA Agency 2007).

Section 16(2) of *CEAA* requires consideration of the following additional mandatory factors as part of the EA of the scoped Project for a comprehensive study:

> *(a) "the purpose of the project;*
>
> *(b) alternative means of carrying out the project that are technically and economically feasible and the environmental effects of any such alternative means;*
>
> *(c) the need for, and the requirements of, any follow-up program in respect of the project; and*
>
> *(d) the capacity of renewable resources that are likely to be significantly affected by the project to meet the needs of the present and those of the future."*

Further factors to be considered in the EIA to meet the requirements of *CEAA* were elaborated in sub-Sections 2.2.2.3 to 2.2.2.10 of the Terms of Reference (Stantec 2012a). The reader is referred to those sections of the Terms of Reference for further information.

4.2.2.2 Provincial Environmental Impact Assessment

The description of the existing environment and assessment of potential environmental effects of the Project were to be described for Valued Environmental Components (VECs) within defined study boundaries. The Final Guidelines (NBENV 2009) suggested the following VECs to be assessed as part of the EIA:

- Atmospheric Environment;
- Freshwater Resources (Groundwater and Surface Water);
- Freshwater/Aquatic Environment;
- Terrestrial Environment;
- Wetland Environment;
- Labour and Economy (and other Socio-economic Effects);
- Community Services and Infrastructure;
- Private/Public Land and Resource Use;
- Current Use of Land and Resources for Traditional Purposes by Aboriginal Persons;
- Heritage and Archaeological Resources;
- Land-Based Transportation/Road Infrastructure;
- Effects on the Environment on the Project; and
- Public Health and Safety.

The factors to be considered for each of these VECs were further elaborated in the Final Guidelines (NBENV 2009). Detailed work plans and methodologies that were proposed and accepted to meet the requirements of the Final Guidelines were detailed in the Terms of Reference (Stantec 2012a), and are assessed in this EIA Report.

4.2.3 Scope of Factors to be Considered

The scope of the factors to be considered for the EIA of the Project was detailed, for each valued environmental component (VEC) of concern, in Section 4.0 of the Terms of Reference (Stantec 2012a). The elements of that identified scope of factors to be considered are extensive, and are not repeated here. The reader is referred to the Terms of Reference (Stantec 2012a) for further details on the specific detailed work plans and methodologies that were proposed (and ultimately accepted by the federal and provincial regulatory agencies) to meet the requirements of the Final Guidelines and of *CEAA*. This EIA Report addresses the full scope of factors as defined in the Terms of Reference for the EIA.

4.3 CONSULTATION AND ENGAGEMENT

This sub-section has been adapted from information provided by SML on the public, stakeholder and Aboriginal engagement activities it has carried out in respect of the Project.

A key requirement of any EIA process is to conduct comprehensive public, stakeholder, and Aboriginal engagement. The overarching goals of such engagement are to inform such parties about the Project, to assist in the identification of key issues and concerns in respect of the Project, to obtain information that may assist in carrying out baseline or predictive studies for the EIA, to collect information in respect of the current use of land and resources for traditional purposes by Aboriginal persons, and to share information in respect of the Project with local communities, stakeholders, First Nations, and the general public. There are additional objectives around building support for the Project in the community and with governments in respect of the Project's direct and indirect benefits.

The Final Guidelines for the EIA of the Project specifically require that Northcliff (now SML):

> *"…must consult with persons and organizations potentially affected by the proposed project and associated infrastructure, and must inform and engage any interested individuals, groups, stakeholders, local hunters and trappers, recreational users, affected communities, and Aboriginal communities in this assessment. This will include local governments and specific groups with mandates/initiatives in this area. The stakeholder consultation program is to be reviewed and accepted in the early stages of the study (e.g., at the TOR stage)."*

Additionally, Section 16(1)(c) *CEAA* requires that the EA must consider comments from the public received in relation to EA, and Section 21.2 of *CEAA* requires that the public is provided with an opportunity to participate in the comprehensive study. The following sub-sections describe SML's public, stakeholder and Aboriginal engagement program for the Project, including how SML has considered the input received through this program.

4.3.1 Engagement Methods and Activities

4.3.1.1 Public and Stakeholder Engagement

The public in general has expressed considerable interest in the Project throughout the EIA process, and the Proponent has considered it essential to a successful EIA and Project to actively engage members of the public to ensure the EIA is scoped adequately, concerns are identified and addressed as appropriate, and members of the public are able to obtain information regarding the Project.

4.3.1.1.1 Public and Stakeholder Engagement Tools

Northcliff/SML has engaged the public and First Nation communities on multiple occasions since November 2010, using a range of communication tools to share Project-related information. Open houses, the information office in Stanley, newsletters, community barbeques, and career information sessions provided a broad-based community outreach approach to introduce and communicate Project details to the general public. In those instances where specific issues and concerns were raised by individuals, stakeholder groups and First Nations, the approach included more detailed discussions through ongoing working groups and workshops.

Up to October 2014, Northcliff/SML held 176 meetings with various stakeholders, stakeholder groups and First Nation leaders or their representatives, and has accumulated an email list of 862 names and a mailing list of 224 individuals.

The communication tools include, but are not limited to:

- Project website;
- newsletters and emails;
- an information office in Stanley;
- open houses;
- working groups;
- presentations to and meetings with stakeholder groups;
- community barbeques;
- career information sessions; and
- workshops.

Project Website

The Sisson Project website (www.sissonsproject.ca) was launched in August 2011, and updated in 2014 (www.sissonpartnership.com). Stakeholder groups and individuals, key government personnel, First Nations community leaders and their representatives, and business organizations were notified by email of the creation of the website. The Project website contains information on the Project, information on SML environmental leadership and sustainable development policies, news releases, frequently asked questions, contact information for SML, a sign-up page for the Project newsletter, and documents available for download (*e.g.,* Project Description (Stantec 2011), Terms of Reference (Stantec 2012a), and an interim Stakeholder and First Nations Engagement Report). The sign-up page also includes a comment form where users can submit comments or questions regarding the Project.

The website is maintained by SML and updated as new information becomes available. Recent updates included changes to the frequently asked questions (FAQ) and the addition of a video on tungsten. The FAQ were updated to include questions identified during the various First Nations and stakeholder engagement activities undertaken for the Project.

The website has proven to be a successful communication tool. During the first 48 week period in 2012 the website had 4,295 visitors, with the average user viewing four different pages within the website structure. Over 160 viewers also completed the sign-up page to receive updated information on the Project. Comments received via this medium were focused almost entirely on employment and contracting opportunities. Going forward, SML will maintain and update the Project website to:

- ensure that Project information is current;
- inform users when Project milestones are reached;
- provide access to latest Project-related documents and news releases; and
- advertise upcoming information sessions and community events.

Newsletters and Email Notifications

Newsletters are distributed as information on the Project becomes available and when there is Project-related news to distribute. Members of the public are able to add their name to the newsletter distribution list through the Project website, by contacting SML directly, or at any consultation or engagement event such as open houses or meetings.

The newsletter is produced in both PDF format for email distribution and also printed for distribution through SML's Fredericton office, the information office in Stanley, and at various industry and public events.

Currently, SML distributes newsletters and other email updates in relation to the Project to approximately 862 email subscribers in addition to mailing 224 hard copies to stakeholders without a known email address. These are sent at key Project milestones and include news releases, employment opportunities and invitations to special events such as barbeques and open houses.

Information Office

SML has established an information office in Stanley, New Brunswick. It is located at 80 Irishtown Road and is open from 3:00 pm to 7:00 pm on Wednesdays, and 10:00 am to 2:00 pm on Saturdays. SML representatives are present to provide information on the Project, answer questions, and collect any comments or questions from members of the public.

Days of operation for the Stanley office were changed during the winter of 2013 to account for winter weather. Due to reduced visits, the Stanley office continued to operate every second Wednesday and every second Saturday throughout 2014.

At the time of writing, approximately 200 people have visited the information office since it opened in mid-August 2011. In addition to a variety of general Project information, copies of Project documents (such as the Project Description, Terms of Reference, and Baseline Technical Reports) are available for public review. Reference materials about mining are also available.

The information office is also used to host a variety of community-based activities including meetings with provincial and municipal government officials, community barbeques, and workshops with key stakeholders, among other uses.

A large number of visitors to the information office expressed interest in possible employment and contracting opportunities, and frequently drop by to inquire about the Project and its schedule. Given the keen interest in employment and contracting opportunities, SML has accepted unsolicited resumés and held them in a database until such time as the Project receives approval. To date, SML has added more than 585 resumés to its database, and continues to receive resumés on a regular basis.

In addition to maintaining its resume database, SML also maintains a database of over 230 businesses with company profiles. There is strong interest by the New Brunswick business community to participate in any contracting or supply opportunities going forward.

Open Houses – September 2011

In addition to several open houses held by Geodex in 2008 and 2009, Northcliff/SML has to date held three open houses in September 2011 as part of the public review of the Draft Terms of Reference, and again in October 2013 (see below). The 2011 open houses were held in Juniper, Millville, and Stanley at the following locations and times:

- Juniper Recreation Centre—September 12, 2011, 4:30-8:30 pm;
- Millville Village Office—September 14, 2011, 4:30-8:30 pm; and
- Upper Nashwaak Lions Club—September 15, 2011, 4:30-8:30 pm.

The public was notified of the open houses in several ways, including:

- two advertisements in the Fredericton Daily Gleaner, on September 9 and 10, 2011;
- two advertisements in the Woodstock Bugle, on September 7 and 9, 2011;
- advertisements placed in the September issues of the monthly community newspapers in Stanley, Millville, and Nackawic;
- posters in post offices, villages offices, convenience stores and restaurants in Stanley, Juniper, Florenceville-Bristol, Cross Creek, and Millville;
- letters sent to the Chiefs of all First Nations communities in New Brunswick;
- email sent to all individuals on newsletter mailing list;
- emails sent to mayors of communities in the Project area (Fredericton, Stanley, Millville, Florenceville-Bristol, and Nackawic) and representatives of local service districts in the Project area (Douglas and Aberdeen);
- email sent to the Member of the Legislative Assembly (MLA) and Member of Parliament (MP) representing the area; and
- notice on the Sisson Project website.

Key regulatory agencies, including the CEA Agency in Halifax and the NBDELG's Environmental Assessment Section were also notified of the open houses via email, and invited to attend.

Open houses were staffed by members of the Sisson Project team, including representatives of Northcliff/SML, Stantec, Knight Piésold, and SRK Consulting. Additionally, a representative of the NBDELG's Environmental Assessment Section attended two of the three open houses. Various poster boards were laid out within the venue to provide key information on various aspects of the Project, the regulatory process including the Terms of Reference, key Project-environment interactions, and key studies planned to be carried out. Project representatives were on hand to speak with attendees, present information, and answer questions. Comments, questions, and concerns from those in attendance were recorded by the Project team.

Posters were presented at the open house and were grouped into five general subject areas:

- Project and Proponent Information—presenting information about the location and preliminary design of Project facilities, Northcliff/SML's commitment to responsible mineral development, information on tungsten and molybdenum, and the geology of the Sisson deposit;
- Acid Rock Drainage Studies—presenting information on acid rock drainage and metal leaching in general, and on the studies being conducted to determine the potential for acid generation at the Project;
- Water Management Including Tailings Management—presenting information on the water monitoring studies that are ongoing and planned for the Project, as well as information on water management principles, including tailings storage facility engineering design considerations, for the Project;
- Aquatic Environment—presenting information on Northcliff/SML's ongoing fish and fish habitat studies surrounding the Project area; and
- Environmental Impact Assessment—providing information of the applicable the federal and provincial environmental assessment processes, key Project-environment interactions, key environmental issues that will be studied in the EIA, an overview of the Terms of Reference including key work plans to address key Project-environment interactions, where copies of the draft Terms of Reference can be downloaded or viewed, and information on how to submit comments and/or questions.

There were at least 17 members of the Project team present at each open house. The structure of the open houses allowed members of the public in attendance to speak with Project representatives with expertise in particular subject areas of interest. Since the Project team members present represented a wide range of technical expertise, detailed and/or technical questions were, for the most part, answered in person.

Total attendance at each open house (excluding Sisson team members) was approximately 35 attendees in Juniper, 40 in Millville, and 46 in Stanley.

Open Houses – October 2013

In October of 2013, SML held three open houses to share information on the content of the EIA Report during the public comment period under the *CEAA* review process. The open houses were held in Stanley, Juniper and Nackawic at the following locations and times:

- Upper Nashwaak Lions Club October 1, 2013, 4:00 – 8:00 pm;
- Juniper Recreation Centre October 2, 2013, 4:00 – 8:00 pm; and
- Nackawic Community Centre October 3, 2013, 4:00 – 8:00 pm.

As in 2011, the public was notified of the open houses in several ways, including:

- two advertisements in the Fredericton Daily Gleaner, on September 24 and 27, 2013;
- two advertisements in the Woodstock Bugle, on September 24 and 27, 2013;
- drop mail cards in the communities of Stanley, Juniper, Glassville, Florenceville-Bristol, Nackawic and Millville;
- advertisements placed in the September issues of the monthly community newspapers in Stanley, Millville, and Nackawic;
- posters in post offices, villages offices, convenience stores and restaurants in Stanley, Juniper, Florenceville-Bristol, Cross Creek, and Millville;
- email and letters sent to all individuals on newsletter mailing list;
- emails sent to mayors of communities in the Project area (Fredericton, Stanley, Millville, Florenceville-Bristol, and Nackawic) and representatives of local service districts in the Project area (Douglas and Aberdeen);
- email sent to the Member of the Legislative Assembly (MLA) and Member of Parliament (MP) representing the area; and
- notice on the Sisson Project website.

Key regulatory agencies, including the Atlantic Region Canadian Environmental Assessment Agency and the New Brunswick Department of the Environment and Local Government (NBDELG), were also notified of the open houses via email, and invited to attend; these regulatory agencies attended part of, or all, the open houses.

Open houses were staffed by members of the Sisson Project team, including representatives of Northcliff/SML, Stantec, and Knight Piésold, a representative of the NBDELG's Environmental Assessment Section and NB Power representatives. The representatives were on hand to speak with attendees, present information, and answer questions. Comments, questions, and concerns from those in attendance were recorded by the Project team. Various poster boards were laid out within the venue to provide key information on various aspects of the Project. Posters were presented at the open house and were grouped into five general subject areas:

1. Project and Proponent Information – presenting information about the location and design of Project facilities, Northcliff/SML's commitment to responsible mineral development, information on tungsten and molybdenum, the geology of the Sisson deposit, project economics and community benefits;
2. Tailings Storage Facility (TSF) and Water and Waste Management – presenting information on the water monitoring studies for the Project, as well as information on water management principles, including tailings storage facility engineering design considerations for the Project;
3. Environmental Impact Assessment Report – presenting information and mitigation strategies on subject areas within the EIA Report including:
   a. Water Resources;
   b. Aquatic Environment, Fish & Fish Habitat;
   c. Human Health & Safety;
   d. Air Quality;
   e. Terrestrial, Wetland and Vegetated Environment;
   f. Land Use & Heritage Resources; and
   g. Closure & Reclamation Planning;
4. NB Power – presenting information on the proposed power routing from Keswick to Sisson Project Site; and
5. Environmental Assessment Process–presenting information on the regulatory process.

There were at least 14 members of the Project team present at each open house. The structure of the open houses allowed members of the public in attendance to speak with Project representatives with expertise in particular subject areas of interest. The Project team members represented a wide range of technical expertise, and were therefore able to provide responses directly to the attendees.

Total attendance at each open house (excluding Sisson team members) was approximately 80 attendees in Juniper, 102 in Nackawic, and 62 in Stanley.

Working Groups

Four working groups have been established thus far for the Project: a Sustainability Working Group; a HADD Working Group; an Aquatics Stakeholder Working Group; and a First Nations Environmental Assessment Working Group, discussed in more detail in Section 4.3.1.2.3.

Sustainability Working Group

The Sustainability Working Group, formed in May 2012, provides a forum for information sharing and discussion. It is comprised of two community members from each of Aberdeen Parish, Millville, and Stanley. Participants include elected municipal leaders, local business owners, a representative of the New Brunswick Professional Outfitters & Guides Association, and a representative from Families of the Upper Nashwaak, which is a Stanley-based non-profit organization. The group is chaired by SML with support provided by Stantec and other experts as needed. The Sustainability Working Group:

- contributes to SML's understanding of local community interests and opportunities related to the Project;
- discusses baseline data results and provide input to data related to communities and regions and users of the Project area;
- discusses Project design, potential effects arising from the Project and potential mitigation or management strategies, and strategies for enhancing local/provincial benefits from the Project;
- contributes to ideas on objectives for mine closure (*i.e.,* end land use objectives); and
- helps to identify areas for further study.

Discussion topics include the EIA and Project plans including mitigation and management strategies that are protective of people and the environment while optimizing Project benefits. From time to time, the working group invites individuals who can provide additional expertise to attend the discussions. To date, representatives from the City of Fredericton and Enterprise Fredericton have attended sessions on Water and Waste Management and Labour and Economy, respectively. The Sustainability Working Group will continue throughout the EIA as participants are recognized as an important conduit for providing information to the communities of Stanley, Juniper, and the Millville/Nackawic region.

Fisheries Act Working Group

The Fisheries Act Working Group is comprised of representatives of the federal Department of Fisheries and Oceans, the provincial departments of Natural Resources and Environment and Local Government; SML; and Stantec technical staff. Its purpose is to:

- inform regulators about the planning and design of the Project as it unfolds;
- discuss field and other aquatic research activities in support of Project planning, preparation of the EIA Report, and future requirements for permits and authorizations, especially authorization under the federal *Fisheries Act* for serious harm to fish or habitat; and
- develop the framework for a conceptual Fish Habitat Offset Plan.

To date, the Fisheries Act Working Group has met four times, on June 15, 2011; November 2, 2011; September 27, 2012; and November 6, 2012. Topics of discussion at these meetings included the Project description, the 2011 aquatic field program plans and results, methods for determination of both direct and indirect losses fish habitat, and potential offsetting opportunities to form the basis of the fish habitat offset plan for the Project based on DFO's hierarchy of preferences. It is expected that the Fisheries Act Working Group will continue to meet throughout the EIA review period and leading up to DFO's eventual Project authorization and associated requirement for offsetting serious harm to fish or fish habitat. Discussions since November 2012 have just involved SML and DFO, with the exception of meetings that also included First Nations on November 19, 2013 and October 9, 2014.

Aquatics Stakeholder Working Group

The Aquatics Stakeholder Working Group is comprised of representatives of the Nashwaak Watershed Association (NWAI), the Canadian Rivers Institute (CRI), the Atlantic Salmon Federation (ASF), the New Brunswick Salmon Council, Stantec technical staff, and SML. Its purpose is to:

- inform key aquatic stakeholders about, and gain feedback on, the planning and design of the Project as it unfolds;
- discuss field and other aquatic research studies in support of Project planning and preparation of the EIA Report, and to receive feedback on the scope and content of those studies; and
- develop ideas for ways to avoid, minimize or compensate for Project environmental effects on the aquatic environment.

To date, the Aquatics Stakeholder Working Group has met three times, on May 24, 2011; December 16, 2011; and December 6, 2012. Topics of discussion at these meetings included Project description, the EIA process, the 2011 and 2012 aquatic baseline studies work plans and results, determination of effects on fish and fish habitat (including population studies and HADD determination), the basis for future fish habitat and environmental effects monitoring, and HADD compensation opportunities—both large-scale and small-scale. The basis of a fish habitat compensation plan and options for locating the TSF and alternatives was also discussed.

In addition to these meetings, Northcliff/SML sent an update report to the Aquatics Stakeholder Working Group on July 3, 2012 on the release of the baseline technical reports and their availability for review, and the design of the 2012 aquatics field program, and how it responded to input received at the December 16, 2011 meeting. Further email communication was also held following the December 6, 2012 meeting.

The First Nations Environmental Assessment Working Group is discussed in Section 4.3.1.2.3.

Presentations and Meetings with Stakeholder Groups

SML continues to be active in meeting and presenting the Project and updates to a number of individuals, stakeholder groups, individuals representing stakeholder groups, business groups, and federal, provincial and municipal officials.

To date, Northcliff/SML has met, communicated with and/or presented Project information to the following groups or their representatives:

- Aberdeen local service district (LSD);

- Acadian Timber;
- Atlantic Salmon Federation (ASF);
- New Brunswick Salmon Council;
- Canadian Rivers Institute (CRI);
- City of Fredericton;
- Conservation Council of New Brunswick (CCNB);
- Douglas LSD;
- Enterprise Fredericton;
- Families of the Upper Nashwaak;
- Fredericton Chamber of Commerce;
- Fredericton Rotary Club;
- Millville Village Council;
- Stanley Village Council;
- Nashwaak Watershed Association (NWAI);
- New Brunswick Metal Workers Association;
- New Brunswick Road Builders Association;
- New Brunswick Professional Guides & Outfitters Association;
- New Brunswick Trappers and Fur Harvesters Federation (NBTFTF);
- Stanley Fire Department Chief;
- Millville Fire Department;
- Southern New Brunswick Truckers Association;
- Town of Woodstock;
- Taymouth Environmental Action Committee;
- Town of Florenceville-Bristol;
- Town of Nackawic Council;

- Upper Miramichi Village Council;
- Miramichi Valley Business Association;
- Carleton County Chamber of Commerce;
- Ignite Fredericton;
- New Brunswick Building Trades Council;
- Post-Secondary Education Training and Labour; and
- NB Trade Training and Apprenticeship Board.

Career Information Sessions

Career information sessions were held June 20, 25, and 28, 2012 in Millville, Stanley, and Juniper, respectively. Northcliff/SML has received many questions about possible employment opportunities with the Project through other engagement activities. These career information sessions were held to provide information about the types of careers the Project will provide, and the availability of applicable education and training programs offered locally.

A series of Project posters, detailed maps showing Project location and mine design were on display and supported by Northcliff/SML staff. Representatives from the New Brunswick Department of Post-Secondary Education, Training and Labour, the New Brunswick Community College, and the New Brunswick Workplace Essential Skills Program also participated in these sessions and were available to provide detailed information on education and skills upgrading programs.

The public was notified of the career information sessions in several ways, including:

- drop mail cards in the communities of Stanley, Juniper, Glassville, Florenceville-Bristol, Nackawic and Millville. In total 1,680 mail-out pieces were delivered through the mail system;
- media release issued to the Daily Gleaner, the Woodstock Bugle, Woodstock radio station CJ104, and Fredericton radio station 92.3 Fred FM;
- posters distributed in the communities of Stanley, Florenceville-Bristol, Juniper, Millville and Nackawic;
- emails sent to mayors of communities (Stanley, Millville, Florenceville-Bristol, and Nackawic, Millville) and representatives of local service districts in the Project area (Douglas and Aberdeen);
- email sent to the Member of the Legislative Assembly (MLA) and Member of Parliament (MP) representing the Project area;
- notice on the Sisson Project website (www.sissonsproject.ca).

- email distribution announcing the event; and
- advertisement in the Woodstock Daily Bugle on June 22 and June 26, 2012.

Nearly 400 people attended the career information sessions. There were approximately 203 attendees in Juniper, 102 in Stanley, and 85 in Millville.

Workshops

Northcliff/SML uses workshops to explore and discuss issues as they arise with different stakeholder groups. Workshops are generally single-issue focused events sponsored by Northcliff/SML in response to recurring questions or concerns raised by several individuals or stakeholder groups.

On October 19, 2011, Northcliff held a Feasibility Study Workshop at its information office in Stanley to help attendees gain a clear understanding of the mine development process. Many questions surrounding economics, engineering and potential environmental effects were addressed, and the process by which these are addressed in the feasibility studies and the EIA was described. Northcliff's chief geologist for the Project gave a presentation explaining the history of the Project from early exploration to development, and outlined the relationship between the feasibility study and the EIA Report including how environmental considerations are factored into the final mine design to ensure financial feasibility and environmental sustainability. The workshop was attended by Mayor and Council for the Village of Stanley, representatives of the Local Service District of Aberdeen (Juniper), and individual stakeholders who own and operate businesses in Stanley.

Throughout the course of various public and stakeholder consultation and engagement activities, much interest was expressed in the tailings storage facility and associated waste and water management. In response, an interactive presentation was developed to address the recurring questions raised by various individuals and stakeholders. The Water and Waste Management Workshop was delivered via webex by Northcliff's engineering consultant based in British Columbia to the following stakeholders and working groups:

- Sustainability Working Group;
- Mayor and Council of the Village of Stanley;
- Taymouth Environmental Action Committee (also present were members of the Nashwaak Watershed Association and the Conservation Council of New Brunswick, as well as interested community members from Taymouth); and
- First Nations Environmental Assessment Working Group (Section 4.3.1.2.3).

4.3.1.2 Aboriginal Engagement

In addition to developing long-term positive partnerships with First Nations, the goal of SML's Aboriginal engagement program for the Project is to identify issues and concerns related to potential impacts on Aboriginal land uses, to explore opportunities to mitigate the environmental effects and enhance the benefits of the Project, and to document assertions of Aboriginal and Treaty Rights for consideration by the provincial and federal Crowns. The objectives of these efforts are to:

- provide information and seek input from First Nations on the Project;
- identify, document, monitor and consider issues and concerns arising from the engagement process;
- discuss the past, current and future use of land and resource for traditional purposes by First Nations and how those activities might be affected by the Project;
- provide early notification of the Project field activities and engagement opportunities associated with the EIA process;
- identify the need for planning, design and management measures that will avoid, mitigate or resolve the issues raised, or otherwise accommodate potential impacts to current and future Aboriginal land uses in the Project area; and
- support the Crown's duty to consult and to consider concerns related to potential environmental effects of the Project on asserted Aboriginal and Treaty Rights.

Throughout the EIA process, Northcliff/SML has sought numerous opportunities to meet with First Nations and their representative organizations in order to share information and discuss the Sisson Project. In addition to those described above for the general public, these opportunities have included: phone calls; both formal and informal face-to-face meetings; the establishment of the First Nations EA Working Group; emails; letters; funding an Indigenous Knowledge Study (IKS); and hosting open houses within First Nations communities.

Northcliff also funded a cross-cultural workshop conducted by First Nation elders and knowledge holders that was focused on Maliseet culture and history; Northcliff staff and consultants participated in the workshop. This workshop was held in the community of the Woodstock First Nation over a period of two days in November 2011. Information provided by First Nations during these engagement activities was taken into consideration in the Project planning and EIA Report preparation.

4.3.1.2.1 Indigenous and Traditional Knowledge

An Indigenous Knowledge Study (IKS) of the area in which the Project is located was funded by Northcliff and managed by St. Mary's, Woodstock, and Madawaska Maliseet First Nations (Moccasin Flower Consulting 2013). A more general Aboriginal Traditional Knowledge (ATK) study of endangered wildlife species of relevance to the Maliseet nation was also prepared by the Maliseet Nation Conservation Council (MNCC 2011), though it provides little information specific to the Project.

The purpose of the IKS was to collect information on the past, current, and possible future use of lands and resources in the Project area for traditional purposes by Aboriginal persons. According to the introduction to the IKS (Moccasin Flower Consulting 2013):

> *"…This report traces Maliseet (known in their own language as Wolastoqiyik) livelihood, land use, rights, and environmental integrity of their territory temporally through the past, present and future. Where appropriate, these topics are further divided spatially into traditional territory, REGIONAL STUDY AREA, and PROJECT AREA. This indigenous knowledge study will provide the reader with an understanding of the importance of the*

> *PROJECT AREA to continued Maliseet livelihood and land use in light of a history of restrictions on rights and a decline in environmental integrity in New Brunswick. …"*

The information in the IKS has been taken into consideration in preparing the EIA Report. This information will also be useful in considering mitigation measures for any potential adverse environmental effects on cultural or traditional uses resulting from the Project.

4.3.1.2.2 Project Information and Traditional Knowledge Study Open House Events

Open house events were held in each of the three communities participating in the IKS (*i.e.,* St. Mary's, Woodstock, and Madawaska Maliseet First Nations). The purpose of these community meetings was to provide information about, and discuss, the Sisson Project and the associated EIA process, and to raise awareness about the plans to undertake an IKS. Northcliff staff and consultants participated in these events. Information presented was similar to that presented at the public open houses held in September 2011, and covered topics such as Project and Proponent information; geochemical studies; water quality and management including tailings management; aquatic environment; and EIA (including regulatory processes, Terms of Reference, and key Project-environment interactions and planned studies). Additionally, other information specific to the IKS and heritage resources was presented. Specifically, the IKS was introduced to community members, and the consultant retained to conduct the IKS (Moccasin Flower Consulting) was on-hand to provide information, answer questions, and collect information and feedback from those in attendance. The open houses were held in:

- Madawaska Maliseet First Nation on April 23, 2012;
- Woodstock First Nation on April 24, 2012; and
- St. Mary's First Nation on April 26, 2012.

4.3.1.2.3 First Nations Environmental Assessment Working Group (FNEAWG)

In response to the interest expressed by First Nations in being actively involved in the EIA process for the Project, Northcliff/SML, the CEA Agency, and the Province of New Brunswick invited First Nations to participate in a First Nations Environmental Assessment Working Group (FNEAWG) chaired by Northcliff/SML. The purpose of the FNEAWG is to:

- support the exchange of information and discussion about the Sisson Project and related studies for the federal and provincial EIA and Project permitting in order to enhance mutual understanding of the interests and concerns of all parties;
- support the exchange of information related to asserted or established Aboriginal or treaty rights of First Nations, and the potential environmental effects of the Project on these rights and means for avoiding or mitigating those effects;
- strengthen responsible Project planning and implementation, should the Project proceed; and
- provide First Nation participants meaningful information, which can be communicated to their respective communities.

The FNEAWG consists of a core group of representatives of First Nations, government departments, and Northcliff/SML. Specifically, this core groups consists of representatives of:

- St. Mary's First Nation;
- Woodstock First Nation;
- Madawaska Maliseet First Nation;
- The Assembly of First Nations Chiefs in New Brunswick (representing the remaining 12 First Nations communities in New Brunswick);
- Northcliff/SML;
- New Brunswick Department of Environment and Local Government (supported from time to time by representatives of various provincial departments);
- New Brunswick Aboriginal Affairs Secretariat; and
- Canadian Environmental Assessment Agency (supported from time to time by representatives of various federal departments).

Additional participants have attended the FNEAWG meetings from time to time, including technical experts from Stantec and Knight Piésold, and representatives of Health Canada, DFO, New Brunswick Archaeological Services, and NBDNR to provide information specific to the topic of a particular meeting.

When possible, FNEAWG meetings are held within a First Nation community. A summary of the meetings held to date (as of the time of writing this EIA Report) is provided in Table 4.3.1.

Table 4.3.1 Summary of FNEAWG and Other Meetings Held

Meeting Date	Location (Host)	Key Topics Discussed (not an inclusive list of all discussions)
April 25, 2012	Delta Hotel, Fredericton (Northcliff)	• Terms of Reference for FNEAWG. • Overview of Project and Mining 101. • 2011 Archaeological Assessment.
May 9, 2012	Crowne Plaza Hotel, Fredericton (Northcliff)	• 2011 Archaeological Assessment. • 2012 Archaeological Test Pitting Program. • Terms of Reference for FNEAWG. • Provincial and Federal Harmonized Environmental Assessment Process. • Northcliff EIA Overview presentation.
June 26, 2012	Maliseet Cultural Centre, St. Mary's First Nation, Fredericton (St. Mary's First Nation)	• Mandate of the FNEAWG. • Archaeology Update. • 2011 Terrestrial Studies (Wildlife, Habitat, Vegetation, Wetlands). • 2011 Aquatic Baseline Studies.
August 14, 2012	Eagles Nest Gaming Palace, Woodstock (Woodstock First Nation)	• EIA Update. • Baseline Studies. • Waste and Water Management.

Table 4.3.1 Summary of FNEAWG and Other Meetings Held

Meeting Date	Location (Host)	Key Topics Discussed (not an inclusive list of all discussions)
September 26, 2012	Kingsclear First Nation Band Office, Kingsclear (Kingsclear First Nation)	• Revisions to the FNEAWG Terms of Reference. • Human Health and Ecological Risk Assessment (HHERA). • Fish Habitat Compensation Overview.
December 5, 2012 *First Nations did not attend this meeting, and it continued as SML/government discussions.*	Crowne Plaza Hotel, Fredericton (Northcliff)	• FNEAWG Scope and Terms of Reference. • Aboriginal Interests and Rights. • Capacity support. • Fish Habitat Compensation Workshop. • Tailings alternatives analysis.
September 5, 2013	Crowne Plaza Hotel, Fredericton (Northcliff)	• Working Group Terms of Reference • Review of EIA Report • Archaeology Test Pitting • Impacts to Rights
September 30 – October 1, 2013	Wu Conference Centre, UNB Fredericton (Northcliff)	• Project Overview • Baseline Water Quality & Water Management • ARD/ML Presentation • Water Treatment Process • Water Quality Predictions & Modeling • Aquatic Habitats • Fish Habitat Compensation Plan • Aquatic Environmental Effects Presentation
October 23, 2013	Wu Conference Centre, UNB Fredericton (SML)	• Current Land and Resource Use for Traditional Purposes by Aboriginal Persons • Human Health and Ecological Risk Assessment • Environmental Effects Assessment of Public Health & Safety
November 20, 2013	Wu Conference Centre, UNB Fredericton (SML)	• Environmental Effects Assessment: Heritage Resources
September 4, 2014[1]	Wu Conference Centre, UNB Fredericton (SML)	• Potential environmental effects on cultural heritage
October 8, 2014	Wu Conference Centre, UNB Fredericton (SML)	• Framework for First Nations participation in the Follow-up and Monitoring Program for the Sisson Project
October 9, 2014	SML Office (SML)	• Fisheries Act authorization and Offsetting Plan

4.3.1.2.4 Support to Aboriginal Employment

In addition to providing employment for First Nations individuals with current Project activities, SML/Northcliff has, since 2011, worked with various New Brunswick organizations to support Aboriginal employment in the mining industry, and to prepare Aboriginal communities and individuals for employment opportunities with the Sisson Project.

Aboriginal Workforce Development Initiative (AWDI)/Joint Economic Development Initiative (JEDI)

SML/Northcliff Resources first met with AWDI in February 2011 to provide senior management with an overview of the Sisson Project, and a commitment to work with the organization in identifying training opportunities for the Sisson Project going forward. SML/Northcliff subsequently hired a member of the Woodstock First Nation as a part-time office administrator based on the recommendation of AWDI's

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[1] Provincial government representatives did not attend this meeting at the request of First Nations.

executive director. SML/Northcliff also committed to informing AWDI of any upcoming summer employment positions for sharing with First Nation communities, and these positions are now routinely posted with AWDI for dissemination through their network. Also in 2011, SML/Northcliff advertised its First Nation Scholarship program with AWDI; three $1,000 scholarships were awarded to First Nation students.

In March 2012, SML/Northcliff representative attended AWDI's Partnership Appreciation Dinner in Fredericton, an event to thank industry and businesses for ongoing work with respect to First Nations training and employment through AWDI. In November 2012, SML/Northcliff provided AWDI with a letter of support in their application for funding through the federally sponsored New Brunswick Mining & Energy Trades Training (NBMET) Program. As in 2011, SML/Northcliff advertised its First Nation Scholarship program with AWDI; three $1,000 scholarships were awarded to First Nation students.

In March 2013, SML/Northcliff participated in a career information sessions hosted by AWDI at the Miramichi and Fredericton campuses of the New Brunswick Community College. The information session was dedicated to First Nation students exploring post-secondary education options. In June 2013, SML/Northcliff provided a project overview and update to members of the Joint Economic Development Initiative (JEDI) and AWDI staff in Moncton.

In 2014, SML/Northcliff joined the steering committee for AWDI's NBMET Program which, in April, finalized details and successfully implemented a heavy equipment operator's course held on Tobique First Nation. Funding for the program was provided under the federal government's Aboriginal Mining and Energy Trade Program. The program was successful in graduating 16 Aboriginal students from various First Nation communities around New Brunswick. Since completion of the program SML has received six resumes from program graduates.

New Brunswick Department of Post-Secondary Education, Training and Labour (PETL)

PETL works to ensure that the New Brunswick workforce is competitive by making strategic investments in people through innovative programs, services and partnerships, and implements New Brunswick's Labour Force and Skills Development Strategy. SML has worked with PETL on basic skills upgrading programs designed for all New Brunswick residents. These include General Educational Development (GED) and Workplace Essential Sills programs.

New Brunswick Community College (NBCC)

SML/Northcliff has been engaged with New Brunswick Community College (NBCC) since 2012 to provide information on the Sisson Project and the anticipated skill sets required for a variety of career opportunities with the Project. NBCC participated in SML/Northcliff's career information sessions in 2012. In January 2015, NBCC approached SML to provide details on their current plans for the Environmental Monitoring Technologist (EMT) Program geared to Aboriginal students from New Brunswick's First Nations communities. The EMT program will involve NBCC matching Aboriginal students from the program with industry opportunities. SML agreed to participate in the program by offering employment and mentorship opportunities, and to work closely with our environmental contractors to ensure on-the-job opportunities are provided to qualified First Nations individuals. SML also agreed to provide guest lecturers for the EMT program.

4.3.2 Summary of Key Issues Raised During Stakeholder Consultation and First Nations Engagement Activities

Throughout the public, stakeholder, and First Nations engagement programs, questions, comments and issues were raised in respect of the Project itself, its design and operation, and its anticipated environmental effects and how they can be addressed. A number of these key issues and concerns resulted in changes to the work plans for the EIA or changes to the design or mitigation planned for the Project itself.

The issues, comments, questions or concerns raised by the various parties to date have been exhaustive, and often ranged beyond matters relating to the Project design or the EIA. Tables 4.3.2 and 4.3.3 provide a summary of the key questions, comments, or issues raised by stakeholders, the general public and by First Nations, with a focus on those that relate to the design of the Project or the preparation of the EIA Report. Both tables also summarize Northcliff/SML's responses or actions taken to address each topic, and list the section of the EIA Report that addresses the question, issue or comment, as applicable. Importantly, it is noted that this listing focuses on key questions, comments or issues, and is not intended to be comprehensive. SML is preparing a more detailed report on its consultation and engagement activities that will be released along with the EIA Report. These tables have been developed from information provided by Northcliff/SML on the public, stakeholder and Aboriginal engagement activities it has carried out in respect of the Project up to March 2014. SML has undertaken no public or stakeholder engagement activities since then; a comprehensive synopsis of concerns raise through First Nations engagement activities through to September 2014, and SML's responses to those concerns, is provided in Table 8.13.5.

Table 4.3.2 Summary of Key Issues or Concerns Identified by the Public and Stakeholder Groups During Consultation and Engagement Activities, and Associated Responses or Actions Taken

Key Questions, Comments or Issues Raised	Response	Section of EIA Report Addressing Question, Comment or Issue
Will SML model for catastrophic failure of the TSF embankment?	Credible accidents, malfunctions and unplanned events are assessed as part of the EIA.	Section 8.17.
Will the TSF overtop if we experience a rain event similar to what occurred in Dec. 2010 in NB?	No. Detailed engineering of the TSF takes into consideration extreme weather events. SML and its engineering consultants developed and delivered a workshop on Water and Waste Management to several stakeholder groups in 2012. Updated information on TSF engineering was presented at these workshops.	Section 8.16.6.1.
Can the TSF withstand earthquakes?	Yes. A seismicity assessment has been carried out for the Sisson Project, including a review of the regional seismicity and a site-specific seismic hazard analysis.	Section 3.2.4.3.3 and 8.16.6.2.
Has SML considered dry stack tailings?	Yes. SML has undertaken an analysis of several tailings options, including dry stack tailings.	Section 3.3.4.
What are the reagents used in the process water and how will are they managed?	Reagents to be used in the process plant, and process water treatment and management, are described in this EIA Report.	Section 3.4.2.2.5.
Will water be released from the tailings storage facility?	Yes, after several years of operation. Site water management is described in this EIA Report.	Section 3.4.2.3.

Table 4.3.2 Summary of Key Issues or Concerns Identified by the Public and Stakeholder Groups During Consultation and Engagement Activities, and Associated Responses or Actions Taken

Key Questions, Comments or Issues Raised	Response	Section of EIA Report Addressing Question, Comment or Issue
What is the quality of the pit water?	Assessment of the pit water, during Operation and of the eventual pit lake at Closure, has been undertaken and is described in this EIA Report.	Section 8.4.4.3.
What about rain and snow melt that comes into contact with the mine?	All contact water will be collected and contained within the TSF. Non-contact water will be diverted.	Section 3.4.2.3.
How will SML manage acid rock drainage?	SML will store PAG tailings and waste rock under water in the tailings storage facility to effectively mitigate the potential for acid generation.	Section 8.4.4.3, 3.4.2.3, and 7.5.
Will SML support the water classification process where the existing provisional "A" classification should be publically changed to a "B" to accommodate construction of a mine?	The process of water classification is a regulatory one to be determined by the Government of New Brunswick. SML is committed to meeting federal and provincial water quality requirements.	N/A
Why is water quality not monitored on the lower reaches of the Nashwaak River as part of the EIA?	Site locations on the Napadogan and McBean brooks offer the best opportunity to detect changes in water quality.	Section 8.4 and 8.5.
Who will pay for water quality monitoring after the mine closes?	SML will be required to provide a financial security for these and other closure costs, based on its Mining and Reclamation Plan. This security will be held by the Province of New Brunswick.	Section 2.6.3.
Will there be seepage from the TSF into groundwater? If so, how will it be managed?	Seepage from the TSF will be collected in downstream water management ponds and recirculated back into the TSF for reuse as process water. Groundwater monitoring wells will be located downstream of the ponds to ensure the water management system is operating according to its design.	Section 3.4.2.3 and 8.4.4.3.2.
What are the effects of reduced water flows on salmon spawning habitat in the Nashwaak?	Reductions in water flows and potential environmental effects to fish habitat in Napadogan Brook are described in this EIA Report.	Section 8.5.5.3.
Is SML aware that Outer Bay of Fundy Atlantic salmon are recommended for SARA listing by COSEWIC, likely to become listed in SARA soon?	SML has acknowledged the recommendation for Outer Bay of Fundy to *SARA* listing and remains committed to working within the regulatory framework.	Section 8.5.2.3.9.
Will SML conduct additional stream assessments as part of it aquatics program?	Based on the recommendations of stakeholders, the 2012 aquatics program included a broader brook trout habitat availability study, and extended the baseline habitat monitoring work. The aquatics program goes beyond what is required in the EIA Terms of Reference.	Section 8.5.5.3.
What is the amount of fish habitat lost?	Calculations of lost fish habitat are included in this EIA Report, and are the basis for preparing a HADD compensation plan required under the Fisheries Act.	Section 8.5.5.3.
What are the impacts to wildlife in project area?	The potential environmental effects to the terrestrial environment are described in this EIA Report.	Section 8.6.4.3.
What effects will mine dust have on plants and wildlife?	SML has completed dust dispersion modelling as part of environmental effects assessment.	Sections 8.2 and 8.9.

Table 4.3.2 Summary of Key Issues or Concerns Identified by the Public and Stakeholder Groups During Consultation and Engagement Activities, and Associated Responses or Actions Taken

Key Questions, Comments or Issues Raised	Response	Section of EIA Report Addressing Question, Comment or Issue
What are the impacts to waterfowl landing in the TSF pond?	There are mitigation strategies to minimize the occurrences of wildlife interactions with mine facilities. This is described in this EIA Report.	Section 8.6.4.3.
Will mine dust affect the health of mine workers?	A human health risk assessment has been conducted.	Sections 7.7 and 8.9.
Lack of public meetings	Northcliff/SML has held multiple community functions to inform the public about the project including: open houses, and Project and career information sessions. SML also maintains an office in Stanley and Fredericton, an interactive website, newsletters, and a variety of additional outreach tools.	Sections 2.7.2 and 4.3.
Will SML commit to public accounting of the bonding requirements and full funding of these requirements on day one of the project?	The Government of New Brunswick (not SML) determines the required bonding based on the costs of reclamation and closure calculated by SML and verified by the GNB. They are included in the 43-101 Technical Report that Northcliff filed in the Canadian Securities Administrators' publically-accessible SEDAR filing system, and in the Mining and Reclamation Plan that SML must provide to the GNB under the *Mining Act.*	N/A
Will community emergency response services be required at the mine – specifically local fire & rescue units?	SML will develop an Emergency Response Plan, have its own on-site emergency response equipment and supplies, and train on-site workers as primary responders to unplanned upsets or events. SML has committed to developing its Emergency Response Plan with local and regional officials.	Section 8.11.
Will local fire departments be made aware of any hazardous materials on site?	Yes. SML has committed to developing its Emergency Response Plan with local and regional officials.	Section 8.11.
How did SML estimate its employment numbers during construction and during operations?	SML and its consultants based its employment estimates on mining experience with projects of similar size in similar locales.	Section 8.10.4.3.
Will the community of Stanley see increased truck traffic?	A number of transportation routes are being considered. Expected transportation routes and traffic volumes are described in this EIA Report.	Section 8.15.4.3.2.
What will you do to protect the safety of recreational users in the area?	There will be an exclusion zone and a safety perimeter around the Project site.	Section 8.12.4.

Legend:

N/A	Not Applicable	FS	Feasibility Study
SEDAR	System for Electronic Document Analysis and Retrieval	EIA	Environmental Impact Assessment
TSF	Tailings Storage Facility	NB	New Brunswick
GNB	Government of New Brunswick	HADD	Harmful Alteration, Disruption or Destruction

Table 4.3.3 Summary of Key Issues or Concerns Identified by Aboriginal Groups During Consultation and Engagement Activities, and Associated Responses or Actions Taken

Key Questions, Comments or Issues Raised	Response	Section of EIA Report Addressing Question, Comment or Issue
Environmental Assessment should consider current, traditional and future use of the Project area by First Nations. Traditional knowledge should augment western science for the EIA.	The scope of the EIA includes past, present and future use by First Nations. Northcliff commissioned preliminary internal ethnohistorical research to understand the written historical record and to assist with initial outreach to potentially affected First Nations. Northcliff/SML sponsored numerous engagement opportunities to understand First Nations views and concerns regarding historical, current and future use of the project area by aboriginal peoples. Northcliff contracted Maliseet elders to provide a cross-cultural information session to learn about Maliseet history and culture. Northcliff funded an indigenous knowledge study (IKS) with three Maliseet First Nation communities (offer was made to others) and this information has been considered in the EIA report.	Section 8.13.
First Nations expressed a desire to ensure that the Project is developed in a manner that exceeds regulatory guidelines and industry best management practices.	SML is committed to meeting or exceeding regulatory requirements and industry best management practices. This is addressed in the EIA report.	Various, including Sections 1.4, 2.5, 2.6, and 3.
EIA should include community input.	There have been and will continue to be opportunities provided for community input. SML continues to offer additional community meetings to each First Nation community as they may wish. Meetings held to date: • Madawaska Maliseet FN – April 23, 2012 open house. • Woodstock FN - April 24, 2012 open house. • St. Mary's FN - April 26, 2012 open house. Component of IKS included interviews with community elders and knowledge holders. FN community representatives to the FN EA working group are expected to be a conduit of information to and from their community. Public comment periods are part of the federal and provincial EA processes; anyone, including FN community members, can provide comments or request information during these periods.	Section 4.3.
Some FNs claimed that the baseline reports were not provided to First Nations for their input.	Ten baseline technical reports were provided to First Nations for their review and comment, well in advance of the EIA report submission.	N/A
First Nations are concerned about their level of involvement (or lack thereof) in the baseline studies.	Engagement opportunities with First Nations were sought by Northcliff throughout the baseline study process to discuss the studies and the Project.	N/A

Table 4.3.3 Summary of Key Issues or Concerns Identified by Aboriginal Groups During Consultation and Engagement Activities, and Associated Responses or Actions Taken

Key Questions, Comments or Issues Raised	Response	Section of EIA Report Addressing Question, Comment or Issue
	First Nations were notified about the commencement of baseline programs, and field technician jobs were posted in First Nations communities as well as with Aboriginal umbrella organizations. First Nations were offered field reconnaissance tours with Northcliff/SML and their consultants to discuss the baseline conditions. Northcliff funded an IKS to assist First Nations to provide information to the EA process. First Nations were advised about the archaeological field studies and were asked for field assistants and input from knowledge holders. Northcliff initiated the FN EA working group to enable government, Northcliff/SML and FNs to directly discuss and address FN concerns relevant to the Project and EA. Discussions have included technical aspects of the EIA report and supporting baseline studies, with experts hired by FNs with funding from Northcliff/SML.	
FNs asked whether the baseline studies would be updated upon completion of the IKS.	IKS was used to inform the EIA and all the associated VECs. It will not be used to update the baseline studies.	N/A
What is the validity of the baseline data if the Project is not built for several years?	Some baseline data collection will continue (*e.g.,* climate, hydrology, water quality) and much of the rest (*e.g.,* vegetation, wetlands) will change very slowly and thus be valid for some time.	N/A
Species identified in the baseline study may not have included species of importance to First Nations.	Baseline data collection includes an inventory of species present at each survey point. Baseline studies were provided to First Nations and, while the reports will not be updated, First Nations are welcome to comment on any perceived gaps in the baseline species lists. The IKS provided additional field information for inclusion in the EIA.	Sections 8.6 and 8.13.
First Nations raised concerns about the level of consultation as part of the archaeology program.	First Nations invited for field visit of 2012 archaeological test pitting program which was undertaken in response to First Nation concerns. Community members were invited to participate in transmission line walkover. Knowledge holders from Woodstock FN were interviewed for their knowledge of the Project area. Presentations and extensive discussion of the archaeology research and test pitting program conducted at the FN EA Working Group (FNEAWG) meetings in April, May and June 2012 and again in October and November 2013.	Section 4.3.

Table 4.3.3 Summary of Key Issues or Concerns Identified by Aboriginal Groups During Consultation and Engagement Activities, and Associated Responses or Actions Taken

Key Questions, Comments or Issues Raised	Response	Section of EIA Report Addressing Question, Comment or Issue
	SML has made an ongoing commitment to meet and discuss the program and consider modifications where warranted. Additional detailed consultation was undertaken prior to starting the 2013 field program, including hiring of three local First Nation field technicians, and a First-Nation appointed monitor.	
Request to have traditional ceremony on site prior any ground breaking activities.	Offer was extended to First Nations to conduct such ceremonies.	N/A
FNs asked if the feasibility study will be made available to First Nations.	The feasibility study (FS) is not a public document and will not be released to anyone, including FNs. Northcliff filed a 43-101 Technical Report on SEDAR which is accessible to the public and of which Northcliff provided copies to First Nations. SML is open to having its engineering team present a summary of the FS to the FNEAWG if requested.	N/A
Concerns were raised generally about the potential environmental effects of exploration drilling.	Exploration is a limited/low impact, temporary use of the land. Water and sediment are closely controlled during drilling, and disturbed areas are reclaimed by re-contouring and re-vegetating for long-term stability.	N/A
Concern was raised on a perceived lack of inhalation pathway for ecological receptors.	This is described in the EIA Report.	Section 7.8.
First Nations want to ensure there is consideration of consumption of country foods by local aboriginal communities.	Health Canada data is available that considers a higher consumption rate of country foods for First Nations that are greater than the general population. First Nations consumption rates are considered in the human health risk assessment of the EIA report.	Section 7.8.
Concerns about potential impacts of the Project on air quality.	This is assessed in the EIA Report.	Section 7.2 and 8.2.
Concerns about potential increase in greenhouse gas emissions.	This is assessed in the EIA Report.	Section 8.2.4.3.
Concerns about potential impacts of the Project on plant health.	This is assessed in the EIA Report.	Sections 8.7.6.2 and 8.13.
Concerns regarding potential environmental effects of the Project on potential plant gathering areas and hardwood stands that are important to the Maliseet (IKS).	Potential environmental effects on vegetation, including plant species, are discussed in the EIA Report.	Section 6.2, 8.7, 8.13
Concern about potential environmental effects of the Project on plants that are species at risk or species of conservation concern.	As indicated in the IKS, several of the species identified within the PDA are traditionally used as food or medicine. All of the species that are listed on page 29 of the IKS that were found within the PDA are species that are abundant in the Province of New Brunswick and are not of conservation concern with the possible exception of “orchid” which can refer to a number of species in the Family Orchidaceae. If such species are encountered, Project activities will avoid them wherever possible; otherwise, relocation of species can occur.	Section 8.7.

Table 4.3.3 Summary of Key Issues or Concerns Identified by Aboriginal Groups During Consultation and Engagement Activities, and Associated Responses or Actions Taken

Key Questions, Comments or Issues Raised	Response	Section of EIA Report Addressing Question, Comment or Issue
Concerns regarding potential environmental effects of the Project on plant species of significance to First Nations (*e.g.* calamus root, a medicinal plant) (IKS).	Calamus root (*Achorus americanus*), which was identified on Page 33 of the IKS as being of particular importance, is a widespread plant in New Brunswick (ranked S4 ["fairly common"] by the ACCDC), but was not identified in the LAA despite extensive walkover of the PDA throughout the growing season of 2011 and part of 2012. Riparian and marsh habitat types where calamus root is typically found were identified prior to surveys as areas of elevated potential for rare plant species and field surveys targeted these areas with increased effort. Goldthread (*Coptis trifolia*), which was also singled out as being of particular importance, is ubiquitous (ranked S5 by ACCDC ["abundant"]) in a variety of wooded habitats across the entire province and was encountered throughout the PDA and beyond. None of the species found in the PDA that were identified in the IKS as having medicinal or food value are of conservation concern according to the ACCDC, nor are they found in the PDA in an unusual abundance that is atypical to other areas of New Brunswick. Sections 8.7 and 8.13 of the EIA Report assess the potential environmental effects of the Project on the vegetated environment, and any plants or vegetation of importance to First Nations, such as calamus root. First Nations will be provided with reasonable opportunity to collect plants of importance in the Project footprint prior to construction.	Section 8.7, 8.13
Concern about the ability of First Nations to harvest plants of importance prior to construction.	First Nations will be afforded reasonable opportunity to collect plants of importance prior to construction.	Section 8.13.
Concerns about potential impacts of the Project on drinking water	This is assessed in the EIA Report.	Section 7.6 and 8.4.
Concern about potential impact of reduction of run-off due to the Project footprint on the Nashwaak River.	This is assessed in the EIA Report.	Section 7.4, 8.4, and 8.5.
Concern about potential impacts on salmon (juvenile habitats and production, adult returns) in the Nashwaak river watershed.	This is assessed in the EIA Report.	Section 8.5.
Concerns regarding potential environmental effects of the Project on water quality, and related potentially deleterious environmental effects on fish and fish habitat (IKS).	This is assessed in the EIA Report.	Section 7.4, 7.6, 8.4 and 8.5

Table 4.3.3 Summary of Key Issues or Concerns Identified by Aboriginal Groups During Consultation and Engagement Activities, and Associated Responses or Actions Taken

Key Questions, Comments or Issues Raised	Response	Section of EIA Report Addressing Question, Comment or Issue
Concerns regarding potential environmental effects on brooks in the Project area and other downstream waterways such as the Nashwaak River from mining activities, particularly from chemicals in the tailings storage facility (IKS).	This is assessed in the EIA Report.	Section 7.4, 7.6, 8.4
Concerns that a reduction in runoff due to the footprint of the Project may reduce water levels in the Nashwaak River (IKS).	This is assessed in the EIA Report.	Section 8.4 and 8.5.
Concerns about potential impacts on hunting, fishing, trapping, and gathering (*i.e.,* First Nations' traditional activities) in the Project area. Concerns that the Project will further reduce access to areas within Maliseet traditional territory where community members hunt, fish, trap and gather.	Though these activities will not be allowed within the Project site for safety reasons, there remains an abundance of representative habitat and species in areas outside the local assessment area. SML will continue to discuss the Project and its potential or actual impacts, and avoidance or mitigation measures, with First Nations throughout all stages. Direct mortality of animals as a result of the Project will be monitored and mitigation strategies employed as appropriate.	Section 8.13.
Concerns that Project employees will begin hunting moose in the area, leading to greater competition for resources.	SML will implement a strict "no hunting" policy for all employees and contractors while they are working at the Project site. It should also be noted that there are strict rules and regulations governing the moose hunt in New Brunswick, and non-aboriginal hunters must receive a license through the annual draw, which allocates a limited number of licenses.	The Environmental Protection Plan for Construction and the Environmental Management Plan for Operation will include this specific mitigation as a part of the ESMS (Appendix D of EIA Report)
Concern that there was no large mammal sampling conducted in the baseline assessment.	Foraging areas are often too large to be representative of the Project site. The baseline data collection methodology includes an inventory of species present at each data point.	Section 7.8.
Questions were raised on the depth of the mine and the resultant potential impacts on the water table and water bodies.	This is described in the EIA Report.	Section 3.2.2 and 8.4.
Concerns raised about the potential impacts of wildlife ingesting water or contaminated food sources directly on the Project site.	Effects on the terrestrial environment, including wildlife, are assessed in the EIA Report.	Section 8.6.
Concerns about potential impact on wildlife such as beavers living adjacent to the brooks in the Project area.	This is described in the EIA Report.	Section 8.6.
Concerns that the Project footprint and Operation (such as facilities, traffic, and personnel) may lead to habitat loss and push moose out of the Project Area (IKS).	This is addressed in the EIA report, in the assessment of potential environmental effects on the terrestrial environment.	Section 8.6

Table 4.3.3 Summary of Key Issues or Concerns Identified by Aboriginal Groups During Consultation and Engagement Activities, and Associated Responses or Actions Taken

Key Questions, Comments or Issues Raised	Response	Section of EIA Report Addressing Question, Comment or Issue
Questions about how First Nations can influence closure and reclamation planning. Concerns about potential environmental effects of the Project on potential future uses of the Project area.	SML is committed to ongoing engagement with First Nations during all phases of mine life. A committee including First Nations representatives and other key local community representatives will be created, following regulatory approval, to work with SML on such topics as environmental monitoring, and reclamation/closure planning (*e.g.*, what are the desired end land uses of the Project site, and how can they be achieved?).	N/A
Questions about employment, contracting and business opportunities and whether they will benefit First Nation communities.	SML is committed to working with First Nation communities so that they can benefit from such opportunities.	N/A
Concerns that people gaining employment in the area may be racist towards First Nations peoples (IKS).	SML expects all employees and contractors to operate within the spirit and intent of its Responsible Mineral Development policy, and will not tolerate any inappropriate behavior at the Project site. SML has clearly stated its intent to hire locally as much as possible, and therefore expects a significant proportion of employees and/or contractors to be New Brunswick residents, including local Aboriginal people.	N/A
Concerns about potential disruption to recreational activities.	This is described in the EIA Report.	Sections 8.12.4 and 8.13.4.
Concerns about potential health risks for local cabin owners.	This is described in the EIA Report.	Section 8.8.4.
Concerns about potential impacts of the Project on recreational fisheries habitat	The potential environmental effects on fish habitat and fishing are described in the EIA Report.	Sections 8.12.4 and 8.13.4.
Concerns about potential impacts of the Project on resource harvesting areas	Effects on harvesting of resources are described in the EIA Report.	Section 8.12.4 and 8.13.4.
Concerns about potential impacts of the Project on access to traditional territory where aboriginal rights are practiced.	This is described in the EIA Report.	Section 8.13.
Concerns that the Project will continue to expand its operations into other areas of its claim block (IKS).	SML is not exploring for minerals in other areas of its mineral claim, and does not have any development plans beyond the current proposal. Should significant changes be proposed in the future, additional regulatory processes will apply, potentially including additional EIA requirements.	Section 3.
Concerns that First Nations do not have capacity to fully participate in and understand the EA process and technical studies	Northcliff established the First Nation EA working group (FNEAWG) to facilitate First Nation discussions with experts and government agency representatives. Northcliff/SML offered to cover costs for First Nations attendees of FNEAWG meetings. Northcliff/SML has made and is willing to make their experts available to First Nations to discuss and explain technical issues.	N/A

Table 4.3.3 Summary of Key Issues or Concerns Identified by Aboriginal Groups During Consultation and Engagement Activities, and Associated Responses or Actions Taken

Key Questions, Comments or Issues Raised	Response	Section of EIA Report Addressing Question, Comment or Issue
	Northcliff/SML sponsored open houses about the Project and the IKs in three Maliseet communities and makes frequent offers to all FNs to hold meetings in their communities. Northcliff/SML offers regularly to do community presentations about the Project and studies. Site tours to understand the Project and technical information have also been offered on several occasions. Northcliff/SML advertises employment opportunities in First Nations communities to work with field crews. Northcliff funded an IKS for First Nations. Northcliff/SML provided financial support to assist First Nations to participate in meetings and to hire technical experts. SML seeks to regularly communicate with all FNs in NB, and asks FNs how they wish to be consulted, as the process is flexible.	
Concerns regarding cumulative environmental effects on First Nations' abilities to practice traditional activities in traditional territories from government actions and industrial uses over time; it was noted that First Nations have been "pushed into" the area surrounding the Project from other more choice areas that were historically/ traditionally preferred. Concerns about the taking up of land for other uses resulting in a decreasing amount of land available for traditional activities, with a growing Aboriginal population.	A cumulative environmental effects assessment on the Current Use of Land and Resources for Traditional Purposes is included in the EIA Report in Section 8.13. Questions of past impacts to Aboriginal or treaty rights throughout New Brunswick from past government activities and permitted industrial activities are outside the scope of this EIA and are appropriately addressed in separate discussions with the Crown.	N/A (except for cumulative environmental effects assessments in Section 8, particularly regarding the current use of land and resources for traditional purposes in Section 8.13)

Acronyms:

N/A	Not Applicable	SAR	Species at Risk
MMFN	Madawaska Maliseet First Nation	EIA	Environmental impact assessment
SOCC	Species of Conservation Concern	TKS	Traditional Knowledge Study
FN	First Nation	WFN	Woodstock First Nation
FS	Feasibility Study	SMFN	St. Mary's First Nation
IBA	Impact Benefits Agreement	ToR	Terms of Reference
NBENV	New Brunswick Department of Environment	CEAA	Canadian Environmental Assessment Agency
AFNCNB	Assembly of First Nation Chiefs in New Brunswick	AWDI	Aboriginal Workforce Diversity Initiative
SEDAR	System for Electronic Document Analysis and Retrieval		

4.3.3 Assertions of Aboriginal and Treaty Rights to Northcliff/SML by Aboriginal Peoples

At meetings, workshops and other engagement activities that Northcliff/SML has participated in with Aboriginal peoples, they stated the importance of the general Project area for their traditional resource harvesting (*e.g.,* hunting, fishing and gathering) and related activities. Northcliff/SML understood these statements to be implicit assertions of Aboriginal or treaty rights to undertake these activities on Crown land in proximity to the Project site.

4.3.4 Future Consultation and Engagement Plans

SML remains committed to continuing and expanding its outreach activities, described in Section 4.3.1 above, to ensure New Brunswick residents are aware of and understand the Sisson Project, and are provided with opportunities to discuss the EIA results and the Project, and to provide feedback. These activities will serve to inform stakeholders, First Nations, and the public about the EIA and its results, and thus assist them in reviewing the EIA Report and in engaging in the EIA review process.

Following EIA approval and permitting, SML will continue its ongoing engagement with the public, stakeholder groups, communities and First Nations throughout Construction, Operation and into Decommissioning, Reclamation and Closure. Key objectives of the ongoing engagement program are:

- to ensure transparency and accountability about the company's environmental management and social responsibility performance;
- to ensure there are continuing opportunities to discuss interests and concerns, and to resolve issues, related to the Project; and
- to work in partnership with local communities and First Nations to have the Sisson Project contribute to the achievement of their own development goals based on their priorities and aspirations.

In fulfilling these objectives, SML will continue with many of the initiatives carried out to date, including the Project website, newsletters and emails, presentations and meetings, and the information office. SML will also offer site tours of the Project and will host open houses at key milestones during Project implementation. A key component of SML's future consultation and engagement program will be a Community Liaison Committee, as outlined in the ESMS (Appendix D).

4.4 SELECTION OF VALUED ENVIRONMENTAL COMPONENTS

Based on the requirements of the Final Guidelines and the Terms of Reference, and in response to the issues and comments received from the public, stakeholders, First Nations, and regulatory agencies, the following VECs have been selected for conducting the environmental effects assessment of the Project:

- Atmospheric Environment;
- Acoustic Environment;
- Water Resources;

- Aquatic Environment;
- Terrestrial Environment;
- Vegetated Environment;
- Wetland Environment;
- Public Health and Safety;
- Labour and Economy;
- Community Services and Infrastructure;
- Land and Resource Use;
- Current Use of Land and Resources for Traditional Purposes by Aboriginal Persons;
- Heritage Resources; and
- Transportation.

Additionally, the Effects of the Environment on the Project have also been selected for assessment in consideration of the nature and location of the Project, the changing global climate, and the potential expenditures that could result from an adverse effect of the environment on the Project.

Finally, in recognition of public concern and the importance of a defensible and comprehensive assessment of accidents, malfunctions and unplanned events that could occur during the various phases of the Project, a separate section on potential Accidents, Malfunctions and Unplanned Events has been prepared which considers the potential environmental effects of credible accidents, malfunctions or unplanned events on all VECs listed above

4.5 IDENTIFICATION OF OTHER PROJECTS OR ACTIVITIES THAT HAVE BEEN OR WILL BE CARRIED OUT

The consideration of other projects or activities that have been or will be carried out in the Regional Assessment Area (RAA) for each VEC is a necessary component of the assessment of cumulative environmental effects. The general approach to the cumulative environmental effects assessment is to identify other past, present, or reasonably foreseeable future projects or activities whose environmental effects could overlap those of the Project. The cumulative environmental effects assessment methodology is discussed further in Section 5.4.3.

The other future projects or activities considered in the cumulative environmental effects assessment in this EIA (*i.e., "other projects or activities that have been or will be carried out"*, as required by *CEAA*) are listed in Table 4.5.1. For convenience, the specific projects or activities that are planned or under construction are grouped with other similar projects, to facilitate the assessment of cumulative environmental effects in logical groupings.

Table 4.5.1 Other Projects or Activities for Consideration of Cumulative Environmental Effects

Category of Projects or Activities	Name of Specific Project or Activity	Brief Description of Specific Project or Activity
Past or Present Projects or Activities that have been Carried Out		
Industrial Land Use (Past or Present)	Past or present use of land or resources for industrial purposes	Historical and current use of land for commercial and industrial development to facilitate modern commerce, employment, and import and export of goods and services to meet modern societal needs. In addition, the past or present operation of several mining operations in New Brunswick, including the Bathurst mining camp and the PotashCorp mine.
Forestry and Agricultural Land Use (Past or Present)	Past or present use of land or resources for forest resource harvesting or farming activities	Historical and current use of natural resources for subsistence and economic development in the RAA, particularly forestry resource harvesting, forestry operations, and agricultural and livestock farming.
Current Use of Land and Resources for Traditional Purposes by Aboriginal Persons (Past or Present)	Past or present use of land or resources for traditional purposes by Aboriginal persons	Current Use of Land and Resources for Traditional Purposes by Aboriginal Persons includes resource gathering and harvesting activities, such as hunting, fishing, trapping, and plant and timber harvesting, and use of land or resources for spiritual, ceremonial or other traditional activities.
Recreational Land Use (Past or Present)	Past or present use of land or resources for recreational activities (hunting, fishing, ATV use, snowmobiling, hiking trails)	Historical and current use of land for recreational purposes, including recreational hunting, fishing, trail development, and use of land for hiking, all-terrain vehicles, or snowmobiling.
Residential Land Use (Past or Present)	Past or present use of land or resources for development of residential dwellings.	Historical and current use of land and resources for residential development and the rural and urban development of modern towns and villages, including the nearby communities of Napadogan, Juniper, Millville, Stanley, and other nearby villages and communities.
Potential Future Projects or Activities That Will Be Carried Out		
Industrial Land Use (Future)	Closure of Brunswick Mine 12	Brunswick Mine 12 is a base metal mine located in northern New Brunswick that will be closed in 2013. The mine occupies approximately 8.5 km^2 within the Little River Watershed.
	Restart of Open Pit Mining	Stratabound Minerals Corp. is proposing to restart open pit mining activities at the reclaimed mine site located approximately 15 km to the northeast of the Heath Steele site. The ore will be transported to the mill at the Brunswick 12 mine for processing.
	AV Nackawic Recovery Boiler Capacity Increase	AV Nackawic Inc. is proposing to increase the capacity of their recovery boiler by installing a separate fan and scrubber on the smelt dissolving tank. This modification will allow the company to increase their production of finished pulp by 50 tonnes per day.
	Shale Gas Exploration	Throughout many parts of New Brunswick, various proponents are exploring the potential for commercial shale gas extraction.
	Mineral Exploration	Mineral exploration occurs throughout New Brunswick under licence from the New Brunswick Department of Natural Resources.
	Mining Operations	Development of new mining operations in the province, with several facilities either under exploration or development (*e.g.,* Halfmile Lake mine, Stratmat mine, reopening of Caribou mine, reclamation of Restigouche mine, reopening of Murray Brook mine, reopening of Mount Pleasant mine).

Table 4.5.1 Other Projects or Activities for Consideration of Cumulative Environmental Effects

Category of Projects or Activities	Name of Specific Project or Activity	Brief Description of Specific Project or Activity
Forestry and Agricultural Land Use (Future)	Forest Resource Harvesting Activities	Future timber harvesting includes the construction and use of forest roads, thinning of trees, and removal of mature trees. Harvested areas are often treated and /or replanted to renew the forest resource. The recently released Forest Management Strategy by the Government of New Brunswick in March 2014 is also addressed, to the extent that its implementation is understood at this time.
	Farming Activities	Future agricultural and livestock farming activities occur in rural areas throughout the province. Preparation of soil, planting of seeds/plants, irrigation, harvesting of crops, and grazing of livestock occurs at farms of various sizes.
Current Use of Land and Resources for Traditional Purposes by Aboriginal Persons (Future)	Current Use of Land and Resources for Traditional Purposes by Aboriginal Persons	Current Use of Land and Resources for Traditional Purposes by Aboriginal Persons includes resource gathering and harvesting activities, such as hunting, fishing, trapping, and plant and timber harvesting, and use of land or resources for spiritual, ceremonial or other traditional activities.
Recreational Land Use (Future)	Hunting and Fishing Activities	Authorized future recreational hunting and fishing activities on Crown land and on private land where permitted by the Crown/landowner and when in season.
	ATV Use, Snowmobile, Hiking Trail Activities	Future recreational use of trail networks in and around the region.
Planned Residential Development (Future)	Residential Subdivisions	Any planned or future residential subdivisions in the area of central New Brunswick between Stanley, Millville, and Juniper.

The list of other projects or activities that have been or will be carried out as outlined in Table 4.5.1 considers projects or activities that are proximal to the Project (*e.g.,* in central New Brunswick) or otherwise have potentially overlapping environmental effects (*e.g.,* for demand on specialized labour).

The list of other projects or activities in Table 4.5.1 considers those projects and activities that, as of March 2013, have been formally proposed by project proponents (*i.e.,* have been registered under the New Brunswick EIA Regulation and/or for which an EA under *CEAA* or *CEAA 2012* has been initiated) as well as known past, present and reasonably foreseeable future activities that may be carried out in the vicinity of the Project based on current knowledge of the area. Other potential projects, proposals, concepts, ideas, visions, or initiatives that may be under consideration, but which have not been formally registered provincially or federally for an EIA/EA, are not included in this list; their cumulative environmental effects with the Project are thus not assessed in this EIA Report. Although some project proponents may have announced their intentions regarding many other proposals or concepts, it is not possible to assess their cumulative environmental effects that overlap with those of the Project because very little concrete information is known about these proposals at this time. Without specific details of each individual development proposal that is being envisioned at this stage, it is not possible to determine where the environmental effects of these other concepts, proposals, ideas or visions may overlap with those of the Project, or to what extent.

Once these other potential projects or activities are formally proposed and assessed provincially and/or federally, their environmental effects that overlap with those of the Project would need to be assessed as part of a cumulative environmental effects assessment in those EIAs. Cumulative environmental effects in the region will be managed in this way in the future.

5.0 ENVIRONMENTAL IMPACT ASSESSMENT METHODS

The methods that are used to conduct the environmental impact assessment (EIA) of the Project are described in this section. The EIA uses a methodological framework developed by Stantec to meet the combined requirements of the *Canadian Environmental Assessment Act* (*CEAA*) and the New Brunswick *Environmental Impact Assessment Regulation* (the "EIA Regulation"). These EIA methods are based on a structured approach that, particularly:

- considers the mandatory and discretionary factors under Section 16 of *CEAA*;
- considers all federal and provincial regulatory requirements for the assessment of environmental effects as defined by *CEAA*, with specific consideration of the requirements of a) the Final Terms of Reference for an Environmental Impact Assessment approved by the Governments of New Brunswick and Canada in April 2012 (Stantec 2012a), and b) the Final Guidelines for an Environmental Impact Assessment (NBENV 2009) as issued by NBDELG;
- considers the issues raised by the public, Aboriginal persons, ENGOs, and other stakeholders during consultation and engagement activities conducted to date;
- focuses on issues of greatest concern that arise from the above considerations; and
- integrates engineering design and programs for mitigation and monitoring into a comprehensive environmental planning and management process.

CEAA defines the term "environment" as:

> *"environment" means the components of the Earth, and includes*
>
> *(a) land, water and air, including all layers of the atmosphere,*
>
> *(b) all organic and inorganic matter and living organisms, and*
>
> *(c) the interacting natural systems that include components referred to in paragraphs (a) and (b).*

The New Brunswick *Clean Environment Act* defines "environment" as:

> *"environment" means the air, water and soil".*

For the purpose of this EIA Report, the definition of "environment" under *CEAA* shall be used, as it more broadly encompasses the combined biophysical and human environment in its definition.

The EIA will focus on specific environmental components (called valued environmental components or VECs) that are of particular value or interest to regulatory agencies, the public, other stakeholder groups, and First Nations. VECs are typically selected for assessment on the basis of: regulatory issues, guidelines, and requirements; consultation with regulatory agencies, the public, stakeholder groups, and First Nations; field reconnaissance; and the professional judgment of the Study Team.

For the purpose of this EIA Report, the term “environmental effect” is as defined in *CEAA* and broadly refers to a change in the environment in response to a Project activity. Specifically:

> *“environmental effect" means, in respect of a project,*
>
> *(a) any change that the project may cause in the environment, including any change it may cause to a listed wildlife species, its critical habitat or the residences of individuals of that species, as those terms are defined in subsection 2(1) of the Species at Risk Act,*
>
> *(b) any effect of any change referred to in paragraph (a) on*
>
> *(i) health and socio-economic conditions,*
>
> *(ii) physical and cultural heritage,*
>
> *(iii) the current use of lands and resources for traditional purposes by aboriginal persons, or*
>
> *(iv) any structure, site or thing that is of historical, archaeological, paleontological or architectural significance, or*
>
> *c) any change to the project that may be caused by the environment,*
>
> *whether any such change or effect occurs within or outside Canada.*

For convenience, the term “environmental effect” as defined in *CEAA* will be taken to be synonymous to the term “impact” as referred to in the EIA Regulation. As such, the EIA Report will assess environmental effects and impacts as defined by the respective federal and provincial legislation.

Taken together, the definitions of “environment” and “environmental effect” in *CEAA* include the biophysical and human environments. As such, socioeconomic components that are part of the human environment are encompassed in the definition of “environmental effect” as defined in *CEAA*, insofar as they may be indirectly affected by changes in the biophysical environment. Thus, for the purpose of this EIA Report, the term “environment” includes the biophysical, human, and socioeconomic components as defined in *CEAA*, as they are required by both the federal and provincial governments.

5.1 OVERVIEW OF APPROACH

The environmental assessment methods address both Project-related and cumulative environmental effects. Project-related environmental effects are changes to the biophysical or human environment that will be caused by a project or activity arising solely as a result of the proposed principal works and activities, as defined by the scope of the Project and as described in the Project Description (Chapter 3). Cumulative environmental effects are changes to the biophysical or human environment that are caused by an action associated with the Project, in combination with other past, present or reasonably foreseeable future projects or activities that have been or will be carried out.

Project-related environmental effects and cumulative environmental effects are assessed using a standardized methodological framework for each VEC, with standard tables and matrices used to facilitate the evaluation. The residual Project-related environmental effects (*i.e.,* after mitigation has been applied) are characterized using specific criteria (*e.g.,* direction, magnitude, geographic extent, duration, frequency, reversibility, and ecological/socioeconomic context). These criteria are described in the guidance of the CEA Agency (FEARO 1994) and the Final EIA Guidelines (NBENV 2009) and Terms of Reference for the Project (Stantec 2012a), and they are specifically defined for each VEC. The significance of the Project-related environmental effects is then determined based on pre-defined criteria or thresholds (also called significance criteria) that reflect a variety of considerations based on these criteria and other relevant considerations.

If there is overlap between the environmental effects of the Project and those of other projects or activities that have been or will be carried out, cumulative environmental effects are assessed to determine whether they could be significant, and to consider the contribution of the Project to them.

The environmental effects assessment methodology used in this EIA is shown graphically in Figure 5.1.1. This methodology involves the following generalized steps.

- **Scope of Assessment –** Scoping of the assessment includes the selection of VEC (and, if required, key indicators for the VEC) and the rationale for its selection; influence of consultation and engagement on the scoping of the VEC; selection of the environmental effect(s); description of measurable parameters; description of temporal, spatial, administrative, and technical boundaries; and identification of thresholds that are used to determine the significance of environmental effects. This step relies upon the scoping undertaken by regulatory authorities; the requirements of the Final Guidelines and the Terms of Reference; consideration of the input of the public, stakeholders, and First Nations that influenced the scope of the assessment; and the professional judgment of the Study Team.

- **Existing Conditions –** Existing (baseline) environmental conditions are established for the VEC. In many cases, existing conditions implicitly include those environmental effects that may have been or may be caused by other past or present projects or activities that have been or are being carried out.

- **Assessment of Project-Related Environmental Effects –** Project-related environmental effects are assessed. The assessment includes descriptions of how an environmental effect will occur or how the Project will interact with the environment, the mitigation and environmental protection measures proposed to reduce or eliminate the environmental effect, and the characterization of the residual environmental effects of the Project. The focus is on residual environmental effects, *i.e.,* the environmental effects that remain after planned mitigation has been applied. All mandatory factors under Section 16(1) and 16(2) of *CEAA* are assessed for all phases of the Project (*i.e.,* Construction, Operation, and Decommissioning, Reclamation and Closure), as well as for Accidents, Malfunctions and Unplanned Events. The evaluation also considers the effects of the environment on the Project.

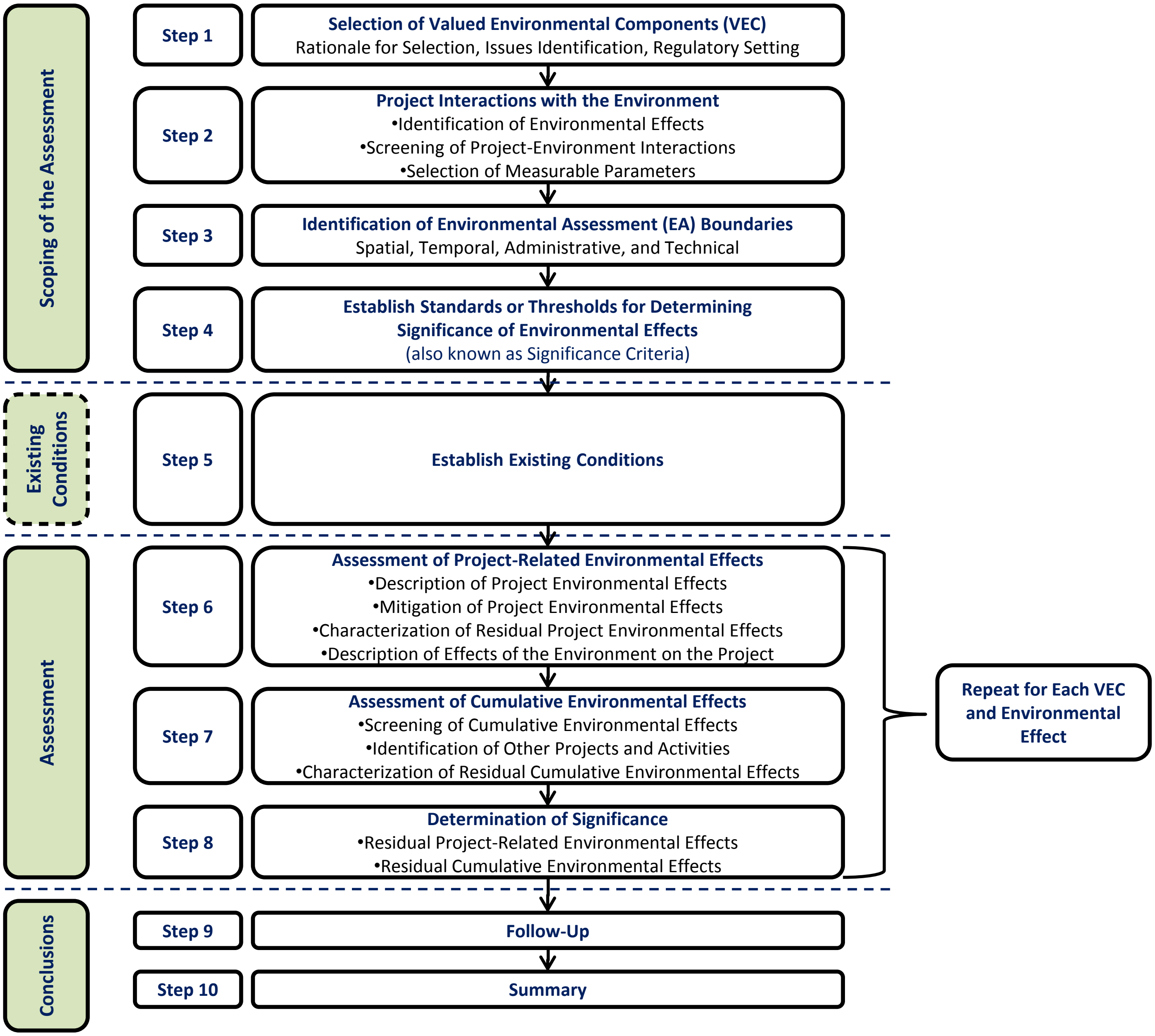


Figure 5.1.1 Summary of Stantec EIA Methodology

- **Assessment of Cumulative Environmental Effects –** Cumulative environmental effects of the Project are identified in consideration of other past, present or reasonably foreseeable future projects or activities that have been or will be carried out, for all phases of the Project (*i.e.,* Construction, Operation, and Decommissioning, Reclamation and Closure). A screening of potential interactions is completed to determine if an assessment of cumulative environmental effects is required (*i.e.,* there is potential for substantive interaction) for that specific Project-related environmental effect that overlaps with those of other projects or activities that have been or will be carried out. The residual cumulative environmental effects of the Project in combination with other projects or activities that have been or will be carried out are then evaluated, including the contribution of the Project to those cumulative environmental effects (as applicable).

- **Determination of Significance –** The significance of residual Project-related and residual cumulative environmental effects, including the contribution of the Project, is then determined, in consideration of the significance criteria.
- **Follow-up or Monitoring –** Follow-up measures that are required to verify the environmental effects predictions or to assess the effectiveness of the planned mitigation, as well as any required monitoring, are recommended, where appropriate and applicable.

Further details on the methodologies that will be used in this EIA are provided in the sub-sections that follow.

5.2 SCOPING OF THE ASSESSMENT

Issues identified through scoping (Chapter 4) are analyzed and grouped into categories to assist in the selection of VECs. VECs are defined as broad components of the biophysical and human environments that, if altered by the Project, would be of concern to regulatory agencies, Aboriginal persons, resource managers, scientists, stakeholders, and/or the general public. These issues, along with the requirements of the Final Guidelines (NBENV 2009) and Terms of Reference for the EIA (Stantec 2012a), form the scope of the environmental assessment (*i.e.,* scope of Project, factors to be considered, and scope of factors to be considered) for the Project.

As discussed in Chapter 4, confirming the recommendations of the Terms of Reference (Stantec 2012a), the following VECs have been selected for this EIA to focus the assessment of environmental effects:

- Atmospheric Environment;
- Acoustic Environment;
- Water Resources;
- Aquatic Environment;
- Terrestrial Environment;
- Vegetated Environment;
- Wetland Environment;
- Public Health and Safety;
- Labour and Economy;
- Community Services and Infrastructure;

- Land and Resource Use;
- Current Use of Land and Resources for Traditional Purposes by Aboriginal Persons;
- Heritage Resources; and
- Transportation.

The environmental effects analysis for each VEC is conducted in its own dedicated subsection within Chapter 8 of the EIA Report. In addition, the effects of the environment on the Project are assessed. Credible Accidents, Malfunctions and Unplanned Events are also assessed for all VECs, on an event basis, in a dedicated section at the end of Chapter 8 of the EIA Report. That section includes the assessment of the consequent environmental effects arising from the effects of the environment on the Project. Such consequent environmental effects are considered accidents, malfunctions or unplanned events as Project design and mitigation is intended to ensure that such events are not likely to occur in a manner that is adverse for the Project. In the environmental effects assessment for accidents, malfunctions and unplanned events, the focus is more on the consequences than the causal mechanisms.

The scope of assessment with respect to each VEC is described in the following sub-sections.

5.2.1 Rationale for Selection of Valued Environmental Component, Regulatory Context, and Issues Raised During Engagement

The rationale for the selection of each VEC is first described. A brief summary of the regulatory setting, ecological, and socioeconomic context of each VEC, and the influence of consultation or engagement on the assessment (as applicable) is also described. The goal is to describe the issues and concerns that arose through legislation, regulatory decision-making, or consultation and engagement activities that influenced the scope of the environmental assessment described in the EIA Report and led to identification of the environmental effects that will be assessed therein.

5.2.2 Selection of Environmental Effects and Measurable Parameters

The environmental effects for each VEC (and if applicable, key indicators) are defined in consideration of the regulatory context for the VEC, issues identified through consultation or engagement, and existing conditions.

For each VEC, one or more measurable parameters are selected to facilitate the measurement of potential Project-related environmental effects and cumulative environmental effects, as shown in Table 5.2.1.

Table 5.2.1 Example: Measurable Parameters for (*Name of VEC*)

Environmental Effect	Measurable Parameter	Rationale for Selection of the Measurable Parameter
Change in *(environmental effect 1)*	*Measurable parameter 1 (units)*	• *(Describe rationale for selecting the measurable parameter and how it assists to quantify the environmental effect).*
	Measurable parameter 2 (units)	• *(Describe rationale for selecting the measurable parameter and how it assists to quantify the environmental effect).*

Table 5.2.1 Example: Measurable Parameters for (*Name of VEC*)

Environmental Effect	Measurable Parameter	Rationale for Selection of the Measurable Parameter
(add more rows as needed for each environmental effect)	*Measurable parameter 3 (units)*	• *(Describe rationale for selecting the measurable parameter and how it assists to quantify the environmental effect).*
	Etc.	• *(Describe rationale for selecting the measurable parameter and how it assists to quantify the environmental effect).*

The degree of change in these measurable parameters is used to characterize Project-related and cumulative environmental effects, which when compared to the defined significance criteria (Section 5.2.6 below), will assist in evaluating the significance of the potential environmental effects.

5.2.3 Temporal Boundaries

The temporal boundaries for the assessment are defined based on the timing and duration of Project activities and the nature of the interactions with each VEC. The purpose of a temporal boundary is to identify when an environmental effect may occur in relation to specific Project phases and activities. Temporal boundaries for the Project generally include the various phases of a Project, which for the Sisson Project have been identified as:

- Construction;
- Operation; and
- Decommissioning, Reclamation and Closure.

In some cases, it is necessary to further refine the temporal boundaries beyond simply limiting them to a specific phase of the Project. This is carried out as necessary within each environmental effects analysis sub-section. Temporal boundaries for the assessment may reflect seasonal variations or life cycle requirements of biological VECs or forecasted trends for socioeconomic VECs.

5.2.4 Spatial Boundaries

Spatial boundaries are established for the assessment of potential Project-related environmental effects and cumulative environmental effects for each VEC. The primary consideration used in the establishment of the boundaries of these assessment areas is the probable geographical extent of the environmental effects (*i.e.*, the zone of influence) to the VEC.

Spatial boundaries represent the geographic extent of the VEC, as they pertain to potential Project-environment interactions. Spatial boundaries are selected to reflect the geographic extent over which Project activities will or are likely to occur, and as such, they may be different from one VEC to another depending on the characteristics of the VEC. Generally, the spatial boundaries are referred to as the Project Development Area (PDA), the Local Assessment Area (LAA), and the Regional Assessment Area (RAA), as required.

- The **Project Development Area (PDA)** is the most basic and immediate area of the Project. The PDA is limited to the anticipated area of physical disturbance associated with the Construction and Operation of the Project. For this Project, the PDA consists of an area of approximately 1,253 hectares (ha) that includes the area of physical disturbance associated with the open pit, ore processing plant, storage areas, tailings storage facility (TSF), quarry, and related facilities. The PDA also includes a site access road linking the Project site to the existing network of forest roads, internal site roads connecting the various Project facilities, the relocation of the Fire Road and the existing 345 kV transmission line traversing the PDA, and a new 138 kV transmission line linking the Project site to existing electrical transmission infrastructure at Keswick, approximately 46 km to the southeast of the Project site.

- The **Local Assessment Area (LAA)** is the maximum area within which Project-related environmental effects can be predicted or measured with a reasonable degree of accuracy and confidence. The LAA is commonly referred to as the “zone of influence” of the Project, and may include areas that could experience Project environmental effects that arise beyond the area of physical disturbance by the Project. The LAA includes the PDA and any adjacent areas where Project-related environmental effects may reasonably be expected to occur. The definition of the LAA varies from one VEC to another, depending on local conditions, species abundance, socioeconomic factors, cultural values, and other factors.
- The **Regional Assessment Area (RAA)** is the area within which the Project’s environmental effects may overlap or accumulate with the environmental effects of other projects or activities that have been or will be carried out such that cumulative environmental effects may potentially occur. The RAA will be defined for each VEC depending on physical and biological conditions and the type and location of other past, present, or reasonably foreseeable projects or activities that have been or will be carried out.

5.2.5 Administrative and Technical Boundaries

As appropriate, Administrative and Technical Boundaries are identified and justified for each VEC.

Administrative boundaries include specific aspects of provincial and federal legislative or regulatory requirements; standards, objectives, or guidelines, policy objectives; as well as regional planning initiatives that are relevant to the assessment of the Project’s environmental effects on the VEC. Common examples of administrative boundaries include ambient air quality objectives for the Atmospheric Environment VEC, zoning or basic planning statements for the Land and Resource Use VEC, the prohibition to affect migratory birds or their nests as part of the Terrestrial Environment VEC, and the like.

Technical boundaries are the technical limitations or considerations for the evaluation of potential environmental effects of the Project, and may include limitations in scientific and social information, data analyses, and data interpretation, or uncertainties in the assessment.

5.2.6 Thresholds for Determining the Significance of Residual Environmental Effects

Threshold criteria or standards for determining the significance of environmental effects are identified for each VEC, beyond which a residual environmental effect would be considered significant. These are generally selected in consideration of provincial and federal regulatory requirements, standards, objectives, guidelines that are applicable to the VEC, societal values, or other planning objectives as developed in the Administrative Boundaries section. They have been developed in consideration of guidance and past practice (*e.g.,* as described by Barnes *et al.* 2012), and adapted to the specific conditions of the receiving environment of the Project and the nature of the potential environmental effects. These thresholds were also included in the government-approved Terms of Reference for the EIA, as required by the Final Guidelines.

In some cases, and particularly where standards, objectives, guidelines or regulatory requirements do not specifically exist, thresholds can be defined for measurable parameters to support measurement that informs the determination of significance.

5.3 EXISTING CONDITIONS

The existing conditions for each VEC are then described, including:

- the status and characteristics of the VEC within its defined spatial and temporal boundaries for the assessment;
- information from past research conducted in the region;
- traditional and ecological knowledge (if applicable or available); and
- knowledge gained from the collection of baseline data through literature review, qualitative and quantitative analyses, and field programs carried out as part of the EIA.

5.4 ENVIRONMENTAL EFFECTS ASSESSMENT

5.4.1 Potential Project-VEC Interactions

Interactions between all relevant Project activities and each environmental effect of the VEC are summarized in tabular format, as shown in Table 5.4.1.

Table 5.4.1 Example: Potential Project Environmental Effects to the *(Name of VEC)*

Project Activities and Physical Works	**Potential Environmental Effects**
	Change in *(Environmental Effect 1)*
Construction	
Activity 1	*X*
Activity 2	*X*
Activity 3 (add more rows as necessary)	*X*
Operation	
Activity 1	*X*
Activity 2	*X*
Activity 3 (add more rows as necessary)	*X*
Decommissioning, Reclamation and Closure	
Activity 1	*X*
Activity 2 (add more rows as necessary)	*X*

Project-Related Environmental Effects
Notes:
Project-Related Environmental Effects were ranked as follows:
0 No substantive interaction. The environmental effects are rated not significant and are not considered further in this report.
1 Interaction will occur. However, based on past experience and professional judgment, the interaction would not result in a significant environmental effect, even without mitigation, or the interaction would clearly not be significant due to application of codified practices and/or permit conditions. The environmental effects are rated not significant and are not considered further in this report.
2 Interaction may, even with codified mitigation and/or permit conditions, result in a potentially significant environmental effect and/or is important to regulatory and/or public interest. Potential environmental effects are considered further and in more detail in the EIA.

Detailed information on the Project activities is provided in Chapter 3. Interactions are ranked according to the potential for an activity to interact with each VEC, according to the following.

- If there is no substantive interaction between a Project activity and the VEC, an assessment of environmental effects is not required. The level of interaction is ranked as 0 and the environmental effects are not considered further in the EIA. The environmental effects of these activities are thus, by definition, rated not significant, with a high level of confidence.
- If a potential interaction between a Project activity and the VEC is identified, but not likely to be substantive in light of planned mitigation, the level of interaction is ranked as 1. Such interactions are well understood and are subject to prescribed mitigation or codified practices. These interactions are subject to a less detailed environmental effects assessment and rated not significant; however, justification is provided for such categorizations and the proposed mitigation described. Such interactions can be mitigated with a high degree of certainty with proven technology and practices. Following this discussion and ranking, the environmental effects of this activity are not considered further in the EIA.
- If a potential interaction between a Project activity and the VEC is identified that may result in more substantive environmental effects despite the planned mitigation, or if there is less certainty regarding the effectiveness of mitigation, the level of interaction is ranked as 2. These potential interactions are subjected to further evaluation in the EIA and a more detailed environmental effects analysis and consideration in the EIA is carried out in order to predict, mitigate, and evaluate potential environmental effects (including cumulative environmental effects).

The use of the 0, 1, and 2 rankings above for Project-environment interactions facilitates the environmental assessment in a manner that focuses the assessment on the key issues of concern for each VEC. Justification for assigning these ranks for each environmental effect and VEC is then provided following the ranking. The Study Team takes a precautionary approach, whereby interactions with a meaningful degree of uncertainty are assigned a ranking of 2, ensuring that a more thorough evaluation is conducted.

5.4.2 Assessment of Project-Related Environmental Effects

Project-related environmental effects are assessed. The assessment is carried out in tabular form (Table 5.4.2) to facilitate the evaluation, followed by a detailed discussion of how the project may interact with the environment, mitigation measures, and the characterization of residual project environmental effects. Further details are as follows.

Table 5.4.2 Example: Summary of Residual Project-Related Environmental Effects on (*Name of VEC*)

Potential Residual Project-Related Environmental Effects	Project Phases, Activities, and Physical Works	Mitigation / Compensation Measures	Residual Environmental Effects Characteristics						Significance	Prediction Confidence	Likelihood	Cumulative Environmental Effects?	Recommended Follow-up or Monitoring
			Direction	Magnitude	Geographic Extent	Duration and Frequency	Reversibility	Ecological/Socioeconomic Context					
Change in *(Environmental Effect 1)*	Construction • *Activity 1* • *Activity 2* • *Activity 3*	• *Describe mitigation.* • *Describe mitigation.* • *Describe mitigation.*	*X*	*X*	*X*	*X/X*	*X*	*X*	*X*	*X*	*X*	*X*	• *Describe follow up or monitoring.* • *Describe follow up or monitoring.* • *Describe follow up or monitoring.*
	Operation • *Activity 1* • *Activity 2* • *Activity 3*	• *Describe mitigation.* • *Describe mitigation.* • *Describe mitigation.*	*X*	*X*	*X*	*X/X*	*X*	*X*	*X*	*X*	*X*	*X*	• *Describe follow up or monitoring.* • *Describe follow up or monitoring.* • *Describe follow up or monitoring.*
	Decommissioning, Reclamation and Closure • *Activity 1* • *Activity 2* • *Activity 3*	• *Describe mitigation.* • *Describe mitigation.* • *Describe mitigation.*	*X*	*X*	*X*	*X/X*	*X*	*X*	*X*	*X*	*X*	*X*	• *Describe follow up or monitoring.* • *Describe follow up or monitoring.* • *Describe follow up or monitoring.*
	Residual Environmental Effects for all Phases								*X*	*X*	*X*	*X*	

Table 5.4.2 Example: Summary of Residual Project-Related Environmental Effects on (*Name of VEC*)

Potential Residual Project-Related Environmental Effects	Project Phases, Activities, and Physical Works	Mitigation / Compensation Measures	Residual Environmental Effects Characteristics						Significance	Prediction Confidence	Likelihood	Cumulative Environmental Effects?	Recommended Follow-up or Monitoring
			Direction	Magnitude	Geographic Extent	Duration and Frequency	Reversibility	Ecological/Socioeconomic Context					

KEY

Direction
P Positive.
A Adverse.

Magnitude
L Low: (define).
M Medium: (define).
H High: (define).

Geographic Extent
S Site-specific: (define).
L Local: (define).
R Regional: (define).

Duration
ST Short-term: (define).
MT Medium-term: (define).
LT Long-term: (define).
P Permanent: (define).

Frequency
O Occurs once.
S Occurs sporadically at irregular intervals.
R Occurs on a regular basis and at regular intervals.
C Continuous.

Reversibility
R Reversible.
I Irreversible.

Ecological/Socioeconomic Context
U Undisturbed: Area relatively or not adversely affected by human activity.
D Developed: Area has been substantially previously disturbed by human development or human development is still present.
N/A Not Applicable.

Significance
S Significant.
N Not Significant.

Prediction Confidence

Confidence in the significance prediction, based on scientific information and statistical analysis, identified technical boundaries, professional judgment and known effectiveness of mitigation:
L Low level of confidence.
M Moderate level of confidence.
H High level of confidence.

Likelihood

If a significant environmental effect is predicted, the likelihood of that significant environmental effect occurring is determined, based on professional judgment:
L Low probability of occurrence.
M Medium probability of occurrence.
H High probability of occurrence.

Cumulative Environmental Effects?
Y Potential for environmental effect to interact with the environmental effects of other past, present or foreseeable future projects or activities in RAA.
N Environmental effect will not or is not likely to interact with the environmental effects of other past, present or foreseeable future projects or activities in RAA.

5.4.2.1 Potential Project Environmental Effects Mechanisms

For each Project-related activity previously ranked as 2, as discussed above, the assessment of each Project-related environmental effect begins with a description of the mechanisms whereby specific Project activities and actions could result in the environmental effect. Where possible, the spatial and temporal extent of these changes (*i.e.*, where and when the environmental effect might occur) are also described.

It is important to note that the EIA focuses on residual environmental effects, *i.e.,* environmental effects after mitigation has been applied. Environmental effects before mitigation are not quantified or assessed, nor is the significance of the environmental effect before mitigation.

5.4.2.2 Mitigation of Project Environmental Effects

Mitigation measures that may help to reduce or eliminate an environmental effect are described, with an emphasis on how these measures help to reduce the environmental effect. Mitigation is defined as a change in the temporal or spatial aspects of the Project and/or the means in which the Project is constructed, operated, or decommissioned, over and above the Project design aspects described in Chapter 3. In addition, mitigation can include specialized measures such as habitat offsetting, replacement, or financial compensation, as well as planned environmental management and response measures (*e.g.,* environmental and social management system, component management plans).

5.4.2.3 Characterization of Residual Project Environmental Effects

Residual environmental effects (*i.e.,* the environmental effects that remain after mitigation has been applied) are described during each Project phase, taking into account how the proposed mitigation would alter or change the environmental effect. The analysis includes both direct and indirect interactions between the Project and the VEC. The analysis considers mitigation measures to reduce adverse environmental effects or to enhance positive environmental effects, as applicable and appropriate. Once mitigation measures are applied, any remaining environmental effect is residual. Only residual environmental effects are assessed for significance.

Environmental effects for each VEC are characterized for each applicable Project phase and activity, and presented in an environmental effects summary table (Table 5.4.2). The characteristics of residual environmental effects include:

- **Direction –** the ultimate long-term trend of the environmental effect (*i.e.,* positive or adverse);
- **Magnitude –** the amount of change in a measurable parameter or variable relative to existing (baseline) conditions, defined for each VEC as low, medium, high, or other qualifier as deemed appropriate;
- **Geographic Extent –** the area where an environmental effect of a defined magnitude occurs, defined for each VEC based on definitions of PDA, LAA, and RAA as appropriate;
- **Frequency –** the number of times during the Project or a specific Project phase or activity that an environmental effect might occur (*e.g.*, one time or multiple times) in a specified time period;

- **Duration –** the period of time required until the VEC returns to its baseline condition or the environmental effect can no longer be measured or otherwise perceived (*e.g.*, short-term, mid-term, long-term, or in some cases permanent);

- **Reversibility –** the likelihood that a measurable parameter will recover from an environmental effect, including through active management techniques (*e.g.*, habitat restoration); and

- **Ecological/Socioeconomic Context –** the general characteristics of the area in which the Project is located, as indicated by past and existing levels of human activity.

A key is provided at the bottom of each environmental effects summary table (Table 5.4.2) which defines these characteristics as necessary for each VEC based on the specific boundaries (*i.e.,* temporal, spatial, administrative, and technical) and significance criteria selected for each VEC. Where possible, these characteristics are described quantitatively for each residual environmental effect. Where these characteristics cannot be expressed quantitatively, they are described qualitatively specifically for the VEC or environmental effect.

Mitigation and recommended follow-up or monitoring measures are also described, as applicable.

Following the assignment of these characteristics, residual environmental effects are described and discussed for the VEC during each Project phase, taking into account how mitigation will alter or change the environmental effect.

5.4.3 Assessment of Cumulative Environmental Effects

The cumulative environmental effects of the Project in combination with other projects or activities that have been or will be carried out are assessed. The assessment is carried out in tabular form to facilitate the evaluation, followed by a detailed discussion of how the Project may overlap with other projects or activities that have been or will be carried out and interact with the environment, mitigation measures, and the characterization of residual cumulative environmental effects. Further details are as follows.

5.4.3.1 Identification of Other Projects or Activities

Other projects or activities that have been or will be carried out are identified for inclusion in the cumulative environmental effects assessment, based on their potential for residual environmental effects that could overlap spatially and temporally with the residual environmental effects of the Project. The environmental effects of other past and present projects or activities that have been carried out are generally reflected in the existing baseline environment, and are therefore more appropriately and logically considered in the Project-related environmental effects assessment for each VEC. The assessment and evaluation of the cumulative environmental effects of the Project in combination with other projects or activities that will be carried out considers the nature and degree of change from these baseline environmental conditions due to both the Project and the other projects or activities.

The screening of other projects or activities relevant to the cumulative environmental effects assessment is generally based on the criteria described in Table 5.4.3. The other projects or activities identified for consideration in the cumulative environmental effects assessment for this EIA were described in Section 4.5.

Table 5.4.3 Criteria for Identification of Other Projects or Activities That Have Been or Will Be Carried Out, for the Cumulative Environmental Effects Assessment

Criteria	Rationale and Application
Status of other project or activity: • Past or present project, or a project or activity that is certain, planned, or reasonably foreseeable.	The environmental effects of past or present projects or activities that have been carried out are evaluated in the assessment of environmental effects of the Project. In some cases, the cumulative environmental effects assessment does not specifically consider past or present projects or activities because the environmental effects resulting from past or present projects or activities are captured in the description of baseline conditions or encompassed in those existing environmental conditions. The exceptions are recently initiated projects or activities where the environmental effects are recent and may not be fully reflected in the baseline conditions, or projects or activities that will probably change in scope in the foreseeable future. Certain, planned, or reasonably foreseeable future projects or activities that will be carried out are those that have a high probability of being implemented, and include the following projects proximal to the Project: • Those undertakings that are currently registered under the New Brunswick *Environmental Impact Assessment Regulation* (under review), and are listed on the NBDELG website (NBDELG 2012a; available at http://www2.gnb.ca/content/dam/gnb/Departments/env/pdf/EIA-EIE/Registrations-Engegistrements/EIA.pdf) for the purposes of this EIA, the NBDELG listing as of March 29, 2013 has been used as the basis for the identification of those future projects or activities; • Those currently undergoing an EA under *CEAA*, and are listed on the Canadian Environmental Assessment Registry website (CEA Agency 2012a; available at http://ceaa-acee.gc.ca/050/index-eng.cfm); and • Those that have been publicly announced as being under serious consideration by proponents but have not yet been formally registered, or that will be registered in the near future. Reasonably foreseeable projects or activities are highly likely to be implemented and include those identified in approved development plans or those that are in advanced stages of planning. Hypothetical and speculative projects or activities are not considered as part of the cumulative environmental effects assessment.
Potential for overlap related to timing of the project and/or activity: • Other project or activity must be carried out or implemented during the time frame that is relevant to the Project.	The Project involves the following phases and associated timeframes. • **Construction:** Construction spanning a period of up to 24 months, expected to begin in late 2015. • **Operation:** Starting with commissioning immediately following Construction, and continuing for approximately 27 years or until the mineral resource is depleted. • **Decommissioning, Reclamation and Closure:** Decommissioning of Project facilities and Reclamation and Closure of the Project site will occur following the completion of Operation. The timeframe for other projects or activities relevant to the cumulative environmental effects assessment must overlap with these periods for the Project, in that they will extend through Construction, Operation, and/or Decommissioning, Reclamation and Closure.
Potential for a spatial overlap of environmental effect: • Other project or activity must be located within the RAA as defined in the environmental effects analysis for each VEC.	Projects with an identified or expected zone of influence that may overlap with the geographic area likely to be affected by the Project (including VEC spatial boundaries) are of interest.

Where a cumulative environmental effects assessment is completed for a VEC, only those projects or activities that could result in an overlapping environmental effect are included in the cumulative environmental effects assessment. The specific projects or activities and actions considered for each environmental effect are outlined in the assessment for the VEC.

5.4.3.2 Screening for Cumulative Environmental Effects

After completing the assessment of potential Project-related environmental effects on the VEC, where residual environmental effects are identified, a cumulative environmental effects assessment is conducted for those Project-related environmental effects that may overlap with the environmental effects of other projects or activities that have been or will be carried out.

The screening for cumulative environmental effects is conducted to determine if there is potential for a cumulative environmental effect. A series of three questions is used to screen cumulative environmental effects:

- Is there a Project-related environmental effect?
- Does the Project-related environmental effect overlap with those of other past, present or future projects or activities that have been or will be carried out?
- Is the Project contribution to cumulative environmental effects substantive and measurable or discernible such that there is some potential for substantive cumulative environmental effects that are attributable to the Project?

If, based on these three questions, there is potential for cumulative environmental effects, it is assessed to determine if it has the potential to shift a component of the natural or human environment to an unacceptable state.

Residual Project-related environmental effects for each VEC are reviewed for potential spatial and temporal overlap with similar environmental effects of other projects or activities. As shown in Table 5.4.4, overlapping projects or activities with the environmental effects of the Project are ranked as 0, 1, or 2 in a manner similar to that described for Project-VEC interactions in Section 5.4.1 (Table 5.4.1) to quantify the level of interaction or overlap between the environmental effects of the Project and those of other projects or activities that have been or will be carried out.

Table 5.4.4 Example: Potential Cumulative Environmental Effects to the *(Name of VEC)*

Other Projects or Activities With Potential for Cumulative Environmental Effects	**Potential Cumulative Environmental Effects**
	Change in *(Environmental Effect 1)*
Past or Present Projects or Activities That Have Been Carried Out	
Other Project/Activity 1	*X*
Other Project/Activity 2	*X*
Other Project/Activity 3 (add more lines as needed)	*X*
Potential Future Projects or Activities That Will Be Carried Out	
Other Project/Activity 1	*X*
Other Project/Activity 2	*X*
Other Project/Activity 3 (add more lines as needed)	*X*

Table 5.4.4 Example: Potential Cumulative Environmental Effects to the *(Name of VEC)*

Other Projects or Activities With Potential for Cumulative Environmental Effects	Potential Cumulative Environmental Effects
	Change in *(Environmental Effect 1)*
Cumulative Environmental Effects	

Notes:

Cumulative environmental effects were ranked as follows:

0 Project environmental effects do not act cumulatively with those of other projects or activities that have been or will be carried out.

1 Project environmental effects act cumulatively with those of other projects or activities that have been or will be carried out, but are unlikely to result in significant cumulative environmental effects; or Project environmental effects act cumulatively with existing significant levels of cumulative environmental effects but the Project will not measurably contribute to these cumulative environmental effects on the VEC.

2 Project environmental effects act cumulatively with those of other projects or activities that have been or will be carried out, and may result in significant cumulative environmental effects; or Project environmental effects act cumulatively with existing significant levels of cumulative environmental effects and the Project may measurably contribute to adverse changes in the state of the VEC.

The use of the 0, 1, and 2 rankings above for identifying overlapping cumulative environmental effects facilitates the environmental assessment in a manner that focuses the assessment on the key issues of concern for each VEC, where the environmental effects of the Project overlap those of other projects or activities. Only projects or activities that are ranked as 2 in Table 5.4.4 are included in the assessment of potential cumulative environmental effects. Interactions ranked as 0 or 1 are discussed and justified, and by definition the resulting residual cumulative environmental effects are rated not significant, with a high level of confidence.

5.4.3.3 Cumulative Environmental Effects Mechanisms

For those cumulative environmental effects ranked as 2, the assessment of each cumulative environmental effect begins with a description of the environmental effect and the mechanisms whereby the Project environmental effects may interact with other projects or activities in the RAA as defined for a particular VEC. Where possible, the cumulative environmental effect is quantified in terms of the degree of change in the appropriate measurable parameter(s) and the spatial and temporal extent of these changes (*i.e.*, where and when the interactions between the Project's residual environmental effects and the residual environmental effects of other projects or activities might occur). The assessment is carried out in tabular form (Table 5.4.5), supported by sufficient justification in the subsequent text.

As the assessment focuses on residual environmental effects, cumulative environmental effects before mitigation are not characterized. The significance of the cumulative environmental effect before the application of mitigation is not described or assessed.

Table 5.4.5 Example: Summary of Residual Cumulative Environmental Effects on the *(Name of VEC)*

Cumulative Environmental Effects	Case	Other Projects, Activities and Actions	Mitigation / Compensation Measures	Residual Cumulative Environmental Effects Characteristics						Significance	Prediction Confidence	Likelihood	Recommended Follow-up or Monitoring
				Direction	Magnitude	Geographic Extent	Duration and Frequency	Reversibility	Ecological/ Socioeconomic Context				
Change in *(Environmental Effect 1)* • *describe;* • *describe;* • *describe.*	Cumulative Environmental Effects with Project	• *List other projects, activities or actions that have environmental effects overlapping with those of the Project.*	• *List proposed mitigation measures.*	*X*	*X*	*X*	*X/ X*	*X*	*X*	*X*	*X*	*X*	• *List follow up or monitoring programs.*
	Project Contribution to Cumulative Environmental Effects			*X*	*X*	*X*	*X/ X*	*X*	*X*	*X*	*X*	*X*	

KEY

Direction
P Positive.
A Adverse.

Magnitude
L Low: (define).
M Moderate: (define).
H High: (define).

Geographic Extent
S Site-specific: (define).
L Local: (define).
R Regional: (define).

Duration
ST Short-term: (define).
MT Medium-term: (define).
LT Long-term: (define).
P Permanent: (define).

Frequency
O Occurs once.
S Occurs sporadically at irregular intervals.
R Occurs on a regular basis and at regular intervals.
C Continuous.

Reversibility
R Reversible.
I Irreversible.

Ecological/Socioeconomic Context
U Undisturbed: Area relatively or not adversely affected by human activity.
D Developed: Area has been substantially previously disturbed by human development or human development is still present.
N/A Not Applicable.

Significance
S Significant.
N Not Significant.

Prediction Confidence
Confidence in the significance prediction, based on scientific information and statistical analysis, identified technical boundaries, professional judgment and known effectiveness of mitigation:
L Low level of confidence.
M Moderate level of confidence.
H High level of confidence.

Likelihood
If a significant environmental effect is predicted, the likelihood of that significant environmental effect occurring is determined, based on professional judgment:
L Low probability of occurrence.
M Medium probability of occurrence.
H High probability of occurrence.

Other Projects, Activities, or Actions
List of specific projects or activities that would contribute to the cumulative environmental effects.

5.4.3.3.1 Use of Temporal Cases

Where several environmental effects are evaluated in a particular VEC, or where the screening of cumulative environmental effects identifies that a detailed evaluation of these cumulative environmental effects is required, temporal cases are defined where appropriate and helpful to assist in the assessment of cumulative environmental effects. Where this occurs, cumulative environmental effects are generally described for three cases, as follows.

- **Base Case –** describes the current status of the measurable parameter(s) for the environmental effect prior to the start of the Project, including all appropriate past and present projects or activities. The Base Case will normally be presented in the existing conditions of the VEC, with explicit reference to the fact that the Base Case reflects the contributions of past and present projects or activities.

- **Project Case –** describes the status of the measurable parameter(s) for the environmental effect with the Project in place, over and above the Base Case. This is usually assessed using the peak environmental effect of the Project or the maximum active footprint for the Project.

- **Future Case –** describes the status of the measurable parameter(s) for the environmental effect as a result of the Project Case in combination with all reasonably foreseeable future projects or activities that will be carried out. Reasonably foreseeable future projects are defined as future projects or activities that will occur with some certainty, including projects that are in some form of regulatory approval process or where a public announcement to seek regulatory approval has been made (*i.e.*, they are likely to occur).

The comparison of the Project Case with the Future Case allows the Project contribution to cumulative environmental effects of all past, present, and reasonably foreseeable projects or activities that have been or will be carried out (*i.e.*, Future Case) to be determined.

5.4.3.4 Mitigation of Cumulative Environmental Effects

As with Project environmental effects, mitigation measures that would reduce the cumulative environmental effects are described, with an emphasis on those measures that would help to minimize the interaction of the Project-related environmental effect with similar environmental effects from other projects, activities, and actions. Three types of mitigation measures are generally considered, as applicable:

- measures that can be implemented solely by the Proponent;

- measures that can be implemented by the Proponent in cooperation with other project proponents, government, Aboriginal organizations, the public, and/or other stakeholders; and

- measures that can be implemented independently by other project proponents, government, Aboriginal organizations, the public, and/or other stakeholders.

5.4.3.5 Characterization of Residual Cumulative Environmental Effects

Residual cumulative environmental effects are described and assessed, taking into account how the proposed mitigation will alter or change the cumulative environmental effect. As described for Project-related environmental effects (Section 5.4.2), cumulative environmental effects are characterized where applicable and appropriate in terms of the direction, magnitude, geographic extent, frequency, duration, reversibility, and ecological or socioeconomic context (Table 5.4.5). The contribution of the Project to cumulative environmental effects is assessed where there is a potential for substantive overlapping environmental effects to occur.

5.5 DETERMINATION OF SIGNIFICANCE

5.5.1 Determination of Significance of Residual Project Environmental Effects

A determination of the significance of Project environmental effects is made using thresholds of significance defined for the VEC and/or the measurable parameters (Section 5.2), beyond which a residual environmental effect would be considered significant. The determination of significance may be made along with the assessment of Project-related environmental effects, or in a separate Determination of Significance section.

The significance determination for Project-related environmental effects is based on significance criteria that reflect a variety of considerations based on criteria defined in guidance (*i.e.,* direction, magnitude, geographic extent, duration, frequency, reversibility, and ecological/socioeconomic context) and other relevant considerations. Other considerations can include other measurable parameters that may better characterize significance, including legislation, and other regulatory standards or other thresholds of acceptability, as described by Barnes *et al.* (2012). These determinations of significance inform decision-making under both the federal and provincial decision-making processes. The level of confidence of the significance determination is identified, in consideration of factors such as the certainty of the scientific information and statistical analysis, identified technical boundaries, professional judgment, and known effectiveness of proposed mitigation.

Where the environmental effects are determined to be significant, there is further consideration of the likelihood of occurrence of that significant environmental effect, based on past experience and the professional judgment of the Study Team. Additionally, since the federal EIA of the Project is a comprehensive study under *CEAA,* if a significant residual environmental effect is likely to occur, the assessment must include consideration of the capacity of renewable resources that are likely to be significantly affected by the Project to meet the needs of present and those of the future.

5.5.2 Determination of Significance of Residual Cumulative Environmental Effects

A determination of the significance of residual cumulative environmental effects is then made using the same standards or thresholds for significance developed for the VEC and/or the measurable parameters. As with residual Project environmental effects, the determination of residual cumulative environmental effects includes a discussion of the level of confidence in the prediction (Section 5.5.1). The determination of significance may be made along with the assessment of cumulative environmental effects, or separately in the Determination of Significance section.

5.6 FOLLOW-UP OR MONITORING

A follow-up program is used, where applicable, to verify environmental effects predictions or to verify the effectiveness of mitigation measures. A monitoring program includes compliance measures used to verify that mitigation was applied or to demonstrate compliance with the requirements of environmental laws or regulations, or the conditions of permits, approvals or authorizations issued under such laws or regulations.

Appropriate follow-up measures are proposed for consideration by regulatory authorities where the scientific uncertainty of the environmental effects predictions or the effectiveness of mitigation warrants the need for such programs. Environmental monitoring measures to demonstrate compliance with legislation or to monitor environmental quality for other purposes are also described as appropriate for consideration by regulatory authorities.

5.7 POTENTIAL ACCIDENTS, MALFUNCTIONS AND UNPLANNED EVENTS

Accidents, malfunctions and unplanned events are assessed for the Project. Potential accidents, malfunctions and unplanned events are identified based on the Project Description using historical performance data for other similar projects at a regional, provincial, national or international scale, as appropriate. Where applicable, for each accident, malfunction, or unplanned event, one or more scenarios relating to how the accident, malfunction, or unplanned event might occur during the life of the Project are developed. The focus of the evaluation is on credible accidents, malfunctions and unplanned events that have a reasonable likelihood of occurring during the lifetime of the Project based on the nature of the Project and the environmental effects that may occur, or for those that could result in significant environmental effects even if their likelihood of occurrence is low. Details on the types of accidents, malfunctions and unplanned events considered in this EIA are provided in Section 8.17.

For each event and/or scenario, a preliminary screening is conducted to determine if the event and/or scenario is likely to affect each identified VEC (Table 5.7.1). Potential interactions are ranked using the same criteria as for Project-VEC interactions (Section 5.4).

Table 5.7.1 Example: Potential Interactions between VECs and *(Accident / Malfunction / Unplanned Event 1)*

Valued Environmental Component (VEC)	Accident/Malfunction / Unplanned Event 1	
	Scenario A	Scenario B
VEC 1	X	X
VEC 2	X	X
VEC 3	X	X
VEC 4	X	X
VEC 5	X	X

Notes:
Interactions between Accidents/Scenarios and the respective VECs were ranked as follows:
0 No interaction, or no substantive interaction contemplated.
1 Interaction may occur. However, based on past experience and professional judgment, the interaction would not result in a significant environmental effect, even without mitigation, or the interaction would clearly not be significant due to application of codified practices.
2 Interaction may, even with codified mitigation, result in a potentially significant environmental effect and/or is important to regulatory and/or public interest. Potential environmental effects are considered further and in more detail in the EIA.

For interactions that are ranked as 2, potential environmental effects of the event and/or scenario on the VEC are assessed. Environmental effects are characterized using the same terms as routine Project-related environmental effects (Section 5.4).

Cumulative environmental effects of accidents, malfunctions, or unplanned events, however, are not assessed as it is not reasonably foreseeable to have overlapping Project-related accidents with those from other projects or activities that will be carried out.

The significance of the Project-related environmental effects for each accident, malfunction, or unplanned event and its likelihood of occurrence is then determined using the same thresholds as determined for the Project-related environmental effects on each applicable VEC.

6.0 ENVIRONMENTAL SETTING (SUMMARY OF EXISTING CONDITIONS)

This chapter describes the environmental setting of Central New Brunswick generally, and (where information exists) the Project Development Area (PDA) specifically, including general information on the historical, biophysical, and socioeconomic and cultural context of these areas. Together, these descriptions provide a high-level summary of existing conditions in the vicinity of the Project.

6.1 OVERVIEW

The Project is located in a sparsely populated rural setting on provincial Crown land approximately 10 km southwest of the community of Napadogan, New Brunswick, and approximately 60 km directly northwest of the City of Fredericton (Figure 1.1.1). The Project straddles a topographical divide that separates the headwaters of the McBean Brook and Napadogan Brook watersheds. Both brooks drain to the Nashwaak River, which enters the St. John River at Fredericton.

Most of the Project is located near the southwestern border of the Central Uplands Ecoregion within the Beadle Ecodistrict, a lake-filled region of rolling hills separated by broad valleys. This area is typically well-drained, forested upland, separated by rolling valleys. The surface elevation typically ranges from approximately 300 m to 350 m above mean sea level (amsl), with some local peaks rising to over 400 m. Small lakes and wetlands are commonly found in low-lying areas (NBDNR 2007). At Juniper (the Environment Canada weather station that is closest to the Project), precipitation averages 1,190.7 mm annually, of which about 26% falls as snow, and daily average temperatures are 17.7°C in July and -12.4°C in January (Environment Canada 2012a). Like much of Central New Brunswick, the area is sparsely populated, and air quality is good to very good most of the time.

The majority of the Project facilities lie within the small Bird and Sisson brook tributary watersheds to West Branch Napadogan Brook, which drains to the upper Nashwaak River. The southwestern portion of the open pit does, however, partially intersect small unnamed tributaries to McBean Brook, a small tributary watershed to the Nashwaak River itself, as do portions of the relocated 345 kV transmission line and realigned Fire Road. The groundwater table is typically observed as a muted version of surface topography. The Nashwaak River watershed supports several fish species including Atlantic salmon, brook trout and bass. The Nashwaak River and some of its tributaries are salmon-bearing; salmon was found in the West and East Branches of Napadogan Brook and at the mouth of Bird Brook during field surveys conducted for the Project. Surface water and groundwater quality is generally good to very good.

The terrestrial habitat in the vicinity of the Project consists primarily of immature and young forest as a result of several decades of historic forestry activity in the area. Wildlife in the vicinity of the Project is typical for Central New Brunswick, with abundant deer, moose, bear, and a wide variety of small mammals. An abundance of preferred bird nesting and breeding habitat is available.

There is a long history of active commercial logging, and thus many forestry roads, landing areas, and forest blocks in various stages of regrowth and maturity are present in the vicinity of the Project. Recreational activity in the area consists of hunting, fishing, trapping, ATV riding, and snowmobiling.

There are no permanent residences located in the immediate vicinity of the Project. The closest permanent residences to the Project are located in Napadogan, a small community on Highway 107 approximately 10 km to the northeast of the Project site. There are approximately 39 privately-owned, active recreational campsite leases on provincial Crown land to the east and southeast of the Project. The closest of these campsites, some of which contain cabins, is approximately 1.5 km to the east of the open pit location and on the opposite side of a prominent ridge separating the open pit from the location of cabins to its east.

The Project site does not include First Nation reserve land, but is within an area which the Maliseet assert as part of their traditional territory. Natural resources in the vicinity of the Project site have been and continue to be used by Aboriginal people.

Further details on the historical, biophysical, and socioeconomic setting of the Project and the surrounding region of Central New Brunswick are provided in the sections that follow.

6.2 HISTORICAL SETTING

Archaeological records confirm that there were Aboriginal campsites in New Brunswick dating back approximately 11,000 years (Jacques Whitford Stantec 2009). The Wolastoqiyik (Maliseet) and Mi'kmaq peoples currently living in New Brunswick have long occupied parts of New Brunswick as their traditional land for centuries, and continue to use its land and resources to this day. Given its rural and relatively undeveloped nature, Central New Brunswick and the area in the general vicinity of the Project have likely been used by Aboriginal people for at least several centuries, and much of that use of land and resources likely continues today.

Colonization of various areas of New Brunswick including Central New Brunswick occurred following the arrival of the Europeans in the early 17th Century, and various rural communities near the Project were developed in response to the economic drivers that formed the areas of Central New Brunswick and its dependence on its natural resources. Many of those communities remain to this day focused around supplying goods, services, resources, and labour to those resource-based industries, including particularly the forestry sector.

This section provides a brief historical overview of Central New Brunswick, including the Pre-Contact Period (*i.e.*, up to the settlement of the area by Europeans) and the Historic Period (*i.e.,* European settlement to the mid-20th Century).

6.2.1 Pre-Contact Period

While it is likely that the peoples from all Pre-Contact time periods may have been the ancestors of the First Nations peoples currently living in the Province, the archaeological record indicates that the Wolastoqiyik (Maliseet) and Mi'kmaq peoples currently living in New Brunswick are the direct descendants of the Woodland Period (approximately 2500-500 years before present (BP)) peoples (Stantec 2012j). Archaeological discoveries on the Project site in 2013 and 2014 appear to date from between 6,500 to 7,500 years before present.

The Nashwaak River watershed is a sub-watershed of the larger St. John River watershed, which is known to be the traditional territory of the Wolastoqiyik people. Villages and camp sites, as well as other types of sites, were located throughout the St. John River watershed (Wallis and Wallis 1957).

The Wolastoqiyik people lived off the land, gathering resources to feed their families through hunting, fishing, trapping, and gathering. Much of the subsistence efforts of the Wolastoqiyik were focused around major river systems, as these were their primary travel routes. The Wolastoqiyik people used the rivers and streams of New Brunswick, extending up the smallest of watercourses, to access food and other resources. Travelling over landforms from one watershed into another led to the establishment of portage routes. Portage routes, in particular those between major watersheds, were a vital component of trade and communication within and outside of New Brunswick.

Archaeologists know little about settlement patterns during the Late Woodland period; although there is some archaeological evidence that groups may have shifted from a more logistical to residential mobility strategy (Blair 2004; Burke 2000). It is postulated that people moved from one living location to another in seeking resources, rather than gathering resources and bringing them to a central living area.

The late Pre-Contact/early Contact Period (or proto-historic period) in the Maritimes region generally began in the early 17th Century, with the arrival of Samuel de Champlain to the area now known as Saint John in 1604. The extent to which indigenous groups living on the St. John River system had direct contact with Europeans during the 17th Century is not known. However, Bourque (1973) suggested that the presence of Europeans (including those who came seasonally in small numbers) fundamentally altered indigenous settlement and subsistence patterns. European settlement during the 18th and 19th Centuries, and the introduction of wage economy, further contributed to significant changes in settlement and subsistence (Bourque 1973) of the Wolastoqiyik. The shifts in seasonal use of the coast and interior caused many Wolastoqiyik to leave their coastal settlements altogether, and join others at major interior villages such as Meductic on the St. John River (Burke 2000).

6.2.2 Historic Period

The French (Acadians) were the first Europeans to settle in areas now known as New Brunswick, following Samuel de Champlain's first arrival to the mouth of the St. John River in 1604. They tended to settle mainly along the New Brunswick coast and/or along the shorelines of major rivers leading to, or in proximity of, the coast, and are not anticipated to have travelled to or settled in any place close to the Project.

By 1600, it is believed that Aboriginal people, including the ancestors of the Mi'kmaq and Wolastoqiyik-Passamaquoddy First Nations people, had inhabited New Brunswick for over 10,000 years. There were an estimated 35,000 Mi'kmaq in the year 1500, but the number of Mi'kmaq people was estimated to decline to 3,500 in as little as 100 years due to the first European contacts and disease (Wynn 1981). The same decline would be expected of the Wolastoqiyik populations. By the 1750s, the First Nations people no longer comprised the majority of the population within the area now known as New Brunswick.

The European-derived population of New Brunswick increased steadily during the early 19th Century. It grew from 25,000 in 1805 to 74,000 in 1824. By 1851, there were almost 200,000 settlers in the province (Wynn 1981).

6.2.2.1 Subsistence

Life in Central New Brunswick in the 18th and 19th Centuries focused heavily on resource-based activities such as small-scale commercial fishing, logging, agriculture, hunting, trapping, and other subsistence-type activities that supported the development of communities and local commerce. The face of the countryside was transformed as villages, dwellings, barns, roads, and bridges were built.

Up until the mid-18th Century, New Brunswick was still almost completely forested. Extensive white pine-hemlock-northern hardwood forest dominated New Brunswick in pre-European times and largely survived until the last decades of the 18th Century (Wynn 1981). Agriculture and the fishery were becoming the main economic drivers in New Brunswick. However, the timber industry emerged as a central economic driver as soon as Napoleon Bonaparte severed Britain's timber source in the Baltic—after which large timber logs began being harvested, squared and shipped from New Brunswick to Britain (Soucoup 2011). The rich forests and resources within New Brunswick offered many opportunities to supply the needs of overseas markets.

The majority of the early 19th Century settlers were farmers (Photos 6.2.1 and 6.2.2), but the lucrative business of shipping sawn timber to Britain saw many shift their activities from agriculture towards a career in the timber industry. Farm clearing in New Brunswick remained an ongoing process though, and by the mid-19th Century, more than 250,000 hectares of land in New Brunswick had been cleared for farming.

Photo 6.2.1 Nashwaak River Valley, *ca.* 1900. View of farmland with a hay wagon in the foreground and the railway line to the left. P5-483 George Taylor, Provincial Archives of New Brunswick (PANB n.d.).

Photo 6.2.2 Moving barrels of potatoes on a sleigh in the winter, Bristol, New Brunswick, *ca.* 1920. Provincial Archives of New Brunswick (PANB n.d.).

Pine rich forests close to rivers and streams were the immediate targets for wood. Lumbermen favored the watersheds of New Brunswick's largest, least-obstructed rivers and streams for log conveyance from forest to sawmill, and by 1835, most tributaries of the Miramichi and St. John Rivers had been used for timber conveyance (Wynn 1981). By the 1890s, most of New Brunswick's rivers were used extensively for floating logs and lumber to market (Photos 6.2.3 and 6.2.4).

Photo 6.2.3 The drive, *ca.* late 1800s. Photographer, lithographer, and artist unknown. Loggers holding peavies are attempting to roll logs into the water. P4-3-12 New Brunswick Museum photographs collection, Provincial Archives of New Brunswick (PANB n.d.).

Photo 6.2.4 Log Jam on the Nashwaak River, *ca.* 1915. Provincial Archives of New Brunswick (PANB n.d.).

Lumbering offered an opportunity for the common man in New Brunswick to improve his way of life (Photo 6.2.5). Countless New Brunswick farmers contributed to the development of the timber trade by combining the seasonal employment of farming and lumbering (Wynn 1981). Some lumbermen would work year-round, and others were part-time farmers as well. They would plant their gardens in the spring and peel or cut pulp until haying season in mid-summer. Becoming part of the early lumber camps was controversial as the rise of the timber industry was seen as destructive to agriculture and settlement efforts. Although many were critical of the influence of lumbering on the agricultural settler, a visiting agricultural chemist, J.F.W. Johnston, noted that in York County "*almost all the farmers in this neighbourhood were lumberers before they were farmers, and it was lumbering* [that] *they got their farms stocked*" (Wynn 1981).

Photo 6.2.5 Lumbering in New Brunswick: Lumbermen at work in the forest by I. Ortel, *ca.* 1858. Published in Illustrated London News, 28 August 1858. Lithographer unknown. MC2946-MS1C2 David Janigan collection, Provincial Archives of New Brunswick (PANB n.d.).

Lumber mills (Photos 6.2.6 and 6.2.7) were built along waterways emptying into the St. John River, and general stores soon appeared (Ketchum n.d.). Lumber camps were built near the logging sites and some of the larger operations would have multiple buildings which would accommodate cooking, sleeping, dining and have a separate carpentry and blacksmith shop (Photo 6.2.8). Logging camps were often built in proximity to a nearby stream and/or by the cutting grounds. Smaller operations would often have a single structure that would serve multiple functions. Some early lumber camps had built-in stone fireplaces used for cooking while later, stoves were hauled in and facilitated the cooking of the camp food (Soucoup 2010). Prior to World War I, the logging camps were generally operated by the lumber companies and workers received room and board in addition to a small wage. Around 1900, many loggers were cutting railroad ties and being paid by the cord (Soucoup 2010).

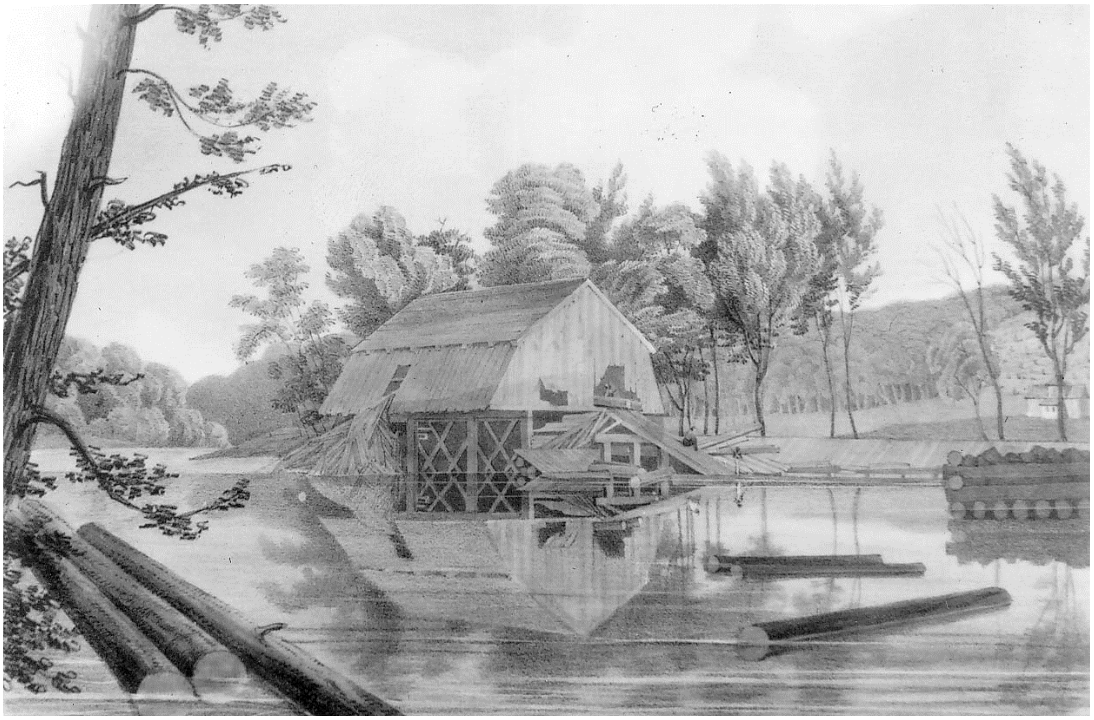


Photo 6.2.6 **The mill at Stanley, August 1835. Published by Ackermann & Co. Photograph of a lithograph, from a series entitled “Sketches in New Brunswick”. P4-3-19 New Brunswick Museum photographs collection, Provincial Archives of New Brunswick (PANB n.d.).**

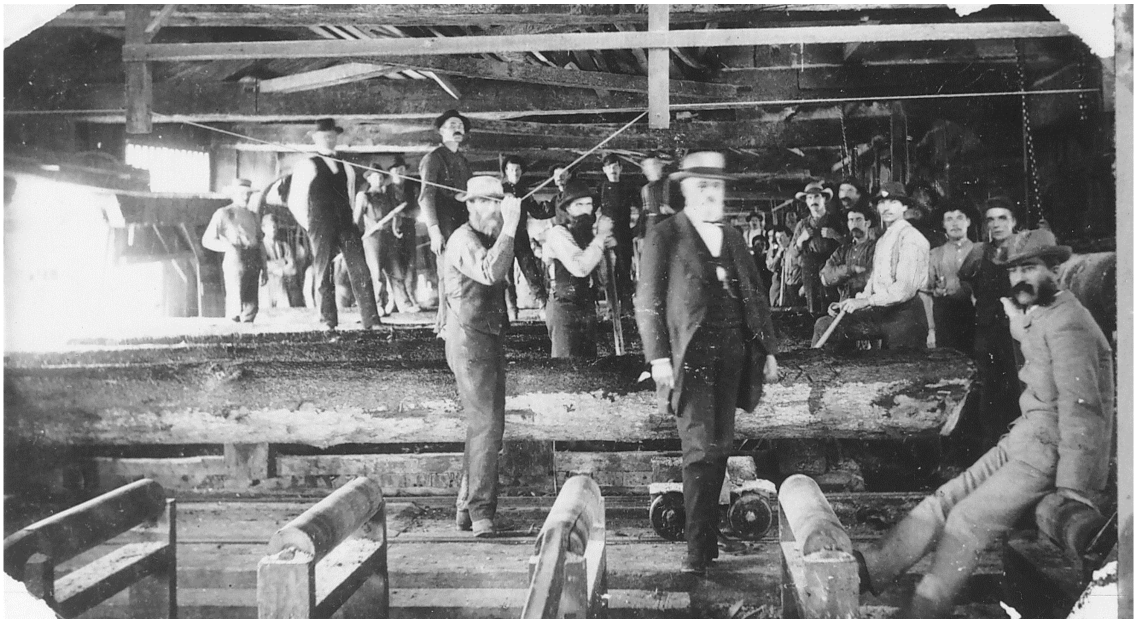


Photo 6.2.7 **Alexander (Boss) Gibson in his sawmill, Marysville, NB, *ca.* 1914. Photographer unknown. Boss Gibson purchased his first mill and timber properties on the Nashwaak River in 1862. P4-2-6 York-Sunbury Historical Society photographs, Provincial Archives of New Brunswick (PANB n.d.).**

Photo 6.2.8 Men relaxing in lumber camp after a hard day's work, *ca.* late 1800's. Photographer, lithographer, and artist unknown. Scenes such as this one would have been common in the New Brunswick woods during the 19th Century. P4-3-9 New Brunswick Museum photographs collection, Provincial Archives of New Brunswick (PANB n.d.).

In the mid-19th Century, intermittent settlements followed the Nashwaak Valley to the Cardigan and Tay settlements and to the village of Stanley. Beyond these settlements, however, "*there stretched almost unbroken forest*" (Wynn 1981). A survey crew working in Central New Brunswick in the 1860s was lost as the crew members found "*not an eye in the wooded landscape*" to provide orientation and they could "make nothing of the country except for boundless forests" (Wynn 1981).

6.2.2.2 Infrastructure

The Wolastoqiyik and the Mi'kmaq had well-developed transportation routes along New Brunswick's waterways (Leroux 2008) which were also used by the European settlers who started arriving in the 17th Century. The Loyalists settled throughout New Brunswick starting in 1784 and with that, roads started to reach out from one community to the next. These roads were built close to and followed rivers in order to facilitate the logging activities in the surrounding forests as a key area of economic activity. The challenges around building roads (and eventually railroads) in New Brunswick were many due to the hilly topography crisscrossed by lakes, wetlands, and fast-flowing streams and rivers (Frink 1997).

The arrival of the railway opened up the interior of New Brunswick to new settlement and business opportunities. The railway age officially began in the Maritimes in 1876 when the first train ran along the Intercolonial Railway (ICR) from Halifax, Nova Scotia to Rivière-du-Loup, Québec (Soucoup 2010). In 1910, construction of the first railway near the PDA was initiated. The National Transcontinental Railway (NTR) was completed in 1912. The 402 km stretch through New Brunswick ran from Moncton to Chipman, and then north to McGivney, Napadogan, Juniper, Plaster Rock, Grand Falls, and Edmundston.

During World War I, the federal government incorporated the NTR into the Intercolonial Railway operation throughout eastern Canada, and in 1918 a new government railway, Canadian National Railway or CNR, was launched. In 1918, CNR became the operator of a vast network of private railways that had been acquired with federal funds by the Canadian Government Railways (Soucoup 2010). In 1919, the Intercolonial Railway was engulfed by the emerging national railway system operated by the CNR (Frink 1997).

Commencing in the early 20th Century, the forest industry transformed to support the development of a pulp and paper industry and a further development of the sawmill industry. Forest harvesting became increasingly industrialized with the advent of motorized vehicles, chain saws, harvesters, and other equipment. More recently, medium-density fibreboard and oriented strand board mills have been opened, and some continue to operate. The pulp and paper industry thrived until the late 20th Century. Several mills have closed in the last two decades and were decommissioned. Two pulp mills, including one in Nackawic approximately 44 km southwest of the Project, were converted in the last decade of the 20th Century and early 21st Century to manufacture dissolving-grade pulp, used in textile manufacture. Generally, global competition due to fast-growing species in warmer climates, labour costs, economies of scale from larger mills in other countries, and a decline in the consumer demand for paper in the computer age have all contributed to the decline.

In parallel to the decline in the pulp and paper sector, the dimension lumber industry has suffered due to a variety of factors including trade policies in the United States, variability in the Canadian dollar, and more recently the recession and housing industry decline of the early 2010s. Several sawmills including those in Juniper (approximately 25 km northwest of the Project) and Deersdale (approximately 12 km north of the Project), were closed in recent years.

In the 20th Century, New Brunswick saw a continued rural to urban migration. Currently, only 49% of the population lives in rural areas (Statistics Canada 2012e). This has reflected the transition from farming and forestry, to urban pursuits including government, post-secondary education, modern services (*e.g.,* engineering, knowledge services), and retail. In the vicinity of the Project, such activities have been centred in Woodstock and in the provincial capital, Fredericton.

6.2.3 Present Day

Today, many of the communities of Central New Brunswick continue to exist in support of the resource-based harvesting of forest and natural resources to supply industries throughout the province as well as to provide products for export. While the forest products industry has declined considerably in recent years due to global competition and economic conditions, forest harvesting activities and the use of the land and resources in Central New Brunswick continue to be the lifeblood of the various communities in the area, including Juniper, Deersdale, Napadogan, Stanley, Millville, and parts in between (Photo 6.2.9). Limited agricultural development is also present in these and surrounding communities.

Photo 6.2.9 Atcon veneer mill, Napadogan, New Brunswick (Janice Cook, July 25, 2006). Located on Route 107 between Williamsburg and Juniper, the mill produced veneers for furniture, flooring, doors, skateboards, and musical instrument cases. P194-598 Miscellaneous photographs collection, Provincial Archives of New Brunswick (PANB n.d.).

The rural nature of these communities, and the availability of goods and services and infrastructure to support what was once a thriving economic community consisting largely of important resource-based industries, provides an attractive backdrop for the development of suburban communities as well as a refuge for those wishing to escape urban developments in favour of a simpler rural life. Communities like Stanley, for example, have grown into an attractive retirement community for those individuals seeking a simpler, more rural lifestyle. Though many of the mills these communities once supported are now gone or temporarily closed, other communities like Juniper, Deersdale and Millville retain their resource-based character to this day. While the population in these rural communities is generally decreasing and services are declining, they continue to provide goods and services that support the forestry, agricultural, and resource-based industries that remain in the area, and these centres provide important services and infrastructure for those industries and developments to come.

6.3 BIOPHYSICAL SETTING

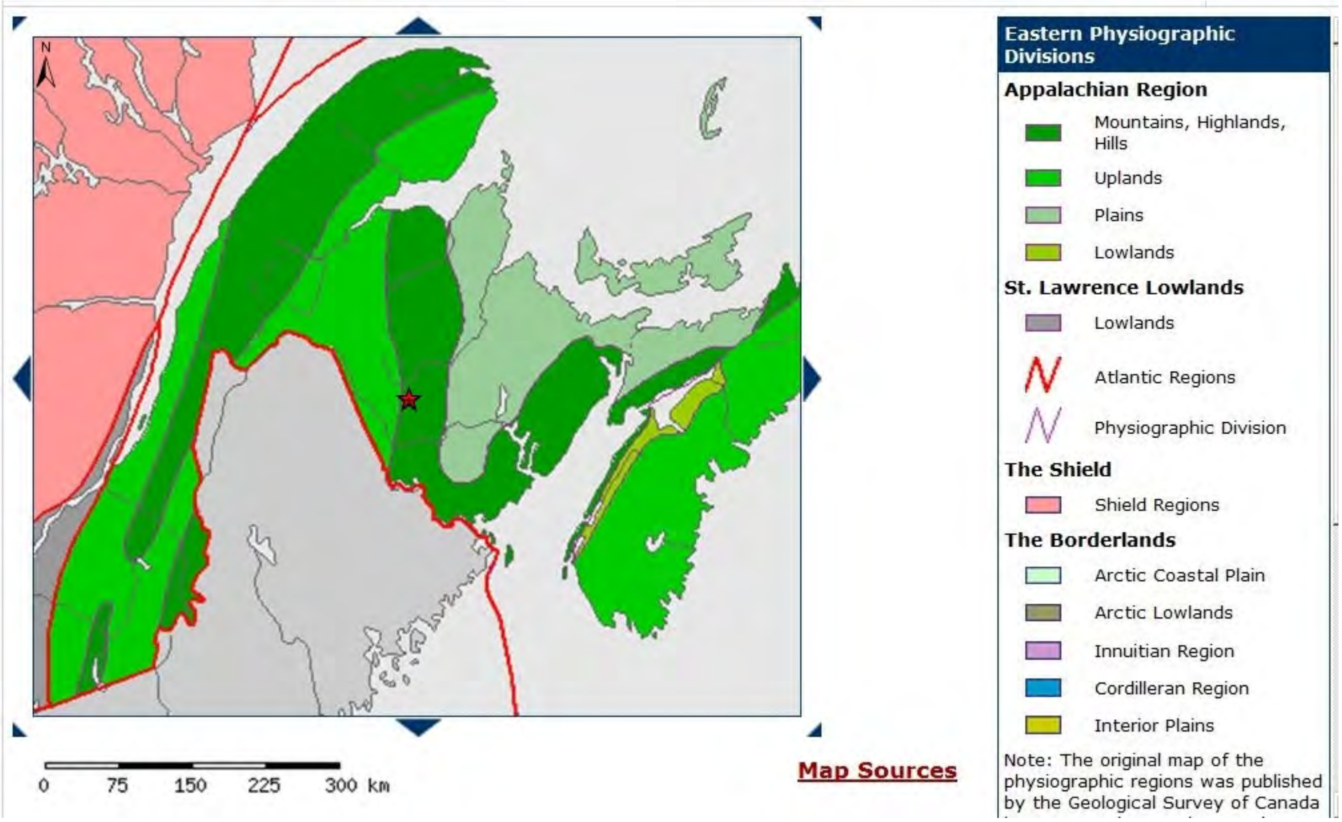
This section provides a brief overview of the biophysical setting of Central New Brunswick.

6.3.1 Physiography and Geology

The Project is located within the Appalachian Region which lies between southern Québec and the Gaspé Peninsula in the north to the Atlantic Continental Shelf in the south. The Appalachian Region spans New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland. The current physiography of New Brunswick reflects mountain building of the Appalachians during tectonic movements between about 480 and 280 million years ago, followed by a long period of relative quiescence and erosion (Bookes 2012).

Within New Brunswick the Appalachian Region is made up of three physiographic units: the New Brunswick Highlands; the Chaleur Uplands; and the Maritime Plain. The Project is located within the New Brunswick Highlands unit, where the regional uplift has maintained smooth-topped uplands and highlands in a Z-shaped belt (Figure 6.3.1), from the Québec border with Vermont and New Hampshire, northeastward to the Gaspé Peninsula, southwestward across New Brunswick, and then continuing northeast north of the Bay of Fundy to Cape Breton Island (NRCan 2012a).

The geology of the Project area comprises Cambrian to Ordovician metavolcanic and metasedimentary rocks which were intruded in the Early to Late Devonian by large granite batholiths and smaller bodies of more mafic composition (NBDNR 2007).



Source: NRCan 2012a.

Figure 6.3.1 Eastern Physiographic Regions

6.3.1.1 Topography and Drainage

Elevations in Central New Brunswick range from over 600 m amsl at Mount Hind and Clark Mountain approximately 80 km north of the Project at Serpentine Lake, to between approximately 400 m and 200 m amsl in the area of the Project (Photo 6.3.1). The Project area elevation typically ranges from 300-350 m amsl, with some local hills rising to over 400 m. The presence of numerous lakes within the region can be attributed to several geological features which can be characterized by undulating hills and wide valleys. Generally poor drainage within the region has resulted in the creation of many lakes, ponds, and wetlands.

The Project is located in the Nashwaak River watershed, which is a tributary to the St. John River. Watercourses north of the Project area generally flow eastward into the Miramichi River; those in the south generally flow southward into the Nashwaak and St. John rivers (NBDNR 2007).

Photo 6.3.1 Aerial view of Project site looking northwest over the Sisson deposit area. Plant site is on the hill in the upper middle of the photo.

6.3.1.2 Surficial Geology and Soils

The ore body for the Project is located in an area mainly overlain by blanket and veneer till consisting of: loamy lodgment till; some lodgment till, sand, gravel; and rubble. The thickness of the till varies between <0.5 (thin veneer) to over 5 m thick (blanket till) with approximately 25% of clasts that are boulder sized (Rampton *et al.* 1984). Based on the soil characteristics of the area, it would appear that soils are primarily coarse-textured (Colpitts *et al.* 1995) and the parent till would appear to be locally-derived from underlying bedrock.

Hilltop soils within the Project area are derived from granitic rock, and include sandy loams, stony tills and generally coarse in texture. More compact soils derived from mafic volcanic or from metasedimentary and igneous rocks are found in the low-lying valleys around the Project. Soil richness varies from moderate to poor, and likewise drainage is moderate to poor as the elevation of the Project area decreases.

There are five different soil units in the vicinity of the Project, as defined by Colpitts *et al.* (1995), as illustrated on Figure 6.3.2 and generally described as follows.

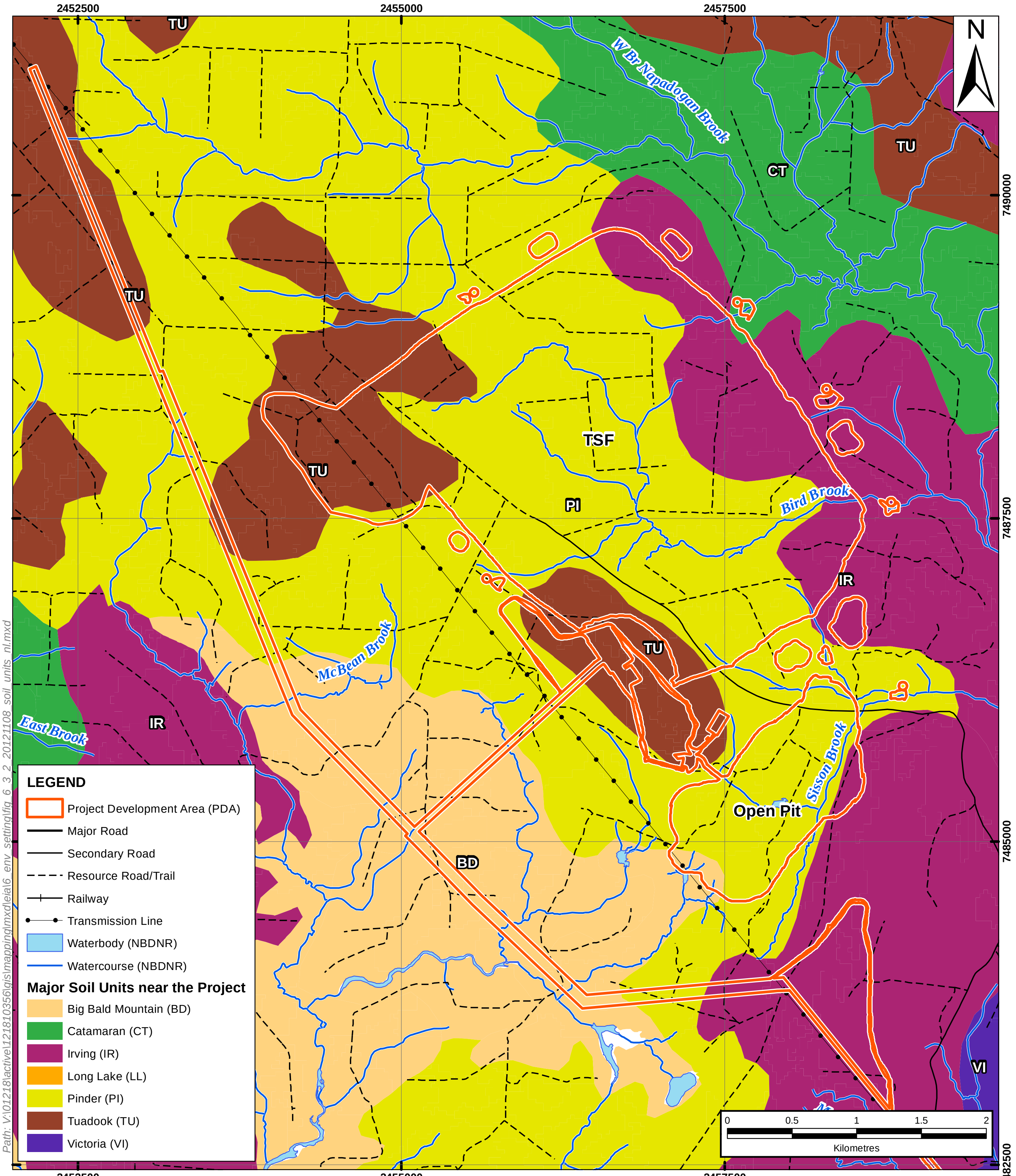
- The majority of the soils near the Project are composed of the Pinder soil unit, which is derived primarily from parent rock of igneous origin, with lesser amounts of metasedimentary rocks. Pinder soils are typically coarse-textured, and formed in highly stony residual materials. Elevated areas such as hillcrests and upper slopes demonstrate colluvial or till material.

- The eastern portion of the Project location is composed of the Irving soil unit which is derived primarily from parent rock of igneous origin, with lesser amounts of metasedimentary rocks. Irving-type soils have a silt loam texture and are composed of well- to imperfectly-drained non-compacted till.

- High elevation areas in the Project location are composed of the Tuadook soil unit. This soil type developed on lodgement till, and has a texture from loam to silt loam, with some coarse fragments. Tuadook soil parent material composition and structure, high in quartz and feldspars, is slow weathering, with slow nutrient release, and rugged topography. Soils are typically compact to a depth of 30 to 65 cm.

- The Big Bald Mountain soil unit is found in the southwestern portion of the Project location. Big Bald Mountain soils are rocky residual, and shallow, formed from the *in situ* weathering of granitic rocks, typically in areas where bedrock outcrops are common, such as hill crests and upper slopes. Soil texture is coarse, including sandy loam, gravel, and stones.

- One small area to the northeast of the Project location, where a small tributary flows into West Branch Napadogan Brook, is composed of the Catamaran soil unit. The Catamaran soil unit is derived primarily from parent rock of igneous origin, with lesser amounts of metasedimentary rocks. Catamaran soils are coarse-textured lodgment tills, occurring in mid-slope positions with low to moderate amounts of coarse fragments, and are compact to a depth of 30 to 65 cm.



NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Major Soil Units near the Project

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Sisson Mines Ltd.

Scale: 1:40,000

Project No.: 121810356

Data Sources: NBDNR

Fig. No.: 6.3.2

Date: (dd/mm/yyyy) 23/11/2014

Dwn. By: JAB

Appd. By: DLM

Map: NAD83 CSRS NB Double Stereographic

6.3.1.3 Bedrock Geology

The Sisson ore body is centred on a north-trending contact between Acadian intrusions to the west and older metavolcanic and metasedimentary rocks to the east. The bedrock geology was described in Section 3.1.3.2 and is illustrated in Figure 6.3.3.

6.3.1.4 Seismicity

Seismicity is the characterization of the likelihood and potential magnitude of seismic events, caused by movements in tectonic plates that form the Earth's crust. Eastern Canada is located in a stable continental region within the North American tectonic plate and has a relatively low rate of seismic activity. However, moderate to large earthquakes have occurred in the region and will occur in the future. The seismicity of eastern Canada is typical of an intra-plate region, which is characterized by generally low levels of seismic activity and earthquakes apparently randomly distributed in location and time. The correlation between recorded earthquakes and geological features in the region is not well known or understood. Seismic activity in the region is thought to be related to regional stress fields, with earthquakes concentrated in regions of crustal weakness (Fader 2005).

The Project lies within the Northern Appalachians seismic zone, one of five seismic zones in southeastern Canada, where the level of historical seismic activity is low. Historical seismic data recorded throughout eastern Canada has identified clusters of earthquake activity. Earthquakes in New Brunswick generally cluster in three regions: the Passamaquoddy Bay region, the Central Highlands (Miramichi) region, and the Moncton region (Burke 2011).

The largest earthquake instrumentally recorded in New Brunswick was a magnitude 5.7 event (on the Richter scale) on January 9, 1982, located in the north-central Miramichi Highlands. This earthquake was followed by strong aftershocks of magnitudes 5.1 and 5.4. Prior to 1982, other moderate earthquakes with estimated magnitudes in the range of approximately 4.5 to 6.0 occurred in 1855, 1869, 1904, 1922, and 1937 (Basham and Adams 1984). The 1869 and 1904 earthquakes were both located within the Passamaquoddy Bay region, with estimated magnitudes of 5.7 and 5.9, respectively (Fader 2005). The maximum credible earthquake magnitude for the Northern Appalachians region is estimated to be magnitude 7.0, based on historical earthquake data and the regional tectonics (Adams and Halchuk 2003).

Figure 6.3.4 shows the recorded historical seismicity of New Brunswick and surrounding regions from 1985 to 2011. Over the 10 year period between September 2002 and September 2012, approximately 160 seismic events have been recorded within 100 km of the Project. These events range in magnitude from <1 to 3.7 on the Richter scale, with the majority being recorded in the McAdam area in southwestern New Brunswick (Earthquakes Canada 2012).

A total of 612 earthquakes have been recorded in the Northern Appalachian seismic zone from September 2011 to September 2012 (Figure 6.3.5) (Earthquakes Canada 2012). Of the events recorded in the Northern Appalachian seismic zone, 79 events were recorded for the same 12 month period. The strongest of these events occurred in Bathurst on March 30, 2012, with a magnitude of 3.4.

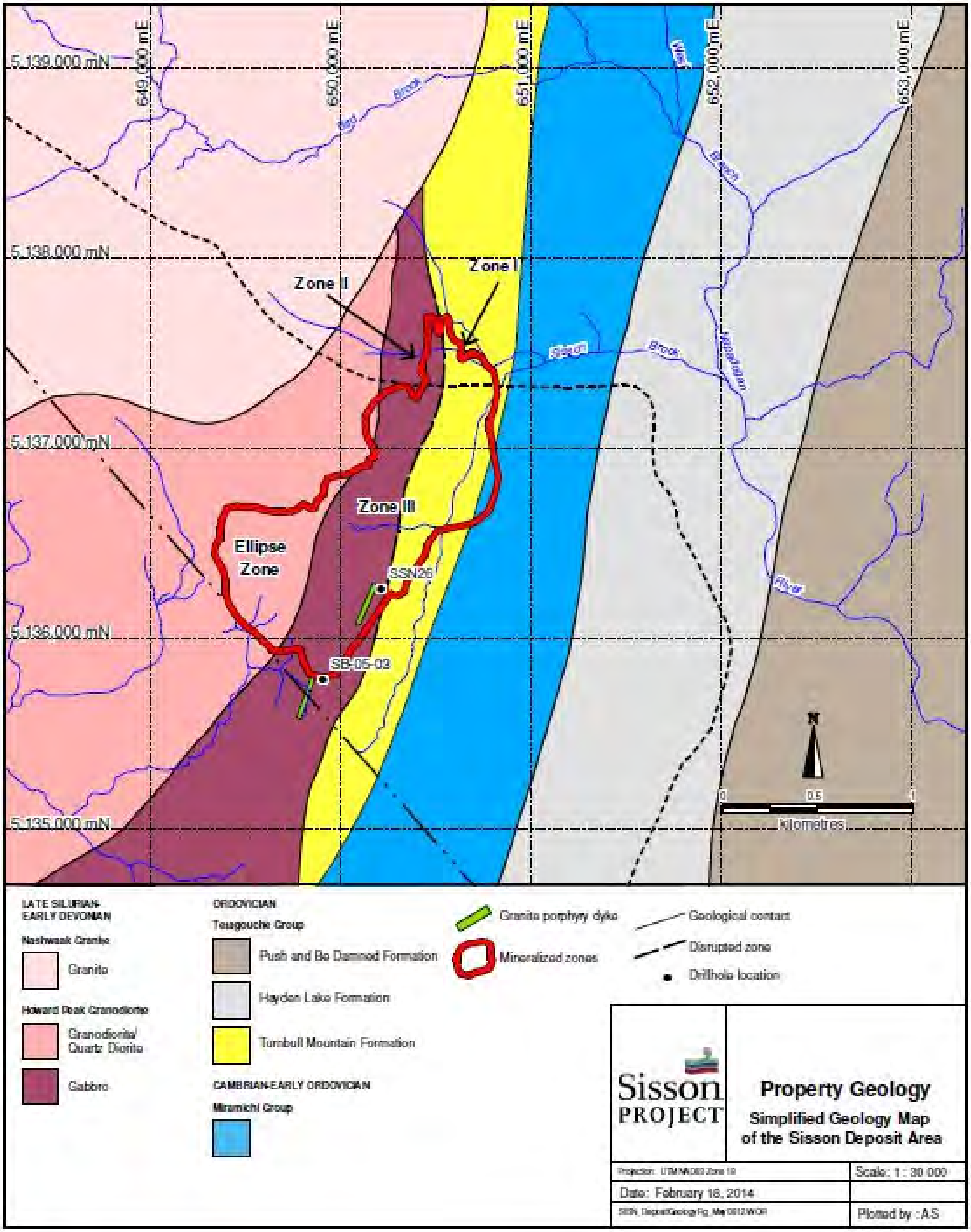
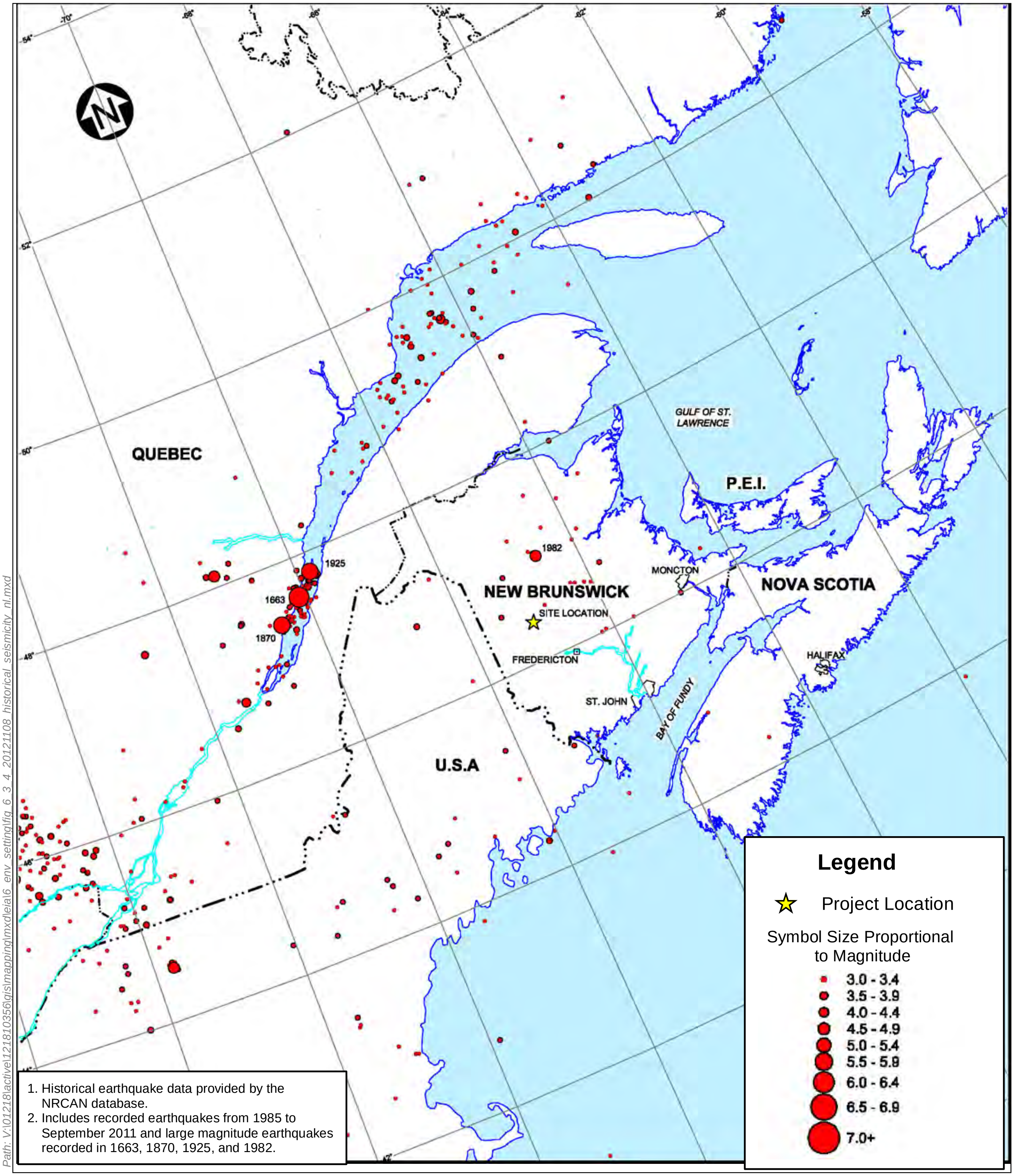


Figure 6.3.3 Simplified Geology Map of the Sisson Deposit Area



1. Historical earthquake data provided by the NRCAN database.
2. Includes recorded earthquakes from 1985 to September 2011 and large magnitude earthquakes recorded in 1663, 1870, 1925, and 1982.

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NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Historical Seismicity of New Brunswick
and Surrounding Regions

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Sisson Mines Ltd.

Scale: NTS

Project No.: 121810356

Data Sources: NRCAN

Fig. No.: 6.3.4

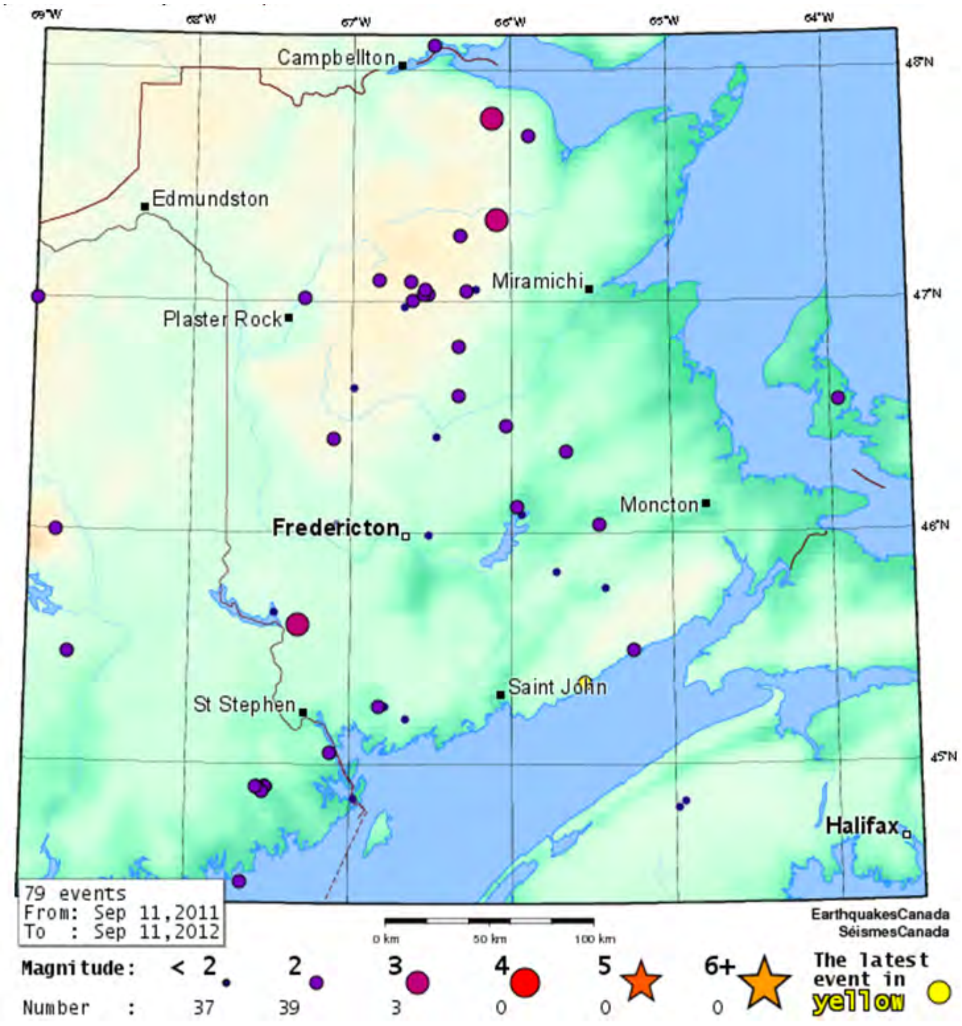
Date: (dd/mm/yyyy) 23/11/2014

Dwn. By: JAB

Appd. By: DLM

Stantec Consulting Ltd. © 2012

Map: NAD83 CSRS NB Double Stereographic



Source: Earthquakes Canada (2012).

Figure 6.3.5 Earthquakes within New Brunswick, September 2011-September 2012

6.3.2 Atmospheric Environment

The Atmospheric Environment comprises the layer of air surrounding the Earth's crust, up to approximately 10 km above the Earth's surface, and is generally characterized in terms of Climate and Air Quality.

6.3.2.1 Climate

The climate of New Brunswick can be generally characterized as continental in the central and northern regions of the province, with more of a moderated climate in the southern and eastern regions of the province due to influence from the Atlantic Ocean.

The climate normals from 1971-2001 for the Fredericton Airport weather station are provided in Table 6.3.1 (Environment Canada 2012b). The Fredericton Airport weather data are considered to be an accurate representation of average weather conditions in central New Brunswick. Daily mean temperatures recorded at the Fredericton Airport range from -9.8°C to 19.3°C, although daily extreme ranges from -35.6°C to 37.2°C have been recorded by the station. The average annual precipitation is 1,143.3 mm, of which 77.5% is in the form of rain. Extremes in daily precipitation occur in August and September and are in the range of 124.0 mm to 148.6 mm.

A meteorological station has been operated at the Sisson Project site since 2007 (Photo 6.3.2), to the south of the ore deposit. This station collects data for wind speed, wind direction, relative humidity, temperature, solar radiation, barometric pressure, snow depth, and precipitation. The mean annual temperature is estimated to be 3.3°C, with minimum and maximum mean monthly temperatures of -16.6°C and 20.0°C occurring in January and July, respectively. The mean annual precipitation is estimated to be 1,350 mm based on a comparison of site data with regional data from the Juniper station. On average, it is estimated that 75% of precipitation falls as rain, and 25% falls as snow. Precipitation is very evenly distributed throughout the year, with July being the wettest month averaging 127 mm, and February being the driest month averaging 83 mm (Knight Piésold 2012d).

Photo 6.3.2 Sisson meteorological station.

Table 6.3.1 Climate Normals – Fredericton Airport (1971-2001)

Station Location - Lat.: 45º52’N, Long.: 66º32’W, Elev.: 20.7 m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Temperature													
Daily Mean (°C)	-9.8	-8.2	-2.4	4.3	11.1	16.2	19.3	18.4	13.1	7	1.1	-6.3	5.3
Daily Maximum (°C)	-4	-2.3	3	9.7	17.5	22.8	25.6	24.7	19.5	12.8	5.6	-1.1	11.2
Daily Minimum (°C)	-15.5	-14.1	-7.8	-1.1	4.7	9.6	13	12.1	6.7	1.2	-3.5	-11.4	-0.5
Extreme Daily Maximum (°C)	14.1	18.6	22.2	30.3	35.2	35.3	36.7	**37.2**	33.9	27.8	21.1	15.9	--
Date (yyyy/dd)	1983/11	1994/20	1962/30	1990/27	1977/23	2001/27	1952/15	**1975/02**	2001/09	1968/16	1956/01	2000/17	--
Extreme Daily Minimum (°C)	-35.6	-37.2	-28.9	-15.1	-6.7	-0.6	1.7	1.3	-3.9	-8.9	-20.2	-33.8	--
Date (yyyy/dd)	1971/19	1962/02	1982/01	1995/05	1951/18	1971/06	1962/03	1978/28	1971/27	1959/22	1996/30	1989/30	--
Precipitation													
Rainfall (mm)	46.2	32.2	48.1	64.1	94.2	88.6	87.1	89.8	94.5	96	85.5	59.4	885.5
Snowfall (cm)	70.2	50.6	54.4	22.5	1.5	0	0	0	0	1.5	18.5	57.3	276.5
Precipitation (mm)	109.6	79.2	102.7	87.4	95.9	88.6	87.1	89.8	94.5	97.7	103.2	107.8	1143.3
Extreme Daily Precipitation (mm)	70.7	51.8	58.8	58.7	83.8	69.9	69.1	**148.6**	124	60.2	81	81.3	--
Date (yyyy/dd)	2000/04	1970/04	1984/14	1954/17	1961/27	1954/27	1970/11	**1989/05**	1999/22	1976/09	1960/01	1967/04	--
Other													
Daytime Relative Humidity (%)	62.2	56.6	56.3	53.4	52	54.1	55.5	55.9	58	58.6	64.7	66.8	57.8
Mean Wind Speed (km/h)	12.7	13	14.6	14.3	13.6	12	10.8	10	10.9	11.8	12.4	12.6	12.4
Most Frequent Wind Direction	W	W	W	W	S	S	S	S	S	S	W	W	S
Extreme Wind Gust Speed (km/h)	119	121	105	100	97	**132**	105	93	105	117	116	103	--
Date (yyyy/dd)	1962/27	1976/02	1959/23	1977/03	1961/28	**1971/30**	1974/03	1991/02	1960/13	1963/29	1963/30	1968/05	--

Notes:
Bold denotes an all-time record.

Source: Environment Canada (2012b).

6.3.2.2 Air Quality

The New Brunswick Department of Environment and Local Government (NBDELG), operates a network of ambient air quality monitoring stations in various regions of the province. The results are documented annually in the publication by the NBENV entitled “New Brunswick Air Quality Monitoring Results”, the most recent of which is available for the 2010 calendar year (NBDELG 2012b).

Ambient air quality in New Brunswick can generally be characterized as good most of the time, with few exceedances of the provincial ambient air quality objectives or Canada-wide Standards. In 2010, compliance with the ambient air quality objectives was greater than 98% for all contaminants measured (NBDELG 2012). NBDELG has observed gradual improvement in air quality in the province in recent years when compared to historical levels, with 2010 having the highest levels of compliance with the provincial objectives on record.

There are no substantive industrial sources (which tend to release air contaminants) of air contaminants located near to the Project. Thus, sources of air contaminants in the immediate vicinity of the Project are generally associated with vehicle and home heating emissions. The nearest industrial facilities to the Project are the Napadogan veneer plant previously mentioned, the former Juniper Sawmill (now decommissioned), and the J.D. Irving sawmills located in Deersdale (approximately 12 km north of the Project) and Doaktown (approximately 75 km east of the Project)—both of which have ceased operations. The AV Nackawic pulp mill is also approximately 44 km southwest of the Project (Environment Canada 2010).

Given than the rate of compliance with the ambient air quality standards in the province overall and the lack of nearby industrial emissions sources, the air quality in the vicinity of the Project is very good, as evidenced by ambient air quality monitoring data collected for the Project and as expected given the rural character of the area (Section 8.2).

6.3.2.3 Sound Quality

Given the largely rural area of the Project, existing sound pressure levels are expected to be typical of sound pressure levels in a rural area. Sources of existing sound in the area are expected to be primarily related to vehicle traffic on provincial Highway 107, wildlife and wind noise and as well as local anthropogenic sounds, *e.g.,* all-terrain vehicles, snowmobiles, and heavy equipment and power tools related to the forestry activity in the area.

Sound pressure levels measured over 24-hour periods in the vicinity of the Project in fall 2011 ranged from 30.6 dB_A to 54.7 dB_A, expressed as a 24-hour equivalent sound pressure levels (L_{eq}). The daytime sound pressure levels in the Project were between 59.1-62.4 dB_A expressed as a 1-hour L_{eq}, with the highest level recorded approximately 2 km northeast of the Project location. Nighttime sound pressure levels range from 47.0 dB_A to 59.0 dB_A expressed as a 1-hour L_{eq}, with the highest level measured at the intersection of Route 107 and the Four Mile Brook Road (Stantec 2012c).

6.3.3 Water Resources

The water resources of the Nashwaak River watershed are described in this section. This includes a description of water availability and quality for both groundwater and surface water resources.

6.3.3.1 Local Watersheds

The Sisson Project is located within the Nashwaak River watershed, which has a drainage area of approximately 1,700 km^2 (Figure 6.3.6). The Nashwaak River flows approximately 110 km from Upper Nashwaak Lake, southward and eastward through the village of Stanley, then southward to its confluence with the St. John River at Fredericton (NBDELG 2007).

Two hydrometric stations operated by the Water Survey of Canada actively monitor the streamflow conditions within the Nashwaak River watershed: the Narrows Mountain Brook gauge, and the Nashwaak River gauge at Durham Bridge (Environment Canada 2012b). The Narrows Mountain Brook gauge has operated since 1971, receives surface water from a drainage area of 3.9 km^2, and records a mean annual flow of 0.09 m^3/s (period of record 1972-2011). The Nashwaak River gauge has operated since 1961, receives surface water from a drainage area of 1,450 km^2, and records a mean annual flow of 36.6 m^3/s (period of record 1961-2011).

Four main sub-watersheds are in or near the Project location: Bird Brook, Sisson Brook, McBean Brook and West Branch Napadogan Brook. Bird, Sisson, and West Branch Napadogan brooks all contribute to Napadogan Brook and then to the Nashwaak River, whereas McBean Brook lies southwest of the Project and flows generally southwest directly to the Nashwaak River (Figure 6.3.7). West Branch Napadogan Brook, East Branch Napadogan Brook, the Lower Napadogan Brook, and the Nashwaak River are considered to be navigable; most other named and other unnamed watercourses in these sub-watersheds would likely be considered minor waters, or not navigable at all. Mean annual flows in Napadogan and McBean Brook watersheds (Figure 6.3.7) have been estimated to be 3.19 and 1.16 m^3/s, respectively (Knight Piésold 2012d).

6.3.3.2 Surface Water Quality

The surface water quality in the Nashwaak watershed has been characterized between 1996 and 2007 using the Water Quality Index at 17 locations in the watershed, including one location on Napadogan Brook (NBDELG 2007). The water quality in the watershed was characterized as “good” at eight of these locations (including Napadogan Brook), and “excellent” at the other nine locations.

Samples of surface water collected for the Project show that the water is generally very soft, containing low concentrations of dissolved minerals, and often having low pH. Surface water was typically clear, with generally non-detectable total suspended solids concentrations (<5 mg/L), and low turbidity (usually around 1 NTU). Nutrient concentrations in surface water were also generally very low (Knight Piésold 2012e).

6.3.3.3 Groundwater

The groundwater resources within the Nashwaak River watershed are limited almost exclusively to fractured bedrock. Groundwater yields near the Project were estimated from regional groundwater maps (NBDOE 1980) to be generally low (less the 0.4 L/s), coinciding with volcanic geology where the ore body is located. Higher groundwater yields are expected in the granite-type bedrock to the west of the Project, and in the sandstones farther to the east, near Stanley.

The New Brunswick Department of Environment has collected groundwater quality data from domestic wells since 1994, and prepared maps of the concentrations of different parameters in groundwater (NBENV 2008). A review of the maps show that very few wells have been installed near the Project, the closest well on record being located about 11 km northwest of the Project, near Nashwaak Lake. The next closest domestic wells on record are located more than 18 km from the Project. Concentrations above the Guidelines for Canadian Drinking Water Quality (GCDWQ; Health Canada 2012a) for antimony, arsenic, iron, manganese, and nitrate were observed in domestic wells in the same hydrogeologic map unit as the Project. Water quality samples collected from monitoring wells installed for the Project also exceed the GCDWQ for arsenic, iron, and manganese (Knight Piésold 2012e).

6.3.4 Aquatic Environment

The Aquatic Environment comprises the rivers, streams, and lakes within Central New Brunswick and the aquatic species that live within them. It also includes the physical and chemical properties of water and sediment in these watercourses and waterbodies, upon which the aquatic life depends.

6.3.4.1 Water Quality

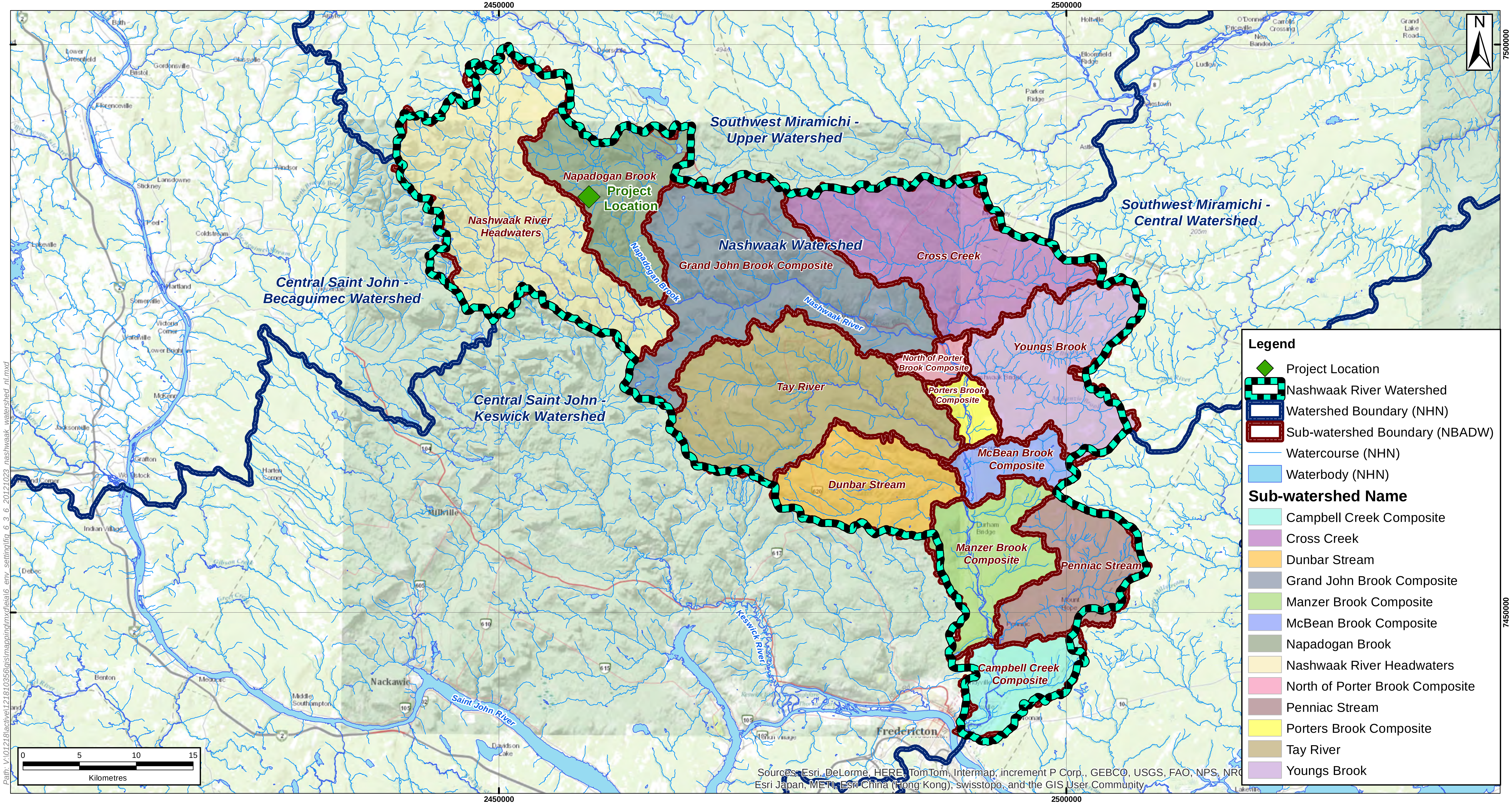
Overall, water quality within the Nashwaak River watershed, as recorded by NBDELG (2007), is considered to be high, as would be expected for this relatively rural and undeveloped area in central New Brunswick. Key indicators of water quality including dissolved oxygen, *E. coli*, nitrate, and pH seldom exceed the CCME Freshwater Aquatic Life Guidelines, indicating that surface waters are, in general, suitable for supporting a variety of fish populations (NBDELG 2007). These observations are consistent with data collected by Northcliff/SML and Stantec in various watercourses surrounding the Project location, as summarized in Section 8.5.2.

6.3.4.2 Sediment Quality

Stantec collected composite fine-grained sediment samples from depositional areas for laboratory analysis during the aquatic baseline surveys. In general, sediment samples collected had moderate organic content, with lower total inorganic carbon. The predominant extractable metals present in sediment samples collected from the Project area included aluminum, calcium, magnesium, iron, and manganese (Stantec 2012d).

6.3.4.3 Fish and Fish Habitat

Fish habitat surveys conducted in the watercourses in the vicinity of the Project (Bird Brook, Sisson Brook, McBean Brook, and the east and west branches of Napadogan Brook) collected data on water flow, depth, overhead cover, temperatures, substrate composition, and other key parameters in accordance with standard NBDNR and DFO methods (Hooper *et al.* 1995). Watercourses contain species of fish that would be expected of a central New Brunswick watershed, including brook trout (*Salvelinus fontinalis*), American eel (*Anguilla rostrata*), Atlantic salmon (*Salmo salar*) (limited to the West and East Branches of Napadogan Brook and at the mouth of Bird Brook), sea lamprey (*Petromyzon marinus*), slimy sculpin (*Cottus cognatus*), blacknose dace (*Rhinichthys atratulus*), pearl dace (*Margariscus margarita*), creek chub (*Semotilus atromaculatus*), common shiner (*Luxilus cornutus*), white sucker (*Catostomus commersonii*), and longnose sucker (*Catostomus catostomus*).



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NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Nashwaak River Watershed and its Sub-watersheds

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Sisson Mines Ltd.

Scale: 1:325,000

Project No.: 121810356

Data Sources: NBDNR

Fig. No.: 6.3.6

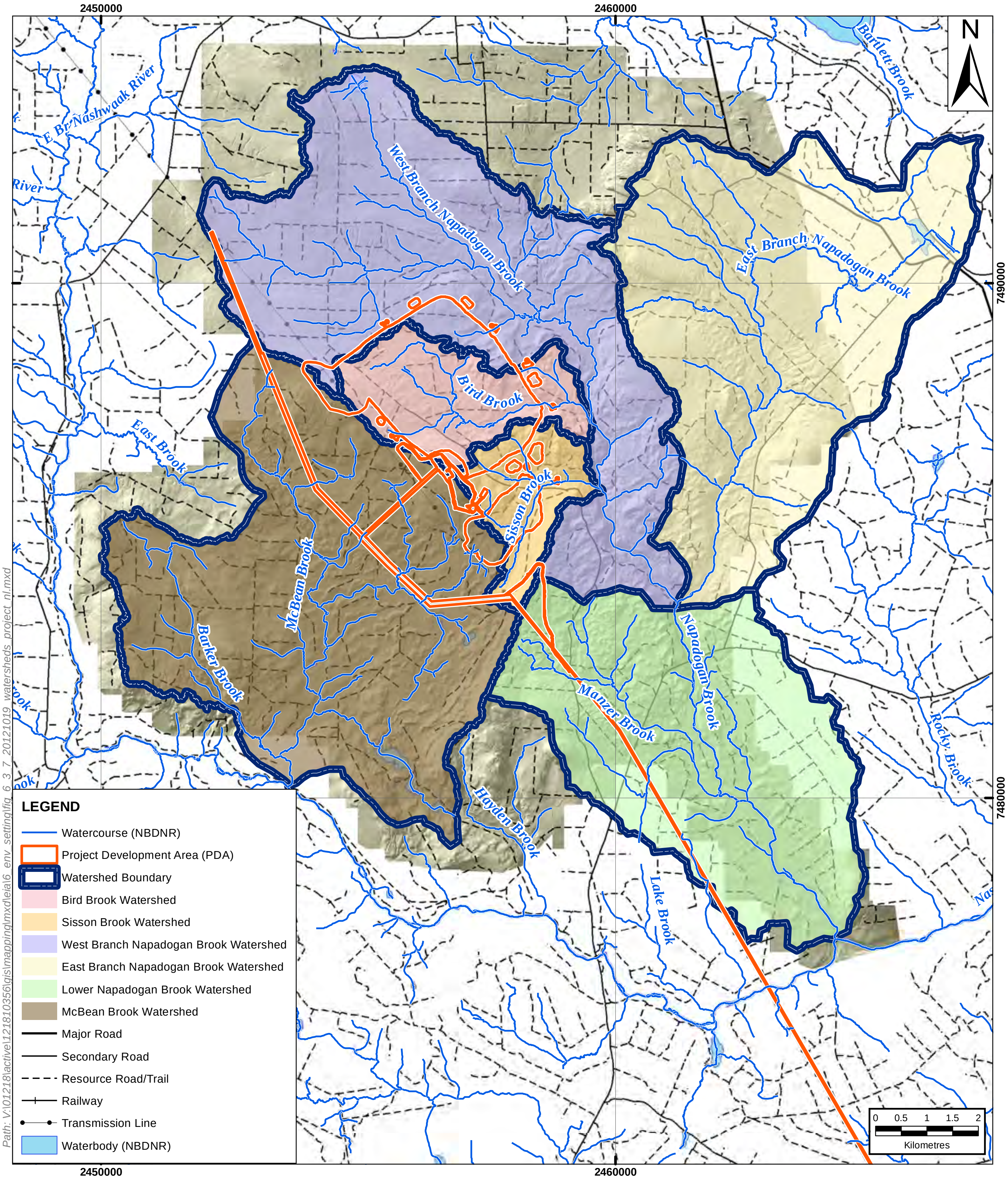
Date (dd/mm/yyyy): 23/11/2014

Fig. By: JAB

Appd. By: DLM

Stantec

Coordinate System: NAD 1983 CSRS New Brunswick Stereographic



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NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Watersheds near the Project

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Sisson Mines Ltd.

Scale: 1:100,000	Project No.: 121810356		Data Sources: NBDNR Leading Edge Geomatics Ltd.	Fig. No.: 6.3.7
Date: (dd/mm/yyyy) 23/11/2014	Dwn. By: JAB	Appd. By: DLM		

Map: NAD83 CSRS NB Double Stereographic

Overall, fish habitat found in surveyed reaches of watercourses in the vicinity of the Project was of good quality, and typical of that expected for a rural and undeveloped area of central New Brunswick. Temperature and substrate conditions were suitable for fish to survive and reproduce (Stantec 2012d). Further details are provided in Section 8.5.2.

6.3.4.4 Fish Resource Use

There is no known active commercial fishery in the Nashwaak River watershed, but there is an extensive recreational sport fishery within the Nashwaak River and some of its tributaries. There is an open season for smallmouth bass from May 1 to October 15. Fishing is permitted for brook trout in most rivers, brooks and streams of New Brunswick, including the Nashwaak River and its tributaries, from April 15 to September 15. Fishing is also permitted for all non-sport fish within the Lower Saint John Recreational Fishing Area (which includes the Nashwaak River and its tributaries) during periods of the year when there is a sport fishery open. There is no open fishing season for Atlantic salmon anywhere in the Nashwaak River watershed (NBDNR 2013).

6.3.5 Terrestrial, Vegetated, and Wetland Environment

6.3.5.1 Ecoregions

The Central Uplands Ecoregion includes two geographically separate but ecologically similar areas: the Madawaska Uplands in northwestern New Brunswick and the Caledonia Uplands in the southeast part of the province near the Bay of Fundy. The Caledonia Uplands area is located approximately 140 km to the southeast of the Madawaska Uplands. The Project is located in the southern portion of the Madawaska Uplands (Figure 6.3.8).

The plateaus of the southern part of the Madawaska Uplands differ from the steeper slopes found in the northern portion of the ecoregion. Generally, watercourses in the northern part of this region flow into the St. John River, whereas those in the southern part of the region primarily flow east and eventually into the Miramichi River. Rivers in the extreme south of the Madawaska Uplands are an exception; these flow into the Nashwaak River, which empties into the St. John River. This ecoregion is at a relatively higher elevation than other ecoregions in New Brunswick, resulting in a somewhat cooler climate that is mediated somewhat by primarily south-facing slopes. The higher elevation and cooler temperatures lead to higher precipitation amounts than are generally found in neighbouring regions (NBDNR 2007).

Within the Madawaska Uplands, the Beadle Ecodistrict, which encompasses the Project location, is characterized by broad valleys, rolling hills, and many lakes. Like the Central Uplands Ecoregion as a whole, the Beadle Ecodistrict has a cool, wet climate, and elevations ranging from 300 m amsl in the south to 600 m amsl in the north (NBDNR 2007).

Approximately 92% of the Beadle Ecodistrict is forested, including forested wetlands (NBDNR 2007). Forests in the ecodistrict transition from coniferous to tolerant hardwood stands. Granite-derived soils with imperfect to poor drainage are typically dominated by black spruce and balsam fir; slopes and hilltops are dominated by sugar maple, yellow birch, and beech. Mixedwood stands are found in transition zones. Calcareous soils are not indicated in the ecodistrict. Correspondingly, species such as eastern white cedar and white spruce are scarce (Colpitts *et al.* 1995; NBDNR 2007).

6.3.5.2 Vegetation and Rare Plants

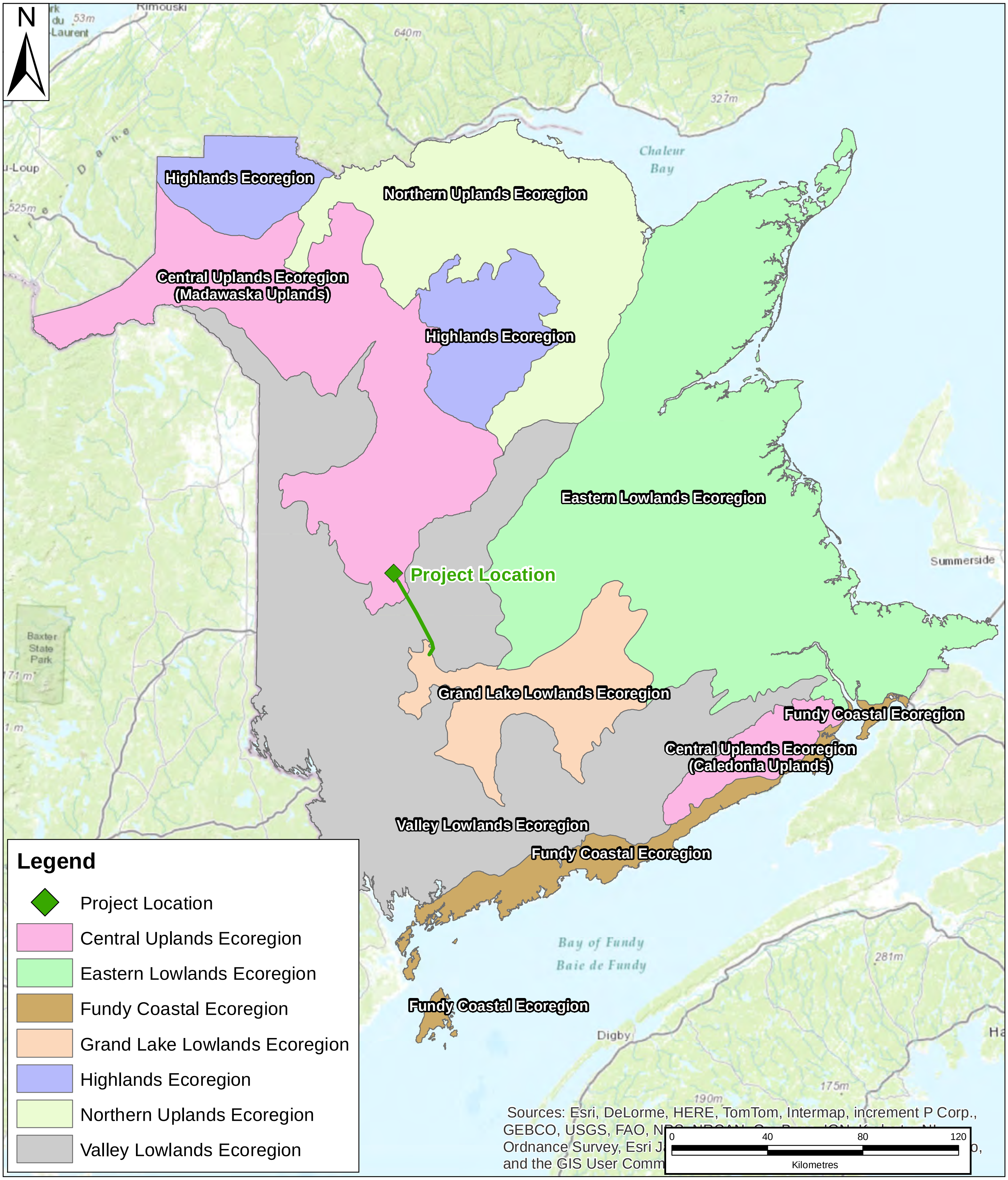
Warmer south-facing slopes in the vicinity of the Project support some southern tree species not seen in nearby colder ecoregions, such as balsam fir (*Abies balsamea*); red, white, and black spruce (*Picea rubens*, *P. glauca*, and *P. mariana*); and tolerant hardwoods such as sugar maple (*Acer saccarum*), yellow birch (*Betula alleghaniensis*), and beech (*Fagus grandifolia*) (NBDNR 2007). Eastern white cedar (*Thuja occidentalis*) is common in calcareous soils, where they occur, in particular in the Little Main Restigouche and Grand River watersheds in the northern part of the Madawaska Uplands. Common understory shrub species include mountain maple (*Acer spicatum*), striped maple (*A. pensylvanicum*), and hobblebush (*Viburnum lantanoides*) (Stantec 2012f). The well-drained soils on higher slope positions support tolerant hardwood stands, although they are lacking in many of the species indicative of rich sites that are found in more northerly areas of the province (Stantec 2012g).

Forests in the Beadle Ecodistrict have been logged since the late 1700s (NBDNR 2007) which has led to a mosaic of young forest stands in the area of the Project. Forestry is still the main economic industry for the region despite the recent closures of sawmills in the communities of Juniper and Deersdale. In addition to the Project, other mineral occurrences and prospects have been found in the ecodistrict, including the small Burnthill tungsten-molybdenum deposit north of Napadogan that was mined for a few years in the mid-1950s (Stewart *et al*. 2011; Lang, J. Personal communication, February 24, 2012).

6.3.5.3 Wetlands

The Central Uplands Ecoregion contains many different wetland types, particularly in southern areas where the landscape is less constrained by steep slopes. Common wetland types include shrub riparian wetlands dominated by alder (*Alnus* spp.), open water wetlands, and peatlands (NBDNR 2007).

The majority of wetlands as mapped by NBDNR near the Project (Figure 6.3.9) are forested, which is typical of the Beadle Ecodistrict and Central Uplands Ecoregion, although there is a conspicuous absence of eutrophic wetlands such as cedar swamps compared to other ecodistricts in the Ecoregion, reflecting the lack of calcareous and predominance of granitic bedrock formations (Stantec 2012g). The forested wetlands are generally poor in nutrients, low in plant diversity, and largely dominated by black spruce and balsam fir with ericaceous shrub understory. There is some minor peat formation in these wetlands, and while the hydrologic input to these maintains wetness with some consistency in lower lying areas, it is not sufficiently wet and/or drainage is not suitable to allow bog formation. The scarcity of bogs in the area of the Project is typical of the Central Uplands Ecoregion. Evidence of beaver activity of varying ages is nearly ubiquitous along watercourses that do not follow ravines. This activity has shaped the hydrology and vegetation communities of the wetlands in the vicinity of the Project.



Sources: Esri, DeLorme, HERE, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, N
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Ecoregions of New Brunswick

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Sisson Mines Ltd.

Scale: 1:2,200,000

Project No.: 121810356

Data Sources: NBDNR
ESRI Online

Fig. No.: 6.3.8

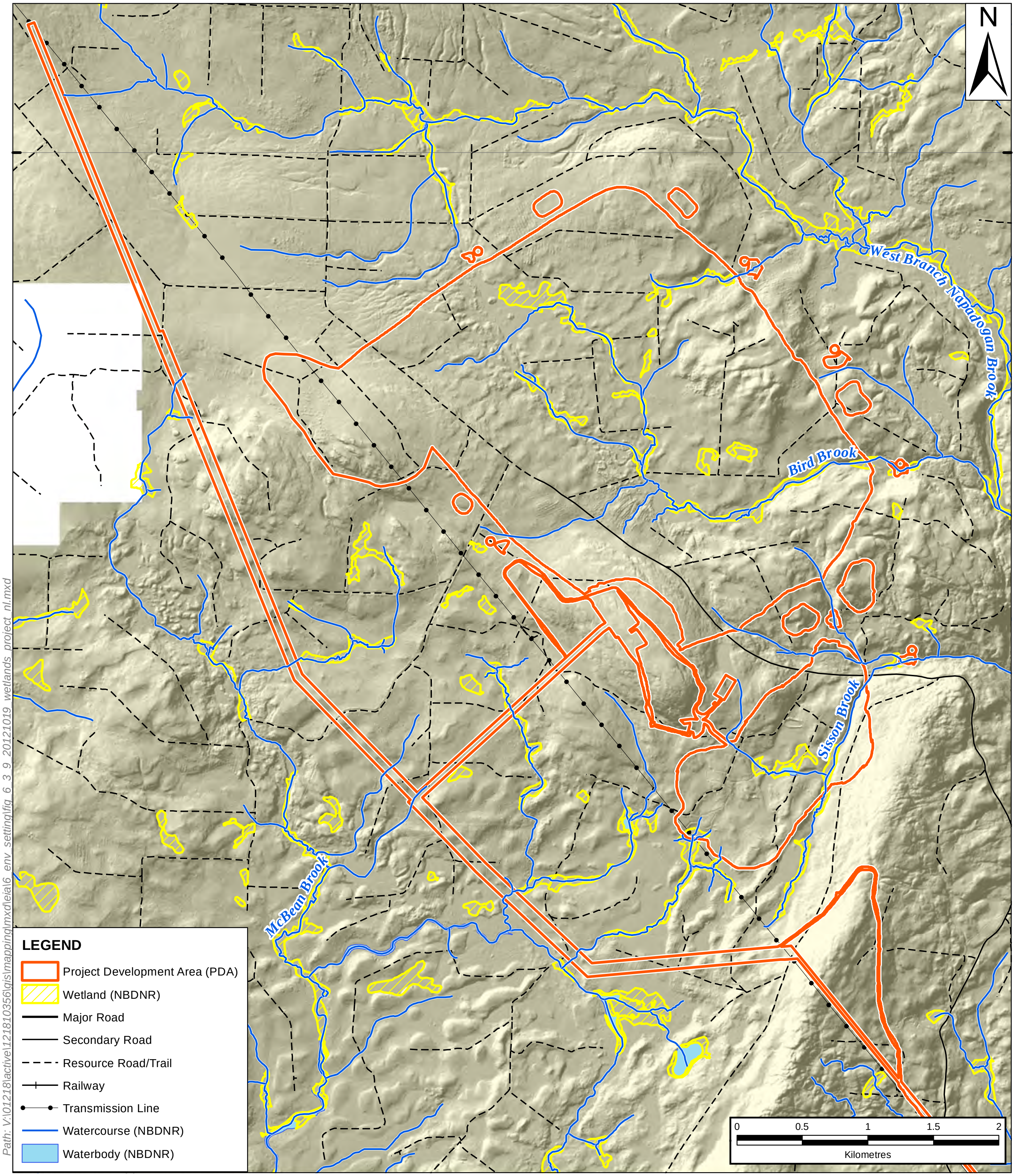
Date: (dd/mm/yyyy) 23/11/2014

Dwn. By: JAB

Appd. By: DLM

Stantec

Map: NAD83 CSRS NB Double Stereographic



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NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Wetlands near the Project

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Sisson Mines Ltd.

Scale: 1:40,000

Project No.: 121810356

Date: (dd/mm/yyyy) 23/11/2014

Dwn. By: JAB

Appd. By: DLM

Data Sources: NBDNR

Fig. No.: 6.3.9

Stantec

Map: NAD83 CSRS NB Double Stereographic

While the poor drainage in lower slope positions support relatively simple black spruce communities, these conditions are also conducive to wetland formation which have elevated potential for species of conservation concern (SOCC) and species at risk (SAR) (Stantec 2012g). Further detail on SAR and SOCC in the vicinity of the Project is provided in Sections 8.6 and 8.7.

6.3.5.4 Wildlife and Wildlife Habitat

A typical assemblage of wildlife is present within the Project area, including moose (*Alces alces*), white-tailed deer (*Odocoileus virginianus*), American black bear (*Ursus americanus*), eastern coyote (*Canis latrans*), American mink (*Mustela vison*), beaver (*Castor canadensis*), striped skunk (*Mephitis mephitis*), porcupine (*Erethizon dorsatum*), raccoon (*Procyon lotor*), and varying hare (*Lepus americanus*). Small mammals such as red squirrel (*Tamiasciurus hudsonicus*), voles, shrews and mice are also common and widespread in the Project area (Stantec 2012f).

A variety of herpetile species are also present including salamanders, frogs, toads, and snakes. One herpetile species, Wood Turtle (*Glyptemys insculpta*) is listed as “Threatened” in the *Species at Risk Act* (*SARA*) and NBDNR General Status Ranks. Wood turtle has been recorded previously by AC CDC north of the Project area within the Miramichi River watershed. Wood turtle are considered a semi-aquatic species, and prefer riparian areas with patchy cover, and clear meandering watercourses with gravely-sandy substrate and banks. No wood turtles were observed in the field surveys conducted in the Project area (Stantec 2012f).

The terrestrial habitat in the vicinity of the Project consists primarily of immature and young forest as a result of decades of historic forestry activity in the area (Figure 6.3.10). The older forests are mostly mature softwood, while the mid-developed forests are dominated by immature-old hardwood and immature-young softwood. Sapling softwood makes up the majority of the young forest stands near in the overall Project area (Stantec 2012f).

The NBDNR has identified 14 deer wintering areas (DWAs) located in proximity of the Project, ranging in size from 38.5 ha (Little Clearwater Brook) to 1,714 ha (Nashwaak), all of which are associated with watercourses or water bodies (Figure 6.3.10). The DWA closest to the Project is the Napadogan Brook DWA, a 446-ha DWA located predominantly along the East Branch Napadogan Brook and partially along the West Branch Napadogan Brook, approximately 0.5 km east of the Fire Road. The existing 345 kV transmission line (Line 3011) between Keswick and northern New Brunswick is currently routed through the Nashwaak DWA to the southeast of the Project location (Figure 6.3.10), and as part of the Project, this 50 m corridor will be widened by an additional 25 m to accommodate the new 138 kV transmission line for the Project. None of the other DWAs will be affected by the Project. NBDNR manages for DWA in forest management plans to ensure there is an adequate supply to support populations regionally.

The NBDNR has identified Old Spruce Fir Habitat (OSFH) blocks near the Project (Figure 6.3.10). Two of these overlap with DWAs (*i.e.,* the Gorby Gulch, Lake Brook and Nashwaak DWAs). The three OSFH blocks range between 743 and 776 ha in area. As with the Nashwaak DWA, the widening of the existing transmission line corridor to construct the new 138 kV transmission line for the Project will affect one of these OSFH blocks (Figure 6.3.10). None of the other OSFH blocks will be affected by the Project.

6.3.5.4.1 Birds

The existing data sources identified a combined total of 114 bird species that could be potentially present in the area near the Project (Stantec 2012f). Field studies for breeding and nesting birds identified 93 bird species in the Project area through point-count surveys conducted in 2011. Fourteen of these species were identified to be either at risk, rare, or uncommon (Table 6.3.2). An abundance of preferred nesting and breeding habitat is available in the vicinity of the Project for these species.

Table 6.3.2 Species At Risk and Species of Conservation Concern with Records Near the Project

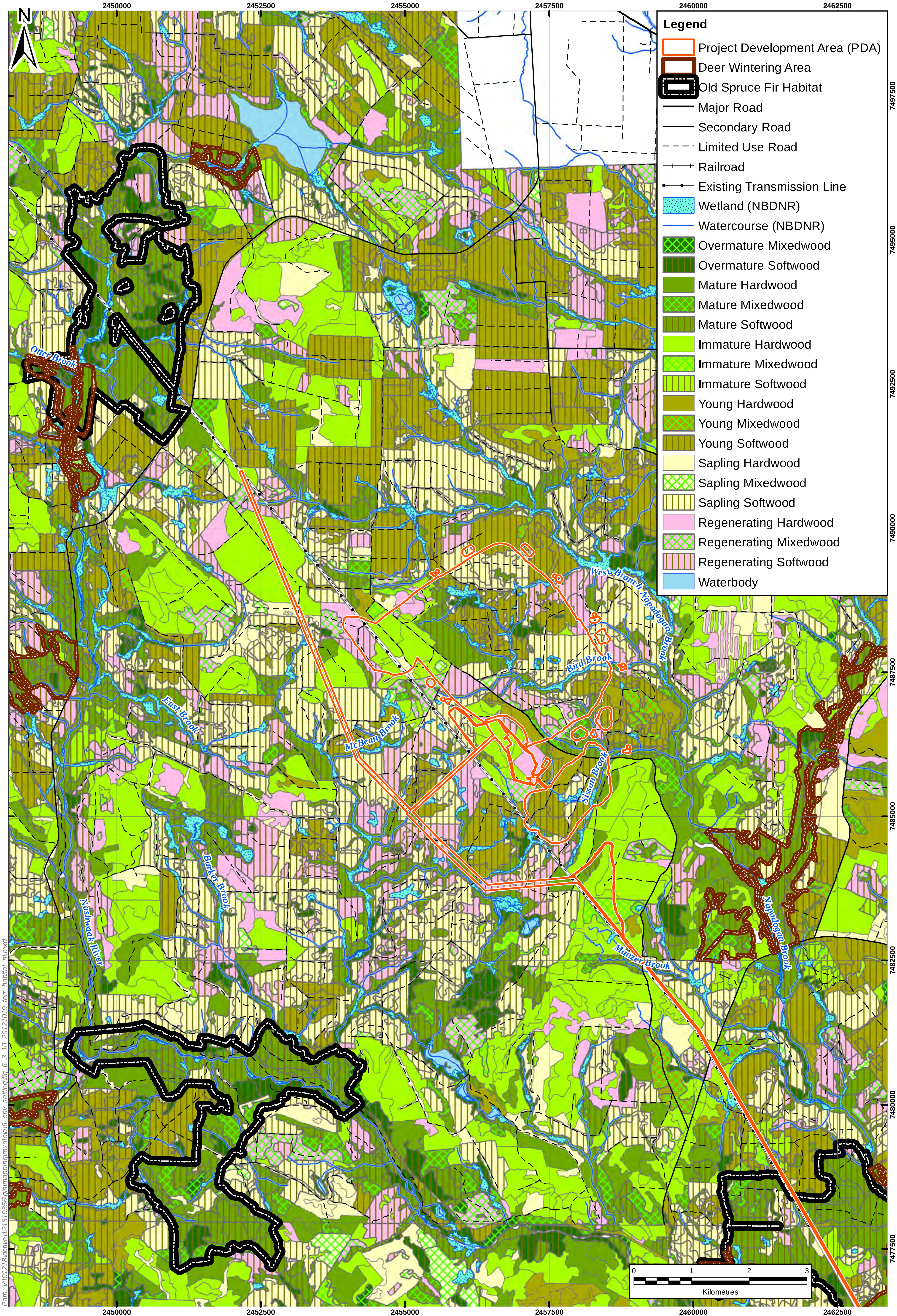
Common Name	Scientific Name	NBDNR Status	NB *SARA* Status	COSEWIC Status	*SARA* Status
Bald Eagle	*Haliaeetus leucocephalus*	At Risk	Endangered	Not At Risk	N/A
Common Nighthawk	*Chordeiles minor*	At Risk	Threatened	Threatened	Schedule 1 (Threatened)
Chimney Swift	*Chaetuar pelagica*	At Risk	Threatened	Threatened	Schedule 1 (Threatened)
Olive-sided Flycatcher	*Contopus cooperi*	At Risk	At Risk	Threatened	Schedule 1 (Threatened)
Eastern Wood-pewee	*Contopus virens*	Secure	Special Concern	Special Concern	N/A
Canada Warbler	*Wilsonia canadensis*	At Risk	Threatened	Threatened	Schedule 1 (Threatened)
Barn Swallow	*Hirundo rustica*	Sensitive	Threatened	Threatened	N/A
Rusty Blackbird	*Euphagus carolinus*	May Be At Risk	Special Concern	Special Concern	Schedule 1 (Special Concern)
Bobolink	*Dolichonyx oryzivorus*	Sensitive	Threatened	Threatened	N/A
Eastern Bluebird	*Sialia sialis*	Sensitive	-	Not At Risk	N/A
Great-crested Flycatcher	*Myiarchus crinitus*	Sensitive	-	-	-
Pine Grosbeak	*Pinicola enucleator*	Sensitive	-	-	-
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	Secure	-	-	-
Vesper Sparrow	*Pooecetes gramineus*	May Be At Risk	-	-	-

Source: Stantec (2012f).

6.3.5.5 Environmentally Sensitive Areas

Included in the AC CDC data is information on environmentally significant areas (ESAs) as originally classified by the Nature Trust of New Brunswick in 1995 (Tims and Craig 1995). Between 1993 and 1995, the Nature Trust of New Brunswick identified over 900 sites of environmental importance across the province based on presence of rare species, rich species diversity, representativeness, and their geology and ecological vulnerability.

While ESAs do not have legal protection, they are used by non-government organizations, consultants and government departments in project planning. One ESA classified as significant for birds is located near the Project: the Miramichi Lake ESA (ESA #472), which includes the lake and surrounding wetlands, approximately 8 km to the northeast of the Project. At the time of its designation in the mid-1990s, this ESA supported one nesting pair of Bald Eagle (*Haliaeetus leucocephalus*), two nesting pair of Osprey (*Pandion haliaetus*), and a small colony (approximately six nests) of Great Blue Heron (*Ardea herodias*).



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Terrestrial Habitats near the Project

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Sisson Mines Ltd.

Scale: 1:60,000

Project No.: 121810356

Data Sources: NBDNR

Fig. No.: 6.3.10

Date: (dd/mm/yyyy) 23/11/2014

Dwn. By: JAB

Appd. By: DLM

Map: NAD83 CSRS NB Double Stereographic

6.4 SOCIOECONOMIC SETTING

This section provides a brief overview of the socioeconomic setting of Central New Brunswick.

6.4.1 Demographic Overview

A demographic overview of New Brunswick as a whole and the regions in the vicinity of the Project (Stantec 2012i) is provided in the sub-sections that follow.

6.4.1.1 Population

The 2011 Census (Statistics Canada 2012e) reported a population of 751,171 in New Brunswick, up 2.9% since the 2006 Census (Table 6.4.1).

Table 6.4.1 Population and Population Change: New Brunswick, York County, and Carleton County, 2006-2011

Location	Population 2011 [a]	Population 2006 [a]	Percent Change
Provincial Total	751,171	729,997	2.9%
York County	97,238	90,026	8.0%
Fredericton	56,224	50,535	11.3%
Stanley	1,322	1,404	-5.8%
Douglas Parish [b]	6081	5,774	5.3%
Millville	307	303	1.3%
Carleton County	27,019	26,632	1.5%
Juniper [c]	981	959	2.3%
Woodstock	5,254	5,113	2.8%
Hartland	947	947	0.00%

Notes:

[a] Numbers are rounded by Statistics Canada and are reported herein exactly as they are reported by Statistics Canada. Totals may not necessarily add up as a result of rounding.

[b] Data discussed includes the communities of Burtts Corner and Napadogan.

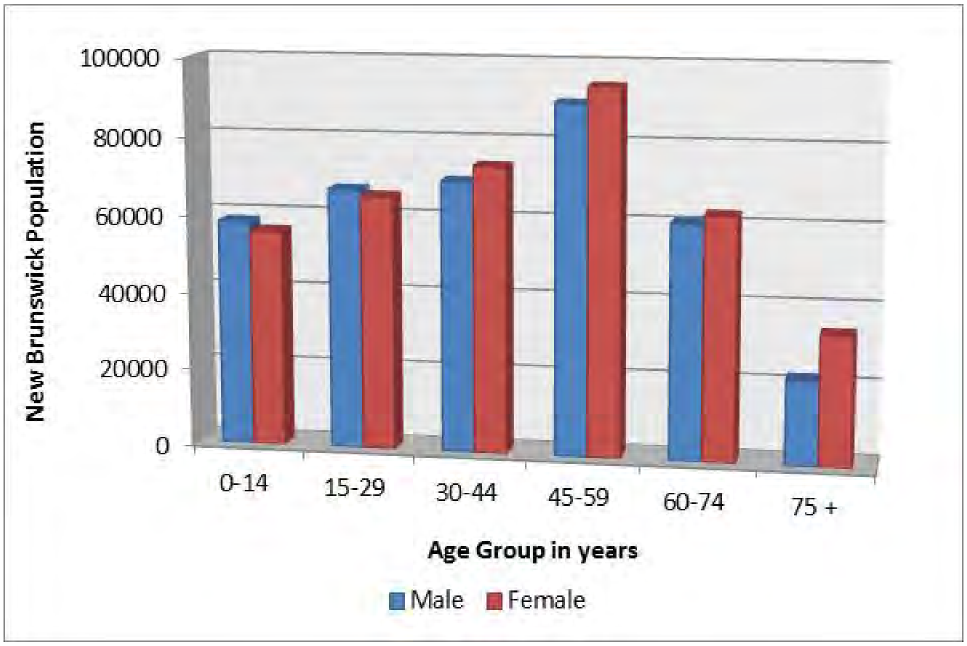
[c] Data supplied by Statistics Canada is described for the Parish of Aberdeen.

Source: Statistics Canada (2012e).

The York County census division includes the City of Fredericton, the Town of Nackawic, the Village of Stanley, and nearby rural areas (Statistics Canada 2012e). The population of York County increased by approximately 8.0% from 2006 to 2011, while the overall population of New Brunswick increased by approximately 2.9% for the same period. The greatest increase (11.3%) was in Fredericton, the capital city of New Brunswick, and the largest decline (5.8%) was in Stanley, the largest village close to the Project. The population of York County accounts for 13% of New Brunswick's total population.

The 2011 population of New Brunswick is displayed graphically by gender and age group in Figure 6.4.1. In 2011, the median age in New Brunswick was 43.7 years, up from 38.6 years in 2001. The percentage of individuals age 20-34 was 17.3% in 2011, down from 19.4% a decade earlier. Individuals in the 50-64 age range accounted for 23.5% of the total population in 2011, up from 17.5% in 2001. These findings suggest that the population of New Brunswick is aging, and young individuals are leaving the area (Stantec 2012i; Statistics Canada 2002).

Carleton County includes the communities of Juniper, Woodstock and Hartland and accounted for 3.6% of New Brunswick's population (Statistics Canada 2012e). The population of Carleton County increased 1.5%, to 27,019, in 2011, this was a reversal in the declining trend of 2% between 2001 and 2006 (Statistics Canada 2007).



Source: Statistics Canada (2007).

Figure 6.4.1 Population by Gender and Age Group, New Brunswick, 2011

6.4.1.1.1 Population Distribution

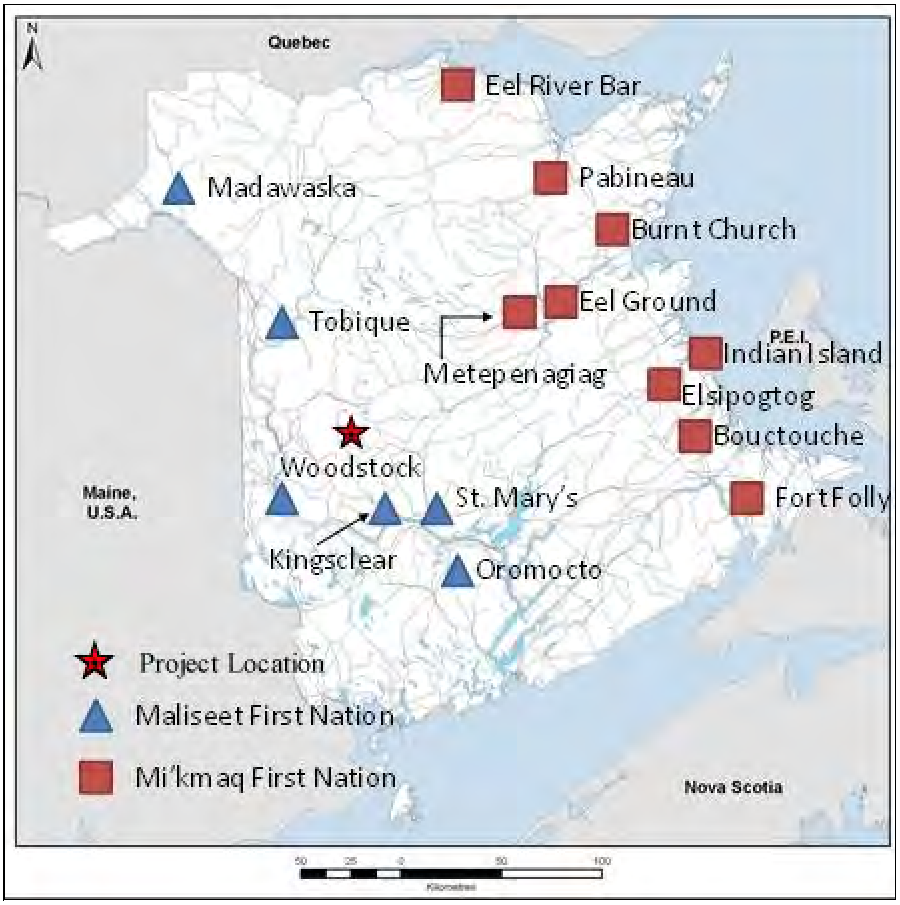
In 2011, approximately 16.5% of New Brunswick's population lived in York and Carleton counties. From 2006 to 2011 the population in those counties rose by 0.6% to 124,257, while the provincial population rose by 2.9% during that same period. The Statistics Canada publication "Population Projections for Canada, Provinces and Territories 2009-2036" predicts that these trends will continue over the next 24 years, showing a small increase in population, with an average of 1.3% between 2011 and 2036, and with the median age increasing steadily (Statistics Canada 2007). These data amplify the continuing decline of small villages and rural areas with the greatest increases in population being recorded in urban centres.

The City of Fredericton is the largest community in York County. Between 2006 and 2011, the population of Fredericton increased by 11.3% (Statistics Canada 2012e). This trend is consistent with national-level changes but is higher than the provincial average (Table 6.4.1) (Statistics Canada 2012e).

The Town of Woodstock is the largest community in Carleton County with a population of 5,254 in 2011, an increase of 2.8% from 2006 (Statistics Canada 2012e).

6.4.1.1.2 Aboriginal Population

The locations of First Nation communities in New Brunswick, including the Maliseet and Mi'kmaq communities, are shown in Figure 6.4.2. The Aboriginal communities located near the Project are Maliseet. There are six Maliseet First Nations in New Brunswick: Madawaska Maliseet First Nation; Tobique First Nation; Woodstock First Nation; St. Mary's First Nation; Kingsclear First Nation; and Oromocto First Nation (Aboriginal Affairs and Northern Development Canada 2012).



Source: Jacques Whitford Stantec (2009).

Figure 6.4.2 First Nations Communities in New Brunswick

As of 2006, the last year for which Census data is currently available in this category, approximately 2.4% of people (17,655 individuals) living in New Brunswick were reported as being of Aboriginal descent (Table 6.4.2) (Statistics Canada 2007). The largest on-reserve Maliseet community is the Tobique First Nation (Table 6.4.3) (Aboriginal Affairs and Northern Development Canada 2012).

Table 6.4.2 Aboriginal and Visible Minority Population: New Brunswick, York County, and Carleton County, 2006

Location	Aboriginal [a]	Visible Minority [a]
Provincial Total	17,655	13,345
York County	2,365	3,815
Carleton County	640	245

Notes:
[a] Numbers are rounded by Statistics Canada.
2011 Census data not yet published for this category.

Source: Statistics Canada (2007).

Table 6.4.3 Population of Selected New Brunswick Aboriginal Communities (Maliseet), 2012

First Nation Community	Population On-Reserve	Population Off-Reserve
Madawaska Maliseet First Nation	145	170
Tobique First Nation	1,449	701
Woodstock First Nation	290	647
St. Mary's First Nation	842	874
Kingsclear First Nation	679	274
Oromocto First Nation	301	335

Source: Aboriginal Affairs and Northern Development Canada (2012).

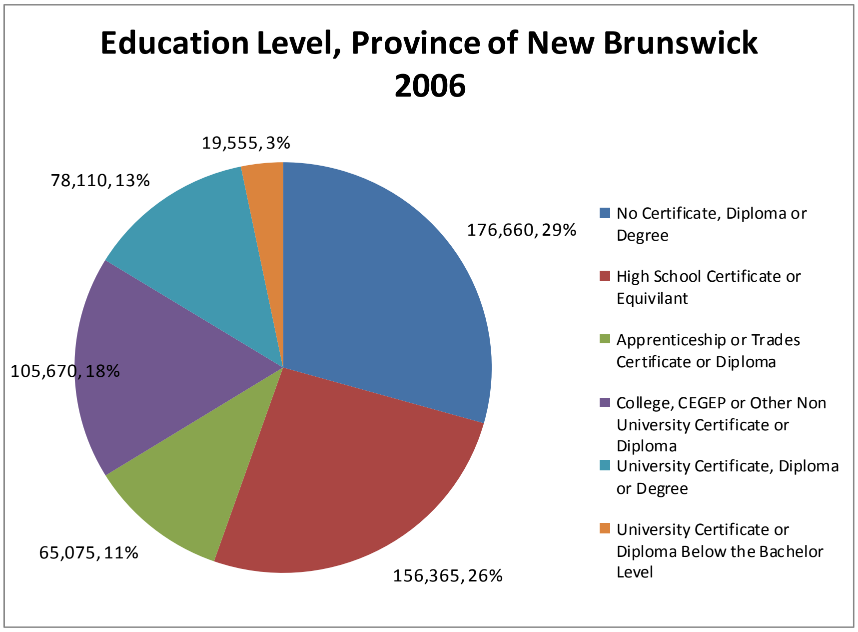
There also exist nine Mi'kmaq Aboriginal communities primarily along the northern and eastern coasts of New Brunswick, but these are located at a considerable distance from the Project.

6.4.1.1.3 Visible Minorities

Census data from 2006 indicate that approximately 1.8% of people living in New Brunswick are visible minorities (defined by Statistics Canada as persons, other than Aboriginal peoples, who are non-Caucasian in race or non-white in colour) (Table 6.4.2).

6.4.1.2 Education

In 2006 (the latest year for which this Census dataset is available at the time of writing), 29% of the province's adult population had not completed high school (Figure 6.4.3), and 13% had a university certificate, diploma or degree (Statistics Canada 2007). Just over half of New Brunswick's working population (those aged 25 to 64 years of age) had completed some form of post-secondary education as of 2006 (GNB 2011a).



Source: Statistics Canada (2007).

Figure 6.4.3 Education Level: New Brunswick, 2006

6.4.1.3 Employment and Income

The median income for all Census families in New Brunswick in 2006 (the latest year for which this Census dataset is available at the time of writing; Table 6.4.4) was $52,878, while the provincial median income for all persons aged 15 years and over was $22,000 (Statistics Canada 2007). In 2006, the median income for all Census families and for persons aged 15 years and older was higher in York County than in Carleton County. Within the counties, both types of income were lowest in Stanley Parish and the Village of Millville, and highest in Fredericton and Douglas Parish. Males had higher median income than females (Table 6.4.4) (Statistics Canada 2007).

Table 6.4.4 Incomes in New Brunswick, York County, and Carleton County, 2006

Location	Median Income - All Census Families	Median Income - Persons 15 Years and Over	Male	Female
Provincial Total	$52,878	$22,000	$28,019	$17,586
York County	$59,447	$24,536	$30,272	$20,294
Fredericton	$60,705	$24,718	$30,094	$21,604
Stanley Parish[a]	$36,958	$17,522	$21,553	$14,410
Douglas Parish[b]	$60,328	$26,738	$30,144	$21,127
Millville	$37,477	$17,000	$20,084	$12,932
Carleton County	$50,528	$21,442	$27,581	$17,189
Aberdeen Parish [c]	$$52,630	$22,302	$29,510	$17,188
Woodstock	$53,290	$21,320	$28,400	$17,403
Hartland	$52,394	$23,912	$31,375	$20,079

Notes:

[a] Data discussed include the Village of Stanley.

[b] Data discussed include the communities of Burtts Corner and Napadogan.

[c] Data discussed include the community of Juniper.

Source: Statistics Canada (2007).

6.4.2 Economic Activity

The New Brunswick economy has traditionally been largely based on natural resource development, centred on its energy, natural resources, and manufacturing industries. Tourism and communication technology industries also contribute substantially to the provincial economy. Although forests occupy 85% of the province's land (equivalent to 6.1 million hectares) and have been an economic mainstay throughout its contemporary history, the forestry sector has become less of an economic driver in recent years due to a decreasing contribution to employment from this sector and global economic forces. This decline has occurred over the past decade with the closure of several lumber and pulp and paper mills throughout the province, including, most recently, the closures of the Juniper Lumbermill and the Deersdale Sawmill, both located near the Project.

The province's major employment sectors include:

- mining, energy, and oil and gas;
- commercial fisheries and aquaculture;
- forestry;
- agriculture;
- tourism; and
- military.

New Brunswick has seen a steady increase in its Gross Domestic Product (GDP) over the decade spanning 2001 to 2010. The increase in GDP from 2006 to 2010 was approximately 14%. Strong exports and manufacturing led the province out of recession in 2010. Higher energy prices, production from the Canaport LNG terminal, and a resurgence in potash exports contributed to the improvement. Real economic activity was estimated to have increased 2% in 2010 due to stronger than anticipated growth in exports. Although the province led the country in export and manufacturing sales growth, it lagged in other areas. New Brunswick was one of only two provinces to show job losses in 2010, while growth in average weekly earnings and retail sales failed to keep pace with the rest of the country (NBDF 2011). Based on third quarter information, real GDP growth in New Brunswick in 2011 was 1.2%. Retail sales showed healthy growth, up 4.8% over 2010, compared to the national increase of 3.5%. New Brunswick's job market was weak in 2011, with employment falling by 4,000 as gains in part-time employment were not enough to offset full-time losses (NBDF 2012).

6.4.3 Labour

In 2006 (the latest year for which this Census dataset is available at the time of writing), the labour force of the province was 382,970 (Table 6.4.5). The participation rate (*i.e.*, the percentage of the working-age population employed or actively looking for employment) in the province was 63.7% in 2006, a nominal increase from 63.1% in 2001 (Statistics Canada 2002; 2007). While urban areas like Fredericton are thriving, unemployment in rural areas is high, particularly Stanley Parish at 24.8% (Table 6.4.5).

Table 6.4.5 Labour Force Characteristics: New Brunswick, York County, and Carleton County, 2006

Location	Total Population 15 years and Over	Labour Force	Employed	Participation Rate (%)	Employment Rate (%)	Unemployment Rate (%)
Provincial Total	601,420	382,970	344,770	63.7	57.3	10
York County	75,040	50,830	47,145	67.7	62.8	7.3
Fredericton	42,560	28,840	26,940	67.8	63.3	6.6
Stanley Parish[a]	1,510	825	615	54.6	40.7	24.8
Douglas Parish[b]	4,730	3,320	3,060	70.2	64.7	7.7
Millville	245	160	145	65.3	59.2	9.4
Carleton County	21,390	14,105	13,140	65.9	61.4	6.8
Aberdeen Parish[c]	790	520	445	65.8	56.3	15.4
Woodstock	4,140	2,565	2,380	62	57.5	7
Hartland	715	505	460	70.6	64.3	7.9

Notes:

[a] Data discussed include the Village of Stanley.

[b] Data discussed include the communities of Burtts Corner and Napadogan.

[c] Data supplied by Statistics Canada include the community of Juniper.

Source: Statistics Canada (2007).

Of the 20 industry sectors identified by the New Brunswick Department of Finance, the most significant job growth in the province over the 2001 to 2006 period came from construction (which increased by 3,500 jobs) and administrative and support services (+3,500), followed by retail trade (+2,900) and health care and social assistance (+2,800). During the same period, employment declines occurred in manufacturing (-3,200); agriculture, forestry, fishing and hunting (-700); and utilities (-300) (Government of New Brunswick 2006).

From 2001 to 2006, the unemployment rate in the Atlantic Provinces dropped from 12.5% to 10%. The 10% unemployment rate was still higher than the national average of 6.6%. As of October 2011, New Brunswick's Central Economic Region had an unemployment rate of 7.9%, while the unemployment rate in the Northwest Economic Region was 7.5%. Labour force statistics for the economic regions are reported as three-month moving averages.

6.4.4 Land and Resource Use

6.4.4.1 Local Planning

Land use and development in the province of New Brunswick is governed by the *Community Planning Act* (for private land) and the *Crown Lands and Forests Act* (for Crown land). Incorporated areas are subject to the *Municipalities Act*.

The Project is not located within the boundaries of an incorporated municipality, or within a Local Service District (LSD). Nearby communities in the vicinity of the Project include Juniper, Glassville, Florenceville-Bristol, Woodstock, Millville, and Stanley.

The local area consists mainly of provincial Crown land that has a variety of uses determined by the provincial government. With the exception of portions of the proposed transmission line to be built to service the Project, the Project is located entirely on Crown land. The majority of land in and around the Project has been routinely used for forestry activities for more than a century. Timber is presently being harvested in the vicinity of the Project, and logging vehicles frequently travel to, from, and through the local area.

6.4.4.2 Industrial, Commercial, and Institutional Land Use

Commercial land and resource use in the vicinity of the Project consists primarily of forestry-related activities such as timber harvesting. There are also several outfitting and guiding businesses offering services during the hunting season near the Project. There is a low level of commercial activity that includes cabins available for short- and long-term rental, convenience stores, and several restaurants.

Industrial land use is limited, and includes the Napadogan veneer mill and the Deersdale Sawmill; the latter recently ceased operations.

There is no known institutional land or resource use in the immediate vicinity of the Project.

6.4.4.3 Residential Land Use

There are no permanent residences located in the immediate vicinity of the Project. The closest residences to the Project appear to be located in Napadogan, which is a small community, located along Highway 107, approximately 10 km to the northeast of the Project.

There are approximately 39 recreational campsite leases, including cabins, in the vicinity of the Project. The closest cabin to the Project is located approximately 1.5 km to the east of the proposed location of the open pit. These cabins are not serviced by the New Brunswick electrical grid, though some appear to operate generators. The cabins may be used at any time of the year.

6.4.4.4 Recreation

Evidence of recreational land use is present throughout much of the Project site and surrounding area. Forestry roads and trails are used opportunistically for snowmobiling, ATV use, and hiking. Recreational fishing of brook trout occurs seasonally in various watercourses within and surrounding the Project site.

The Project area is used for hunting a variety of game, including deer, moose, black bear, ruffed grouse and woodcock, as well as for trapping (*e.g.,* hare snaring). The hunters and trappers using these resources are generally residents of the surrounding communities, though some tourists also hunt for bear and moose, sometimes through the services of the local guides and outfitters (Stantec 2012i).

6.4.5 Community Services and Infrastructure

6.4.5.1 Housing and Accommodation

6.4.5.1.1 Private Dwellings

In 2006, there were 295,960 occupied private residential dwellings in New Brunswick. Seventy-five percent of these were owned, and 25% of them were rented. In 2011, there were 314,005 occupied private dwellings in the province (Statistics Canada 2012b). The Multiple Listings Service (MLS) average housing price in New Brunswick increased by 1.8% from $157,240 in 2010 to $160,000 in 2011 (CMHC 2011a).

The number of private dwellings occupied by residents in York County in 2006 was 37,155, of which 73% (26,970) were owned and 27% were rented. The average value of an owned dwelling in York County in 2006 was $153,664, approximately 23% above the provincial average. In 2006, renters in York County paid an average of $699 each month (Statistics Canada 2007d). In 2011, there were 40,375 occupied private dwellings in the County (Statistics Canada 2012e).

Carleton County had 10,374 occupied private dwellings in 2006. The majority of these (81%) were owned, and 18% were rented. The average rent in the area was $545 each month, and the average value of an owned dwelling was $106,406 (Statistics Canada 2007). In 2011, there were 10,895 occupied private dwellings in Carleton County (Statistics Canada 2012e).

6.4.5.1.2 Housing Starts

There were an estimated 3,100 housing starts in New Brunswick in 2011, a decrease of 24.4% from 2010. MLS sales were also down 4.1%, from 6,702 in 2010 to 6,425 in 2011 (CMHC 2011a).

The provincial Rural Planning District Commission (RPDC) provides building inspection, development and planning services to unincorporated areas of New Brunswick within its jurisdiction on behalf of the Minister of Environment and Local Government. In 2011, the RDPC issued 350 building permits in rural areas of York County. In 2010-11, the RPDC approved plans for 224 subdivisions ranging in size from one lot to 34 lots (Stantec 2012i). In 2011, RPDC issued 144 construction permits in Carleton County. In 2010-11, there were plans to develop 85 subdivisions, with the largest having four lots (Stantec 2012i).

6.4.5.1.3 Affordable Housing

The New Brunswick Department of Social Development is the government agency responsible for the province’s social assistance and affordable housing programs. Social housing programs administered by the department include public housing, rent supplement, rural and native housing programs, non-profit and cooperative housing programs, a federal/provincial repair program, an energy efficiency retrofit program, an affordable rental housing program, home completion and home ownership assistance programs, and other housing loan programs (New Brunswick Department of Social Development 2011).

The latest available Statistics Canada Census numbers in this category (2006) indicate that the province of New Brunswick has 29,400 households in core housing need (New Brunswick Housing Corporation n.d.). Core housing need refers to households with problems related to adequacy (*i.e.,* housing requires major repairs), suitability (*i.e.,* housing does not have enough bedrooms for the size and make-up of resident households) and/or affordability (*i.e.,* housing costs more than 30% of total before-tax household income). Based on these statistics, New Brunswick has the second lowest percentage of households in core housing need in the country, after Alberta (CMHC 2009). Affordability is the major housing problem for low-income households in New Brunswick. However, there also exists an adequacy problem as over 40% of households in need reside in inadequate dwellings. New Brunswick’s high level of adequacy need is caused by four factors: the age of

New Brunswick's housing stock, the preponderance of home ownership units owned by low-income households, the absence of province-wide building code enforcement, and the rural nature of New Brunswick (New Brunswick Housing Corporation n.d.).

6.4.5.1.4 Temporary Accommodations

There are approximately 500 hotels, inns, vacation homes, bed-and-breakfasts, and fishing and hunting lodges in New Brunswick, and 36 of these temporary accommodations are located in York and Carleton Counties. Of these, 64% are located in Fredericton where there are 20 hotels, motels and resorts, and six bed-and-breakfasts, inns, and tourist homes. Though not accounted for as accommodations, there are also two campgrounds in the Fredericton area (Stantec 2012i).

There are no motels, hotels, inns, or bed and breakfasts in the Village of Stanley. The two closest accommodation options to Stanley are the River's Edge campground and the Riverbend Bed and Breakfast/Inn in Durham Bridge, approximately 26 km from Stanley.

Neither Napadogan nor Burtts Corner has temporary accommodations. The closest options are the On the Pond Country Retreat in Mactaquac, and the Riverside Resort and Conference Centre in Keswick. Located in Millville are MacFarlane Sporting Camp (a hunting and fishing lodge offering cabin/log style accommodation), as well as Larsen's Log Lodge (a country retreat with five suites). An inn and a motel are also located in Nackawic, and a bed and breakfast is located in Nortondale.

There are several accommodation options in Woodstock, including bed and breakfasts, inns, hotels, motels, cottages, and campgrounds. Accommodations in Hartland include the Ja-Sa-Le Motel, the Covered Bridge Bed and Breakfast, and Brigitte's Bed and Breakfast (Stantec 2012i).

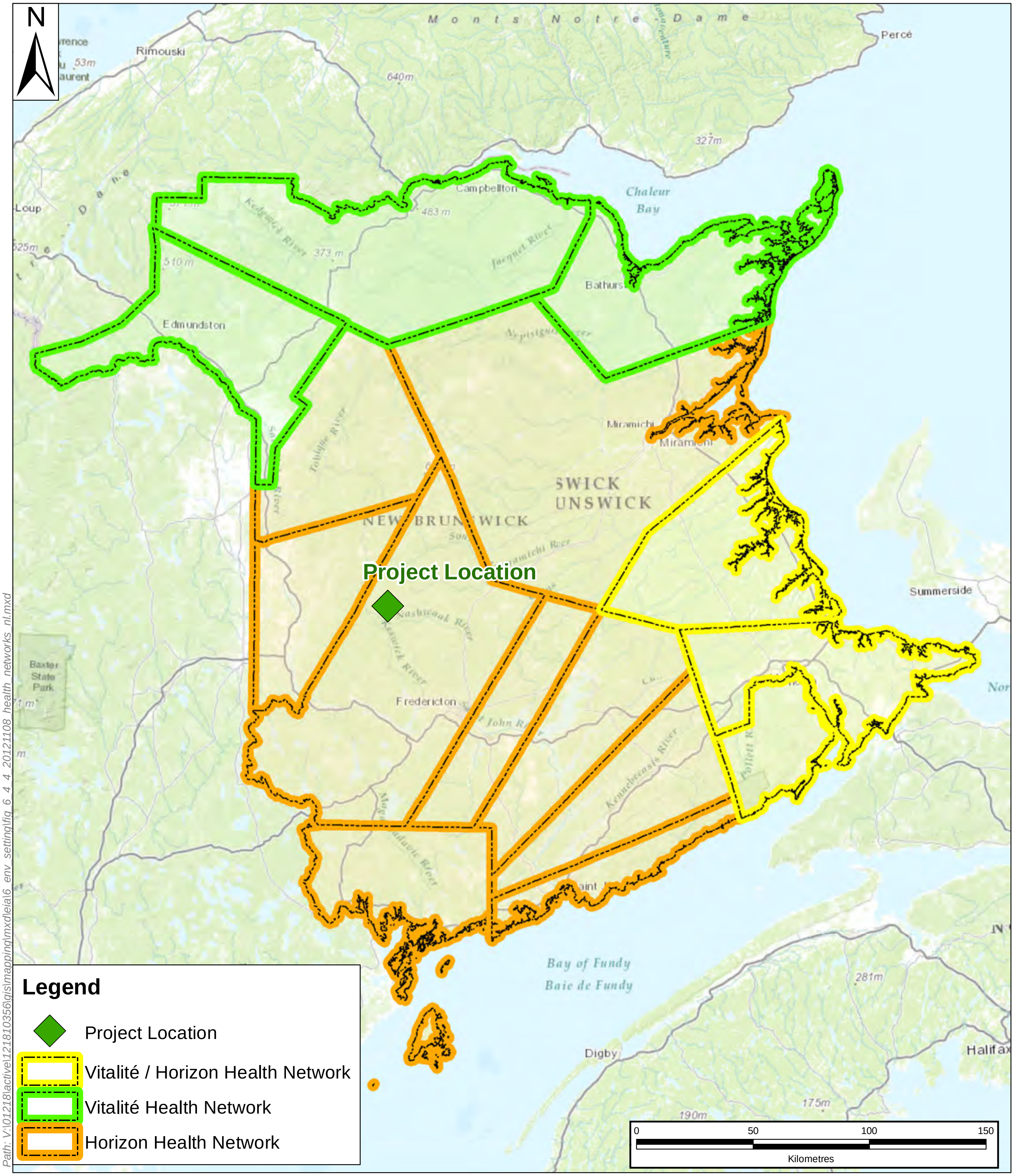
The main listing for accommodations in the Juniper area is for the Governor's Table/Paper Birch Lodge, a facility that offers a number of cabins. It is located on the Miramichi River. Other nearby options include the River Country Campgrounds and Cabins in Wicklow, and the Shamrock Suites in Florenceville-Bristol, a 19th Century home conversion that offers private nightly, weekly and monthly accommodations.

Finally, there are a number of outfitters operating throughout Carleton County that offer accommodations.

6.4.5.2 Public Infrastructure

6.4.5.2.1 Health Administration

In 2008, New Brunswick's eight former Regional Health Authorities (RHAs) merged to form two new RHAs to deliver health services within New Brunswick: Horizon Health Network (Horizon) and Vitalité Health Network (Vitalité). The areas managed by Horizon Health Network and Vitalité Health Network are outlined in Figure 6.4.4.



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NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

New Brunswick Health Networks

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Sisson Mines Ltd.

Scale: 1:2,250,000

Project No.: 121810356

Date: (dd/mm/yyyy) 23/11/2014

Dwn. By: JAB

Appd. By: DLM

Data Sources: SNB
Esri, DeLorme, NAVTEQ, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community

Fig. No.: 6.4.4

Stantec

Map: NAD83 CSRS NB Double Stereographic

Horizon, which operates all of the healthcare centres in York and Carleton Counties, includes 12 hospitals, with more than 1,600 beds, and over 100 facilities, clinics and offices. It provides medical services ranging from acute care to community-based health services (Horizon Health Network 2011a).

The Vitalité Health Network provides health care and services to nearly 250,000 people in northern and southeastern New Brunswick. It has 11 hospitals, a psychiatric hospital centre, six community facilities, four addiction treatment centres, and 11 main offices for the Extra-Mural Program, which specializes in home visits (Vitalité Health Network 2011).

The Government of New Brunswick's Hospital Services Branch within the Department of Health is responsible for ensuring the availability of hospital services through planning, funding, and monitoring the ongoing operational needs of the two Regional Health Authorities with their healthcare facilities.

In the Fredericton area, Horizon operates a network of health facilities and services that include a regional hospital (the Dr. Everett Chalmers Hospital), a community hospital, and 11 community health centres and clinics. There is a veterans' health unit and the Stan Cassidy Rehabilitation Centre, which are tertiary centres of rehabilitation services for the Province of New Brunswick. Over 3,500 employees and over 220 physicians work in the Fredericton area, assisted by more than 500 volunteers (Horizon Health Network 2011b).

In other parts of York County, there are community healthcare centres and clinics in the Village of Stanley as well as in Nackawic. These and other community health centres provide primary care, chronic disease management, health promotion, disease prevention, and community development (Horizon Health Network 2011b).

In Carleton County, the Upper River Valley Hospital located in Waterville, north of the Town of Woodstock, is the newest hospital in New Brunswick with 45 beds. It receives approximately 30,200 emergency patients annually, providing services to Woodstock and surrounding communities including 24/7 emergency, ambulatory care, breast screening, cardiac testing, laboratory, maternal and child services, ophthalmology, outpatient oncology and palliative care (Horizon Health Network 2011c). The acute care occupancy rate at the Upper River Valley Hospital was 118% in 2010-11 and 108% the previous year (Horizon Health Network 2011b).

6.4.5.2.2 Community Programs

New Brunswick provides comprehensive addiction and mental health services, including a range of acute, inpatient, outpatient, and community services. Programs are organized in the areas of assessment and crisis intervention, children and youth, adult, geriatrics, and community care.

In the Fredericton area, there are approximately 55 inpatient acute care beds at the Dr. Everett Chalmers Regional Hospital to provide psychiatric and addictions services. The hospital also offers emergency mental health services. Other addiction and mental health services in the area include children and youth treatment programs, gambling and methadone treatment programs, and individual and family and group counseling.

There are three Addiction and Mental Health Services centres in the Fredericton area, and one Mobile Mental Health Crisis Intervention Team. There are two Addiction and Mental Health Service centres in Woodstock, and one Mobile Mental Health Crisis Intervention Team (Horizon Health Network 2011b).

6.4.5.2.3 Public Health

Public Health Services of the New Brunswick Department of Health prevent, manage and control communicable diseases, promote healthy lifestyles and healthy families, and provide environmental protection. The services offered by Public Health include anonymous HIV/AIDS testing; communicable disease prevention, management, and control; early childhood initiatives; a healthy learners program; health emergency planning; immunization; and a sexual health program (Horizon Health Network 2011b).

There are four public health units in the Fredericton Area and one in Woodstock (Horizon Health Network 2011b).

6.4.5.2.4 Extra-Mural Program

The Government of New Brunswick's Extra-Mural Program provides a comprehensive range of coordinated healthcare services for individuals of all ages for the purpose of promoting, maintaining, and/or restoring health within the context of their daily lives or to enable individuals with terminal illnesses to remain at home. This is accomplished through the provision of services in the home, schools and community, and includes acute care, palliative care, chronic care, long-term care, rehabilitation, and home oxygen therapy. Extra-Mural units are located in Fredericton and Woodstock (Horizon Health Network 2011b).

6.4.5.3 Emergency Services

6.4.5.3.1 Ambulance Services

Ambulance New Brunswick Inc. (ANB) is contracted by the Department of Health to provide air and land ambulance services in New Brunswick (New Brunswick Department of Health 2011).

There are over 80 ANB stations throughout the province, including one in Stanley and a fleet centre/paramedic station/regional office in Fredericton. Construction is currently underway on a station in Hartland (ANB 2011).

In 2009-10, ANB had a fleet of 134 vehicles operating out of its 80 stations. It employed approximately 1,000 people, including paramedics, critical care nurses, and medical transportation dispatchers. In the 2009-10 fiscal year (*i.e.,* April 2009 to March 2010), it received 93,062 calls, a decrease of approximately 15,000 calls from 2008-09 fiscal year. During the 2010-11 fiscal year, ANB received 94,063 calls, an increase of approximately 1,000 calls over the previous year (ANB 2010; 2011). The air ambulance service currently employs nine full-time critical care flight nurses, three part-time and three casual employees. In the 2009-10 fiscal year, the air ambulance service responded to 724 calls, including 554 patient transfers. In the 2010-11 fiscal year, they completed 564 patient transfers out of 719 requests for service (ANB 2010; 2011).

ANB's contract with the Department of Health says that in 90% of calls, the ambulance must reach an urban caller within nine minutes and a rural caller within 22 minutes. All performance requirements were met in the 2010-2011 fiscal year, and in ANB's western region, response times were achieved for over 95% of all calls (ANB 2011).

6.4.5.3.2 Policing Services

The New Brunswick RCMP, or "J" Division, is comprised of a variety of professional employees specifically trained to address policing needs in New Brunswick communities. As of January 1, 2011, the New Brunswick RCMP had 928 regular members, 87 civilian members, and 160 public-service positions responsible for providing policing service to provincial residents. It operates out of 12 district offices, 57 satellite offices, and seven federal offices. Its provincial headquarters are located in Fredericton. "J" Division maintains 530 established vehicles, 80 snowmobiles/all-terrain vehicles, and 17 boats to patrol 98% of the New Brunswick land mass, 400 km of land border and 2,300 km of coastline in partnership with other law enforcement agencies (RCMP 2008; 2011).

Based on a regional policing model, each district consists of several detachments located within a specified geographic region of the province. There are 11 RCMP districts (or regional police forces) in New Brunswick (Figure 6.4.5). The Codiac Regional RCMP also operates a district office. Each district is overseen by a District Commander (the RCMP equivalent of a Chief of Police) in charge of operations for that area (RCMP 2011).

The two RCMP districts within York and Carleton Counties are District 2 (Oromocto) and District 7 (Carleton-York). District 2 (Oromocto) lies in the central part of the province, including an office in Stanley. District 7 (Carleton-York) is in the western central region and includes offices in Hartland and Woodstock. RCMP detachments also exist in Nackawic and Keswick Landing (RCMP 2013).

6.4.5.3.3 Fire Protection

The Fredericton Fire Department has five stations and 118 employees. The Department services the City of Fredericton and eight LSDs under a Fire Protection Services Agreement with the Province. It also has mutual aid agreements with neighbouring municipalities to provide them with dispatch services.

The Fredericton Fire Department responded to 3,626 calls for service in 2010, 3.5% fewer than in 2009. This was the lowest number of calls received by the department in four years. Most of the calls for service were for medical assistance, with 1,948 calls in 2010. This number was a decrease of 3.6% from 2009, and represented another four-year low. There were 446 fire calls in 2010, down 9.5% from 493 in 2009. Of the 446 fire calls, 28 were for actual structure fires, one of the lowest numbers in the last 10 years. The Department also responded to 23 calls under the Provincial Local Service District Agreement and four calls under the Capital District Mutual Aid Agreement (Fredericton Fire Department 2011).

The Villages of Stanley and Millville each have volunteer fire departments with 25 and 18 members, respectively. The Stanley Fire Department has two pumper trucks and a rescue vehicle with first responder medical equipment on-board. The Millville Fire Department has one rescue vehicle and two fire trucks, and it is in the process of purchasing new rescue equipment. There is also a volunteer fire department in Burtts Corner with approximately 15 members (Stantec 2012i).

There is a fire department in Woodstock, which consists of four full-time drivers, a full-time fire chief, a deputy chief, two captains, a lieutenant, and 22 volunteer firefighters. The Woodstock Fire Department provides 24-hour emergency fire protection and rescue services to the Town of Woodstock and adjacent rural communities. It also has mutual aid agreements with neighbouring municipalities to provide them with dispatch services.

The Hartland Fire Department has one station with 32 volunteer fire fighters for fire/accident response and an eight-person volunteer rescue team. The Department does not employ any full-time staff. It owns three tanker/pumper combination vehicles with water capacity ranging from 4,000 to 9,500 litres. The Hartland Fire Department has recognized a need for ongoing equipment replacement and upgrades. The Town of Hartland's municipal plan for 2009-13 has identified that purchasing new fire department equipment will be a project in 2012 (Town of Hartland 2009).

There is also a volunteer fire department in Juniper that has 12 members and no full-time staff. The department owns two tanker/pumpers, each with 5,500 litre water capacity, and one rescue van. Volunteer fire departments also exist in Nackawic and Keswick Ridge.

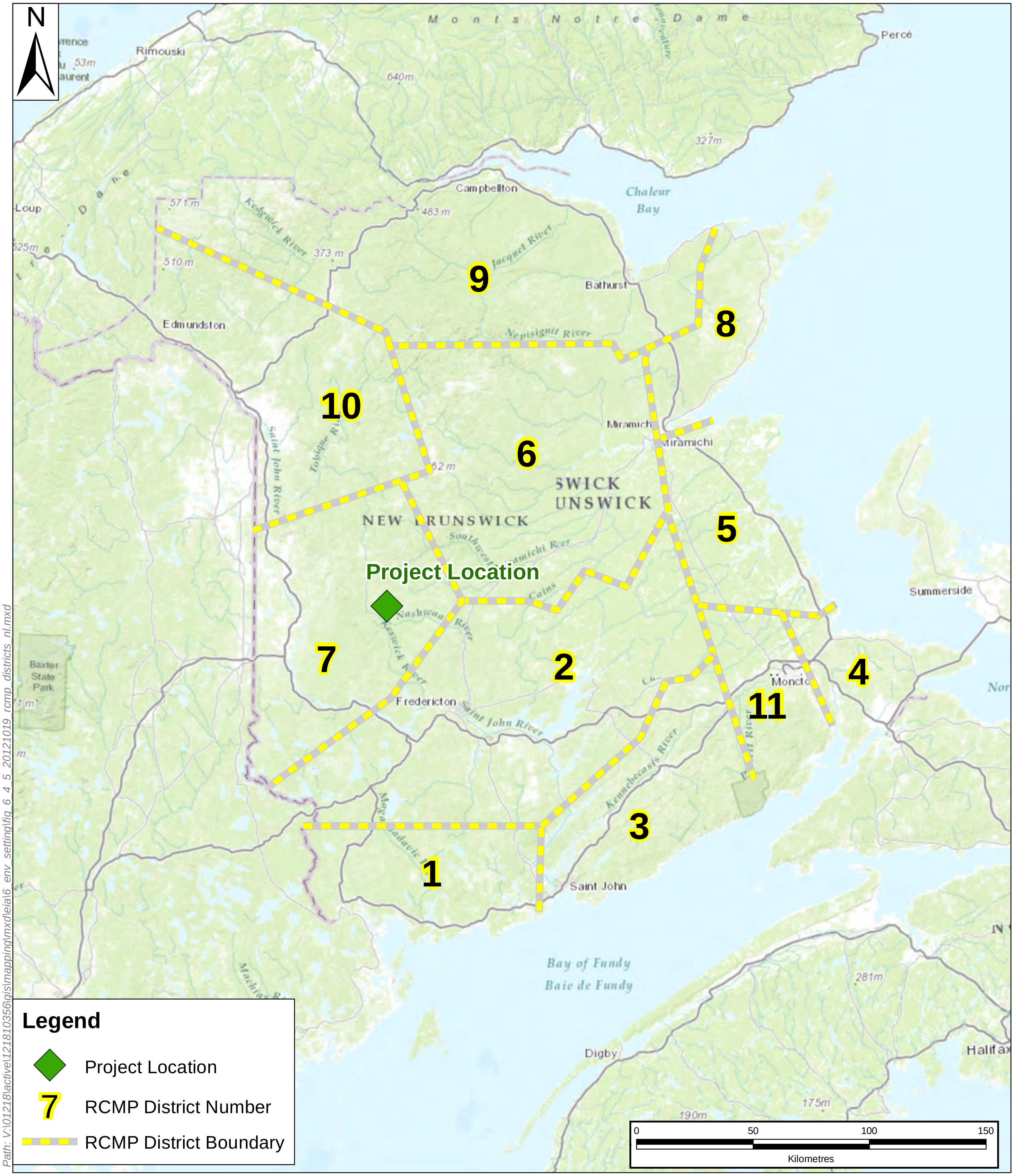
6.4.6 Heritage Resources

6.4.6.1 Built Heritage

A search of the register of Canada's Historic Places (CRHP 2012), and a review of New Brunswick Historic Places (NBHP 2010) did not reveal any registered built heritage places or historic sites in the vicinity of the Project. As of the time of writing, there were no provincial Historic sites listed in the communities of Juniper, Maple Grove Station, Centreville, Williamsburg, Currieburg, Boyds Corner, Stanley, Cross Creek, Deersdale, or Half Moon (NBHP 2010). There are no National Parks or National Historic Sites in the vicinity of the Project (Parks Canada 2008).

The Historic Places Section of the New Brunswick Department of Tourism, Heritage and Culture indicates there are few built heritage structures near the Project. Two structures in the Community of Napadogan were added to the NBHP (formerly the Canadian Inventory of Historic Buildings database) in 1989. These structures include the Old Railway Office in Napadogan (built in 1908), and the Old Round House (estimated build date of 1908) (Stantec 2012j).

The remains of an old dam at Otter Brook Canyon in the Deersdale District, documented as part of the JDI Unique Areas Program (J.D. Irving, Limited n.d.), are located near a canyon that was created by water erosion from Otter Brook. The dam may have been created as part of a series of small dams used to facilitate log drives during the peak of the timber industry. This dam is located approximately 10 km away from the Project, and due to the isolated nature of the dam and small watercourse, it is not anticipated that a sawmill would have been associated with this feature.



Legend

- Project Location
- 7 RCMP District Number
- RCMP District Boundary

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NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

RCMP Jurisdictions, New Brunswick

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Sisson Mines Ltd.

Scale: 1:2,250,000

Project No.: 121810356

Date: (dd/mm/yyyy) 23/11/2014

Dwn. By: JAB

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Data Sources:
SNB
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Fig. No.: 6.4.5

Stantec

Map: NAD83 CSRS NB Double Stereographic

6.4.6.2 Palaeontological Resources

The sedimentary rock units within the Project site are from the Cambrian to Early Ordovician Periods. The Early Ordovician Meductic Group is comprised of igneous formations within the Meductic Group which do not contain fossils, and the Porten Road Formation which is primarily a porphyritic rhyolitic flow and breccia, would not contain fossils (Stantec 2012j). The Belle Lake Formation of the Meductic Group is fossil-bearing and known to contain graptolite fossils (Fyffe *et al.* 1983 as cited by Randall Miller 2011); however, it is located outside of the Project site. The Cambrian-Early Ordovician Woodstock Group located within the Project area includes the Baskahegan Lake Formation, a grey to green turbiditic sandstone and shale with minor red sandstone and shale. The Woodstock Group resembles the Grand Pitch Formation of central Maine, which contains the Cambrian trace fossil Oldhamia (Neuman 1984, as cited by Randall Miller 2011).

6.4.6.3 Archaeological Resources

There were no known archaeological sites in the vicinity of the Project prior to the initiation of the shovel testing recommended within the PDA in 2012. However, it must be acknowledged that no professional archaeological survey of this area had even been undertaken prior to this EIA. An Archaeological Potential Map provided by the Archaeological Services unit of the New Brunswick Department of Tourism, Heritage and Culture indicates that the lands bordering all watercourses in the vicinity of the Project, within a distance of 80 m (and 100 m at watercourse confluences) of the watercourses, have been determined to have high or medium potential for archaeological resources, subject to confirmation through walkover and shovel testing. A visual assessment of these areas was conducted by Stantec in 2011, and shovel testing to determine the presence of archaeological resources in these areas was initiated in the Fall of 2012 (Stantec 2012j), and continued in 2013 and 2014. To date, over 500 artifacts have been discovered during shovel testing of the PDA, particularly in one area within the footprint of the Open Pit. The discovery of archaeological resources in the PDA during shovel testing carried out in 2013 and 2014 provides further evidence that there has been Aboriginal use of this area in the distant past. The archaeological resources discovered within the PDA appear to date from between 6,500 and 7,500 years before present, based on the shape of the projectile points that have been recovered. Further information on these resources is found in Section 8.14.2.3.

6.4.7 Transportation and Transportation Infrastructure

New Brunswick's transportation network connects New Brunswick and the Atlantic provinces with the major markets in central Canada through Québec, the northeastern United States through Maine, and internationally through its two major ports at Saint John and Belledune.

6.4.7.1 Road

New Brunswick has a network of well-maintained highways, with many kilometres of four-lane expressway connecting the major centres via the Trans-Canada Highway (Route 2) as well as Routes 1, 7, and 15. The main major highway near the Project is a collector highway, Route 107, and various forestry roads can also be used to access the Project location and to connect to other major highways in the province.

Route 107 connects with Route 148 at Nashwaak Bridge and to Route 8 (through the new Marysville Bypass recently opened) to the east of the Project, through Cross Creek, the Village of Stanley, Napadogan, and Juniper, before intersecting with Route 105 at Florenceville-Bristol to the west of the Project site. Route 107 has an approximate length of 100 km.

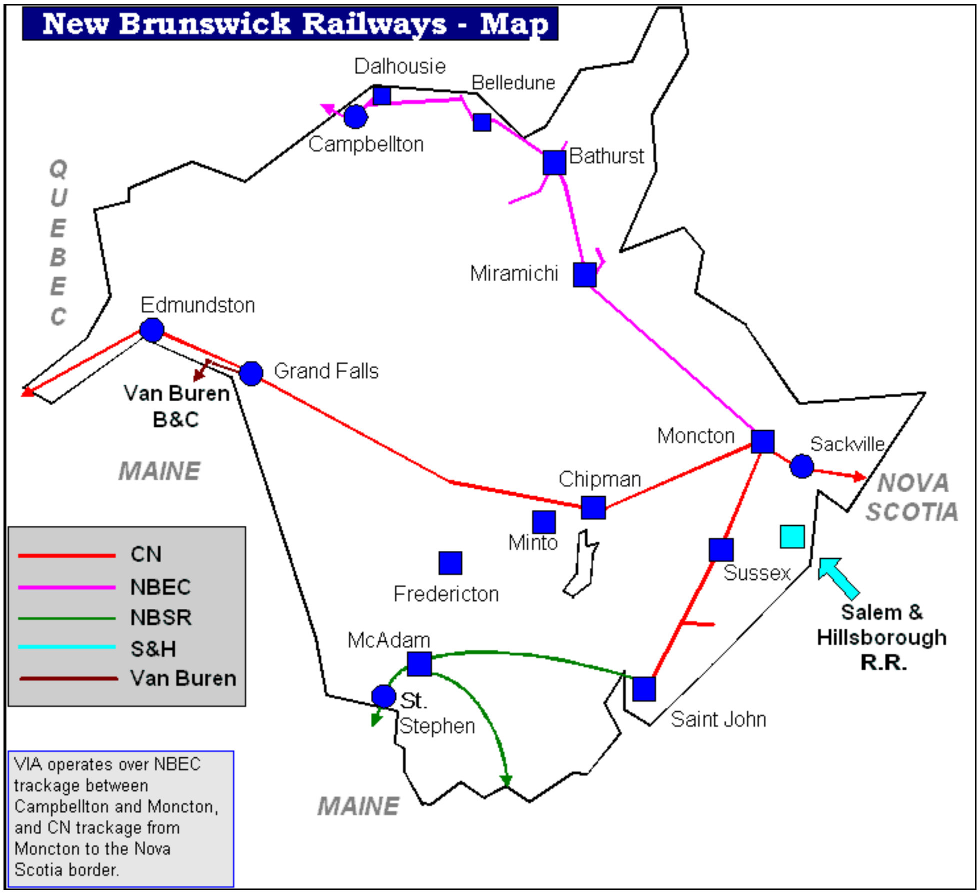
Local highways are maintained by the New Brunswick Department of Transportation and Infrastructure (NBDTI), and fill out the highway network and connect small communities and areas to major highways. These roads are subject to seasonal weight restrictions and lower speed limits, particularly as they cross smaller communities. The speed limit is generally 80 km/h or lower depending on road design standards. Forest resource roads on Crown land are the responsibility of the New Brunswick Department of Natural Resources (NBDNR), who often delegate the responsibility for their maintenance to the holders of Crown leases for timber management.

6.4.7.2 Rail

New Brunswick has three rail freight routes that tie into national and international transportation routes (Figure 6.4.6). Rail freight within New Brunswick is primarily provided by Canadian National Railway (CNR), and is a vital component of New Brunswick’s transportation network. The federally-regulated service provides an important link between New Brunswick and the national railway system including major markets in central and western Canada, the northeastern United States, as well as a connection to Atlantic Canada’s major ports. A major regional intermodal terminal is operated by CNR in Moncton, which services users from New Brunswick, Prince Edward Island, and parts of Nova Scotia. There is also a transload facility located in Edmundston, New Brunswick (Figure 6.4.6). CNR’s mainline in conjunction with New Brunswick’s other shortline railways, moves 97% of Atlantic Canada’s international freight traffic (Atlantic Gateway 2010).

In addition to CNR, New Brunswick has two provincially regulated rail-freight shortline carriers, New Brunswick East Coast Railway (NBEC) and New Brunswick Southern Railway (NBSR). The NBEC connects the CNR mainline at Moncton with the northern shore of New Brunswick, including stations in Campbellton and through to Québec.

The NBSR operates from the Port of Saint John and the Maine border, and continues through the New England states to Montréal and Québec (Figure 6.4.6). The NBSR is a member of the Irving Group of companies based in Saint John. NBSR delivers freight rail services to various industrial and commercial customers and offers direct intermodal service between Saint John, New Brunswick and Ayer, Massachusetts (NBSR 2012). NBSRs closest station to the Project is a reloading station located in McAdam, approximately 90 km south of the Project.



Source: TrainGeek.ca (2011).

Figure 6.4.6 New Brunswick Railways

6.4.7.3 Ports

New Brunswick has four marine cargo ports located in Saint John, Belledune, Bayside, and Dalhousie, collectively capable of handling over 30 million tonnes of cargo annually.

The Port of Saint John is located approximately 140 km south of the Project, and is eastern Canada's second largest container port and the fourth largest port by tonnage in Canada. The Port of Saint John offers deep water service year-round through the Bay of Fundy. In 2011, the Port of Saint John handled more than 27 million tonnes of cargo (Saint John Port Authority 2012).

The Port of Belledune is located approximately 170 km north of the Project. The Port of Belledune also offers year-round service, and is a deep water point of access through the Gulf of St. Lawrence. In 2011, the Port of Belledune completed an important expansion which included the construction of two new terminals; a Roll-on/Roll-off terminal and a fourth terminal for barge traffic. For the calendar year 2011, the Port of Belledune handled approximately 2.1 million tonnes of cargo from approximately 105 vessels (Port of Belledune 2012).

New Brunswick's two smaller marine ports located at Bayside and Dalhousie provide shallow port facilities. The Port of Bayside provides services to the aggregate, lumber, paper products, frozen fish, potatoes, salmon, fish feed, and fertilizer industries. The Port of Dalhousie's primary commodity is fuel oil for the Dalhousie Generating Station (now slated for decommissioning).

6.4.7.4 Air

New Brunswick has three airports that are part of the National Airport System, located at Fredericton, Moncton, and Saint John. The Greater Moncton International Airport is New Brunswick's centre for air cargo activity in Atlantic Canada, as a result of its central location and access to integrated cargo services (Province of New Brunswick n.d.).

Four smaller, municipally owned and operated airports located in Saint-Léonard, Charlo, Bathurst, and Miramichi currently provide courier and charter services.

7.0 SUMMARY OF KEY PREDICTIVE STUDIES

A number of the environmental effects assessments detailed in Chapter 8 depend upon predictive studies regarding the release and fate of air contaminants, greenhouse gases (GHG), sound, and effluent from the Project throughout the phases of Construction, Operation, and ultimately Decommissioning, Reclamation and Closure. Emissions, releases and wastes from the Project have been characterized in Sections 3.4.1 to 3.4.3 based on existing information about the Project developed in support of the feasibility study. In this section, summaries of the key predictive studies that were carried out to support the environmental effects assessments are presented. These include:

- air quality modelling of the Project's emissions to the atmosphere and their dispersion in the ambient environment (Section 7.1);
- characterization of the Project's emissions of GHGs, and their placement in the context of provincial, national and global GHG emissions (Section 7.2);
- characterization and modelling of the Project's sound and vibration emissions in the ambient environment, and their transport to nearby noise sensitive receptors (Section 7.3);
- a discussion of how the Project might affect fish habitat in and around the Project Development Area (PDA), resulting in loss of habitat directly and indirectly, and how such habitat loss might be offset (Section 7.4);
- characterization of the potential for acid rock drainage (ARD) and/or metal leaching (ML) to result from ore and wastes from the Project, and potential associated environmental effects to water quality (Section 7.5);
- prediction of how releases from the Project might affect downstream water quality in receiving watercourses (Section 7.6); and
- human health and ecological risk assessment (HHERA) modelling to understand the effect of emissions and releases from the Project on human and ecological health in the surrounding environment (Section 7.7).

7.1 AIR QUALITY MODELLING

Emissions of air contaminants during Construction and Operation of the Project were presented in Section 3.4.1.6.1 and 3.4.2.5.1, respectively. Emissions during Decommissioning, Reclamation and Closure were conservatively assumed to be the same as those occurring during Construction.

Stantec carried out dispersion and deposition modelling of air contaminant emissions resulting from Construction and Operation of the Project for the purposes of:

- predicting changes to ambient air quality arising from the Project's emissions, to determine the potential for exceedances of ambient air quality objectives; and
- providing inputs to the Human Health and Ecological Risk Assessment (HHERA) study for the Project.

Dispersion refers to the dispersal of an exhaust plume from an air contaminant emission source. Plume dispersion occurs due to mixing of the exhaust gases with ambient air. Plume dispersion is modelled to predict air contaminant concentrations downwind at ground-level. Deposition refers to particulate matter or gaseous air contaminants, from a single emission source or a group of sources, which are deposited at the ground surface. There are two forms of deposition: dry, and wet. Dry deposition occurs when air contaminants are transported downwind through dispersion of the exhaust plume, which is eventually deposited at the ground surface. Wet deposition occurs when air contaminants are captured in precipitation and are deposited at the ground surface when precipitation falls. The dispersion and deposition of air contaminants released from the Project is an important component to aid in the understanding of how ambient air quality may be affected by the Project's activities.

7.1.1 Dispersion and Deposition Modelling Methodology

7.1.1.1 Model Selection

As discussed in Section 4.1 of the Terms of Reference (Stantec 2012a), the maximum short-term (1-h, 8-h, and 24-h), and long-term (annual) average ground-level concentrations and annual deposition rates arising from emissions from the Project during Construction and Operation were predicted using the most recent version of the American Meteorological Society and Environmental Protection Agency developed Regulatory Model (AERMOD) dispersion model. The AERMOD model is a commonly used dispersion and deposition model for modelling emissions from point, volume, and area sources of air contaminants. AERMOD has been used for dispersion and deposition modelling applications in New Brunswick for several years, and is accepted by the New Brunswick Department of Environment and Local Government (NBDELG).

7.1.1.2 Model Inputs

The inputs for the dispersion and deposition modelling generally consist of three main components:

- meteorological data;

- receptor grid and terrain data; and
- point source characteristics and emissions data.

These are described in the following text.

7.1.1.2.1 Meteorological Data

The AERMOD model uses hourly meteorological data (*e.g.*, wind speed and direction, temperature) for a continuous 6-year period—in this case, from the beginning of January 2006 to the end of December 2011. The hourly meteorological data for the Fredericton Airport were considered by the Study Team to be representative of the Project site, and were obtained from the National Climatic Data Centre (NCDC 2012) and Environment Canada (Environment Canada 2012).

The model also uses upper air sounding data from a representative upper air station. Twice daily upper air sounding data were obtained for the Caribou, Maine weather station (NOAA 2012), the nearest representative upper air station to the Project site.

Data for the following meteorological parameters are used in the dispersion and deposition model:

- wind speed (m/s) and wind direction (degrees) – surface and upper air;
- temperature (Kelvin or K degrees) – surface and upper air;
- station pressure (kPa) – surface and upper air;
- precipitation (mm/h) – surface only;
- altitude (m) – upper air only;
- cloud cover (tenths of a degree) – surface only; and
- relative humidity (%) – surface and upper air.

Since precipitation data for 2011 were missing for the Fredericton Airport station, precipitation data from the Sisson meteorological station (Northcliff Resources 2012c) were used for the 2011 year.

The raw data (as identified above) for the area were used to calculate stability parameters and mixing layer depths (mixing heights) with the aid of the American Meteorological Society and Environmental Protection Agency developed Regulatory Meteorological Pre-processor (AERMET) meteorological pre-processor. AERMET merges the surface data set with the upper air data, to provide a quality assured and quality controlled meteorological data set. There are three stages to processing the data:

- the first stage extracts meteorological data from archive data files and processes the data through various quality assessment checks;

- the second stage merges all data available for 24-hour periods and stores these data together in a single file; and
- the third stage reads the merged meteorological data and estimates the parameters required by the model.

The AERMET processor requires hourly values of wind speed, direction, temperature, cloud cover as well as the 1200 GMT (7:00 am Local Standard Time) upper air sounding to generate the requisite data for modelling.

7.1.1.2.2 Receptor Grid and Terrain Data

The dispersion and deposition modeling uses a receptor grid covering the Local Assessment Area (LAA) for the Atmospheric Environment (see Section 8.2.1.4) and reflects that recommended in the Terms of Reference (Stantec 2012a).

The receptor grid selected for this modelling is shown in Figure 7.1.1. The receptor grid consisted of a 25 km by 25 km Cartesian grid with the Project site near the centre of the grid. The receptor grid spacing was 100 m apart for the first 10 km by 10 km grid centered near the Project. Receptors were then spaced 250 m apart for the next 3 km from the edge of the 10 km x 10 km grid; this 250 m grid spacing was shifted slightly to the east to cover the community of Napadogan and provide additional resolution in the area where the nearest permanent residences are located. The receptors were then spaced 500 m apart for the remainder of the 25 km by 25 km domain.

Terrain elevation data used in the development of the receptor grid were obtained from Service New Brunswick (SNB 2012).

7.1.1.2.3 Point Source Characteristics and Emissions Data

The source data required to run the AERMOD model include the following:

- the physical location of each of the point, area, and volume emission sources;
- the emission rate (g/s) of the selected air contaminant from each source;
- the physical height (m) of the point emission source (*i.e.,* stack height) above surrounding ground-level;
- the dimensions and release parameters (m) of the area and volume sources;
- the diameter of the stack of each point source (m) at its exit (*i.e.,* stack exit diameter);
- the average stack exhaust gas exit velocity for each point source (m/s); and
- the average stack exhaust gas exit temperature for each point source (Kelvin degrees, or K).

The source parameters were based on operational parameters provided by Northcliff. Emission rates of air contaminants during Construction and Operation were based on emissions inventories developed by Stantec based on operational parameters from Northcliff as well as published emission factors, as presented previously in Sections 3.4.1.6.1 and 3.4.2.5.1.

Tables 7.1.1 and 7.1.2 provide the model input parameters for the point, area, and volume sources[1] included in the modelling of emissions during the Construction phase. The model input parameters for the point, area, and volume sources included in the modelling of emissions during the Operation phase are provided in Tables 7.1.3 to 7.1.5. The emissions were estimated and modelled for the months of the Construction and Operation phases during which the most heavy equipment and trucks would be operational, representing a conservative estimate of emissions during Construction and Operation.

The point source, area source, and volume source input parameters in the tables below are estimated based on the dimensions of each source. The procedure for estimating initial dimensions for volume sources is outlined in the Industrial Source Complex (ISC) dispersion model User Guide Volume I (USEPA 1995).

Table 7.1.1 Dispersion Model Input Parameters – Construction Phase, Point Sources

Source	Exhaust Gas Temperature (K)	Exhaust Gas Exit Velocity (m/s)	Exhaust Point Height above ground-level (m)	Exhaust Point Exit Diameter (m)
On-Site Heavy Mobile Equipment	750	25	2.4	0.16

Table 7.1.2 Dispersion Model Input Parameters – Construction Phase, Volume Sources

Source	Initial Lateral Length [a] (m)	Initial Vertical Length (m)	Estimated Release Height Above Ground-level (m)
On-Site Roads			
Open Pit to Crusher (3 sources – total length approx. 465 m)	155	0.93	2.0
Open Pit to Tailings Storage Facility (TSF) (8 sources – total length approx. 1,200 m)	155	0.93	2.0
Quarry to TSF (8 sources – total length approx. 1,200 m)	155	0.93	2.0

Notes:

[a] Haul routes (open pit to crusher, open pit to tailings and quarry to tailings) divided into equal segments in the model to maintain acceptable volume source dimension inputs. The total emissions along each route were also divided equally between each segment/source.

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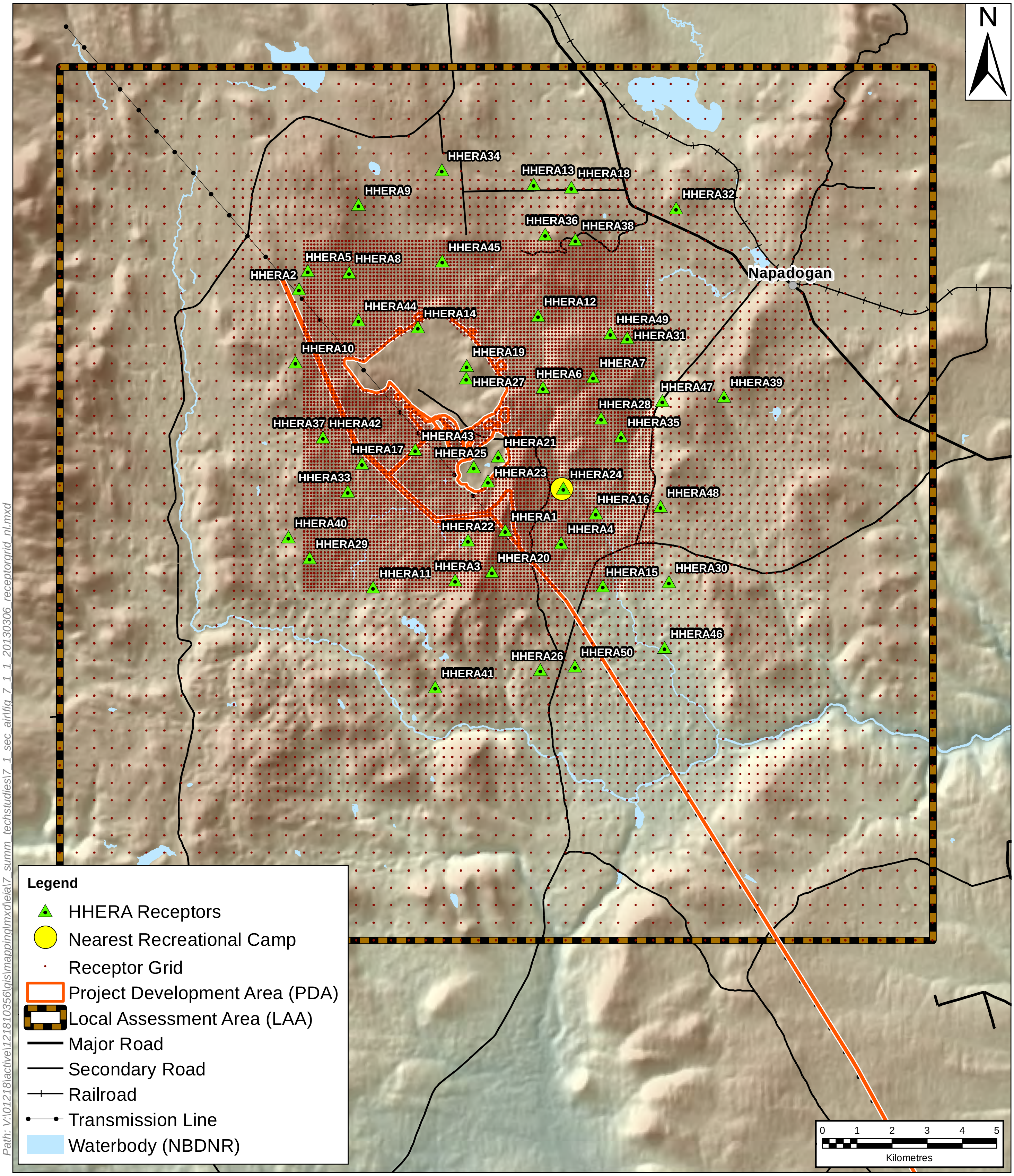
[1] Point sources include releases from stacks and vents. Volume sources include fugitive releases with initial volume. Area Sources include surface based fugitive releases over a specific surface area.



Path: V:\01218\active\121810356\gis\mapping\mxd\eia\7 summ techstudies\7 1 sec airfig 7 1 1 20130306 receptorgrid nl.mxd

NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Receptor Grid for Dispersion and Deposition Modelling

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Sisson Mines Ltd.

Scale: 1:150,000

Project No.: 121810356

Data Sources: NBDNR

Fig. No.: 7.1.1

Date: (dd/mm/yyyy) 23/11/2014

Dwn. By: JAB

Appd. By: DLM

Stantec

Stantec Consulting Ltd. © 2013

Map: NAD83 CSRS NB Double Stereographic

Table 7.1.3 Dispersion Model Input Parameters – Operation Phase, Point Sources

Category	Exhaust Gas Temperature (K)	Exhaust Gas Exit Velocity (m/s)	Exhaust Point Height Above Ground-level (m)	Exhaust Point Exit Diameter (m)
Mineral Processing				
Haul Trucks	770	30	5.0	0.25
Other Mining Equipment	770	30	2.0	0.15
Primary Crusher	298	10	15	0.5
Ammonium Paratungstate (APT) Plant				
Boiler	423	13.2	13.8	0.6
H_2S Scrubber	293	14.3	15.3	0.6
NH_3 Scrubber	313	14.3	15.3	0.6

Table 7.1.4 Dispersion Model Input Parameters – Operation Phase, Area Sources

Source	Estimated Release Height Above Ground-level (m)	Initial Dimension – X Direction (m)	Initial Dimension – Y Direction (m)	Initial Dimension – Z Direction (m)
Coarse Ore Stockpile	3	43.2	43.2	4.5
Tailings Beaches	2	950	350	3.5

Table 7.1.5 Dispersion Model Input Parameters – Operation Phase, Volume Sources

Source	Initial Lateral Length (m)	Initial Vertical Length (m)	Estimated Release Height (m)
On-Site Roads			
Open Pit to Crusher (3 sources – total length approx. 465 m) [a]	155	0.93	2.0
Open Pit to Tailings Storage Facility (TSF) (8 sources – total length approx. 1,200 m) [a]	155	0.93	2.0
Quarry to TSF (8 sources – total length approx. 1,200 m)[a]	155	0.93	2.0
Material Transfer Points			
Truck Unloading at Crusher	1.16	0.93	2.0
From Crusher to Conveyor	1.16	0.93	2.0
From Conveyor to Stockpile	1.16	0.93	2.0
Miscellaneous			
Pit Blasting	25.6	0.47	1.0

Notes:

[a] Haul routes (open pit to crusher, open pit to tailings and quarry to tailings) divided into equal segments in the model to maintain acceptable volume source dimension inputs. The total emissions along each route were also divided equally between each segment/source.

7.1.1.2.4 Building Downwash

The modelling considers the effects of downwash due to wind flow over and around the surrounding buildings. Since building wake effects may influence the predictions (USEPA 1997), the input file includes building heights and widths using the USEPA Building Profile Input Program (BPIP-PRIME).

7.1.1.2.5 Model Outputs, Data Processing, and Interpretation of Results

After running the dispersion and deposition model, output files were generated for the maximum 1-hour, 8-hour and 24-hour predicted ground-level concentrations and annual average ground-level concentrations at each receptor for the complete 6-year time period spanned by the meteorological input file.

Deposition modelling provides deposition rates for selected Non-Criteria Air Contaminants (Non-CAC) Non-CAC in support of the HHERA. Stantec modelled deposition, including wet and dry particulate and gaseous deposition, of applicable air contaminants. The deposition parameters used for the modelling for each air contaminant are from the document entitled “Deposition Parameterizations for the Industrial Source Complex (ISC3) Model” (Wesley *et al.* 2002).

A screening level modelling analysis of the fugitive particulate matter emissions from road dust due to vehicle movements on off-site access roads during both Construction and Operation was also conducted. This screening level analysis was separate from the modelling of the on-site Project sources since the off-site routes are relatively far from the other sources (>2 km) therefore the resulting ground-level dust concentrations should not overlap. This was modelled with the screening level version of AERMOD (AERMOD Screening Model, AERSCREEN).

Odour threshold values used for comparison with the odour modelling results came from published odour thresholds (Verschueren 1996; AIHA 1989; Amoore and Hautala 1983; Environment Canada 1984; van Gemert 2003; and AENV 2011). It should be noted that odour detection is subjective with different people detecting different odours at varying concentrations or amounts. For this reason, odour is often evaluated by a large group, or odour panel. Odour thresholds are defined as concentrations where 50% of the participants in an odour panel test would detect the odour. To account for potential short-term environmental effects due to odourous compounds, an averaging period of 10 minutes is typically used.

7.1.1.3 Establishing Background Conditions

The Baseline Ambient Air Quality Technical Report (Stantec 2012b) provides measured ambient air quality data to characterize the existing (baseline) ambient air quality conditions. A summary of these existing conditions is also provided in Section 8.2.2. These data establish the background concentrations used in the dispersion and deposition modelling. The dispersion model establishes the incremental changes related to Project activities during the Construction and Operation phases, and includes consideration of these baseline values by adding maximum model-predicted values to measured ambient (*i.e.*, background) air quality values.

The estimate of baseline ambient air contaminant concentrations near the Project for relevant averaging periods considers monitoring data from the baseline monitoring conducted by Northcliff at Napadogan (Stantec 2012b), as well as regional monitoring data from the NBDELG. Wherever available, the baseline uses data from the Napadogan site as it is the nearest monitoring site to the Project. For averaging periods of 24-h or less, the established background value is the maximum 90th percentile of the baseline monitoring data, or the most recent monitored data from NBDELG. The use of the 90th percentile for background concentrations for short-term averaging periods is based on guidance from the Alberta Department of Environment (AENV 2009). For annual averaging periods, the baseline values are the six month averages of the data collected at Napadogan.

Table 7.1.6 presents the Criteria Air Contaminant (CAC) background concentrations used in the modelling analysis. The Non-CAC background concentrations are provided in Table 7.1.7. Ambient baseline values are estimated where data exist for relevant averaging periods. For certain air contaminants, limited or no ambient data exist. For the cases where no data exist, the background concentrations were assumed to be negligible. Where limited data exist, details of the tables below specify the data treatment.

Table 7.1.6 Ambient Background Criteria Air Contaminant (CAC) Concentrations Used for Modelling

Criteria Air Contaminant (CAC)	Averaging Period	Background Ground-Level Concentration Used ($\mu g/m^3$)	Notes
Sulphur dioxide (SO_2)	1-hour [a]	5.5	Based on the maximum 90th percentile of weekly values from baseline monitoring in Napadogan. 1-hour and 24-hour average background concentration estimated using the Ontario Ministry of Environment (OMOE) relation. Annual background concentration based on six month average of weekly values.
	24-hour [a]	2.3	
	Annual	1.1	
Nitrogen dioxide (NO_2)	1-hour [a]	13	Based on the maximum 90th percentile of weekly values from baseline monitoring in Napadogan. 1-hour and 24-hour average background concentration estimated using OMOE relation. Annual background concentration based on six month average of weekly values.
	24-hour [a]	5.5	
	Annual	2.0	
Carbon monoxide (CO)	1-hour [a]	1,818	Estimated using annual average concentration measured at Fredericton (Aberdeen Street) station and OMOE relation.
	8-hour [a]	1,016	
Total particulate matter (PM)	24-hour	23	Based on the maximum 90th percentile of 24-hour values from baseline monitoring in Napadogan. Annual background concentration based on six month average of 24-hour values.
	Annual	11	
Particulate matter less than 10 microns (PM_{10})	24-hour	- (not measured)	No ambient monitoring for PM_{10} near the Project site or at other nearby stations operated by Industry or the NBDELG.
Particulate matter less than 2.5 microns ($PM_{2.5}$)	24-hour	6.1	Based on the maximum 90th percentile of 24-hour values from baseline monitoring in Napadogan.
Ammonia (NH_3)	24-hour	-	No ambient monitoring for Ammonia near Project site or at other nearby stations operated by Industry or NBDELG.
Hydrogen sulphide (H_2S)	1-hour	-	No ambient monitoring for H_2S near Project site. Since the Project site is located in a remote wooded area, background H_2S concentrations are expected to be negligible.
	24-hour	-	

Notes:

[a] Ambient background concentrations (24-h or weekly) were converted to an alternate averaging period using the following equation described in Table 7-1 in the OMOE's document "Procedure for Preparing an Emission Summary and Dispersion Modelling Report", dated July 2005: $C_0 = C_1 \times (t_1/t_0)^n$ where C_0 = the concentration at the averaging period t_0, C_1 = the concentration at the averaging period t_1, and n = 0.28.

Table 7.1.7 Ambient Background Non-Criteria Air Contaminant (Non-CAC) Concentrations Used for Modelling

CAS Number	Non-Criteria Air Contaminant (Non-CAC)	Averaging Period	Background Ground-Level Concentration Used [a] (µg/m^3)
124-18-5	Decane [e]	24-hour	-
100-41-4	Ethylbenzene [e]	24-hour	-
91-20-3	Naphthalene [e]	24-hour	-
25549-16-0	Tri-isooctylamine [e]	1-hour	-
7429-90-5	Aluminum	1-hour [b, c]	0.70
7440-38-2	Arsenic	24-hour	2.5E-03
7440-43-9	Cadmium	24-hour	8.2E-04
		Annual [d]	7.2E-04
7440-47-3	Chromium (total)	24-hour	1.0E-03
7440-50-8	Copper	24-hour	0.27
7439-92-1	Lead	24-hour	2.7E-03
		30 days [c]	1.0E-03
7439-98-7	Molybdenum	24-hour	1.2E-03
7439-97-6	Mercury	24-hour	8.0E-06
7440-02-0	Nickel	24-hour	1.2E-03
		Annual [d]	1.1E-03
7782-49-2	Selenium	24-hour	4.1E-03
7440-33-7	Tungsten	24-hour	0.03
7440-66-6	Zinc	24-hour	0.02

Notes:

[a] Unless otherwise noted, the maximum annual 90th percentile of 24-h values measured during the baseline monitoring at the Napadogan site was used.

[b] For non-criteria air contaminants with no OMOE criteria, a 1-h averaging period was considered.

[c] Ambient background concentrations (24-h) were converted to an alternate averaging period using the following equation described in Table 7-1 in the OMOE's document "Procedure for Preparing an Emission Summary and Dispersion Modelling Report", dated July 2005: $C_0 = C_1 \times (t_1/t_0)^n$ where C_0 = the concentration at the averaging period t_0, C_1 = the concentration at the averaging period t_1, and n = 0.28.

[d] Six month average of 24-hour concentration data collected at Napadogan site.

[e] No ambient monitoring for air contaminant near Project site or at other nearby stations operated by Industry or NBDELG.

7.1.2 Dispersion and Deposition Modelling Results

The results of the dispersion and deposition modelling carried out for the Project for Construction and Operation are presented in this section.

7.1.2.1 Construction

Tables 7.1.8 and 7.1.9 provide the results of the dispersion modelling of air contaminant emissions resulting from Construction activities.

Table 7.1.8 Dispersion Modelling Results – Maximum Predicted Ground-Level Concentrations of Criteria Air Contaminants (CACs) – Construction Phase – On-site Project Sources

Contaminant	Averaging Period	Background Concentration (µg/m^3)	Location of Modelled Maximum Concentration		Maximum Overall Predicted Ground-Level Concentration from the Project (µg/m^3)	Maximum Overall Predicted Ground-Level Concentration from the Project plus Background (µg/m^3)	Objective, Guideline or Standard (µg/m^3)	Percentage of Objective/ Guideline or Standard
			UTM X (m)	UTM Y (m)				
SO_2	1-hour maximum	5.5	650,800	5,135,600	0.16	5.66	900	<1%
	24-hour maximum	2.3	648,900	5,137,100	0.02	2.32	300	<1%
	Annual average	1.1	648,900	5,137,100	0.002	1.10	60	2%
NO_2	1-hour maximum	13	650,800	5,135,600	61.4	74.4	400	19%
	24-hour maximum	5.5	648,900	5,137,100	7.08	12.6	200	6%
	Annual average	2.0	648,900	5,137,100	0.94	2.94	100	3%
CO	1-hour maximum	1,818	650,800	5,135,600	41.4	1,859	35,000	5%
	8-hour maximum	1,016	648,900	5,137,100	8.81	1,025	15,000	7%
PM	24-hour maximum	23	649,300	5,136,700	22.5	45.5	120	38%
	Annual average	11	649,300	5,136,700	1.82	12.8	70	18%
PM_{10}	24-hour maximum	-	649,300	5,136,700	6.83	-	50	14%
$PM_{2.5}$	24-hour maximum	6.1	648,900	5,137,100	1.01	7.11	30	24%

Notes:
A value in **bold** indicates a value in excess of the applicable objective, guideline or standard.

Table 7.1.9 Dispersion Modelling Results – Maximum Predicted Ground-Level Concentrations of Criteria Air Contaminants (CACs) – Construction Phase – Off-site Access Road Dust Emissions

Contaminant	Location	Background Concentration (µg/m^3)	Maximum Overall Predicted 24-hour Average Ground-Level Concentration from the Project (µg/m^3)	Maximum Overall Predicted 24-hour Average Ground-Level Concentration from the Project plus Background (µg/m^3)	Objective/ Guideline/ Standard µg/m^3)	Percentage of Objective/ Guideline/ Standard
PM	100 m from access road	23	**553**	**576**	120	**480%**
	Nearest Residence (850 m from access road)		37.0	60.0		50%
	Nearest Camp (1,250 m from access road)		21.4	44.4		37%
PM_{10}	100 m from access road	-	**150**	**-**	50	**299%**
	Nearest Residence (850 m from access road)		10.0	-		20%
	Nearest Camp (1,250 m from access road)		5.80	-		12%
$PM_{2.5}$	100 m from access road	6.1	15.0	21.1	30	70%
	Nearest Residence (850 m from access road)		1.00	7.10		24%
	Nearest Camp (1,250 m from access road)		0.58	6.68		22%

Notes:
A value in **bold** indicates a value in excess of the applicable objective, guideline or standard.

There are no known substantive sources of non-criteria air contaminants expected during the Construction phase. As such, the dispersion modelling results presented above are limited to criteria air contaminants.

Figures 7.1.2 to 7.1.5 depict the predicted maximum ground-level concentrations during Construction for 1-hour NO_2, 24-hour PM, 24-hour PM_{10} and 24-hour $PM_{2.5}$, respectively. These include the predicted ground-level concentrations due to on-site Project sources plus background, with the exception of 24-hour PM_{10}, which does not include background concentrations (as noted above). Since predicted ground-level concentrations of SO_2 and CO associated with the Project were very low compared to background and the associated objective/standard these are not presented graphically. Numerical results for these parameters are provided in Table 7.1.8.

As shown in Table 7.1.8, predicted maximum ground-level concentrations of other contaminants (*i.e.,* SO_2, NO_2, CO, PM, PM_{10} and $PM_{2.5}$) during Construction result in a maximum overall predicted ground-level concentration from the Project plus background that is less than 25% of the objective, guideline or standard, and are thus considered negligible. As shown in Table 7.1.9, the predicted maximum ground-level concentrations of PM, PM_{10} and $PM_{2.5}$ are also well below the applicable objectives and standards at the nearest residences and recreational campsites, but maximum ground-level concentrations of PM and PM_{10} exceed the respective objectives or standards on occasion as a result of fugitive dust emissions on forest resource roads.

There are no substantive emissions of Non-CAC during Construction. Modelling is therefore not required for these parameters.

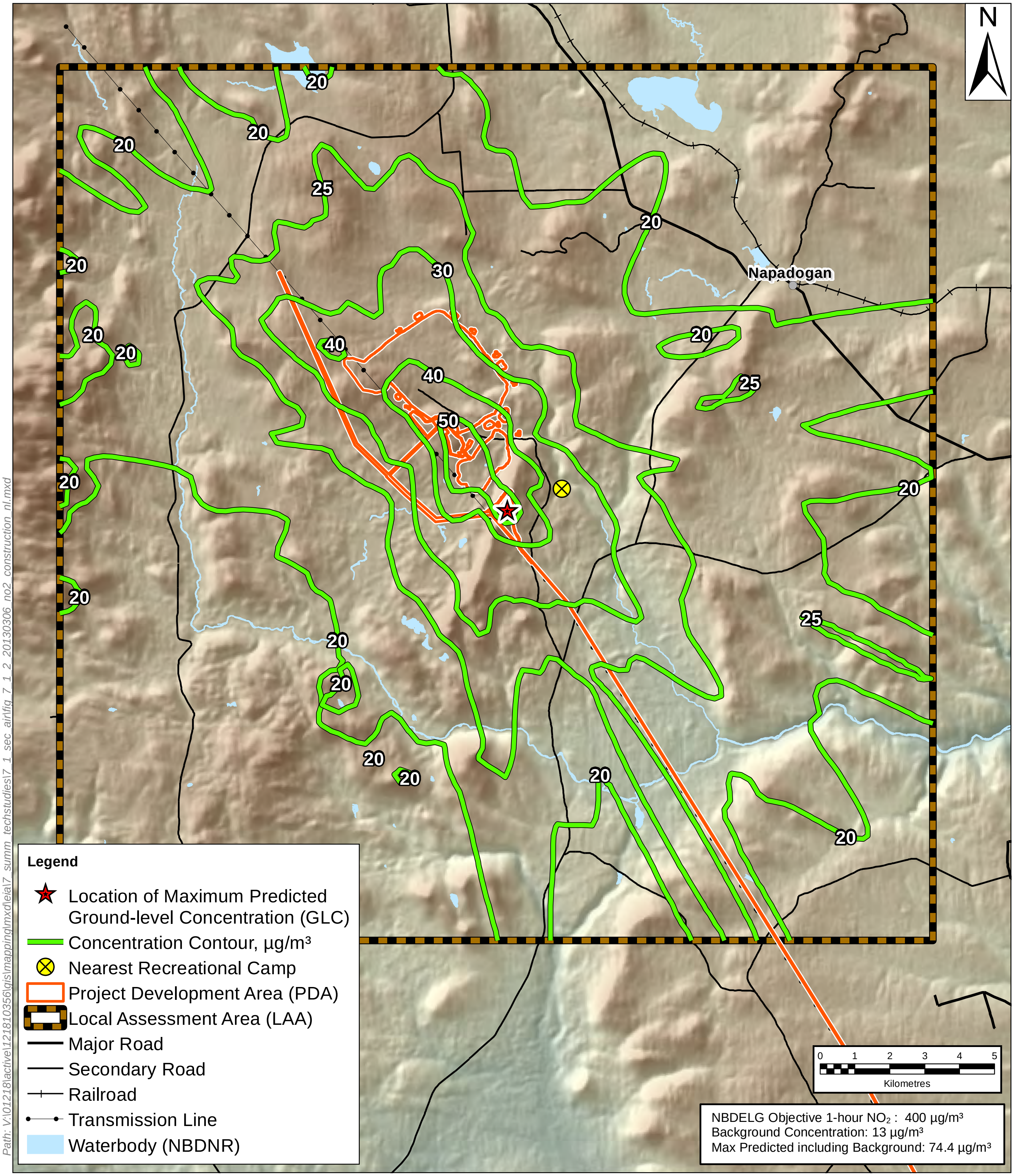
7.1.2.2 Operation

Tables 7.1.10 and 7.1.11 provide the results of the dispersion modelling for criteria air contaminants (CAC) during the Operation phase. Table 7.1.12 provides the dispersion modelling results for the non-CAC emissions during the Operation phase.

Table 7.1.10 Dispersion Modelling Results – Maximum Predicted Ground-Level Concentrations of Criteria Air Contaminants (CACs) – Operation Phase – On-Site Project Sources

Contaminant	Averaging Period	Background Concentration (µg/m^3)	Location of Modelled Maximum Concentration		Maximum Overall Predicted Ground-Level Concentration from the Project (µg/m^3)	Maximum Overall Predicted Ground-Level Concentration from the Project plus Background (µg/m^3)	Objective, Guideline or Standard (µg/m^3)	Percentage of Objective/ Guideline or Standard
			UTM X (m)	UTM Y (m)				
SO$_2$	1-hour maximum	5.5	648,900	5,137,300	0.12	5.62	900	<1%
	24-hour maximum	2.3	648,800	5,137,400	0.03	2.33	300	<1%
	Annual average	1.1	648,800	5,137,400	0.01	1.11	60	2%
NO$_2$	1-hour maximum	13	651,400	5,137,600	87.6	101	400	25%
	24-hour maximum	5.5	650,800	5,135,600	20.0	25.5	200	13%
	Annual average	2.0	651,100	5,136,900	3.24	5.24	100	5%
CO	1-hour maximum	1,818	651,400	5,137,600	38.2	1,856	35,000	5%
	8-hour maximum	1,016	651,700	5,136,900	21.7	1,038	15,000	7%
PM	24-hour maximum	23	649,300	5,136,700	**526**	**549**	120	**458%**
	Annual average	11	649,300	5,136,700	14.9	25.9	70	37%
PM$_{10}$	24-hour maximum	--	649,300	5,136,700	38.8	-	50	78%
PM$_{2.5}$	24-hour maximum	6.1	649,300	5,136,700	6.05	12.1	30	40%
NH$_3$	24-hour maximum	--	648,800	5,137,400	0.44	-	100	<1%
H$_2$S	1-hour maximum	--	648,800	5,137,400	4.98	-	15	33%
	24-hour maximum	--	648,800	5,137,400	0.94	-	5	19%

Notes:
A value in **bold** indicates a value in excess of the applicable objective, guideline or standard.



NBDELG Objective 1-hour NO_2 : 400 µg/m³
Background Concentration: 13 µg/m³
Max Predicted including Background: 74.4 µg/m³

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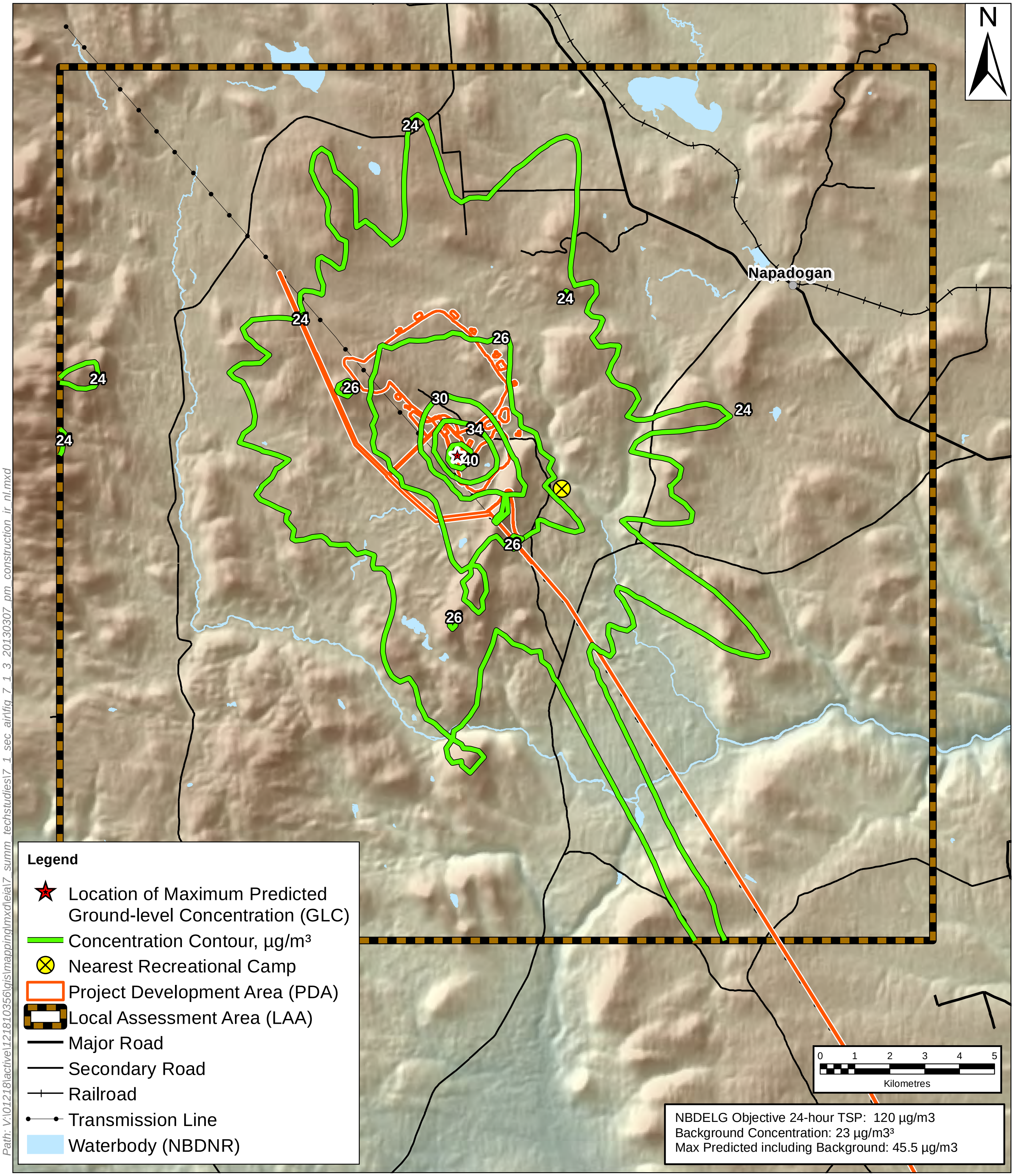
NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Maximum Predicted 1-Hour Ground-Level Concentrations of Nitrogen Dioxide Construction Phase - Project Plus Background Sisson Project: Environmental Impact Assessment (EIA) Report, Napadogan, N.B.	Scale: 1:150,000	Project No.: 121810356		Data Sources: NBDNR	Fig. No.: 7.1.2
	Date: (dd/mm/yyyy) 23/11/2014	Dwn. By: JAB	Appd. By: DLM		
Client: Sisson Mines Ltd.					

Stantec

Map: NAD83 CSRS NB Double Stereographic



NBDELG Objective 24-hour TSP: 120 µg/m3
Background Concentration: 23 µg/m3³
Max Predicted including Background: 45.5 µg/m3

Path: V:\01218\active\121810356\gis\mapping\mxd\eia\7_summ_techstudies\7_1_sec_air\fig_7_1_3_20130307_pm_construction_ir_nl.mxd

NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Maximum Predicted 24-Hour Ground-Level Concentrations
of Total Particulate Matter
Construction Phase - Project Plus Background

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Sisson Mines Ltd.

Scale: 1:150,000

Project No.: 121810356

Data Sources: NBDNR

Fig. No.: 7.1.3

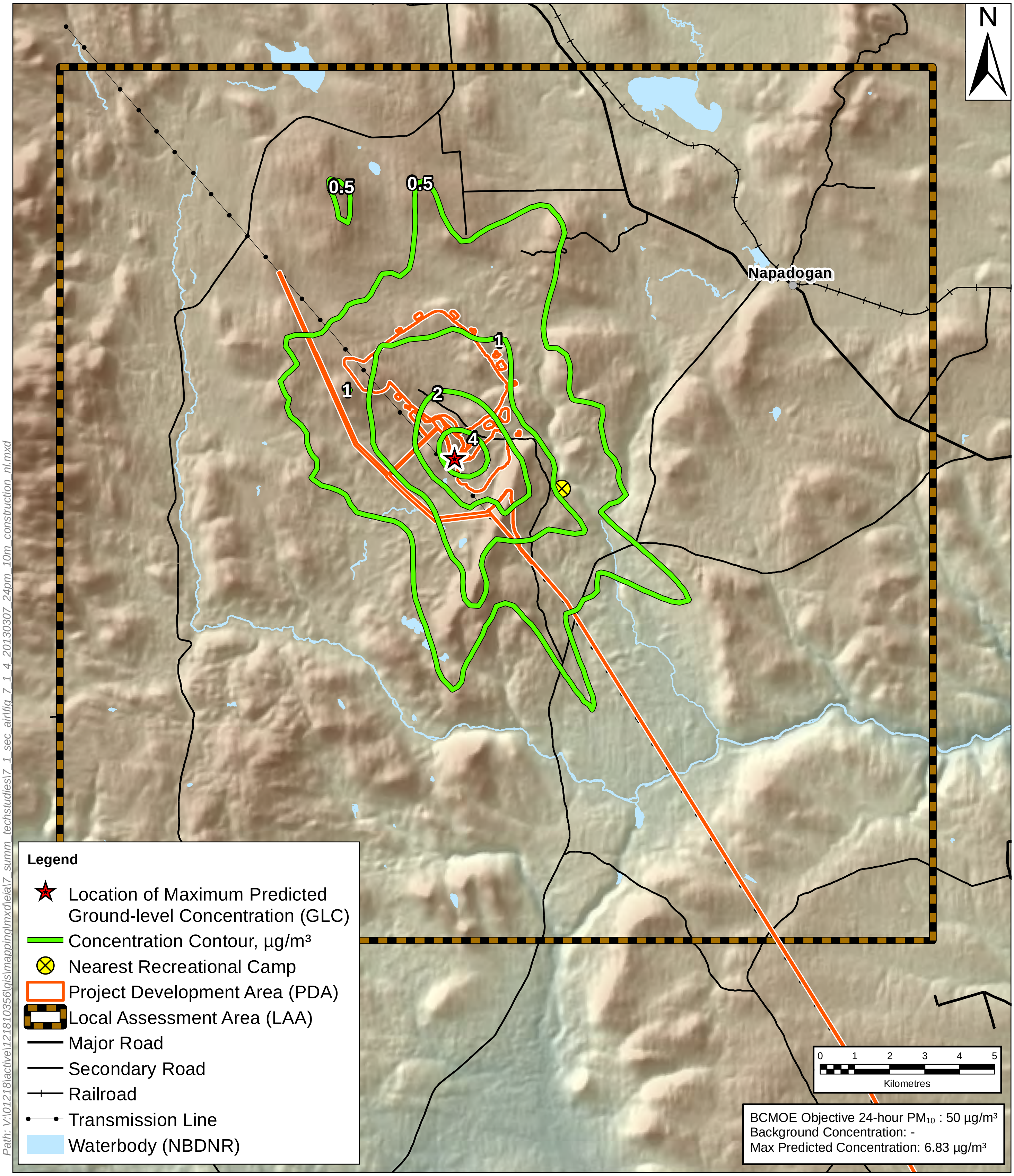
Date: (dd/mm/yyyy) 23/11/2014

Dwn. By: JAB

Appd. By: DLM

Stantec

Map: NAD83 CSRS NB Double Stereographic

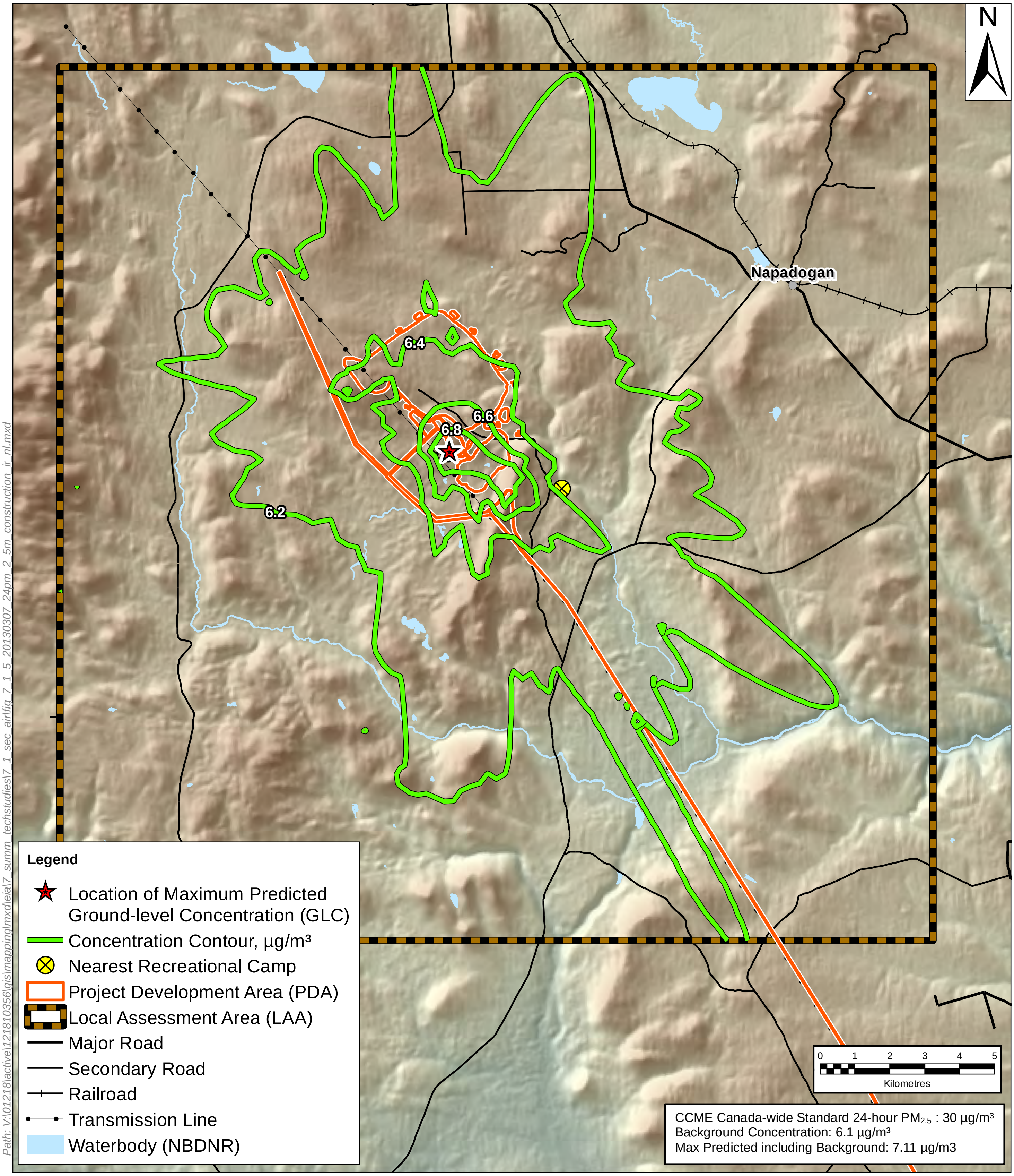


Path: V:\01218\active\121810356\gis\mapping\mxd\eia\7 summ techstudies\7 1 sec air\fig 7 1 4 20130307 24pm 10m construction nl.mxd

NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Maximum Predicted 24-Hour Ground-Level Concentrations of Particulate Matter Less Than 10 Microns Construction Phase - Project Alone Sisson Project: Environmental Impact Assessment (EIA) Report, Napadogan, N.B.	Scale: 1:150,000	Project No.: 121810356	Data Sources: NBDNR	Fig. No.: 7.1.4
	Date: (dd/mm/yyyy) 23/11/2014	Dwn. By: JAB	Appd. By: DLM	
Client: Sisson Mines Ltd.				

Map: NAD83 CSRS NB Double Stereographic



Legend

- ★ Location of Maximum Predicted Ground-level Concentration (GLC)
- 🟩 Concentration Contour, µg/m³
- ⊗ Nearest Recreational Camp
- ▭ Project Development Area (PDA)
- ▨ Local Assessment Area (LAA)
- — Major Road
- — Secondary Road
- ┼ Railroad
- •—• Transmission Line
- 🟦 Waterbody (NBDNR)

CCME Canada-wide Standard 24-hour $PM_{2.5}$: 30 µg/m³
Background Concentration: 6.1 µg/m³
Max Predicted including Background: 7.11 µg/m3

Path: V:\01218\active\121810356\gis\mapping\mxd\eia\7_summ_techstudies\7_1_sec_air\fig_7_1_5_20130307_24pm_2_5m_construction_ir_nl.mxd

NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Maximum Predicted 24-Hour Ground-Level Concentrations of Particulate Matter Less Than 2.5 Microns - Construction Phase - Project Plus Background

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client:	Sisson Mines Ltd.
Scale:	1:150,000
Project No.:	121810356
Data Sources:	NBDNR
Fig. No.:	7.1.5
Date: (dd/mm/yyyy)	23/11/2014
Dwn. By:	JAB
Appd. By:	DLM

Stantec

Map: NAD83 CSRS NB Double Stereographic

Table 7.1.11 Dispersion Modelling Results – Maximum Predicted Ground-Level Concentrations of Criteria Air Contaminants (CACs) – Operation Phase – Off-site Access Road Dust Emissions

Contaminant	Location	Background Concentration (µg/m^3)	Maximum Overall Predicted 24-hour Average Ground-Level Concentration from the Project (µg/m^3)	Maximum Overall Predicted 24-hour Average Ground Level Concentration from the Project plus Background (µg/m^3)	Objective/ Guideline/ Standard (µg/m^3)	Percentage of Objective/ Guideline/ Standard
PM	100 m from access road	23	**814**	**837**	120	**698%**
	Nearest Residence (850 m from access road)		54.5	77.5		65%
	Nearest Camp (1,250 m from access road)		31.6	54.6		46%
PM_{10}	100 m from access road	-	**217**	**-**	50	**434%**
	Nearest Residence (850 m from access road)		14.5	-		29%
	Nearest Camp (1,250 m from access road)		8.40	-		17%
$PM_{2.5}$	100 m from access road	6.1	22.4	28.5	30	95%
	Nearest Residence (850 m from access road)		1.50	7.60		25%
	Nearest Camp (1,250 m from access road)		0.87	6.97		23%

Notes:
A value in **bold** indicates a value in excess of the applicable objective, guideline or standard.

Table 7.1.12 Dispersion Modelling Results – Maximum Predicted Ground-Level Concentrations of Non-Criteria Air Contaminants (Non-CACs) – Operation Phase

Contaminant	Averaging Period	Background Concentration (µg/m^3)	Location of Modelled Maximum Concentration		Maximum Overall Predicted Ground-Level Concentration from the Project (µg/m^3)	Maximum Overall Predicted Ground-Level Concentration from the Project plus Background (µg/m^3)	Objective, Guideline or Standard (µg/m^3)	Percentage of Objective/ Guideline or Standard
			UTM X (m)	UTM Y (m)				
Decane	1-hour	--	648,800	5,137,400	42.3	--	60,000	<1%
Ethylbenzene	24-hour	--	648,800	5,137,400	0.33	--	1,000	<1%
Naphthalene	24-hour	--	648,800	5,137,400	1.19	--	22.5	5%
Tri-isooctylamine	1-hour	--	648,800	5,137,400	41.9	--	--	--
Aluminium	1-hour	0.70	649,300	5,136,700	226	227	--	--
Arsenic	24-hour	2.5E-03	649,300	5,136,700	0.022	0.024	0.3	8%
Cadmium	24-hour	8.2E-04	649,300	5,136,700	0.011	0.011	0.025	45%
	Annual	7.2E-04	649,300	5,136,700	3.0E-05	7.5E-04	0.005	15%
Chromium	24-hour	1.0E-03	649,300	5,136,700	0.035	0.036	0.5	7%
Copper	24-hour	0.27	649,300	5,136,700	0.10	0.37	50	<1%
Lead	24-hour	2.7E-03	649,300	5,136,700	0.024	0.026	0.5	5%
	30 days	1.0E-03	649,300	5,136,700	9.2E-03	0.010	0.2	5%
Mercury	24-hour	8.0E-06	648,800	5,137,400	6.0E-05	6.8E-05	2	<1%
Molybdenum	24-hour	1.2E-03	649,300	5,136,700	0.029	0.030	120	<1%
Nickel	24-hour	1.2E-03	649,300	5,136,700	0.011	0.012	0.2	6%
	Annual	1.1E-03	649,300	5,136,700	2.5E-04	1.4E-03	0.04	3%
Selenium	24-hour	4.1E-03	649,200	5,136,600	7.8E-04	4.9E-03	10	<1%
Tungsten	24-hour	0.03	649,300	5,136,700	0.051	0.081	--	--
Zinc	24-hour	0.02	649,300	5,136,700	0.079	0.099	120	<1%

Notes:
A value in **bold** indicates a value in excess of the applicable objective, guideline or standard.

The maximum predicted ground-level concentrations during the Operation phase for selected air contaminants are presented in Figures 7.1.6 to 7.1.11. These include the predicted ground-level concentrations due to on-site Project sources plus background, with the exception of 24-hour PM_{10} or naphthalene, which does not include background concentrations (as previously noted).

During Operation, there were no predicted exceedances of the ground-level air quality objectives for NO_2, SO_2, CO, NH_3 and H_2S, including background where applicable. Similarly, the predicted maximum ground-level concentrations of PM, PM_{10} and $PM_{2.5}$ are below the applicable objectives and standards at the nearest residences and recreational campsites. The 24-hour PM objective was exceeded at three receptors near the primary crusher (approximately 20 m to the southwest of the crusher); however, the frequency of exceedance at these receptors is low (*i.e.*, up to four exceedances of the 24-hour PM objective over the 6-year meteorological file, or 0.2% of the time). Additionally, the model predicts maximum ground-level concentrations of PM and PM_{10} above the respective objectives and standards on occasion, along off-site access roads.

Table 7.1.13 provides the maximum predicted ambient ground-level concentrations of odourous compounds as 10-minute averages.

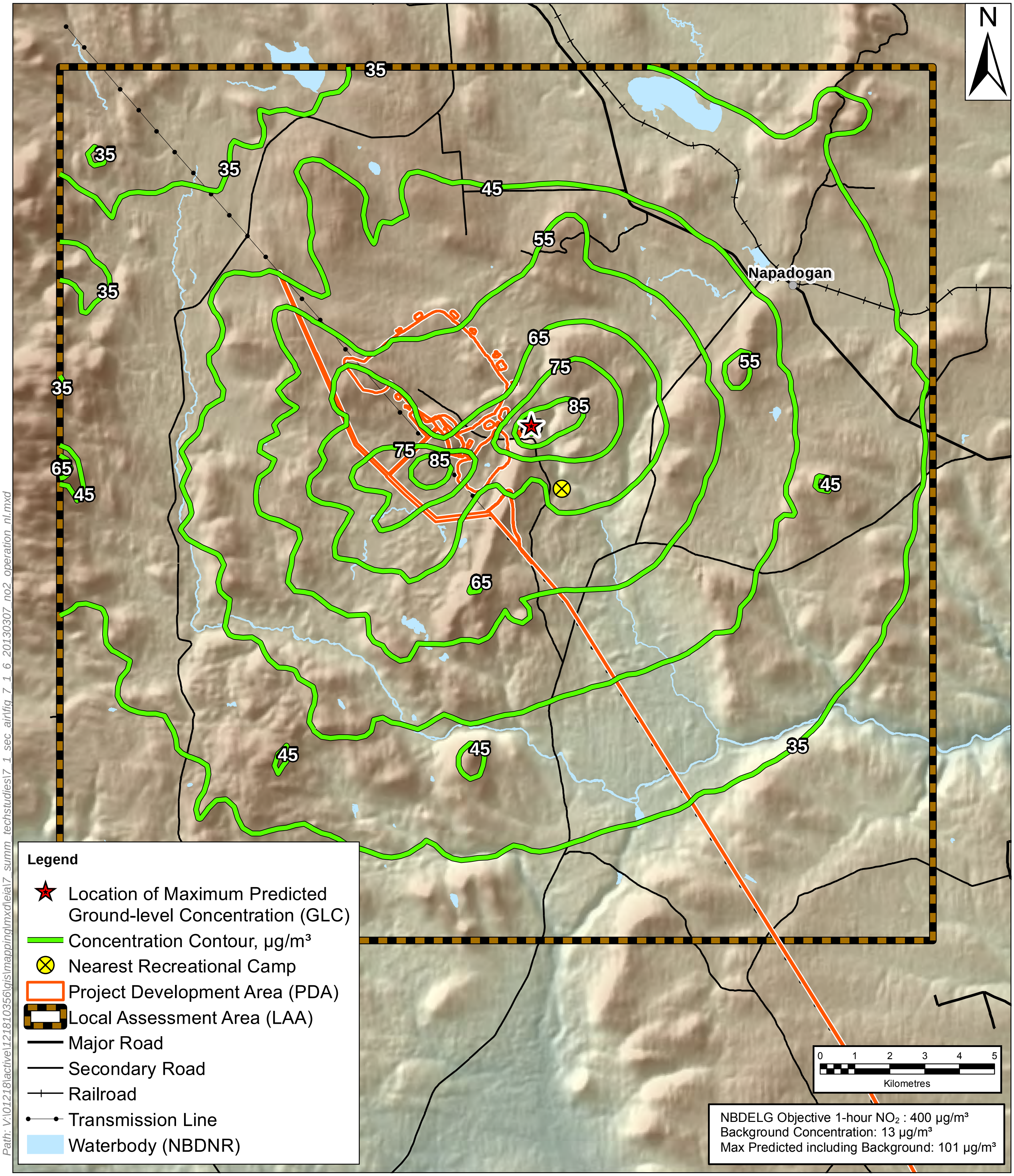
Table 7.1.13 Dispersion Modelling Results – Maximum Predicted 10-minute Ground Level Concentrations of Odourous Compounds – Operation Phase – Project Alone

Odourous Compound	Location of Modelled Maximum Ground-level Concentration		Maximum Overall Predicted 10-minute Ground-Level Concentration from the Project (µg/m^3)	Odour Threshold (µg/m^3)	Percentage of Odour Threshold
	UTM X (m)	UTM Y (m)			
Ammonia	648,800	5,137,400	0.72	2,312	<1%
Hydrogen Sulphide	648,800	5,137,400	**8.22**	7.4	**111%**
Decane	648,800	5,137,400	313	11,149	3%
Ethylbenzene	648,800	5,137,400	2.39	289	<1%
Naphthalene	648,800	5,137,400	8.66	50	17%

Notes:
A value in **bold** indicates a value in excess of the applicable odour threshold.

During Operation, the model predicts maximum 10-minute H_2S ground-level concentrations above the odour threshold at four locations. At the receptor location with the maximum predicted 10-minute H_2S ground-level concentration, the odour threshold is infrequently exceeded (*i.e.,* nine occurrences over the 6-year meteorological file, or less than 0.03% of the time). These receptors are located within 20 m to the southwest of the APT plant, on the Project site. No perceivable odour is expected beyond approximately 20 m of the APT plant.

Stantec modelled deposition, including wet and dry particulate and gaseous deposition, of applicable air contaminants. The deposition modelling was conducted using AERMOD. The predicted annual wet, dry and total deposition rates of trace metals and naphthalene were provided for inclusion as inputs to the human health and ecological risk assessment modelling.



NBDELG Objective 1-hour NO_2 : 400 µg/m³
Background Concentration: 13 µg/m³
Max Predicted including Background: 101 µg/m³

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NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Maximum Predicted 1-Hour Ground-Level Concentrations
of Nitrogen Dioxide –
Operation Phase – Project Plus Background

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Sisson Mines Ltd.

Scale: 1:150,000

Project No.: 121810356

Date: (dd/mm/yyyy) 23/11/2014

Dwn. By: JAB

Appd. By: DLM

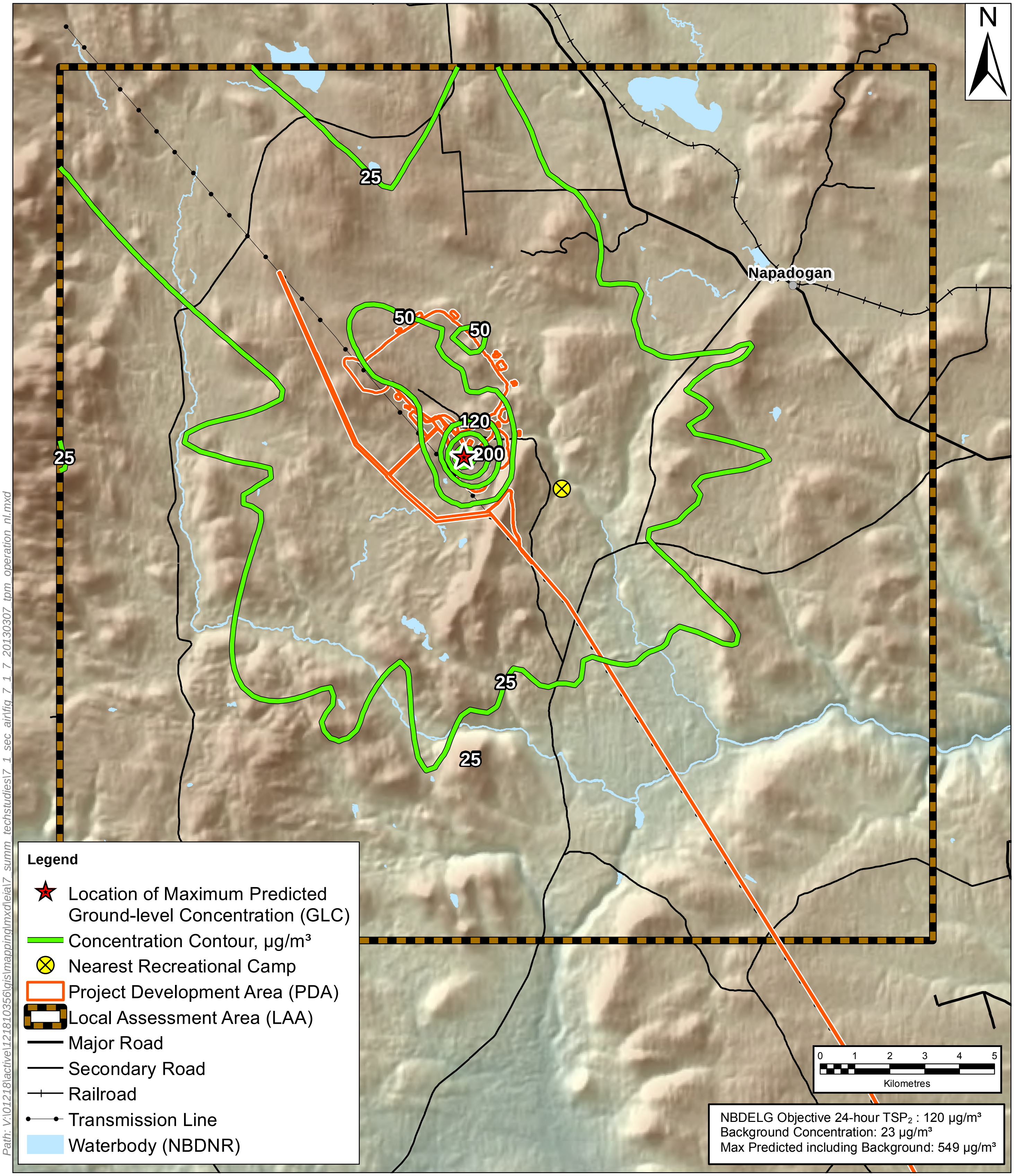
Data Sources: NBDNR

Fig. No.: 7.1.6

Stantec

Stantec Consulting Ltd. © 2013

Map: NAD83 CSRS NB Double Stereographic



Legend

★ Location of Maximum Predicted Ground-level Concentration (GLC)
🟩 Concentration Contour, µg/m³
⊗ Nearest Recreational Camp
🟥 Project Development Area (PDA)
▨ Local Assessment Area (LAA)
— Major Road
— Secondary Road
┼ Railroad
•—• Transmission Line
▨ Waterbody (NBDNR)

NBDELG Objective 24-hour TSP_2 : 120 µg/m³
Background Concentration: 23 µg/m³
Max Predicted including Background: 549 µg/m³

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NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Maximum Predicted 24-Hour Ground-Level Concentrations
of Total Particulate Matter –
Operation Phase – Project Plus Background

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Sisson Mines Ltd.

Scale: 1:150,000

Project No.: 121810356

Date: (dd/mm/yyyy) 23/11/2014

Dwn. By: JAB

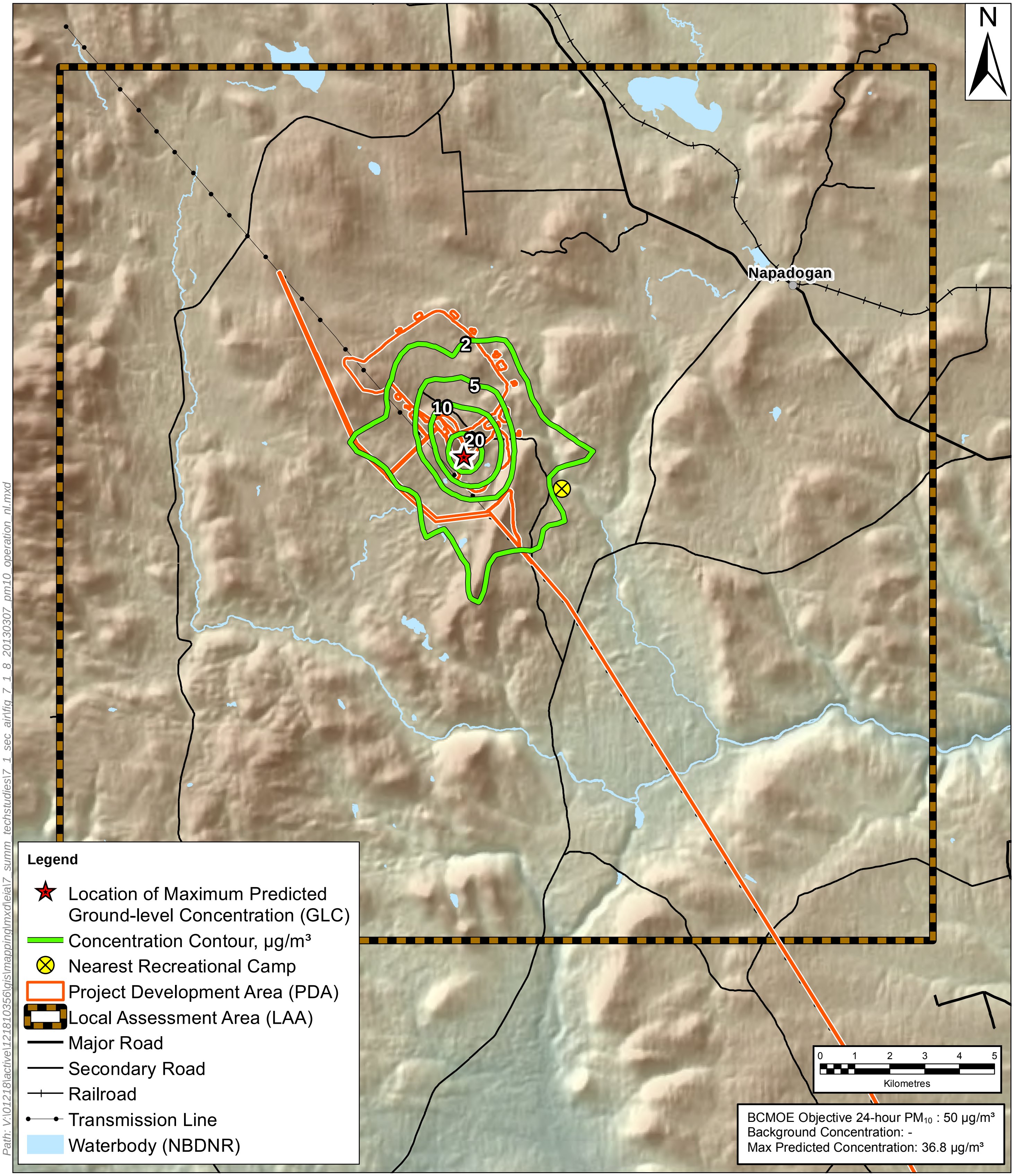
Appd. By: DLM

Data Sources: NBDNR

Fig. No.: 7.1.7

Stantec

Map: NAD83 CSRS NB Double Stereographic



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NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Maximum Predicted 24-Hour Ground-Level Concentrations of Particulate Matter Less Than 10 Microns – Operation Phase – Project Alone

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Sisson Mines Ltd.

Scale: 1:150,000

Project No.: 121810356

Data Sources: NBDNR

Fig. No.: 7.1.8

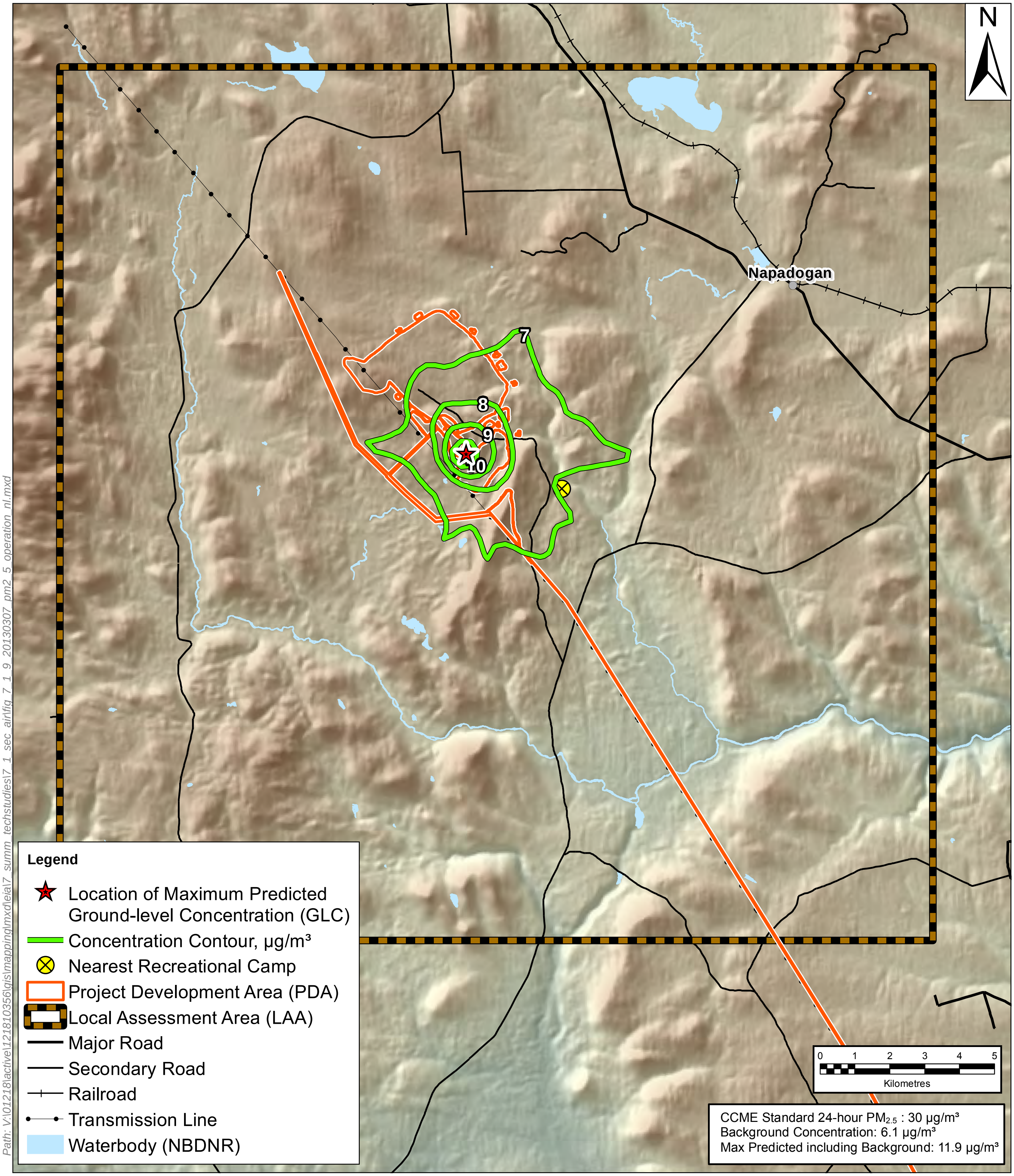
Date: (dd/mm/yyyy) 23/11/2014

Dwn. By: JAB

Appd. By: DLM

Stantec

Map: NAD83 CSRS NB Double Stereographic



CCME Standard 24-hour $PM_{2.5}$: 30 µg/m³
Background Concentration: 6.1 µg/m³
Max Predicted including Background: 11.9 µg/m³

Path: V:\01218\active\121810356\gis\mapping\mxd\eia\7 summ techstudies\7 1 sec airfig 7 1 9 20130307 pm2 5 operation nl.mxd

NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Maximum Predicted 24-Hour Ground-Level Concentrations
of Particulate Matter Less Than 2.5 Microns –
Operation Phase – Project Plus Background

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Sisson Mines Ltd.

Scale: 1:150,000

Project No.: 121810356

Date: (dd/mm/yyyy) 23/11/2014

Dwn. By: JAB

Appd. By: DLM

Data Sources: NBDNR

Fig. No.: 7.1.9

Stantec

Map: NAD83 CSRS NB Double Stereographic

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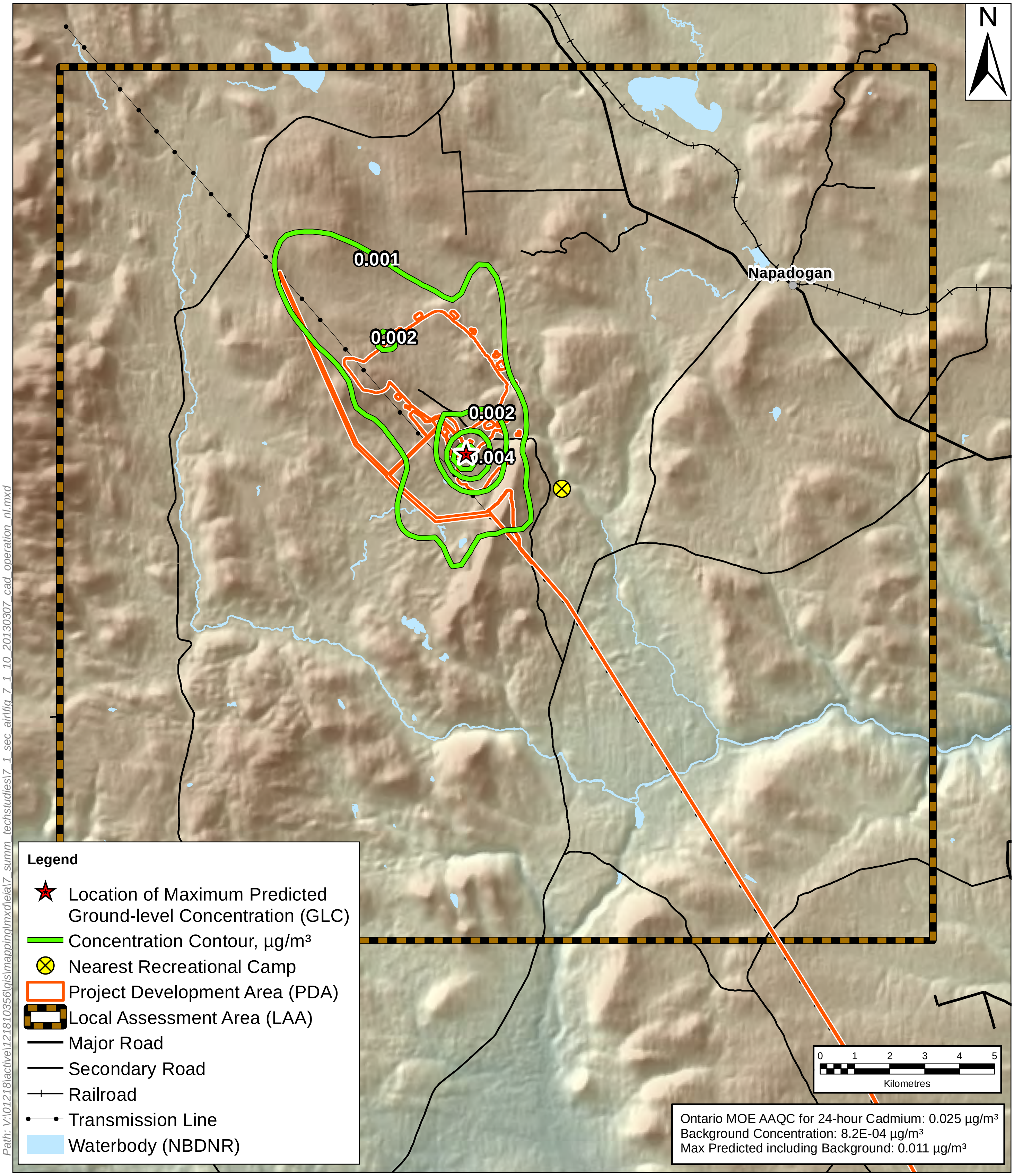


Ontario MOE AAQC for 24-hour Cadmium: 0.025 µg/m³
Background Concentration: 8.2E-04 µg/m³
Max Predicted including Background: 0.011 µg/m³

NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Maximum Predicted 24-Hour Ground-Level Concentrations
of Cadmium -
Operation Phase - Project Plus Background

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Sisson Mines Ltd.

Scale: 1:150,000

Project No.: 121810356

Data Sources: NBDNR

Fig. No.: 7.1.10

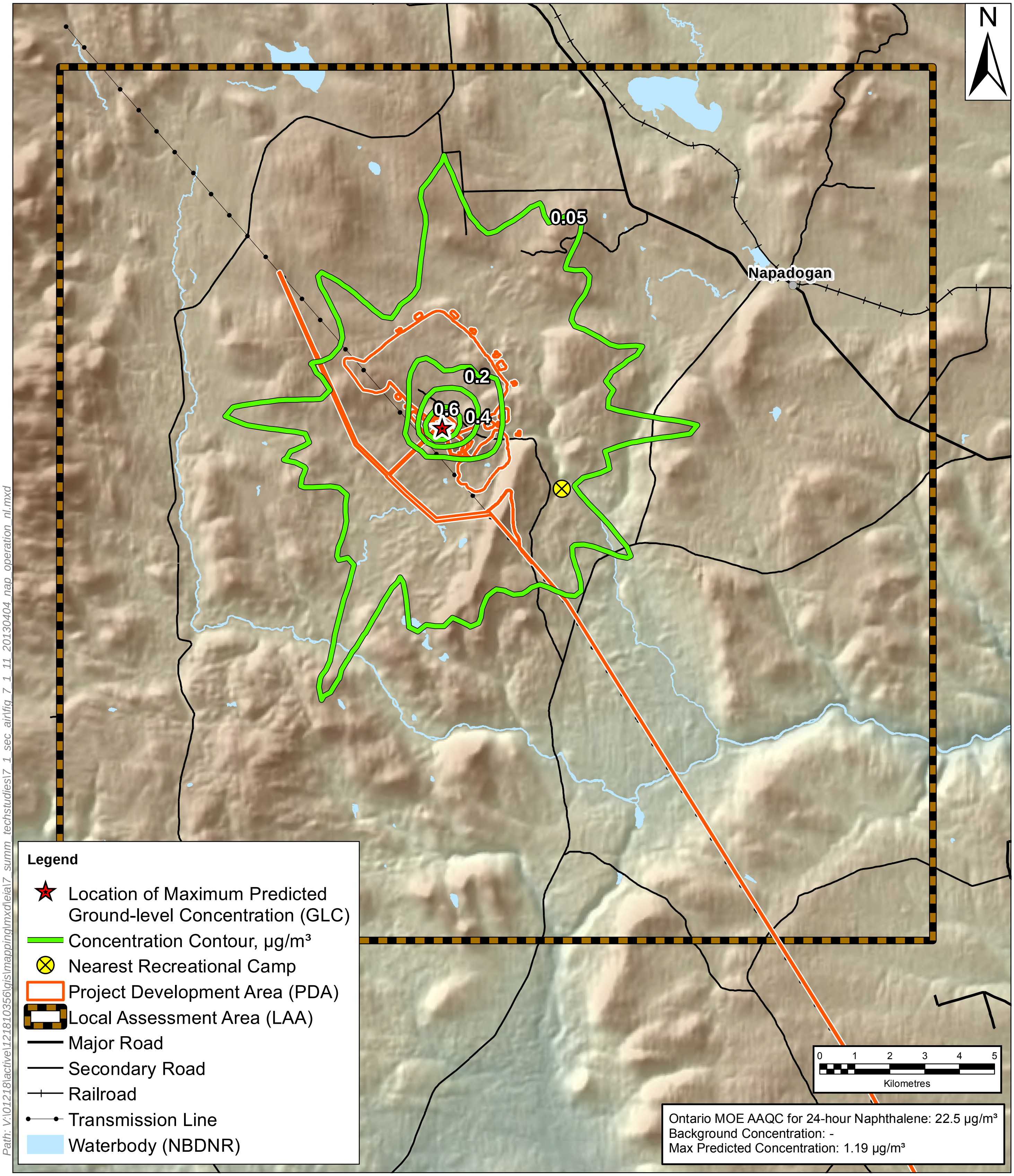
Date: (dd/mm/yyyy) 23/11/2014

Dwn. By: JAB

Appd. By: DLM

Stantec

Map: NAD83 CSRS NB Double Stereographic



Ontario MOE AAQC for 24-hour Naphthalene: 22.5 µg/m³
Background Concentration: -
Max Predicted Concentration: 1.19 µg/m³

Path: V:\01218\active\121810356\gis\mapping\mxd\eia\7 summ techstudies\7 1 sec air\fig 7 1 11 20130404 nap operation nl.mxd

NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Maximum Predicted 24-Hour Ground-Level Concentrations of Naphthalene –
Operation Phase – Project Alone

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Sisson Mines Ltd.

Scale: 1:150,000

Project No.: 121810356

Date: (dd/mm/yyyy) 23/11/2014

Dwn. By: JAB

Appd. By: DLM

Data Sources: NBDNR

Fig. No.: 7.1.11

Stantec

Map: NAD83 CSRS NB Double Stereographic

7.2 GREENHOUSE GAS (GHG) EMISSIONS

7.2.1 Project GHG Emissions Compared to New Brunswick, Canadian, and Global GHG Emissions

To quantitatively evaluate the change in GHG emissions provincially and globally due to Project Construction and Operation, estimated Project emissions were compared to published summary data for the province, Canada and the world. Table 7.2.1 presents these data.

Table 7.2.1 Comparison of Estimated Project GHG Emissions to Provincial and Global Totals

GHG Source	Total Estimated Emissions (kilotonnes CO_2e/a)
Project Construction (per year, based on 2 years of construction)	13.6
Project Operation – direct – per year	47.7
Project Operation – indirect (electricity) – per year	184
New Brunswick – Electricity and Heating sectors (per year, based on 2010 emissions)	5,470
New Brunswick Total (per year, based on 2010 emissions)	18,600
Canada Total (per year, based on 2010 emissions)	692,000
World Total (CAIT 2012)[a]	34,000,000

Notes:

[a] Represents CO_2 only.

In comparison to other large GHG emitters in New Brunswick, the Project is a relatively small contributor to provincial emissions, estimated to represent less than 0.3% annually during Operation (based on direct emissions).

In terms of indirect GHG emissions related to electricity use, the magnitude of these emissions will be essentially controlled by the emission factor for electricity provided from the New Brunswick electrical grid. The Project's GHG emissions during Operation are less than 3% compared to overall emissions from electrical generation in the province (Project indirect emissions) (New Brunswick Department of Energy 2011). It is important to also note that existing regulations and guidelines, for the most part, focus on direct emissions with the requirement that the emitter is responsible for their emissions management.

7.2.2 Project GHG Emissions Compared to Other Mining Operations in Canada

For comparison, GHG emissions from other operations within the mining industry were also reviewed. Fifteen metal mining operations reported GHG emissions to Environment Canada in 2010 (Environment Canada 2011b). Environment Canada requires reporting of GHG emissions from mining operations that release more than 50 kilotonnes (kt) per year of GHG. A summary of the reported emissions is provided in Table 7.2.2.

Table 7.2.2 Summary of Reported GHG Emissions from Canadian Mines - 2010

Facility	Reporting Company	Province	Material Mined[a]	Mining Type[a]	Reported Emissions (kilotonnes CO_2e/a)
Brunswick Mine	Xstrata Canada Corporation	New Brunswick	Lead, Zinc, Copper, Silver, Gold	Underground with Concentrator	58.3
Carol Project	Iron Ore Company of Canada	Newfoundland and Labrador	Iron	Open Pit with Concentrator	1,128
Fire Lake Mine[b]	ArcelorMittal Mines Canada	Québec	Iron	Open Pit	1.2
Meadow Bank Division	Agnico-Eagle Meadowbank	Nunavut	Gold	Open Pit with Concentrator	135
Mine du Mont-Wright	ArcelorMittal Mines Canada	Québec	Iron	Open Pit with Concentrator	151
Mines Wabush – Sept-Iles	Mines Wabush	Québec	Iron	Concentrator	396
Mount Polley Mine	Imperial Metals Corporation	British Columbia	Copper, Gold	Open Pit with Concentrator	45.3
Musselwhite Mine	Goldcorp Canada Ltd.	Ontario	Gold	Underground with Concentrator	48.8
Raglan Mine	Xstrata Canada Corporation	Québec	Nickel, Copper, Cobalt	Open Pit, Underground, with Concentrator	136
Teck Highland Valley Copper Partnership	Teck Highland Valley Copper Partnership	British Columbia	Copper, Molybdenum	Open Pit with Concentration	182
Thompson Operations	Vale Canada Limited	Manitoba	Nickel, Copper, Cobalt	Open Pit, Underground, with Concentrator	51.9
Usine de Bouletage	ArcelorMittal Mines Canada	Québec	Iron	Iron Pellet Plant	957
Voisey's Bay Mine	Vale Newfoundland and Labrador Limited	Newfoundland and Labrador	Nickel, Copper, Cobalt	Open Pit with Concentrator	67.3
Wabush Mines – Scully	Mines Wabush	Newfoundland and Labrador	Iron	Open Pit with Concentrator	96.1
Xstrata Nickel Sudbury Smelter	Xstrata Canada Corporation	Ontario	Nickel, Copper, Cobalt	Underground	115

Notes:

[a] The Mining Association of Canada (2011).

[b] Only operates between May and October (ArcelorMittal n.d.).

As shown in Table 7.2.2, the reporting mines released between 1.2 kt CO_2e and 1,128 kt CO_2e per year. The Project's estimated GHG emissions of 47.7 kt CO_2e/a during Operation are thus within the range of other mining operations and less than most reported.

Only GHG emissions from sources operated by the mine (*e.g.,* heavy equipment and stationary combustion fuel use) are reportable under the Environment Canada system. For the purpose of this EIA, some third party emissions were also included (*e.g.,* personnel transport, delivery vehicles) although those contributions were minor in comparison to the total facility GHG emissions.

7.2.3 GHG Emissions Intensity from the Project

With regard to GHG emissions intensity, the Sisson Project, with annual direct GHG emissions of approximately 47.7 kt CO_2e and 10.5 million tonnes of processed ore per year, therefore has a calculated GHG emissions intensity of 0.005 t CO_2e per tonne of ore processed.

Stantec conducted a review of available information on GHG intensities from mines in Canada. The Mount Polley mine is an open pit mine in British Columbia with an average mining rate of 20,000 tonnes per day (Imperial Metals 2010). The GHG emissions intensity of this mine is approximately 0.006 t CO_2e per tonne of ore processed. This is similar to the GHG emissions intensity of the Sisson Project.

The direct GHG emissions intensity for mining across all metal mining sectors in Canada in 2010 was approximately 0.014 t CO_2e per tonne of ore milled (CIEEDAC 2012). The GHG intensity of the Sisson Project is below the Canada-wide GHG emissions intensity.

7.2.4 Loss of Carbon Dioxide Sinks

With respect to the loss of carbon storage due to tree removal to accommodate the Project, the mass of carbon dioxide that is stored in trees within the PDA, based on a PDA area of 1,253 ha, is estimated at 8,419 t CO_2. This is a one-time loss that will be released from the aerobic decomposition of trees, which have been conservatively assumed to be cut and allowed to decay, whereas in reality, merchantable timber will be sold and other timber in the area of the TSF will be cut, buried in tailings and flooded before it decays. The total estimated CO_2 storage capacity in trees in New Brunswick is approximately 41 Mt CO_2. It was assumed that the trees in New Brunswick are 50% deciduous and 50% coniferous, with carbon storage data from the United States Department of Energy (USDOE 2000).

7.3 SOUND QUALITY AND VIBRATION MODELLING

As discussed in Chapter 3, the Project will release sound and vibration emissions to the ambient environment through Construction, Operation, and ultimately through Decommissioning, Reclamation and Closure activities. Among other sources, sound and/or vibration emissions may result from:

- the movement and use of heavy equipment on-site during Construction, and from the movement of ore and waste rock during Operation;
- the movement of heavy-duty trucks and passenger vehicles (including medium and light-duty vehicles) on-site and to and from the Project site during Construction, Operation, and Decommissioning, Reclamation and Closure;
- blasting activities during Construction and Operation for the movement of rock for construction purposes, and from ore extraction and mining activities during Operation; and
- operation of the mill and processing facilities, in particular from the crushers and associated conveying equipment, during Operation.

The assessment of the Project-related environmental effects on Sound Quality (Section 8.3) is based on the following three steps:

- monitoring of baseline sound pressure levels in the ambient environment near the Project in 2011 to determine existing (baseline) sound pressure levels in and near the PDA (see Section 8.3.2);
- estimating Project-related emissions of sound and vibration from the anticipated inventory of stationary and mobile sound emission sources associated with the Project during each phase, and anticipated emissions for these sources based on existing literature of sound power levels (see Sections 3.4.1.6.2 and 3.4.2.5.2 for sound emissions inventory during Construction and Operation, respectively); and
- modelling sound pressure levels and vibration emissions in the ambient environment using computer software that simulates how the emitted sound or vibration waves from the Project will propagate in the ambient environment near the Project (this Section).

7.3.1 Modelling Methodology

7.3.1.1 Sound

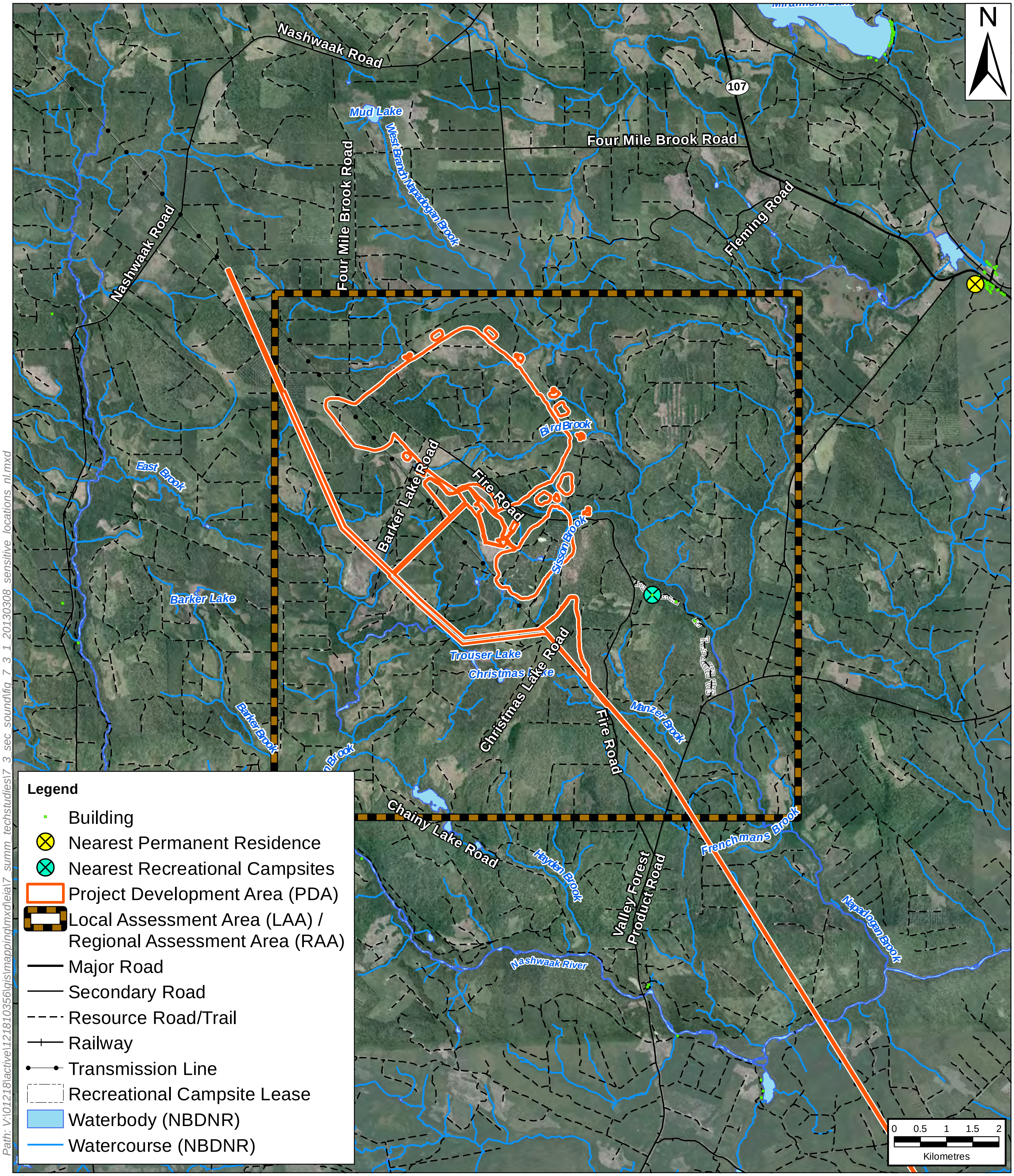
Stantec used the computer modelling software CadnaA (version 4.1.137) to estimate sound pressure levels from Project activities during Construction and Operation. Sound pressure levels from the Project during Decommissioning, Reclamation and Closure were assumed to be similar to those which would result during the Construction phase (*i.e.,* earth moving activities and hauling of decommissioned Project-related infrastructure to and from the Project site).

Inputs to the CadnaA model include: sound power levels at the source for Project-related equipment (*e.g.,* mobile equipment, stationary sources); terrain elevations; estimated hourly traffic volumes during each phase; and the identification of noise sensitive receptors.

The nearest noise sensitive receptors selected for the prediction of Project-related sound emissions were identified as the nearest residential receptor in Napadogan (approximately 10 km to the northeast of the Project site), and the nearest recreational campsite (located approximately 1.5 km to the east of the Project site) (Figure 7.3.1). Recreational campsites at further distances can be expected to experience lower sound pressure levels due to the Project in comparison to this location. This is supported by the model results shown in Figure 7.3.3 and 7.3.4.

Vehicle traffic on the two main access roads to the Project was also included in the model. As shown in Figure 7.3.2, Project-related vehicles may access the Project site via the Valley Forest Products Road (starting in Nackawic, identified in this EIA Report as the “Primary Site Access” route or “PSA”) or via the Four Mile Brook Road (starting about 6 km west of Napadogan off Route 107, identified in this EIA Report as the “Secondary Site Access” route, or “SSA”). It was assumed in the model set-up that transportation activities during all phases will only occur during daytime/evening hours (07:00 to 22:00). The Project traffic used in the modelling was provided by Northcliff based on expected activities during each phase (Tables 3.4.10 and 3.4.33).

The existing background sound pressure levels at the recreational campsite and at the nearest residence receptor to the Project in Napadogan were based on measured data (Section 8.3.2). Note that monitoring to represent Napadogan was conducted near the intersection of the Four Mile Brook Road and Route 107, along the SSA route, to represent anticipated sound pressure levels at residential receptors in Napadogan. Based on the proximity to the highway, these data are considered to be representative of the noise from traffic passing through Napadogan and as could be experienced at residential receptors in this community. From the monitoring results, the maximum daytime and nighttime 1-h L_{eq} levels were selected in order to conservatively represent the background conditions. These levels were compared to the 1-h L_{eq} criteria (65 dB_A during daytime and 55 dB_A during nighttime). These criteria are based on typical regulatory values applied in New Brunswick through Certificates of Approval to Operate issued to industrial facilities under Regulation 97-133 of the *Clean Air Act*. For the nearest residential receptor in Napadogan (approximately 10 km northeast of the mine site), the highest daytime and nighttime background 1-h L_{eq} sound levels were established as 59 dB_A, as measured near the intersection of Four Mile Brook Road and Route 107. These measurements indicate that trucking on Route 107 (the main suspected cause of these sound levels) occurs during day and night. At the nearest recreational campsite (approximately 1.5 km east of the open pit location), the highest monitored daytime and nighttime background levels were 62 dB_A and 46 dB_A, respectively. The predicted Project sound emissions were added to these background levels to estimate the combined future sound pressure level at the nearest receptors. The estimates are considered conservative (*i.e.*, worst case) due to the use of the maximum 1-h L_{eq} measured backgrounds, thereby estimating the combined Project and background sound pressure levels during the loudest hour of the day and night.



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NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Noise Sensitive Locations

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Sisson Mines Ltd.

Scale: 1:100,000

Project No.: 121810356

Data Sources: NBDNR

Fig. No.: 7.3.1

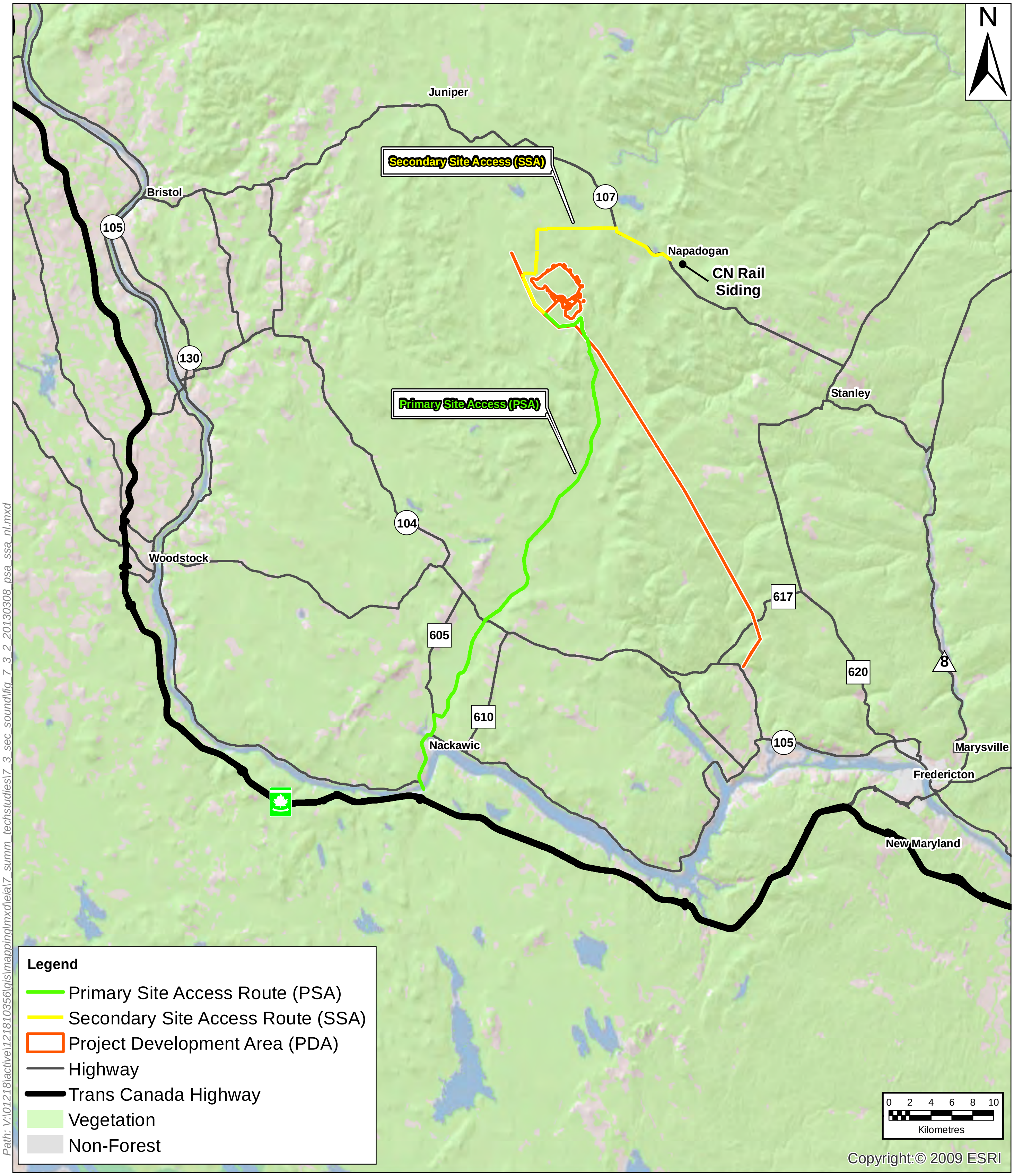
Date: (dd/mm/yyyy) 23/11/2014

Dwn. By: JAB

Appd. By: DLM

Stantec

Map: NAD83 CSRS NB Double Stereographic



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NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Primary Site Access (PSA) Route and Secondary Site Access (SSA) Route

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Sisson Mines Ltd.

Scale: 1:500,000	Project No.: 121810356		Data Sources: NBDNR ArcGIS Online	Fig. No.: 7.3.2
Date: (dd/mm/yyyy) 23/11/2014	Dwn. By: JAB	Appd. By: DLM		

Stantec

Map: NAD83 CSRS NB Double Stereographic

A further comparison was made using the percent highly annoyed metric, as advocated by Health Canada's EA guidance (Health Canada 2010d). The monitored average day-night equivalent (L_{DN}) was used to estimate the average baseline percent annoyed at Napadogan and at the recreational campsite. The 24 1-h L_{eq} values for the average day were added to the predicted Project contribution to determine the percent annoyed during Construction and Operation of the Project. The algorithm to calculate the percent highly annoyed is an empirical relation defined by ISO 1996-1:2003 (Canadian Standards Association 2003) and referenced by Health Canada (Health Canada 2010d).

7.3.1.2 Vibration

The equation to estimate vibration from equipment at various distances is:

$$PPV = PPV_{ref}\, x(\frac{25}{D})^{n}$$

Peak particle velocity (PPV) is the estimate of the speed of the wave front at the distance D (the highest value for a given circumstance, soil type as an example), PPV_{REF} is the reference PPV at 7.6 m (25 feet), and n is the attenuation rate. The reference PPV is a value established for a given piece of equipment, and used here as a guideline value for purposes of estimating vibration levels at distances further out from the source. Jones & Stokes (2004) recommend the use of 1.1 for the value of n as a conservative attenuation rate in typical soil. Jones & Stokes developed a manual of practical guidance for the California Department of Transportation for use by engineers, planners, and consultants addressing vibration issues associated with the construction, operation, and maintenance of transportation and construction projects (Jones & Stokes 2004).

Baseline vibration monitoring was not conducted because there are no substantive vibration producing sources near the Project site, and existing levels of vibration are therefore expected to be negligible. In Napadogan, passing vehicles, including transport trucks, may induce a vibration near the roadway. However the transient vibration of passing vehicles would not act cumulatively with Project-related vibration. This is because only one truck would be passing at any given time (in each direction potentially). Therefore an evaluation of the vibration from a passing truck at the nearest residence would be representative of vibration from existing or Project related traffic.

7.3.2 Modelling Results

7.3.2.1 Construction

7.3.2.1.1 Sound

To estimate sound pressure levels from the Project during Construction, Stantec considered the worst case scenario where construction equipment is located at the edge of the PDA nearest the recreational campsite. Due to the planned mining schedule, where the farthest extent of the pit will not be reached until later in the Operation phase, it is likely that construction equipment will actually be at further distances from the recreational campsite than those used in the model. Thus, the modelling should represent conservatively high predictions for sound pressure levels at the recreational campsites during Construction.

Modelling was not conducted for the nighttime period for the Construction phase, as construction activities, including trucking, are not anticipated to occur at night. Hence, the nighttime sound pressure levels were assumed to be identical to the nighttime background levels at each receptor.

The results of the modelling of Construction activities are provided in Tables 7.3.1 (hourly L_{eq} evaluation) and 7.3.2 (change in % highly annoyed evaluation). The predicted sound pressure levels within 100 km^2 surrounding the Project during Construction are also shown graphically in Figure 7.3.3.

Table 7.3.1 Construction Sound Modelling Results – 1-h L_{eq}

Receptor	Daytime Background Level – Maximum Observed 1-h L_{eq} (dB_A)	Predicted Project Daytime 1-h L_{eq} (dB_A)	Project + Background 1-h L_{eq} (dB_A)	Below 65 dB_A?
Closest Residential Receptor (Napadogan, approximately 10 km northeast of Project site)	59	3	59	Yes
Closest Recreational Campsite (approximately 1.5 km east of open pit)	62	29	62	Yes

Notes:
As sound pressure levels are a logarithmic measure, Project + Background L_{eq} is calculated using a logarithmic equation (not directly additive). $L_\Sigma = 10 \cdot \log_{10}(10^{\frac{L_1}{10}} + 10^{\frac{L_2}{10}} + \cdots + 10^{\frac{L_n}{10}})dB$

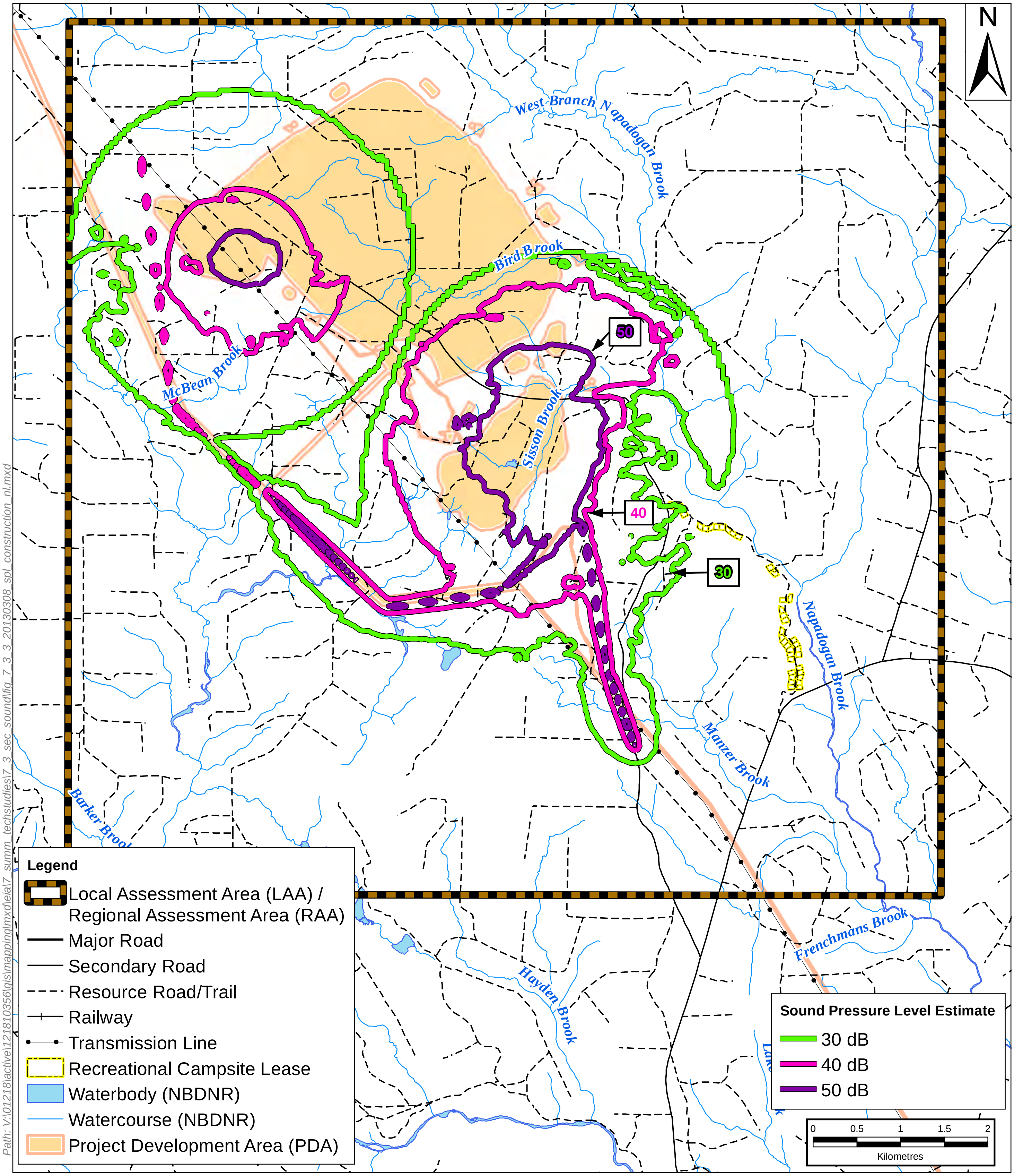
Table 7.3.2 Construction Sound Modelling Results – Percent Highly Annoyed

Receptor	Average Background L_{DN} (dB_A)	Predicted Project Daytime 1-h L_{eq} (dB_A)	Project + Background L_{DN} (dB_A)	% Highly Annoyed Background	% Highly Annoyed (Project + Background)	Difference
Closest Residential Receptor (Napadogan, approximately 10 km northeast of Project site)	58	34	58	5.8	5.8	0
Closest Recreational Campsite (approximately 1.5 km east of open pit)	48	29	48	1.7	1.7	0

Notes:
Percent Highly Annoyed is calculated as described in Annex D of ISO 1996-1:2003, based on Schultz curve, represented by
$HA = 100 / [1 + \exp(10.4 - 0.132 L_{dn})]\%$

Note that transportation sources on Route 107 are currently the main contributing sources to sound pressure levels in Napadogan.

As presented in Table 7.3.2, the day-night equivalent sound pressure level will not noticeably increase with Project activities, and no change in % highly annoyed is expected.



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NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Sound Pressure Level Estimates - Construction Phase

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Sisson Mines Ltd.

Scale: 1:60,000

Project No.: 121810356

Data Sources: NBDNR

Fig. No.: 7.3.3

Date: (dd/mm/yyyy) 23/11/2014

Dwn. By: JAB

Appd. By: DLM

Stantec

Map: NAD83 CSRS NB Double Stereographic

7.3.2.1.2 Vibration

The largest piece of mobile construction equipment at the Project site is likely to be a large bulldozer, which has a reference PPV of 2.3 mm/s at a distance of 7.6 m. At a distance of 1,500 m (to the nearest recreational campsite from the edge of the open pit), the estimated PPV due to the operation of a large bulldozer is 0.007 mm/s, which is well below the threshold of perceptibility of 0.15 mm/s for steady-state vibration reported by Jones & Stokes (2004). For context, the largest distance for which vibration from construction activities would be perceivable is approximately 300 m.

No pile driving will be required during Construction.

7.3.2.1.3 Sound and Vibration from Blasting

Blasting at the plant site will be required using a balanced cut and fill method to level the area for the ore processing plant. This blasting will use smaller holes and charges than required in the pit during Operation. Some blasting and crushing of rocky material may occur in the quarry area during Construction. Some blasting in the open pit area will also occur during Construction as stockpiling of ore for start-up begins. Since the quarry and the ore processing plant are located farther from the recreational campsites than the open pit (approximately 5.6 km), the analysis of vibration from the open pit during Construction and Operation will be considered to conservatively evaluate vibration from blasting in other areas during Construction. The sound pressure level due to blasting in the quarry and at the ore processing plant may be noticeably above background at the recreational campsites, but is anticipated to be lower in magnitude than the sound pressure level due to blasting in the open pit once Operation begins (due to the further distance between the recreational campsites and the quarry and ore processing plant, in comparison to the open pit). Thus, if analysis of vibration and sound pressure levels from blasting during Operation of the open pit is shown to be within criteria, it can be inferred that vibration and sound pressure levels from blasting during Construction will also be within the criteria given its farther distance from residential or recreational receptors than the open pit.

7.3.2.2 Operation

7.3.2.2.1 Sound

The modelling of sound emissions from Operation was based on normal Operation activities, including drilling of blasting holes, blasting, ore loading onto the mine trucks, transportation, processing of ore material, and transportation of products. For the purpose of modelling, Stantec placed mining equipment at representative locations throughout the site, including the open pit, the processing building, the tailings storage facility (TSF), and the quarry.

The modelling results are presented in Tables 7.3.3 (1-h L_{eq} evaluation) and 7.3.4 (% highly annoyed). The predicted sound pressure levels within 100 km^2 surrounding the Project during Operation are shown in Figure 7.3.4.

Table 7.3.3 Operation Sound Modelling Results – 1-h L_{eq}

Receptor	Daytime Background Level - Max (dB$_A$)	Nighttime Background Level - Max (dB$_A$)	Project Daytime Hourly L_{eq} (dB$_A$)	Project Nighttime Hourly L_{eq} (dB$_A$)	Project + Max Background Hourly L_{eq} Daytime (dB$_A$)	Project + Max Background Hourly L_{eq} Nighttime (dB$_A$)	Meets 1-h Guidance?
Closest residential receptor (Napadogan, 10 km from site)	59	59	35	No Contribution[a]	59	59	No - maximum background is above 55 dB$_A$.
Closest recreational campsite (1.5 km from open pit)	62	47	29	23	62	47	Yes

Notes:

[a] It is assumed that there are no trucking activities at night during Operation ,and sound from site activities is predicted to not be perceivable in Napadogan.

1) As sound pressure levels are a logarithmic measure, Project + Background L_{eq} is calculated using a logarithmic equation (not directly additive). $L_\Sigma = 10 \cdot \log_{10}(10^{\frac{L_1}{10}} + 10^{\frac{L_2}{10}} + \cdots + 10^{\frac{L_n}{10}})dB$

Table 7.3.4 Operation Sound Modelling Results – Percent Highly Annoyed

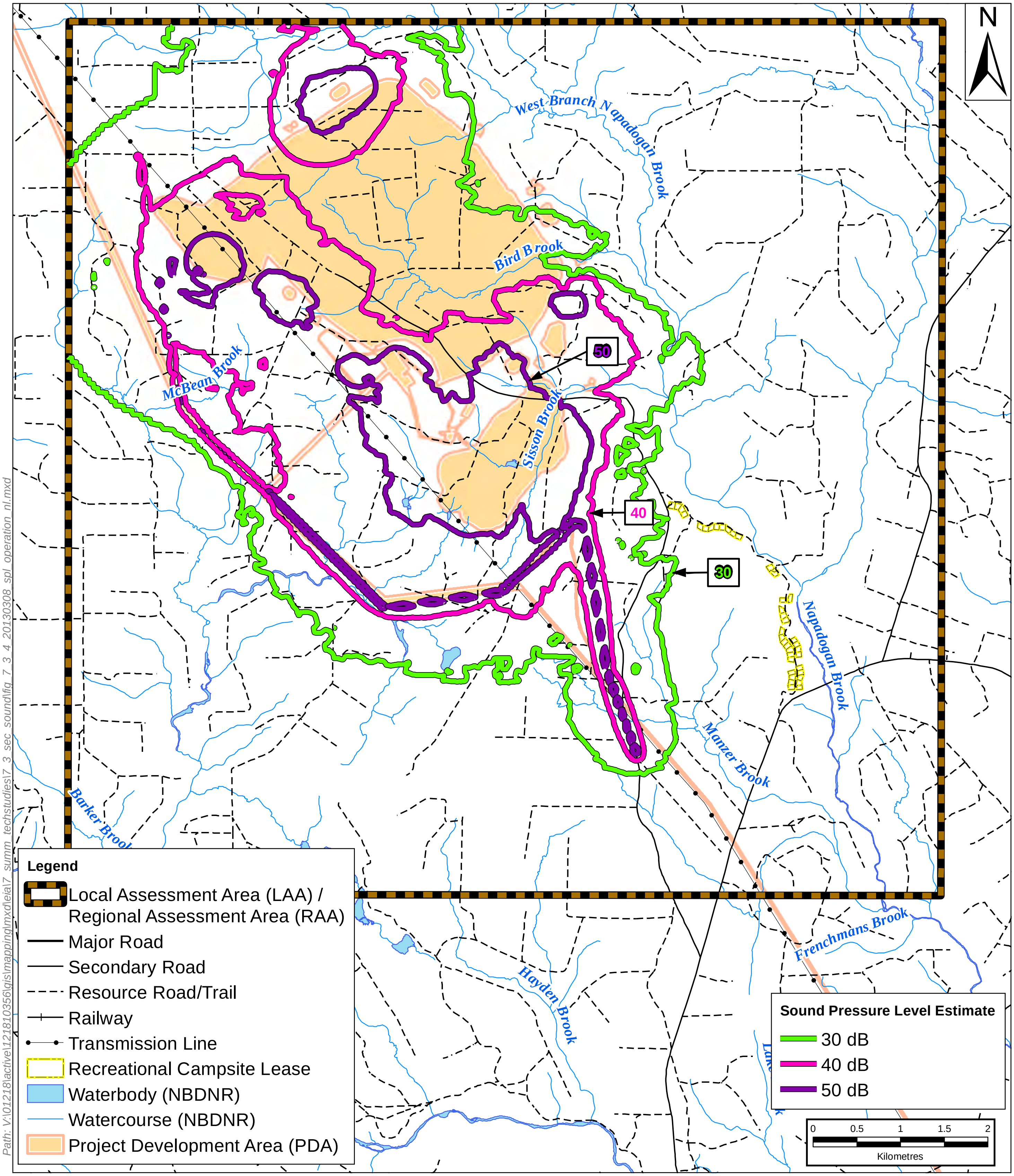
Receptor	Average Background L_{DN} (dB$_A$)	Project Daytime Hourly L_{eq} (dB$_A$)	Project Nighttime Hourly L_{eq} (dB$_A$)	Project + Background L_{DN} (dB$_A$)	% HA Background	% HA (Project + Background)	Difference
Closest residential receptor (Napadogan, 10 km from site)	58	33	0 (no trucking at night)	58	5.8	5.8	0
Closest recreational campsite (1.5 km from open pit)	48	25	23	48	1.7	1.7	0

Notes:

Percent Highly Annoyed is calculated as described in Annex D of ISO 1996-1:2003, based on Schultz curve, represented by $HA = 100/[1 + \exp(10.4 - 0.132 L_{dn})]\%$

The instantaneous sound pressure levels (during a two-second blast at the surface and at the commencement of mining before the activity recedes into the pit) from open pit blasting at the nearest recreational campsite and the nearest residential receptor are predicted to be 80 dB$_A$ and 56 dB$_A$, respectively. For context, a sound pressure level of 75 dB$_A$ can be experienced by standing at the corner of a busy traffic intersection (ERCB 2007b).

The sound pressure level at the recreational campsite is predicted to be above the measured daytime background during blasting; however, considering that the impulse noise will last only for several seconds, the 1-h L_{eq} for any hour with a blasting event will increase slightly (predicted to be to 2 to 15 dB$_A$ considering both the highest and lowest measured daytime L_{eq}). Blasting may occur at night; the subsequent 1-h L_{eq} may be as high as 48 dB$_A$ (considering the minimum 1-h L_{eq} measured as background). At the residences in Napadogan, the sound pressure level due to blasting will be similar or less than the background level.



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NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Sound Pressure Level Estimates - Operation Phase

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Sisson Mines Ltd.

Scale: 1:60,000

Project No.: 121810356

Data Sources: NBDNR

Fig. No.: 7.3.4

Date: (dd/mm/yyyy) 23/11/2014

Dwn. By: JAB

Appd. By: DLM

Stantec

Map: NAD83 CSRS NB Double Stereographic

7.3.2.2.2 Vibration

The main sources of vibration during Operation are the movement of the loaded trucks from the pit to the crushing equipment and the crushing equipment itself. Similar to the assessment of vibration from construction equipment, reference PPVs from loaded trucks were found and are provided in Table 3.4.11.

The estimated PPV at the nearest residential campsite is 0.007 mm/s, which is below the threshold of perceptibility of 0.15 mm/s for steady state vibration (Jones & Stokes 2004).

7.3.2.2.3 Sound and Vibration from Blasting

Sound and vibration levels due to blasting events were estimated using the prediction graphs in “Guidelines on Information Required for the Assessment of Blasting Noise and Vibration” produced by the Ontario Ministry of Environment (OMOE 1985). The scaled distances for sound and vibration were estimated for an average instantaneous charge of 998 kg and various distances to a receptor; these are shown in Table 7.3.5.

Table 7.3.5 Estimated Sound Pressure Levels and Peak Particle Velocities Associated with Blasting

Emission	Distance From Source (m)				
	1,000	1,500	3,000	5,000	10,000
Sound Pressure Level (dB_A)	85	80	71	65	56
Vibration (mm/s)	4.5	2.4	0.8	0.4	0.1

Notes:
1) Threshold of vibration perception is 0.15 mm/s (Jones & Stokes 2004).
2) The linear dB results were converted to the A-weighted dB scale by subtracting 45 dB (assuming a frequency of 25 Hz for blasting noise).

Ground vibration at the nearest recreational campsite (1,500 m away) during a blasting event may reach a PPV of 2.4 mm/s for several seconds. The PPV perceived during a blast at the nearest campsite would be similar to the vibration experienced when a large bulldozer operates 7.6 m away. The occupants of the recreational campsite may find this PPV perceptible (Jones and Stokes 2004), especially considering that the warning horns would have alerted occupants to an imminent blast. Approximately 8.5 km from the blasting event, the vibration is anticipated to be imperceptible.

7.4 FISH HABITAT LOSS AND PLAN TO OFFSET SERIOUS HARM TO FISH

7.4.1 Overview

As discussed in Chapter 3, the Project will alter the drainage patterns and stream flows in the Napadogan Brook watershed (and to a lesser extent in the McBean Brook watershed) as a result of Project-related activities to be conducted during the Construction, Operation, and ultimately Decommissioning, Reclamation and Closure phases of the Project. These flow alterations will result in both the direct loss of physical habitat for fish and other aquatic organisms, and the indirect loss of habitat due to flow reductions downstream of the Project. Direct loss is the direct destruction of fish habitat that will occur where the physical features and facilities associated with the Project encroach on existing watercourses. Indirect loss is the indirect destruction, reduction, or alteration of fish habitat area that may occur where stream flows are reduced due to Project-induced changes in watershed (or catchment) area, thereby resulting in a reduction in the available area of fish habitat.

As required by the *Fisheries Act*, and as discussed in Section 4.1.2.1, serious harm to fish that are part of a CRA fisheries will need to be authorized under Section 35(2) of the Act. Along with this authorization, the serious harm needs to be offset with an Offsetting Plan approved by DFO. SML has made considerable efforts to avoid or mitigate the direct and indirect loss of aquatic habitat, and the consequent serious harm to fish, during the design and planning phases of the Project. The watercourses within the Project Development Area (PDA) (Figure 1.2.1) that will be lost to the Project facilities, and those that will experience flow reductions as a result of the Project, are discussed in this section in order to characterize both direct and indirect loss of fish habitat, and the consequent harm to fish, that will result from the Project and ultimately require authorization and associated offsetting under the *Fisheries Act*.

As part of this assessment, the prediction of what level of loss of fish habitat could accrue, both directly and indirectly, as a result of the Project features and activities was carried out. As discussed in the sub-sections that follow, these predictions included the direct, physical loss of fish habitat arising from the encroachment of the Project facilities, as well as indirect losses that could arise due to alterations to stream flows in McBean and Napadogan Brook watersheds.

In the sub-sections that follow, the direct loss of fish habitat arising from the construction of Project facilities is discussed. Then, indirect loss of fish habitat arising from flow alterations in Napadogan and McBean Brook watersheds is presented, including the results of numerical modelling that was conducted to quantify these reductions in habitat area in Lower Napadogan Brook using a wetted perimeter approach. The total estimated fish habitat loss arising from both direct and indirect loss as a result of the Project is then quantified. Finally, an Offsetting Plan for the serious harm to fish and fisheries that would result from this total habitat loss is presented.

7.4.2 Direct Habitat Loss

Direct loss of fish habitat, when discussed in this EIA report, is defined as fish habitat that is directly lost through Project activities and that is no longer present or functional and able to support aquatic life. Habitat that is within the areas to be occupied by the open pit and tailings storage facility (TSF) will be lost completely, and these are examples of direct loss of fish habitat. Direct loss will only occur within the PDA, which includes the Project components and the linear facilities corridors. However, no direct loss will occur as a result of the new 138 kV transmission line or the relocated 345 kV transmission line, since all transmission line structures will be placed outside of riparian zones and no disturbance will occur within 30 m of watercourses, in order to avoid encroachment on watercourses and associated habitat loss. Similarly, no direct loss will occur as a result of the relocated Fire Road, since although watercourse crossings will be required, temporary disruption to fish habitat is not considered by DFO to result in serious harm to fish.

7.4.2.1 Methodology: Estimating Direct Habitat Loss

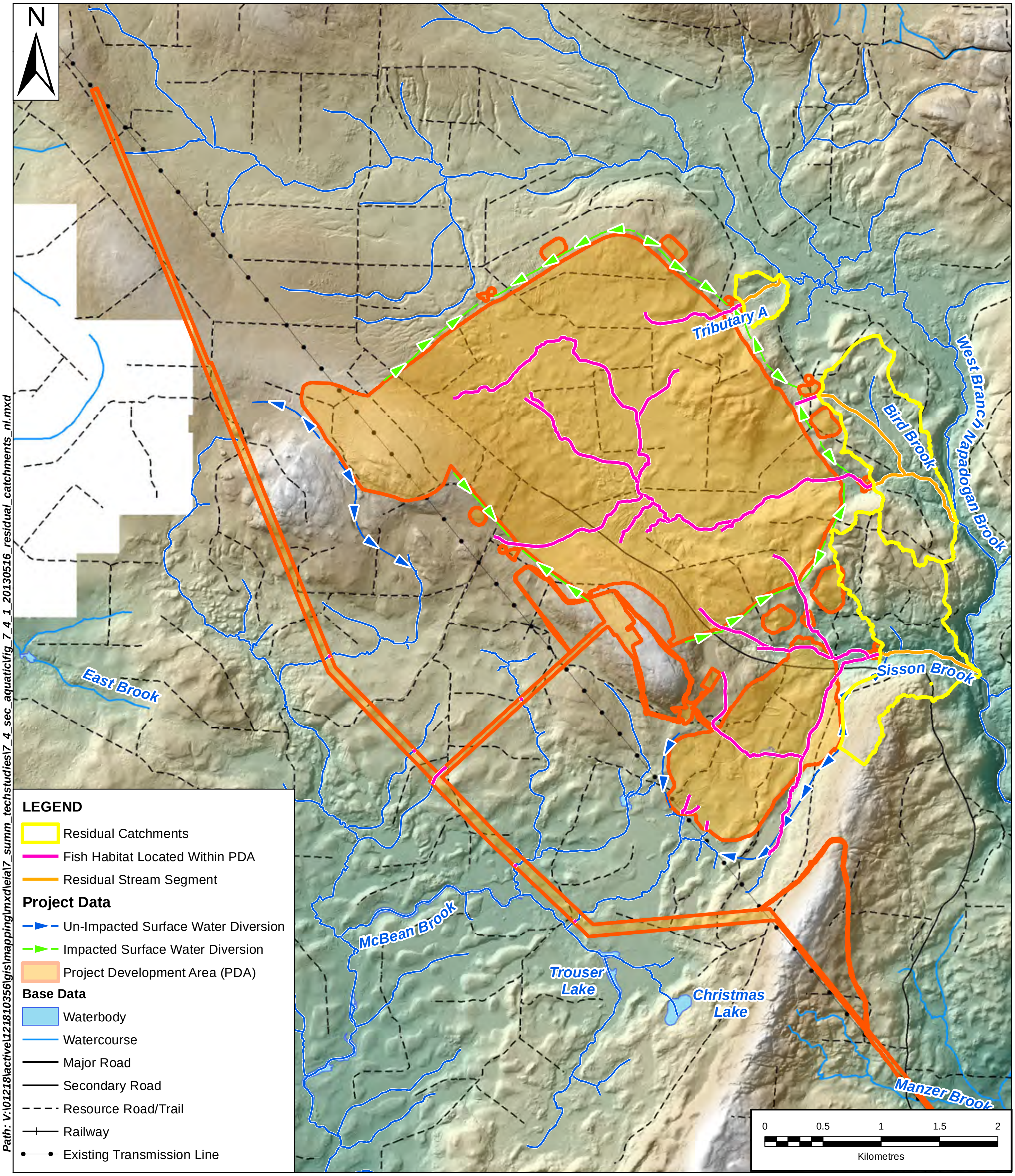
The direct loss of fish habitat was estimated using field data collected as part of extensive aquatic field surveys carried out in the PDA, as documented in the Baseline Aquatic Environment Technical Report (Stantec 2012d). The geographic extent and quality of the fish habitat in the watercourses that are directly affected by the mine were characterized through an extensive aquatic field survey program carried out in 2011 (Stantec 2012d), with further characterization of fish habitat to be affected by the Fire Road relocation carried out in 2012 (Stantec 2013c). As part of these programs, all watercourses within the PDA were surveyed in their entirety, and measurements of bankfull width, watercourse length, and other data were recorded for each reach of these watercourses.

The total surface area of the watercourses within the PDA was calculated from these measurements and using a geographic information system (GIS) supplemented by LiDAR data. The total direct loss of fish habitat was assumed to be represented by the total surface area of the watercourse lost. This approach for calculating the habitat area does not differentiate on habitat suitability, but conservatively assumes that the entire length and width of the stream that is lost is equally suitable for supporting aquatic life.

Several beaver dams were observed during the aquatic surveys. These dams resulted in ponded areas upstream of the dams, and thus increased the stream widths within the ponded areas. The stream widths at these ponded areas were not used in the calculations of habitat areas due to the ephemeral nature of beaver ponds. Instead, stream widths for the ponded areas upstream of beaver dams were estimated based on upstream and downstream widths. This approach was accepted by Fisheries and Oceans Canada (DFO) (Parker, E. Personal communication, November 6, 2012).

7.4.2.2 Results: Direct Habitat Loss

There will be direct loss to the PDA of a portion of a small unnamed tributary to the West Branch Napadogan Brook (referred to as Tributary “A”), portions of Bird Brook and Sisson Brook and their tributaries, and portions of small fingertip tributaries to McBean Brook (Figure 7.4.1). A summary of the loss of fish habitat within the PDA and its function in relation to the life processes of warm and cold water fish species for each of the affected watercourses is provided below. Table 7.4.1 outlines that direct loss to watercourses within the PDA. The habitat loss areas are presented in 100 m^2 “fish habitat units” as is typical for large-scale projects.



Path: V:\01218\active\121810356\gis\mapping\mxd\eia\7_summ_techstudies\7_4_sec_aquatic\fig_7_4_1_20130516_residual_catchments_nl.mxd

NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Location of Directly Affected Fish Habitat and Catchment Areas of Residual Stream Segments Sisson Project: Environmental Impact Assessment (EIA) Report, Napadogan, N.B.	Scale: 1:45,000	Project No.: 121810356	Data Sources: Leading Edge Geomatics NBDNR	Fig. No.: 7.4.1
Client: Sisson Mines Ltd.	Date: (dd/mm/yyyy) 23/10/2012	Dwn. By: JAB	Appd. By: GPY	

Stantec Consulting Ltd. © 2013

Map: NAD83 CSRS NB Double Stereographic

Table 7.4.1 Direct Fish Habitat Loss by Major Project Component in the PDA

Project Component	Affected Watercourse	Type of Loss	Area Lost (fish habitat units[1]), Requiring Compensation/Offsetting	Rationale	Offsetting and Authorization
Open Pit	Sisson Brook	Direct	112	Permanent direct habitat loss = serious harm.	*Fisheries Act* Section 35(2)
	McBean Brook	Direct	2	Permanent direct habitat loss = serious harm.	*Fisheries Act* Section 35(2)
Tailings Storage Facility (TSF)	Bird Brook	Direct	172	Permanent direct habitat loss from deposition of tailings = serious harm.	*MMER* Schedule 2 amendment
	Bird Brook	Direct	72	Permanent direct habitat loss from construction of TSF embankment = serious harm.	*Fisheries Act* Section 35(2)
	Sisson Brook	Direct	2	Permanent direct habitat loss from construction of TSF embankment = serious harm.	*Fisheries Act* Section 35(2)
	Tributary "A" to West Branch Napadogan Brook	Direct	6	Permanent direct habitat loss from construction of TSF embankment = serious harm.	*Fisheries Act* Section 35(2)
Total Direct Habitat Loss, Required for Compensation/Offsetting			**366**		

Notes:
[1] fish habitat unit = 100 m^2 of fish habitat.

Further discussion of these losses and the associated habitat characteristics of these watercourses as determined by the aquatic field surveys conducted in 2011 (Stantec 2012d) is as follows. Further details can be found in Section 8.5.2 and Stantec (2012d).

Tributary "A" to the West Branch Napadogan Brook

Direct loss will occur to a total of 6 fish habitat units along a 971 m long section of Tributary "A" to the West Branch Napadogan Brook (WBNB) as a result of the Project. Tributary "A" is a first-order watercourse that flows directly to the West Branch Napadogan Brook (Figure 7.4.1) at the northern extent of the TSF.

The upper 130 m of this tributary has a steep grade with no defined channel and does not provide fish habitat though it is conservatively included in the calculations of habitat loss. Habitat was of average quality in the lower reaches and was suitable for spawning and rearing of brook trout and other warm and cold water species. Portions of the watercourse sustain brook trout and are suitable for rearing, spawning and feeding for all life stages. There are also portions of watercourse that are marginal or fair, such as beaver ponds that support fish but are not ideal habitat.

Bird Brook and Tributaries

Direct loss will occur to a total of 244 fish habitat units along 10,276 m of Bird Brook and its tributaries within the PDA, due to the presence of the TSF. There are six first-order tributaries to Bird Brook, two second-order sections of tributary to Bird Brook, and the third-order main stem of Bird Brook within the PDA (Figure 7.4.1).

First-order tributaries start in the headwaters with intermittent flow and increase in size moving downstream. First-order habitat and water quality, and habitat structure is suitable rearing habitat for brook trout outside of the headwater sections. The two second-order tributaries within the PDA meet at a small wetland pond to form the main stem of Bird Brook. Fish were observed in the pond and water quality was suitable in the ponded areas along with the flowing sections within the PDA for cold and warm water fish species (CCME 1999).

Second-order tributaries are a mix of high quality habitat for feeding and rearing and poor quality impounded habitat that is generally not supportive of most fish.

The third-order section of Bird Brook has some ponding of water present in the middle reach as a result of an old beaver dam. Overall, third-order habitat and water quality of Bird Brook within the PDA represents good to high quality fish habitat suitable for spawning, feeding and rearing of cold and warm water fish species.

There were several locations on all first-order tributaries with low dissolved oxygen (DO) and pH, generally these are areas surrounded by or passing through wetlands, or in headwater areas with groundwater upwelling. Poor water quality in second-order tributaries are the result of slow moving waters through beaver impoundments, as well as wetland that surrounds much of Bird Brook. There were no issues with water quality within the third-order sections of Bird Brook.

Bird Brook as a whole has habitat that ranges from poor to very high quality for brook trout. Wetland surrounds much of Bird Brook, resulting in lower pH and in some cases extremely low concentrations of DO. Habitat within the PDA is not suitable for Atlantic salmon; however, sections of Bird Brook downstream of the PDA are salmon habitat (Stantec 2012d).

Sisson Brook and Tributaries

Direct loss will occur to a total of 114 fish habitat units along 7,393 m of Sisson Brook and its tributaries within the PDA, due to the presence of the open pit, and another 2 fish habitat units due to the presence of the TSF. There are four first-order tributaries, two second-order tributaries and a portion of the third-order main stem of Sisson Brook located within the PDA (Figure 7.4.1).

The two southernmost first-order tributaries are low grade and surrounded by wetlands and beaver ponds. A large beaver pond encompasses the majority of the tributary that lies in the centre of the proposed open pit location. The two northernmost first-order tributaries are high grade with intermittent flow in the headwaters. Habitat structure and water quality within the all the first-order tributaries of Sisson Brook represents good to excellent rearing habitat for brook trout.

There are two second-order tributaries to Sisson Brook within the PDA. The southernmost tributary has wetland meadow in its upper reach; both tributaries increased in grade moving downstream. Second-order tributaries of Sisson Brook are good to excellent brook trout habitat (spawning, rearing and feeding).

Overall, Sisson Brook has habitat that ranges from poor to excellent quality fish habitat. Headwater habitats are variable ranging from wetland beaver ponds to steep rocky valleys. There is a natural barrier to fish passage, a waterfall, located approximately 280 m upstream of the mouth of Sisson Brook which likely limits the migration of all fish species except American eel (which can scale vertical surfaces when young).

Tributaries to McBean Brook

Direct loss will occur to a total of 2 fish habitat units along 415 m of first-order tributaries of McBean Brook within the PDA (Figure 7.4.1) due to the presence of the open pit.

A total of 415 m of headwater habitat will be lost in McBean Brook within the PDA. The three first-order tributaries all flow into a small beaver pond under the existing transmission line. All tributaries are surrounded by wetland meadow and the watercourses are often undefined and braided through the wetland. Existing habitat is marginal brook trout habitat as a result of the wetland characteristics and lack of flow.

Overall, the habitat within McBean Brook to be directly lost as a result of Project activities is fair to good fish habitat. Habitat to be directly lost is headwater habitat made up of mostly wetland drainage and pond. The habitat present is most suitable for warm water fish species that prefer slow moving or ponded waters.

7.4.2.3 Summary of Direct Habitat Loss

As summarized in Table 7.4.1, a total of 366 fish habitat units will be directly lost within the PDA. The habitat to be lost ranges from poor quality habitat comprised of wetland ponds and beaver pond, to excellent quality riffle run ideal for salmonid spawning, rearing and feeding. Water quality in all the watercourses within the PDA is relatively good to high quality, with a few locations that are not suitable for most fish species.

7.4.3 Indirect Habitat Loss

Indirect loss of aquatic habitat, when discussed in this EIA report, is defined as habitat that is lost as an indirect consequence of Project activities due to decreased flow in watercourses downstream of the PDA. Indirect losses are considered for two groups of watercourses: residual watercourse segments; and flow reductions in downstream watercourses, specifically Napadogan and McBean brooks.

7.4.3.1 Indirect Habitat Loss in Residual Watercourse Segments

Relatively small residual watercourse segments will remain after the direct losses described in Section 7.4.1 in Bird Brook and Sisson Brook, and a tributary to WBNB, as shown in Figure 7.4.1.

Methodology: Indirect Habitat Loss in Residual Stream Segments

The residual stream segments identified on Figure 7.4.1 will experience stream flow reductions due to Project activities that will alter the watershed drainage areas upstream of these segments. The reduction in stream flow as a ratio of the pre-development (pre-Project) mean annual flow (MAF) can be estimated directly from the ratio of the reduction in watershed area. The reduction in watershed area shown in Table 7.4.2 is equivalent to the reduction in MAF through a process called areal proration. As an example, direct losses in Bird Brook will result in an 84% reduction in watershed area, which will in turn result in an 84% reduction in MAF.

Table 7.4.2 Reduction in Watershed Area for Residual Stream Segments

Watercourse	Existing Watershed Area (km^2)	Watershed Area Lost (km^2)	Reduction in Watershed Area (%)
Tributary to WBNB	1.5	1.3	87
Bird Brook	8.1	6.8	84
Sisson Brook	5.2	3.0	58

Source: Knight Piésold (2012h).

The scientific literature suggests that stream flow reductions greater than 30% of MAF will result in fundamental ecological change in the stream (Bradford and Heinonen 2008; Poff *et al.* 2010). As shown in Table 7.4.2, the stream flow reductions in the residual stream segments are predicted to be greater than 30%. Therefore, the entire length of the residual stream segments are conservatively considered a total indirect loss.

The habitat area for these residual stream segments is estimated in the same manner as the direct losses described in Section 7.4.1.1.

Results: Indirect Habitat Loss in Residual Stream Segments

There will be indirect loss of fish habitat in residual stream segments of Tributary “A” to WBNB, Bird Brook and Sisson Brook (Figure 7.4.1). A summary of the habitat within these stream segments and its function in relation to the life processes of warm and cold water fish species for each of the affected watercourses is provided below. Table 7.4.3 outlines the indirect loss to residual stream segments. A brief discussion of the indirect loss in these residual stream segments and their associated habitat characteristics as determined by the aquatic field surveys conducted in 2011 (Stantec 2012d) follows Table 7.4.3.

Table 7.4.3 Indirect Fish Habitat Loss by Major Project Component

Project Component	Affected Watercourse	Type of Loss	Area Lost (fish habitat units), Requiring Compensation/Offsetting	Rationale	Offsetting and Authorization
Residual Stream Segments	Sisson Brook	Indirect	36	Serious harm due to substantial reduction in catchment area of residual stream segment.	*Fisheries Act* Section 35(2)
	Bird Brook	Indirect	77	Serious harm due to substantial reduction in catchment area of residual stream segment.	*Fisheries Act* Section 35(2)
	Tributary “A” to West Branch Napadogan Brook	Indirect	10	Serious harm due to substantial reduction in catchment area of residual stream segment.	*Fisheries Act* Section 35(2)
Downstream Flow	Lower Napadogan	Indirect	55	Serious harm due to indirect loss due to mean	*Fisheries Act* Section 35(2)

Table 7.4.3 Indirect Fish Habitat Loss by Major Project Component

Project Component	Affected Watercourse	Type of Loss	Area Lost (fish habitat units), Requiring Compensation/Offsetting	Rationale	Offsetting and Authorization
Reductions	Brook			annual flow reductions downstream >10%.	
Total Indirect Habitat Loss, Required for Compensation/Offsetting			**178**		

Notes:
1 fish habitat unit = 100 m^2 of fish habitat.

Tributary "A" to West Branch Napadogan Brook

Indirect loss will occur to a total of 10 fish habitat units along the residual first-order watercourse of Tributary "A" to West Branch Napadogan Brook. The watercourse is of moderate grade that decreases as it nears the WBNB. There is a small beaver dam in the lower section resulting in some ponding. Water quality was good and habitat in the residual stream segment for the tributary to the WBNB was found to be good to excellent brook trout habitat for rearing, spawning and feeding.

Bird Brook

Indirect loss will occur to a total of 77 fish habitat units along the residual segments of Bird Brook. The existing habitat in the first-order sections of Bird Brook that will experience indirect loss of watershed area are marginal fish habitat. First-order watercourses flow intermittently though wetland. Water quality ranged from poor to good within the first-order tributaries. Headwater sections were not suitable fish habitat, lower sections likely support brook trout as were found in similar watercourses inside and outside of the PDA (Stantec 2012d).

Second-order sections of Bird Brook that will experience indirect loss of watershed area represent good fish habitat. Second-order watercourses have good water quality, were of moderate grade and flowed through some sections of old beaver impoundments. Existing habitat in third-order sections of Bird Brook are excellent quality fish habitat, suitable for spawning, rearing and feeding of Salmonids and Cyprinids.

Sisson Brook

Indirect loss will occur to a total of 36 fish habitat units along the residual segments of Sisson Brook. Approximately 823 m of third-order stream channel outside of the PDA will experience total indirect loss. There is also a first-order tributary of Sisson Brook that flows northeast that will be truncated and diverted to McBean Brook by the construction of the open pit and experience indirect loss (Figure 7.4.1) (with corresponding increase in stream flow in McBean Brook watershed as a result of this diversion).

Existing habitat in the first-order tributary of Sisson Brook that will experience indirect loss is good quality habitat. The first-order watercourse section flows through several wetlands and old beaver meadows. The third-order section of Sisson Brook consists of high quality fish habitat. Water quality in this reach was excellent. Habitat in this section of Sisson Brook is good to excellent spawning rearing and feeding brook trout habitat. A waterfall approximately 280 m from the mouth of Sisson Brook likely prevents migration of fish into Sisson Brook with the exception of American eel.

7.4.3.2 Indirect Habitat Loss in Napadogan Brook

Stream flow reductions in Napadogan Brook will result from the stream flow reductions in Tributary “A” to West Branch Napadogan Brook, Bird Brook, and Sisson Brook, and will result in indirect habitat loss in Napadogan Brook. This section describes the methodology used to predict the indirect loss of fish habitat in Lower Napadogan Brook, first regarding how the flow reductions were calculated and then how the habitat loss was determined due to the flow reductions. The section concludes with the overall results of the indirect habitat loss calculations.

Methodology: Predicting Flow Reductions in Lower Napadogan Brook

Predictions of stream flow alterations in Napadogan Brook were conducted by Knight Piésold (2012h). These predictions are based on long-term unit area flows developed for station NB-2B, located on Napadogan Brook, upstream of the confluence of West Branch Napadogan Brook with East Branch Napadogan Brook. The unit area flows were then multiplied by the catchment areas of the seven numbered locations in Napadogan Brook, as shown on Figure 7.4.2. In this section, Lower Napadogan Brook refers to the portions of Napadogan Brook that will be affected by stream flow reductions arising from the Project, starting on the West Branch Napadogan Brook immediately above its confluence with Bird Brook, to the combined West Branch Napadogan Brook and East Branch Napadogan Brook immediately prior to their confluence with the Nashwaak River.

A range of flows was selected for the modelling to assess the potential variability of changes to wetted perimeter under various conditions that may be observed in Lower Napadogan Brook. The seven different stream flow scenarios selected for the analysis are listed in Table 7.4.4. As shown in the table, the statistics vary across the expected range of flows in Lower Napadogan Brook, from high flows (0.15th percentile) to low flows (95th percentile).

Table 7.4.4 Flow Scenarios for HADD Modelling in Lower Napadogan Brook

Scenario Number	Flow Percentile [a]	Corresponding Description
1	0.15	Maximum Annual Flow
2	32	Mean Annual Flow (MAF)
3	61	DFO Maintenance Flow A [b]
4	74	DFO Maintenance Flow B [c]
5	88	Winter Low Flow
6	94	Summer Low Flow
7	95	Minimum Annual Flow

Notes:

[a] Percentile values represent percentage of time the flow statistic is equaled or exceeded on the flow duration curve. Percentile values were provided by Knight Piésold (2012h).

[b] DFO Maintenance Flow A: The 50% exceedance of the flow duration curve is multiplied by 0.7 to determine the required Maintenance Flow. (Currie, T. Personal communication, April 12, 2012).

[c] DFO Maintenance Flow B: Maintenance flow is 25% of predicted mean annual flow. (Currie, T. Personal communication, April 12, 2012).

The flow statistics for baseline and future case scenarios were developed at the seven locations intended to represent the upper and lower boundaries of six key hydraulic sub-reaches of Lower Napadogan Brook. These locations are listed below and are shown in Figure 7.4.2:

1. above confluence with Bird Brook (River station 13881.3);

2. below confluence with Bird Brook (River station 13307.8);
3. below confluence with Sisson Brook (River station 11677.5);
4. below confluence with East Branch Napadogan Brook (River station 8370.4);
5. below confluence with Manzer Brook (River station 4144.4);
6. below confluence with Frenchman Brook (River station 2186.2); and
7. above confluence with Nashwaak River (River station 300.6).

The flow reductions were then used as inputs to the model used to calculate the indirect loss of fish habitat in downstream Lower Napadogan Brook, using a technique called wetted perimeter modelling. Wetted perimeter modelling uses a one dimensional (1-D) numerical model called Hydrologic Engineering Centers River Analysis System ("HEC-RAS"), developed by the United States Army Corps of Engineers (USACE 2010), discussed further below. The wetted perimeter model was developed at each of the seven locations above for two cases:

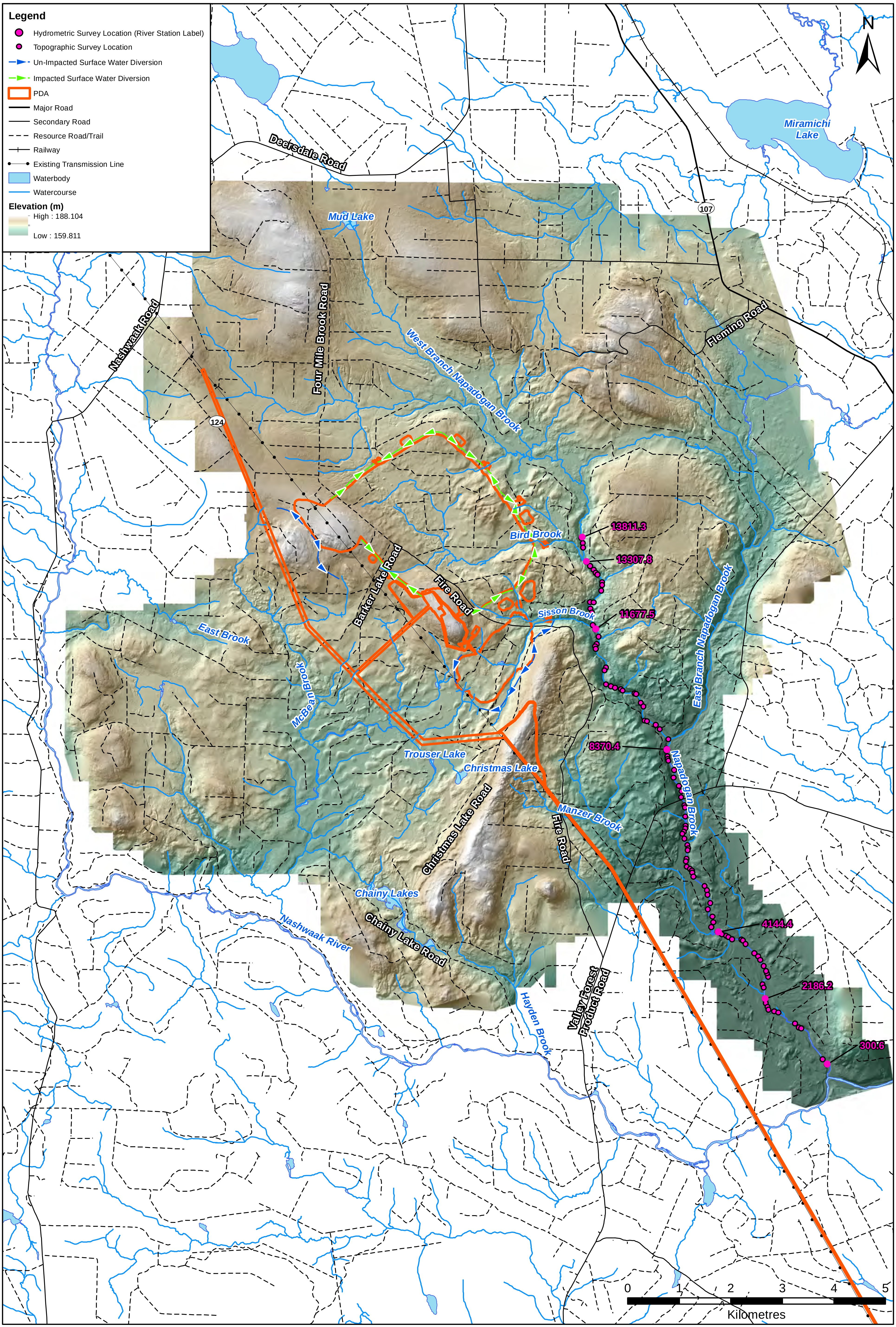
- a "baseline conditions" case, to simulate flows and associated areal extent of fish habitat currently in the absence of the Project; and
- a "future conditions" case, to simulate flows and associated areal extent of fish habitat in the future, once the Project is operational and water from Tributary "A" to WBNB, Bird and Sisson Brooks is no longer discharged to Napadogan Brook as a result of direct loss and indirect loss in residual stream segments.

The inputs to the wetted perimeter model for each of the seven flow statistics at each location were provided by Knight Piésold (2012h). These flows were used as inputs to the wetted perimeter model on a sub-reach basis. Stream flows within each sub-reach are assumed to be constant within the model.

It is important to note that the "future conditions" case (*i.e.*, once the Project is in Operation) assumes zero discharge of water from the Project and all water contained within the PDA is sequestered. This will be the case during Years 1-7 of Operation, when all mine contact water within the PDA will be stored in the TSF. However, starting in about Year 8 of Operation, water in the TSF will be in a surplus condition, and thus surplus water will be treated (as necessary to meet discharge requirements) and released to the former Sisson Brook channel, thereby restoring some flow to Lower Napadogan Brook. Similarly, while the open pit is being filled during Closure, over a period of about 12 years, there will be no discharge to the former Sisson Brook channel, but surplus water will be treated and discharged thereafter. For the purpose of this analysis, it has been assumed that no surplus water is released to the Sisson Brook channel. This results in the most conservative estimates of areas of indirect habitat loss in Lower Napadogan Brook, as there will be surplus water to discharge at different stages during Operation and at Post-Closure.

The modelling uses channel transect data collected in lower Napadogan Brook during the months of September and October 2011. Data collected include topographic surveys of channel geometry at the transects (*i.e.*, stream width, channel bottom elevations and water surface elevations) and spot stream discharge data from stream depths and velocity measurements. These data were collected at

106 locations along Napadogan Brook, from above Bird Brook to the mouth of Napadogan Brook where it meets the Nashwaak River (Figure 7.4.2). These data were used to prepare a one-dimensional (1-D) HEC-RAS model to assist in the assessment of potential changes of fish habitat arising from the loss of wetted perimeter due to downstream flow reductions in the brook. In addition, a range of flow statistics were calculated from Project stream flow monitoring, and modelling data and were used to assess potential changes in wetted perimeter resulting from Project development.



NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Location of Developed Flow Statistics

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Sisson Mines Ltd.

Scale:	1:68,000
Project No.:	121810356
Date: (dd/mm/yyyy)	02/04/2013
Dwn. By:	JAB
Appd. By:	DLM
Data Sources:	NBDNR, SNB, Leading Edge Geomatics Ltd.
Fig. No.:	7.4.2

Stantec

Map: NAD83 CSRS NB Double Stereographic

Methodology: Estimating Habitat Areas in Lower Napadogan Brook

The HEC-RAS model was developed to estimate the area of habitat that exists within Lower Napadogan Brook for a variety of baseline and projected future flow conditions (Stantec 2012l). HEC-RAS is a one-dimensional steady/unsteady flow hydraulics program capable of simulating a full network of open channels such as watercourses and man-made channels, as well as hydraulic structures such as bridges, culverts, and weirs, with variable spatial discretization (USACE 2010). HEC-RAS is widely used, is in the public domain, and has been applied to a variety of ecosystem function problems such as simulating floodplain inundation, evaluating fish passage through culverts, and predicting changes to aquatic habitat.

The Lower Napadogan Brook model was created from surveyed transects along the length of the brook from above Bird Brook to its confluence with the Nashwaak River. A sample cross-section for a transect in the HEC-RAS model that was created from the survey data is shown in Figure 7.4.3 (note that there is considerable vertical exaggeration in this figure, for illustration purposes). The model was calibrated to site conditions (stage and flow) observed during the months of September and October, 2011.

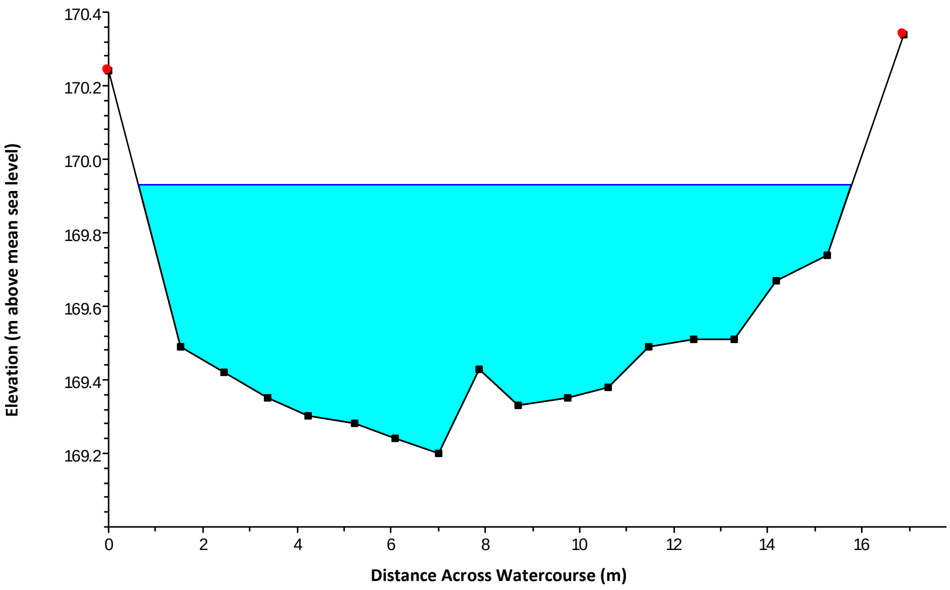


Figure 7.4.3 Sample Transect Cross-Section from HEC-RAS Model

The flow statistics prepared by Knight Piésold are presented on Tables 7.4.5 and 7.4.6 for the baseline conditions case and the future conditions case, respectively. The River Station locations provided are shown on Figure 7.4.2.

Table 7.4.5 Scenario Stream Flow Rates (m³/s) under Baseline Conditions (Pre-development) Case

Flow Percentile	River Station (m upstream of confluence with Nashwaak River)						
	13811.3	13307.8	11677.5	8370.4	4144.4	2186.2	300.6
0.15	8.9	11.3	13.5	26.2	31.1	33.8	34.8
32	0.807	1.025	1.227	2.379	2.823	3.067	3.158
61	0.312	0.396	0.473	0.919	1.090	1.184	1.219
74	0.202	0.256	0.307	0.595	0.706	0.767	0.790
88	0.102	0.125	0.147	0.262	0.304	0.327	0.336
94	0.062	0.077	0.092	0.173	0.204	0.221	0.228
95	0.056	0.070	0.084	0.158	0.186	0.202	0.208

Table 7.4.6 Scenario Stream Flow Rates (m³/s) under Future Conditions (Development) Case

Flow Percentile	River Station (m upstream of confluence with Nashwaak River)						
	13811.3	13307.8	11677.5	8370.4	4144.4	2186.2	300.6
0.15	8.4	8.9	10.2	22.9	27.8	30.5	31.5
32	0.765	0.805	0.929	2.081	2.525	2.769	2.860
61	0.295	0.311	0.358	0.804	0.975	1.069	1.104
74	0.191	0.201	0.232	0.520	0.631	0.692	0.715
88	0.097	0.101	0.115	0.233	0.276	0.299	0.308
94	0.058	0.061	0.070	0.153	0.184	0.201	0.207
95	0.053	0.056	0.064	0.139	0.167	0.183	0.189

The predicted reductions in flows along Lower Napadogan Brook are summarized in Table 7.4.7 for each station. For example, a 24% reduction in mean annual flow is predicted in Napadogan Brook at the confluence with Sisson Brook (River Station 11677.5). The reduction falls to about 12% below the confluence with East Branch Napadogan Brook (River Station 8370.4), and to about 9% at the confluence with the Nashwaak River (River Station 300.6), depending on the flow scenario (percentile). It is important to recall that these are conservative estimates since water discharged to Sisson Brook during Operation, and especially Post-Closure, will reduce these environmental effects.

Table 7.4.7 Reduction of Stream Flow Rates (m³/s) and Percentage Reductions (%) of Future Conditions Compared to Baseline Conditions

Flow Percentile	River Station (m upstream of confluence with Nashwaak River)						
	13811.3	13307.8	11677.5	8370.4	4144.4	2186.2	300.6
0.15	0.500 (6%)	2.40 (21%)	3.30 (24%)	3.30 (13%)	3.30 (11%)	3.30 (10%)	3.30 (9%)
32	0.042 (5%)	0.220 (21%)	0.298 (24%)	0.298 (13%)	0.298 (11%)	0.298 (10%)	0.298 (9%)
61	0.017 (5%)	0.085 (21%)	0.115 (24%)	0.115 (13%)	0.115 (11%)	0.115 (10%)	0.115 (9%)
74	0.011 (5%)	0.055 (21%)	0.075 (24%)	0.075 (13%)	0.075 (11%)	0.075 (10%)	0.075 (9%)
88	0.005 (5%)	0.024 (19%)	0.032 (22%)	0.029 (11%)	0.028 (9%)	0.028 (9%)	0.028 (8%)
94	0.004 (6%)	0.016 (21%)	0.022 (24%)	0.020 (12%)	0.020 (10%)	0.020 (9%)	0.021 (9%)
95	0.003 (5%)	0.014 (20%)	0.020 (24%)	0.019 (12%)	0.019 (10%)	0.019 (9%)	0.019 (9%)

The HEC-RAS model was run for each of the seven flow scenarios for the baseline conditions case as well as for the future conditions case. Habitat areas were estimated for the flow simulations by multiplying the simulated wetted perimeter at each surveyed transect by half the upstream and downstream distance between transects.

An example of the simulated change in wetted perimeter ("WP") calculated using the HEC-RAS model is shown in Figure 7.4.4. In the figure, the wetted perimeter associated with the baseline conditions case ($WP_{baseline}$) is shown in light blue solid line, and the wetted perimeter associated with the future conditions case (WP_{future}) is shown in a darker blue dashed line. As shown in Figure 7.4.4, the wetted perimeter for the future conditions case is smaller than that for the baseline conditions case, due to the withholding of water from Bird and Sisson Brooks by the Project.

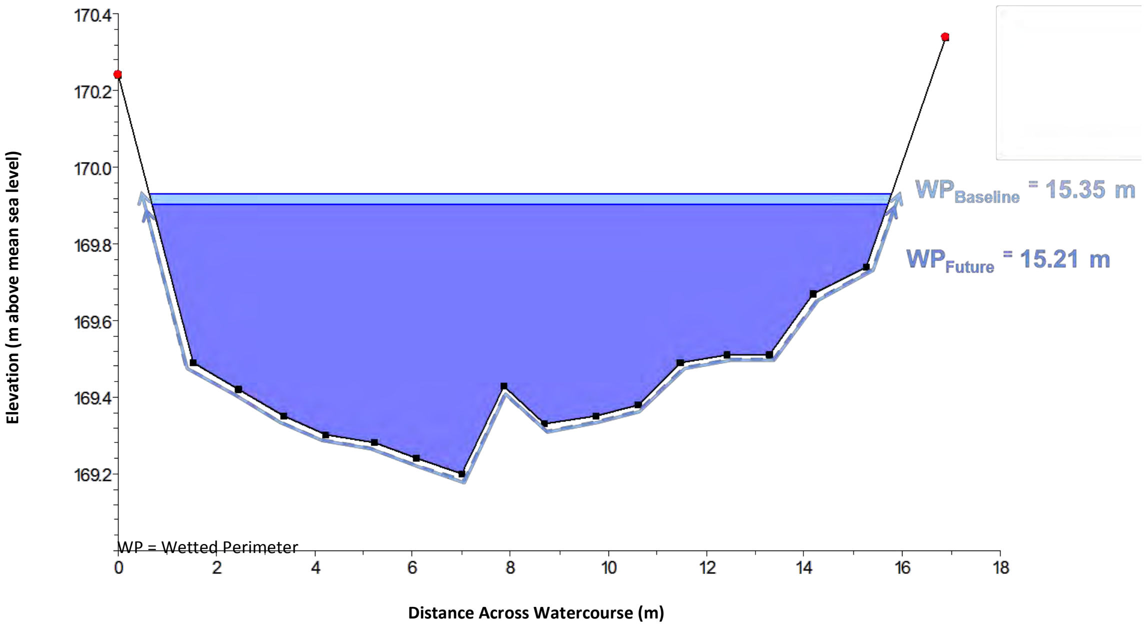


Figure 7.4.4 Simulated Change in Wetted Perimeter for a Sample Transect

The changes to available fish habitat were calculated by summing the differences between the estimated areas for the baseline conditions case and the future conditions case for stream reaches that are predicted to experience more than 10% reduction in MAF. Reductions in mean annual flow that are less than 10% are assumed to not cause serious harm to CRA fisheries (DFO 2013b). The percentage reductions in MAF (which corresponds to the 32nd flow percentile in Napadogan Brook) are shown by stream reach on Table 7.4.7. A summary of the cumulative calculated areas that experience more than 10% reduction in MAF is presented in Table 7.4.8.

Results: Indirect Habitat Loss in Lower Napadogan Brook

The reduction in fish habitat for the various flow statistics is presented in Table 7.4.8. The reduction is calculated as the sum of all changes in habitat area that experience more than 10% reduction in MAF; that is, the total habitat calculated during the baseline conditions case less the total habitat calculated during the future conditions case.

Table 7.4.8 Estimated Total Reductions to Habitat Areas for Various Flow Scenarios

Flow Percentile	Future Conditions Case: Reduction in Fish Habitat		
	(m²)	(fish habitat units)	(% reduction[a])
0.15	n/a	n/a	n/a
32	2,380	24	1.3
61	4,480	45	2.7
74	5,150	52	3.5
88	4,760	48	4.0
94	5,540	55	5.4
95	4,760	48	5.0

Notes:

[a] % reduction as compared to baseline conditions case.

As shown in Table 7.4.8, changes in habitat area are not provided for the 0.15th flow percentile scenario, as these flow conditions resulted in the model predicting water levels above the banks of the main channel. This model was not calibrated to account for overbank flow conditions, as all observations were collected when the water levels were within the bank-full width of the channel. Therefore, this condition could not be properly simulated in the model using available data. Furthermore, this condition is not representative of fish habitat, as peak flows occur for a very short periods of the year. For these reasons, this scenario is not considered further.

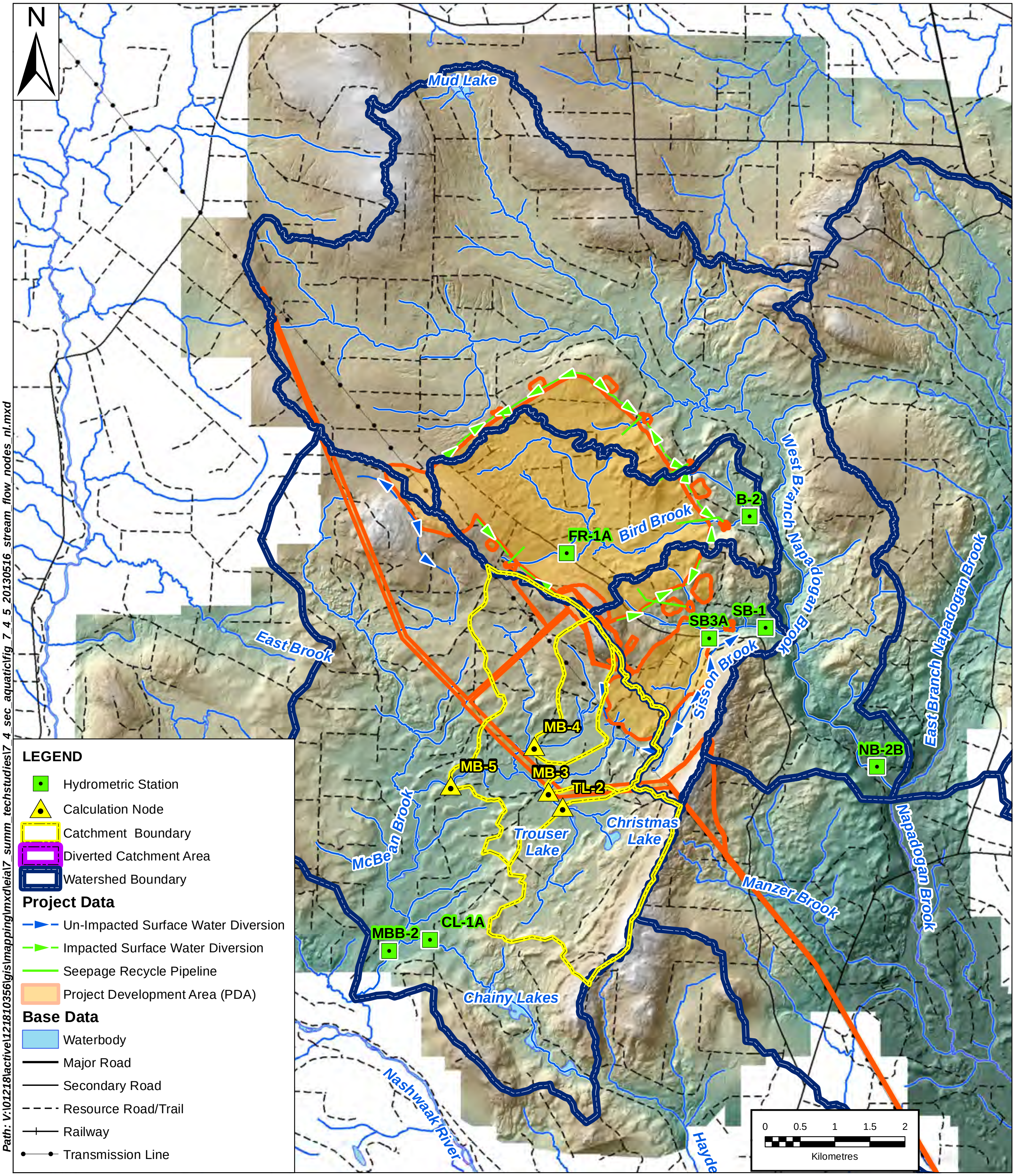
The modeling scenarios conducted indicate an indirect loss of aquatic habitat between 24 and 55 fish habitat units depending on which flow statistic is used. In order to maintain the conservative nature of the estimates of indirect habitat loss already employed, the largest loss estimate of 55 fish habitat units was conservatively assumed for Lower Napadogan Brook. This is assumed to be a permanent loss for which authorization from DFO with associated compensation will be sought, whereas flow may be partially restored at some stages of the Project life as surplus treated water is released. Seeking authorization for this loss and associated compensation is thus a conservative approach.

7.4.3.3 Indirect Habitat Loss in McBean Brook

Stream flow reductions in McBean Brook will result from the stream flow reductions in the first-order tributaries that will be directly lost as described in Section 7.4.2.2.4. However, as is illustrated below, this will be in part offset by the diversion of a portion of the Sisson Brook watershed area into McBean Brook.

Methodology: Predicting Indirect Habitat Loss in McBean Brook

Stream flow reductions in McBean Brook as a result of the Project activities over the life of the mine were estimated by Knight Piésold (2012f). The flows were estimated at several nodes within the McBean Brook watershed using the watershed model developed for the Project (Knight Piésold 2012b) as shown on Figure 7.4.5. The stream flow is calculated at each node as the sum of water from direct runoff of precipitation and contributions from groundwater discharge within the drainage area of each node.



Path: V:\01218\active\121810356\gis\mapping\mxd\eia\7_summ_techstudies\7_4_sec_aquatic\fig_7_4_5_20130516_stream_flow_nodes_nl.mxd

NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Location of Stream Flow
Estimation Node in McBean Brook Watershed

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Sisson Mines Ltd.

Scale: 1:75,000

Project No.: 121810356

Data Sources:
Leading Edge Geomatics
NBDNR

Fig. No.: 7.4.5

Date: (dd/mm/yyyy) 02/04/2013

Dwn. By: JAB

Appd. By: GPY

Map: NAD83 CSRS NB Double Stereographic

The predicted stream flow reductions in McBean Brook are presented in Table 7.4.9. As shown in the table, the greatest reduction in stream flow is predicted at node MB-4, while an increase in stream flow is predicted at node MB-3. The combined effect of stream flow alterations at node MB-5, located downstream of the combined flows from nodes MB-3 and MB-4, is a reduction of one percent of the mean annual flow.

Table 7.4.9 Predicted Flow Reductions in McBean Brook Watershed

Node	Average Annual Flow (L/s)				Maximum Reduction in Average Annual Flow (%)
	Baseline	Year 2	Year 15	Year 27	
TL-2	105	105	105	103	2
MB-3	36	53	44	41	-14
MB-4	33	32	31	29	12
MB-5	277	294	284	274	1

Source: Knight Piésold (2012f).

It is important to note that the predicted reductions in stream flow at TL-2, MB-4 and MB-5 are due mostly to baseflow reductions, which increase over the life of the mine with increased development of the open pit. Once dewatering of the open pit ceases, the baseflow contributions to these streams are anticipated to return to the baseline levels.

Results: Indirect Habitat Loss in McBean Brook

As a result of the direct loss of habitat in McBean Brook described in Section 7.4.2.2.4, and the reductions in baseflow predicted above, there will be a small indirect loss downstream in three first-order tributaries. Indirect losses due to stream flow reductions upstream of station MB-4 are anticipated to be offset by enhancements to habitat due to stream flow gains at station MB-3, due to the diversion of stream flow from a portion of Sisson Brook. The one percent flow reduction predicted in McBean Brook at MB-5 is negligible, and would not result in any reduction in habitat area. Therefore, no net indirect loss of habitat is anticipated for McBean Brook.

Existing habitat in the first-order watercourse of McBean Brook provide fair to good fish habitat. Habitat to be directly lost is headwater habitat made up of mostly wetland drainage and pond. The habitat present is most suitable for warm water fish species that prefer slow moving or ponded waters.

7.4.3.4 Summary of Indirect Habitat Loss

A total of 178 fish habitat units will be indirectly lost downstream of the PDA as a result of Project activities. This includes 55 fish habitat units that are predicted to be lost as a result of in stream flow reductions in Napadogan Brook. A summary of the indirect habitat loss is provided in Table 7.4.10.

Table 7.4.10 Summary of Indirect Loss by Category

Indirect Loss Category	Indirect Habitat Loss (fish habitat units)
Indirect Loss from Residual Stream Segments	123
Indirect Loss from Downstream Flow Reductions in Napadogan Brook	55
Indirect Loss from Downstream Flow Reductions in McBean Brook	0
Total	**178**

Notes:
1 fish habitat unit = 100 m^2 of fish habitat.

The habitat to be lost ranges from fair to excellent quality, first-order headwaters to fourth order watercourse. Habitat that will be indirectly lost ranges from ideal for salmonid spawning, rearing and feeding habitat in Napadogan Brook to fair salmonid habitat in first-order tributaries of Bird Brook.

7.4.4 Total Estimated Fish Habitat Loss

As summarized in Table 7.4.11, a total of 544 fish habitat units are estimated to result from the Project.

Table 7.4.11 Summary of Habitat Loss by Category

Loss Category	Habitat Loss (fish habitat units)
Total Direct Loss	366
Total Indirect Loss	178
Total	**544**

Notes:
1 fish habitat unit = 100 m^2 of fish habitat.

A conceptual plan to offset for the loss of fish habitat, and the consequent serious harm to fish and fisheries, is summarized in Section 7.4.5 below.

7.4.5 Offsetting Plan for Serious Harm to Fish and Fish Habitat

7.4.5.1 Regulatory Overview

The *Fisheries Act* is administered by Fisheries and Oceans Canada (DFO) and is the main legislation protecting fish, fisheries, and fish habitat in Canada. Under Section 35 of the *Fisheries Act*, a project or development cannot cause "serious harm to fish that are part of a commercial, recreational or Aboriginal fishery" without authorization from DFO. "Serious harm" to fish is defined in the *Fisheries Act* as "the death of fish or any permanent alteration to, or destruction of, fish habitat". Authorization will not be granted unless the proponent agrees to offset any serious harm to fish that were part of or supported a commercial, recreational or Aboriginal fishery such that they would maintain or improve the productivity of the fisheries. The Offsetting Plan is evaluated by DFO following the "Fisheries Productivity Investment Policy: A Proponent's Guide to Offsetting" (DFO 2013).

Offsetting is also required under Section 36 of the *Fisheries Act*, which stipulates that *"no person shall deposit or permit the deposit of a deleterious substance of any type in water frequented by fish"* without authorization. Authorizations for metal mines to deposit deleterious substances into waters are permitted under the *Metal Mining and Effluent Regulations* (*MMER*). Where water or places set out in Schedule 2 contain fish habitat and have been designated as a tailings impoundment area, Section 27.1 of *MMER* requires a plan to offset the fish habitat resulting from the deposit of a deleterious substance into the tailings impoundment area and is approved by the Minister. The *MMER* also requires that the proponent submit an irrevocable letter of credit to cover the cost of the fish habitat offset plan.

In addition to requirements under the *Fisheries Act*, Section 16(1)(d) of the *Canadian Environmental Assessment Act* (*CEAA*) requires that the EIA must consider "*mitigation measures that are technically and economically feasible and that would mitigate any significant adverse environmental effects of the project*". In this light, compensation measures that are technically and economically feasible may constitute part of the overall mitigation approach to minimize the potential for significant adverse environmental effects arising from the Project.

7.4.5.2 Estimated Amount of Fish Habitat Offsetting Required

While under the *Fisheries Act* as amended in 2012, the focus is on sustaining the productivity of CRA fisheries, the amount of fish habitat units affected by a project, and in an offsetting project, remains an indicative metric. Under the *Fisheries Act* before it was amended in 2012, DFO typically required that lost habitat be compensated for at a 3:1 ratio. Thus, by the fish habitat unit metric, the total required offsetting arising as a result of the Sisson Project would be 544 habitat units times three, or 1,632 habitat units.

7.4.5.3 Fish Habitat Offsetting Opportunities

Given the relatively large amount of offsetting fish habitat indicated for the Project, it is impractical to attempt offsetting with typical industry standard small-scale compensation measures, or limiting their geographic extent to be near to the Project. Similarly, it is impractical to compensate exclusively in habitats that are like the small watercourses where loss of fish habitat and productivity will occur.

Therefore, large-scale opportunities are preferred, supplemented by small-scale opportunities if necessary. Large-scale opportunities are considered to be significant physical works like dam removals, installation of fish passes around large natural barriers such as waterfalls, or other opportunities that offer major habitat offsetting credit. Small-scale opportunities include replacement or modification of standard culverts, bank stabilization, or other opportunities that typically result in smaller habitat offsetting credit.

Opportunities Evaluated

Large-scale opportunities were identified on a map provided by DFO, which reportedly included input from provincial regulators and Ducks Unlimited Canada (DUC). Of the identified opportunities, the following three were selected for further evaluation in consultation with DFO and NBDNR:

- establishment of a fish pass at Dunbar Stream Falls;
- removal of Campbell Creek Dam;
- removal of Lower Lake Dam; and
- removal of an existing water-level control dam and road culvert on the Nashwaak River just below its exit from Nashwaak Lake.

The locations of these four opportunities are shown on Figure 7.4.6.

Dunbar Stream Falls is a natural waterfall that is 3.35 m in height and completely prevents the passage of Atlantic salmon. Excellent Atlantic salmon habitat exists above and below the falls, so the opportunity for compensation is to provide upstream migratory access for adult Atlantic salmon to the spawning habitat located upstream of the falls. Through consultation with provincial regulators, it was determined that introduction of fish species into habitat where they have not historically occurred due to natural barriers is undesirable, and therefore this opportunity was not considered further as compensation for the Project.

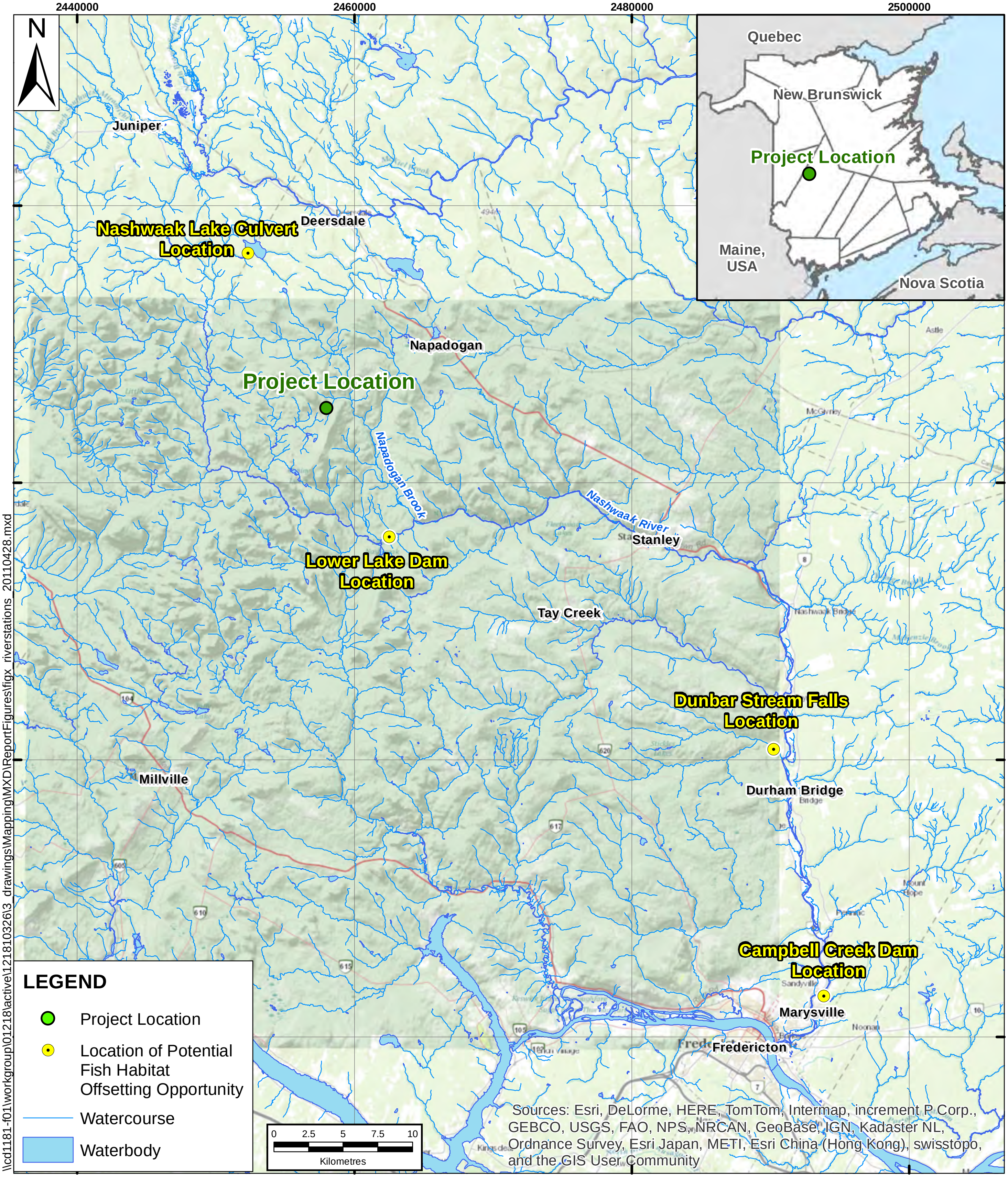
Campbell Creek Dam, north of Fredericton, was built in the early 1900s to provide water to the Marysville cotton mill, and its presence is a complete barrier to fish passage in both directions. Campbell Creek above the new Route 8 likely provides good quality habitat for brook trout, Atlantic salmon, and American eel and so the opportunity for compensation is to provide the opportunity for improved/renewed use of this habitat by these species. During the evaluation process, it was determined that the offsetting credit for undertaking this opportunity is not sufficient (approximately 10% of the required total habitat offset) to justify the considerable expense and other risks associated with the undertaking. Therefore this opportunity was not considered further as compensation for the Project.

The Lower Lake Dam is located on the Nashwaak River, approximately 2.5 km upstream of the Napadogan Brook confluence. It was constructed in the 1960s to facilitate log drives on the river to support lumbering activity in the area. Following submission of the EIA Report to governments in July 2013 in which removal of this dam was proposed as the selected habitat offsetting opportunity, it was demonstrated that Lower Lake Dam is a partial barrier to fish passage – for some species at some flows. While removal of the dam would probably increase the fish productivity of the Nashwaak River watershed above the dam, it became clear that the beneficial effect to fish productivity would be difficult to predict and demonstrate in a scientifically defensible manner. Thus, removal of this dam was removed from consideration as an offsetting project.

Therefore, only removal of the existing water-level control dam and road culvert on the Nashwaak River was determined to be a viable potential opportunity to achieve the offsetting requirements for the Sisson Project. It is discussed below.

Selection of Opportunity: Nashwaak Lake Dam/CulvertReplacement

To offset the serious harm as a result of the Sisson Project, SML proposes to remove an existing water-level control dam and road culvert on the Nashwaak River just below its exit from Nashwaak Lake to facilitate the passage of various fish species. The location of the Nashwaak Lake culvert is shown in Figure 7.4.6. The structure is a timber “box” with steel beams supporting the road deck (Photo 7.4.1). It is presently owned by NBDNR.



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Location of Potential Large-Scale Fish Habitat Offsetting Opportunities

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Sisson Mines Ltd.

Scale: 1:375,000

Project No.: 121810356

Date: (dd/mm/yyyy) 04/02/2013

Dwn. By: JAB

Appd. By: DLM

Data Sources:
ArcGIS World Topo
NBDNR
SNB

Fig. No.: 7.4.6

Stantec

Map: NAD83 CSRS NB Double Stereographic

Photo 7.4.1 Barrier to Fish Passage Structure at Entrance to Nashwaak Lake.

The water plunges from the flat bottom of the structure, with an air space behind the water, thereby creating a vertical leap barrier. Immediately downstream is a series of cascading steps that do not provide sufficient depth for fish to make the leap (Plante, F. Personal communication, October 24, 2013). For these reasons, the structure is considered to be a partial to full barrier to upstream fish passage, thereby preventing most fish species within the Nashwaak River from accessing the habitat in Nashwaak Lake.

It is proposed that the existing water-level control dam and road culvert be removed, and replaced with a standard “woods road” bridge. The proposed bridge structure would consist of a structural steel frame bearing on concrete, timber crib, or gabion abutments, with a timber driving surface (see Figure 7.4.7). The approach slopes currently consisting of timber cribbing may be left in place; however, during removal of the existing structure they may be damaged and need to be removed.

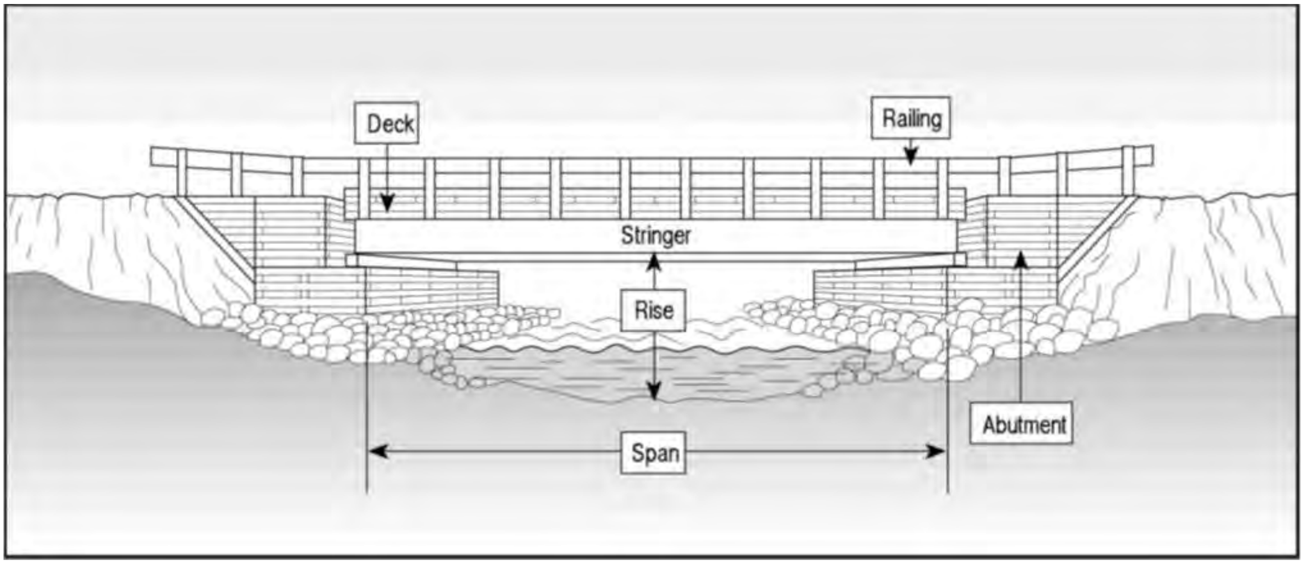


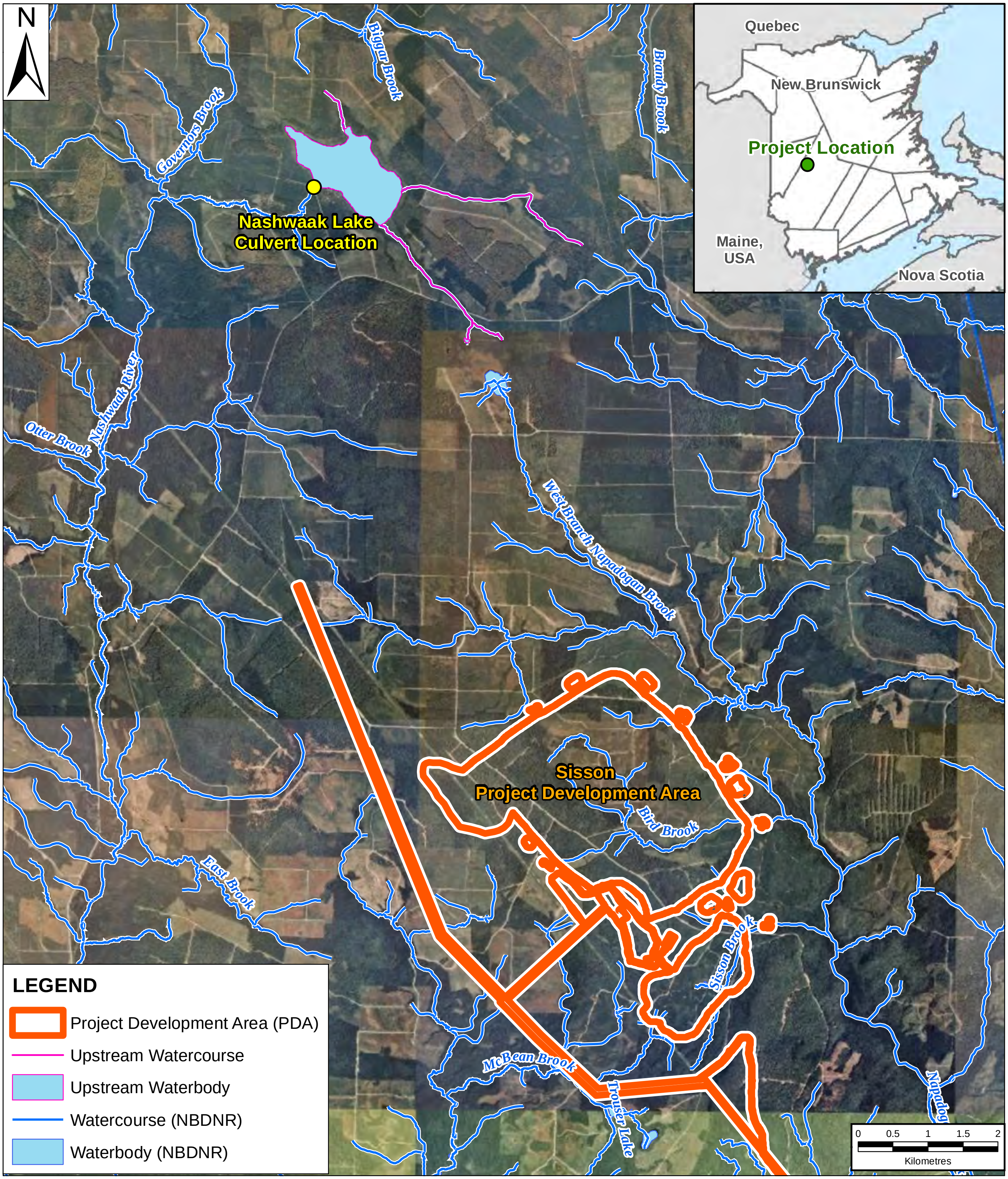
Figure 7.4.7 Typical One-Lane “Woods Road” Bridge

How the Opportunity Offsets Serious Harm

The Offsetting Plan for the removal of the existing water-level control dam and road culvert at Nashwaak Lake meets all of the “Guiding Principles” for fisheries protection (DFO 2013a). At this time, DFO is still working with provinces and territories to determine how Federal/Provincial/Territorial Fish Management Objectives will be incorporated for use in the regulatory review process. Local priorities do include the removal of anthropogenic barriers to fish migration, such as the removal of the existing water-level control dam and road culvert at Nashwaak Lake. In terms of productivity, the removal of the existing water-level control dam and road culvert will increase ecological productivity as defined in DFO (2012) as “the capacity of a given habitat or area”. Therefore, for the purposes of the Sisson Project and the required offsetting, fish productivity is inferred from the quantity of fish habitat, which is available to all CRA fish species.

Nashwaak Lake is located within the Nashwaak River watershed, the same watershed as the Project. The project is considered by DFO to provide “in-kind” offsetting as it offsets for habitat lost to brook trout, and possibly other species which are present within the area where serious harm is occurring. The Offsetting Plan proposes the existing water-level control dam and road culvert will be replaced with a clear span bridge which will provide the opportunity for the unimpeded movement of alewife, brook trout, possibly Atlantic salmon and other species between the Nashwaak River and the lake and its first and second-order tributaries. The majority of habitat upstream of the existing water-level control dam and road culvert is different from the PDA, in that it is lacustrine, and the habitat within the PDA is riverine; however brook trout are found in lake habitats and will likely benefit.

Nashwaak Lake (Figure 7.4.8) is a natural water body, with freshwater input from two first-order watercourses and one second-order watercourse. The lake has a maximum depth of 8.5 m (28 feet, as shown in Figure 7.4.9), with a fairly uniform trough-like bottom contour running in a northwest to southeast direction. There is a relatively shallower bay on the northern side of the lake. The lake has a diverse fish community which includes both resident and stocked brook trout.



NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Nashwaak Lake and its Tributaries

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Sisson Mines Ltd.

Scale: 1:75,000

Project No.: 121810356

Data Sources:
NBDNR
SNB

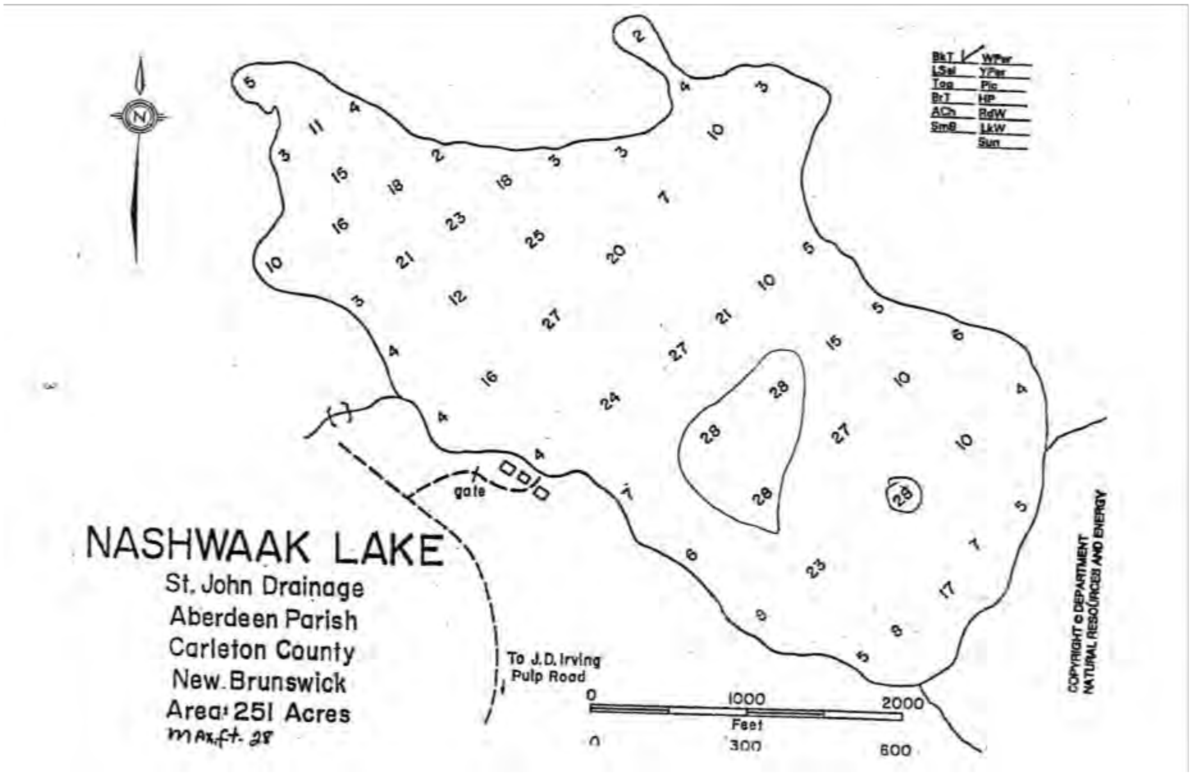
Fig. No.: 7.4.8

Date: (dd/mm/yyyy) 13/11/2014

Dwn. By: JAB

Appd. By: DLM

Map: NAD83 CSRS NB Double Stereographic



Source: Seymour, P. Personal communication, October 24, 2013.)

Figure 7.4.9 Bathymetry of Nashwaak Lake

The largest increase in the productivity of CRA fish species that is anticipated from the removal of the existing water-level control dam and road culvert at Nashwaak Lake is due to the additional habitat that will be available for the spawning of alewife (*Alosa pseudoharengus*) and rearing of early life stages of juveniles. Although alewife and blueback herring (*Alosa aestivalis*) are commonly called “gaspereau”, it is commonly understood that blueback herring do not spawn in lakes, and therefore it is likely that only alewife will benefit.

Alewife are a commercially important species, used fresh or salted for human consumption, and used as bait, fish meal and fish oil (Pardue 1983). Within the maritime region the larger commercial fisheries for gaspereau (<1,000 t annually) occur in the St. John River and Miramichi River (DFO 2001). In the St. John River and most of Atlantic Canada, the majority of the gaspereau run is made up of alewife (DFO 2001). Alewives spawn in large rivers, small streams, ponds and lakes (Pardue 1983). Spawning substrates include gravel, sand, detritus, and submerged vegetation with sluggish water flows and water depths of 15 cm to 3 m (Pardue 1983).

It is likely that alewife did spawn in Nashwaak Lake prior to the downstream development of water control dams and road crossing structures (Seymour, P. Personal communication, November 5, 2013). With the recent removal of Barker Dam, the only other known potential fish passage impediment between Nashwaak Lake and the St. John River is the Lower Lake Dam on the main stem of the Nashwaak River.

Brook trout may make use of the deeper areas of the lake as cold water refugia during summer months, and may also reside there during winter months. They may also make use of the habitat within the lake for spawning or rearing. Brook trout will also likely use the habitat found in the tributaries which flow into the lake for spawning and rearing, or for thermal refuge during summer months.

The proposed Offsetting Plan provides additional benefits to fisheries productivity by allowing alewife, a species that was likely historically present in Nashwaak Lake, to access spawning and rearing habitat in the lake. Allowing alewife access into Nashwaak Lake may also increase lake productivity by increasing marine nutrients through excretion and morality each year, with the potential to affect food web dynamics and nutrient cycling with in the lake (Walters *et al.* 2009). It may also improve CRA fisheries productivity by increasing or improving access to additional lacustrine habitat for brook trout, and additional habitat for Atlantic salmon within the tributaries flowing into Nashwaak Lake. The removal of the Nashwaak Lake culvert will generate self-sustaining benefits in the long-term as the culvert removal is permanent and will allow access for CRA species into perpetuity.

The offsetting will begin during Project Construction in order to reduce the delays associated with offsetting at a later time, as the majority of serious harm will occur during the Construction phase of the Project. The removal and replacement of the culvert will take place during the first year of the Offsetting Plan and the associated monitoring will take place the following year. The purpose of this Offsetting Plan is to generate self-sustaining benefits to fisheries productivity by improving access to the lake and its associated tributaries as habitat for migratory fish species into perpetuity.

7.4.6 Estimate of the Offsetting Credit

To estimate the amount of offsetting of serious harm to fish that would be achieved by restoring fish passage at this location, existing aerial imagery and GIS was used to calculate the total surface area of the lake, and the lengths of the tributaries. The width of the tributaries was assumed to be 3 m, which is consistent with first-order streams in this region. Using this methodology, the total surface area of the Nashwaak Lake itself is estimated as 11,238 fish habitat units, and the total combined surface area of the three tributaries and outlet is 199 fish habitat units. The combined total area is thus 11,437 fish habitat units.

Given that the lake presently provides habitat for a number of fish species, it is unlikely that a full credit would be granted for this entire area. For example, when considering the Dunbar Stream Falls project, DFO suggested that the credit for providing access to Atlantic salmon would equal 25% of the upstream habitat area. Applying the same factor to the Nashwaak Lake culvert project, a more likely offsetting credit is estimated at 2,859 fish habitat units (25% of 11,437), to be confirmed with DFO. Thus, in terms of the productivity measure represented by fish habitat units, the habitat offsetting from the removal of the existing water-level control dam and road culvert at Nashwaak Lake and its replacement with an open span bridge is more than five times the amount required for the Sisson Project (544 habitat units). Thus, the removal of the existing water-level control dam and road culvert will likely allow sufficient increases in productivity to account for any uncertainty associated with the offsetting and any time lags associated with implementing the offsetting during the Construction phase of the Project.

7.4.7 Supplementary Small-Scale Habitat Enhancement Opportunities

Separately, SML may consider funding small-scale opportunities to enhance fish habitat as part of its community or First Nations relations programs over the life of the Project, but these would not be part of the offsetting compensation or authorization requirement under the *Fisheries Act* for the loss of fish habitat and associated fish productivity associated with the Project.

These potential projects would be identified by community members, special interest groups and First Nations and brought to the Community Liaison Committee for review and consideration. SML is committed to working with the communities around the mine and First Nations to develop opportunities that will result in a positive contribution to the community and the environment over the life of the Project, *i.e.,* during Construction and Operation.

7.5 GEOCHEMICAL CHARACTERIZATION OF WASTE MATERIALS

Information presented in this sub-section has been provided by SRK Consulting based on SRK (2013).

As described in Chapter 3, the Project will generate various waste materials, which for the purposes of the geochemical characterization include wastes produced by mining and ore processing (barren rock and tailings), mid-grade ore, pit walls exposed by mining, and borrow materials used for Construction purposes (quarry rock). Because these materials have the potential to result in metal leaching and acid rock drainage (ML/ARD), a geochemical characterization of their ML/ARD potential was conducted by a number of analytical laboratory and field techniques (SRK 2013) so that potential environmental effects could be mitigated if necessary. The methodology and characterization results of Sisson Project waste materials are described in the following sections.

7.5.1 ML/ARD Assessment Methods

7.5.1.1 Geological Context for ML/ARD Potential

A description of the geological setting of central New Brunswick is provided in Section 6.3.1, and a description of the Sisson deposit is provided in Section 3.1.3, however a summary of the geological setting of the PDA is provided here as it relates to characterizing ML/ARD potential.

The Sisson deposit has been described as a granite-related porphyry tungsten-molybdenum-copper deposit (Geodex 2009). Regional metamorphism is overprinted by contact metamorphism due to the intrusion of the Howard Peak Granodiorite. Porphyry-style alteration is present, although it is not as intense or widely distributed as typical copper porphyry systems. The most common alteration observed is biotite and sericite, with strongest alteration along the contact of the western gabbro with the eastern section of the deposit, referred to as the Porten Road formation. Tungsten and molybdenum are predominantly present as scheelite and molybdenite that appear to be vein and fracture controlled. As it is currently understood, the economically-viable part of the deposit is made up of Zone III and the Ellipse Zone (see Figure 3.1.2). Zone III is a roughly north-south striking, while the Ellipse Zone is northwest-southeast striking, south of Zone III. The western half of Zone III is predominantly gabbro, and lithologies to the east of the gabbro intrusion and north of the Ellipse Zone are metamorphosed, consisting predominantly of volcanic and sedimentary rocks. The Ellipse Zone is made up of quartz diorite and lesser gabbro. The major lithologies are listed in Table 7.5.1 including a brief description and the associated lithocodes used in Figures 7.5.1 to 7.5.3.

Table 7.5.1 Summary of Major Rock Types Expected in Barren Rock at Sisson

Lithocode	Rock Name	Description
FTA	Felsic Tuff With Augen	Similar to FTQ but contains up to >10% large feldspar augen. Very strong metamorphic fabric. Locally important rock type.
FTQ	Felsic Tuff With Quartz	Medium to coarse-grained, commonly strong foliation, well-annealed.
IGB	Gabbro Intrusion	Gabbro intrusion; medium-grained, equigranular, weak to no metamorphic fabric.
IQD	Quartz Diorite Intrusion	Quartz diorite intrusion, mostly found in Ellipse Zone; possible dykes encountered in 2010 drill holes. Medium-grained, equigranular to porphyritic, weak to no metamorphic fabric.
MTF	Mafic Tuff	Fine-grained, massive, can have a strong foliation.

Table 7.5.1 Summary of Major Rock Types Expected in Barren Rock at Sisson

Lithocode	Rock Name	Description
WKB	Biotite Wacke	Mostly fine-grained and laminated foliation. A meta-sedimentary rock type with high concentration of biotite.
WKS	Biotite Wacke With Sericite	Similar to WKB but muscovite accompanies biotite.

The sulphide minerals pyrite and pyrrhotite typically average 1 to 2%, with minor arsenopyrite, sphalerite, galena and bismuth. Carbonates appear to be minor and are associated with narrow (*i.e.,* less than 50 cm) quartz veins. Based on geologic observation, there appears to be potential for ARD given the presence of sulphides and limited amounts of carbonate minerals.

7.5.1.2 Barren Rock, Pit Walls, and Mid-Grade Ore

The rock types selected to represent barren rock, pit walls, mid-grade ore, and quarry material for this geochemical characterization include the major lithologic areas of the Sisson deposit referred to as Zone III and the Ellipse Zone. They include gabbro, felsic volcanic rocks, mafic volcanic rocks, meta-sedimentary rocks and quartz diorite. Tungsten and molybdenum mineralization is vein and fracture controlled at Sisson, and large blocks of different lithologic zones with inherent varying alteration patterns will be mined.

Acid-base accounting (ABA) tests were performed on the composite drill core samples using the modified neutralization potential (NP) method (MEND 1991), paste pH, paste conductivity, total sulphur, sulphur as sulphate (sodium carbonate and hydrochloric acid methods) and total carbonate analysis. Element analysis included a scan by inductively coupled plasma mass spectrometry (ICP-MS) following *aqua regia* digestion, and total barium, low level mercury and total fluoride. In total, 269 barren rock, 68 pit wall, and 20 mid-grade ore drill core composites were tested by the methods listed above.

Laboratory humidity cells were started on September 19, 2011, and at the time of finalizing SRK (2013), results for 89 weeks of testing had been received. There are currently 13 cells being tested on barren rock samples and one mid-grade ore composite. Samples were selected to represent the range of major lithologies and sulphide concentrations expected in barren rock, pit walls and mid-grade ore. The testing procedure is following the protocol outlined by the Mine Environment Neutral Drainage (MEND) program (1991) with weekly monitoring of water volume, pH and conductivity, and bi-weekly analysis of acidity, alkalinity, sulphate, chloride, fluoride, low level mercury and a metal scan by ICP-MS. For quality assurance and quality control purposes (QA/AC) one barren rock sample was tested as a duplicate, and one blank cell was also included in the testing.

Saturated column tests were started on March 8, 2013 to evaluate water quality expected from barren rock submerged in the TSF and, at the time of finalizing SRK (2013), nine weeks of results were available.

Mineralogical characterization of representative splits from all humidity cells included optical petrography, quantitative (Rietveld) X-ray diffraction, and electron microprobe analysis of sulphide and carbonate grains selected during optical petrography observations.

Field kinetic tests (barrels) were started on September 13, 2011 and, at the time of finalizing SRK (2013), results from nearly two years of testing had been received. The field barrels were set up at the

Sisson Project site to evaluate leaching under site conditions for comparison with laboratory tests. Five barrels contain approximately 300 kg of barren rock representing gabbro, felsic tuff, mafic tuff, biotite wacke and quartz diorite. Samples were selected from drill core and crushed and blended by SGS Lakefield prior to being placed into the 200 L field barrels. During the open-water season, leachate was monitored weekly for pH, conductivity and oxidation-reduction potential (ORP), and samples were collected once a month for analysis of the same parameters as the humidity cells listed above. One barrel was set up as a field blank for QA/QC purposes. Splits of all five barrel samples were also set-up as humidity cells.

7.5.1.3 Quarry Rock (Borrow)

A quarry will be used to source rock for the TSF embankment construction. The quarry will be located near the north-west corner of the TSF and the primary rock types are gabbro and granite. Approximately 29,066 m^3 of rock will be quarried. Six drill core composites were selected from the proposed quarry location.

The same testing procedure as outlined for barren rock (Section 7.5.1.2) was performed on quarry material, with the exception of mineralogical characterization and field barrel testing. Two humidity cells were started on September 10, 2012 and, at the time of finalizing SRK (2013), 38 weeks of data had been received. The two samples represent a composite of gabbro and a composite of granite with the same testing frequency and parameters as barren rock.

7.5.1.4 Tailings

Tailings from metallurgical processing of a master ore grade composite were generated for ML/ARD characterization. The master composite was comprised of the six major lithologies expected at Sisson and assumed to represent the average ore characteristics of the first ten years of mining. Two tailings streams were produced from molybdenum concentration and tungsten concentration, with cleaner and rougher fractions for each. Tungsten will be refined in an ammonium paratungstate (APT) plant. Residues from the APT plant have not been tested as they will be stored in sealed drums off-site.

Tailings samples were separated into three size fractions (+0.149 mm; -0.149+0.074 mm; and -0.074 mm) and then submitted for the same composition analyses as performed on barren rock (Section 7.5.1.2).

Two humidity cells were set up for tungsten rougher tailings (combined particle size), one on April 2, 2012 and the other on November 5, 2012. At the time of finalizing SRK (2013), 61 weeks of data had been received for the initial humidity cell and 28 weeks for the second humidity cell test. The testing frequency and parameter list was the same as barren rock. The one addition was the analysis of nitrogen forms. Humidity cell testing was not completed on the molybdenum sample as this material was assumed to require water submergence due to the high sulphide concentration in the tailings.

Mineralogical characterization (as per Section 7.5.1.2) was also completed on the tungsten rougher tailings.

Additional testing completed for understanding TSF water included tailings supernatant chemical characterization as well as supernatant aging tests.

7.5.1.5 QA/QC Measures

Quality assurance and quality control were a major component of all test work. Approximately 10% of all samples were tested as duplicates, in addition to blanks being tested for 10% of all leachate analyses. Any duplicate samples with relative percent differences (RPDs) greater than ±15% were re-analyzed, in addition to any leachate analyses with ion balances with RPDs greater than ±15%.

7.5.1.6 ARD Potential Classification Criteria

Acid rock drainage potential classification of all waste material was based on neutralization potential (NP) to acid potential (AP) ratios (hereafter referred to as NPRs). Samples with a NPR less than 1 were classified as potentially acid generating (PAG), samples between 1 and 2 as uncertain, and samples greater than 2 as non-potentially acid generating (NPAG). In addition, if the sulphur concentration was less than 0.1%, samples were classified as NPAG, regardless of the NPR.

The use of NPR greater than 2 to classify materials as NPAG (as opposed to 3) was determined based on findings from mineralogical characterization and nearly two years of humidity cell testing. The former showed that carbonate is present primarily as calcite. The latter showed that materials with NPR values greater than one are not expected to produce acid.

7.5.2 Sisson Waste Material ML/ARD Characterization

7.5.2.1 Barren Rock Characterization

Approximately 54% of the barren rock samples were classified as PAG, 16% as uncertain, and 30% as NPAG. NPRs ranged from a minimum of 0.1 to a maximum of 7.6, with an average of 0.9 (Figure 7.5.1). The dashed line in Figure 7.5.1 represents 0.1% sulphur, while the solid lines define the 1:1 and 2:1 NP/AP ratios for ARD classification.

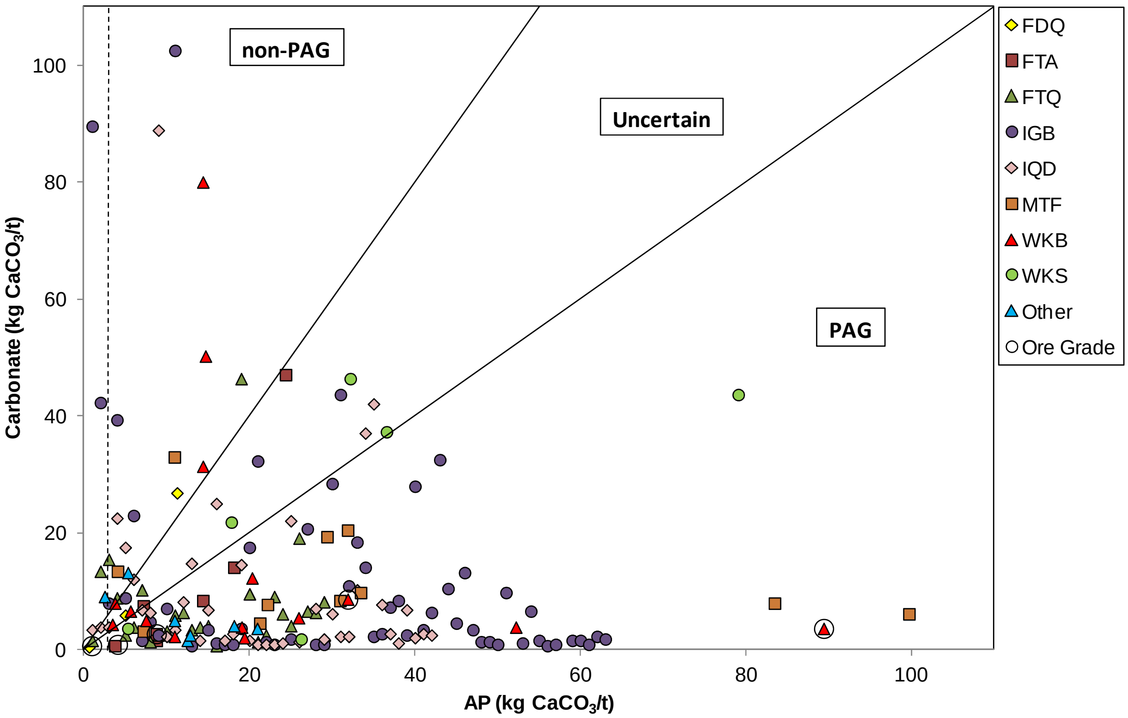


Figure 7.5.1 **Carbonate NP Versus Sulphide AP**

Based on the current understanding of the local geology and mine plan, PAG zones do not appear to be restricted to certain lithologies or mineable blocks. As a result, all barren rock has been assumed to be PAG for the purpose of barren rock management planning, and it will be stored sub-aqueously within the TSF to effectively inhibit potential generation of acid and metal leaching.

Delay to onset of ARD was estimated from one year of humidity cell testing and applying a geochemical scaling factor of 0.14. Oxidation rates from field barrel testing results and experience at other mine sites were used to calculate the geochemical scaling factor. Generally (at least in Canada), slower sulphide oxidation rates are observed in full-scale waste facilities compared to laboratory rates. The main difference is due to colder temperatures on-site. Gas exchange can also be limited in full scale facilities and limit oxidation rates, but this has not been taken into consideration here.

Geochemically “scaled” rates based on kinetic testing in the laboratory and field have been interpreted to indicate that the average delay to onset of ARD is 100 years, with the fastest rate estimated at 10 years. A comparison of humidity cell leachate pH for all samples is provided in Figure 7.5.2.

Metal leaching from barren rock is anticipated for arsenic, based on comparison to global crustal averages reported by Price (1997). Based on mineralogical and kinetic testing results, this is due to sulphide oxidation; measures to limit sulphide oxidation through sub-aqueous storage of barren rock in the TSF should also effectively inhibit arsenic leaching from barren rock.

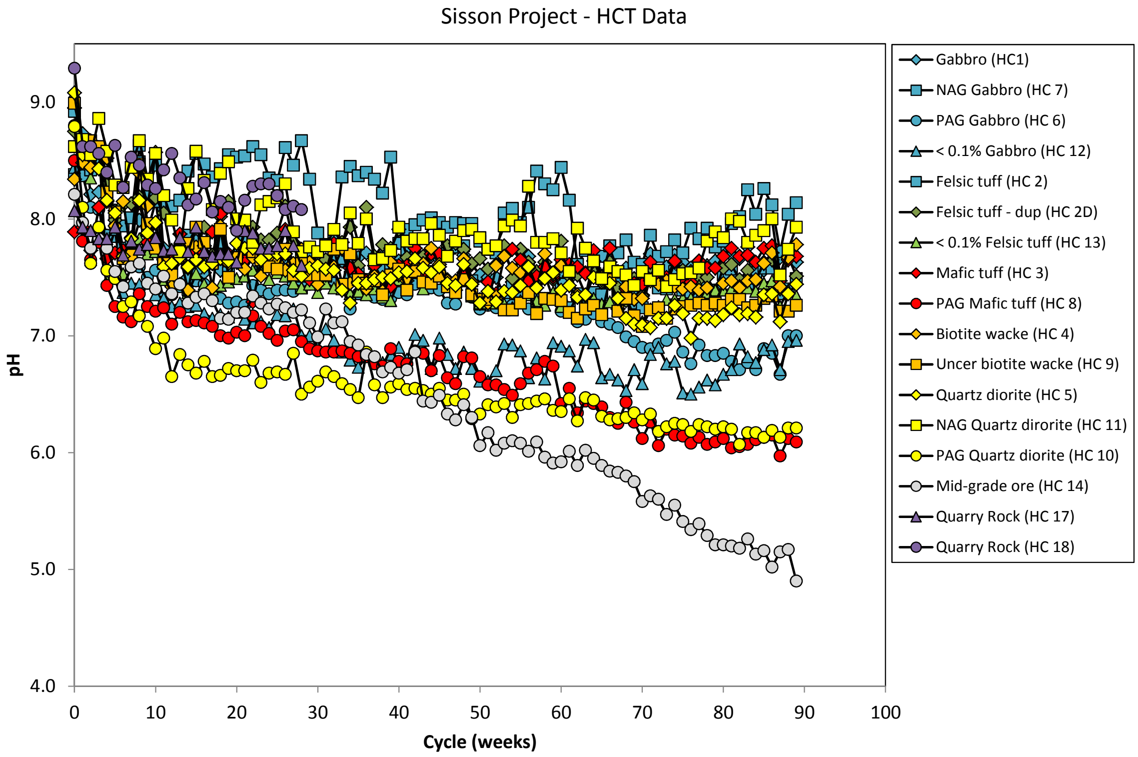


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Figure 7.5.2 Humidity Cell Leachate pH for Barren Rock and Mid-Grade Ore Samples

7.5.2.2 Pit Walls Characterization

Pit wall material has been classified as PAG with an average NPR ratio of 0.5 (mineralogical carbonate used for NP). By depth, no trends were apparent. Drill hole NPRs are illustrated in Figure 7.5.3, with an average for all samples and a moving average by 50 m intervals shown in dashed lines. The drill holes were selected to spatially cover the extent of the pit wall limits at end of mine life.

Timing to onset of ARD is estimated to be greater than 100 years, which is based on oxidation rates of barren rock humidity cells in the laboratory with similar sulphur and carbonate composition and geochemically scaled in the same manner as barren rock. Flooding of the pit is expected to occur in less than 100 years and this will effectively inhibit ARD production. Arsenic leaching is anticipated from pit walls because of elevated concentrations in the wall rock when compared to global crustal averages reported by Price (1997). However, this will be due to sulphide oxidation, and flooding of the pit walls should inhibit long-term arsenic leaching.

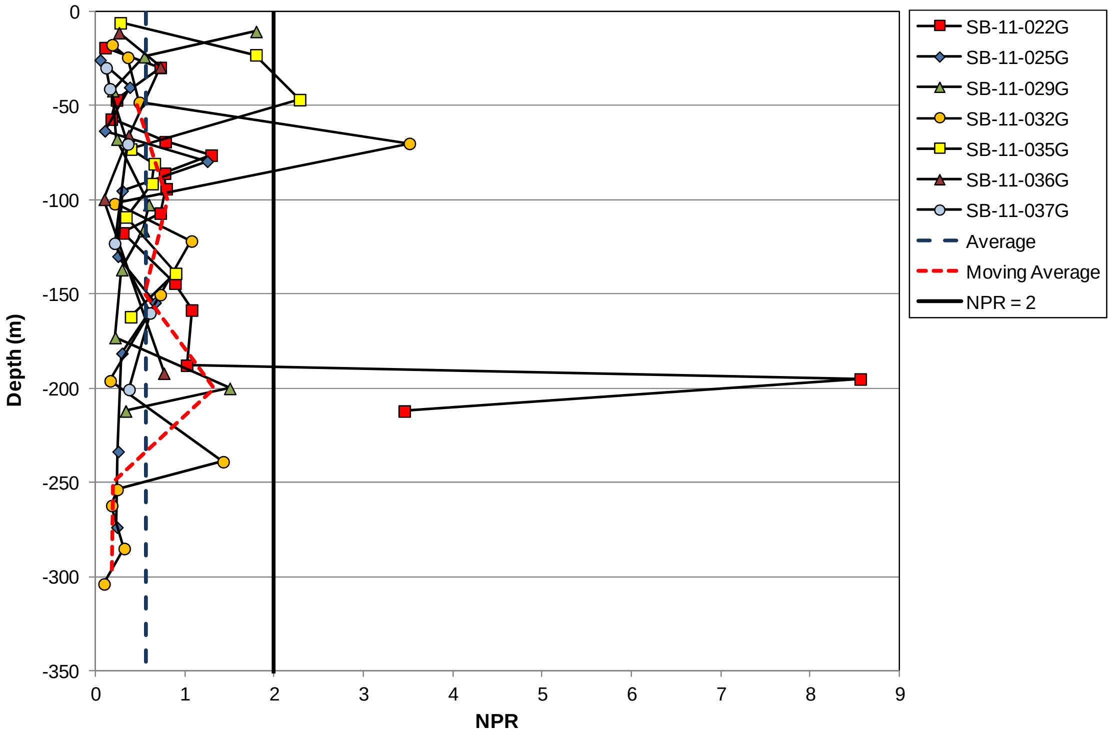

Figure 7.5.3 **Pit Wall NPRs by Drill Hole and Depth**

7.5.2.3 Mid-Grade Ore Characterization

Mid-grade ore has been classified as PAG. Delay to onset of ARD is estimated at 10 years when a 0.14 geochemical scaling factor is applied to the laboratory humidity cell oxidation rate. Metal leaching due to sulphide oxidation is possible due to enriched concentrations of arsenic, copper, molybdenum and selenium. Fluorine (as fluoride) is also enriched. Placement of the mid-grade ore within the TSF area for eventual sub-aqueous storage, if it is unused, should effectively inhibit potential generation of acid and metal leaching.

7.5.2.4 Quarry Rock Characterization

Quarry rock for embankment construction of the TSF was classified as NPAG based on static and kinetic testing of material to date. Sulphur concentrations were generally below detection (*e.g.,* 0.02% total sulphur) and metals and other contaminants were also near or below analytical detection limits.

7.5.2.5 Tailings ML/ARD Potential

Two tailings streams are expected from processing ore from the Project: a molybdenum tailings stream, and a tungsten tailings stream. The ore composite was classified as PAG due to an NPR of 0.7.

A summary of acid-base accounting (ABA) testing to date is provided in Figure 7.5.4. The dashed red line in Figure 7.5.4 denotes 0.1% sulphur.

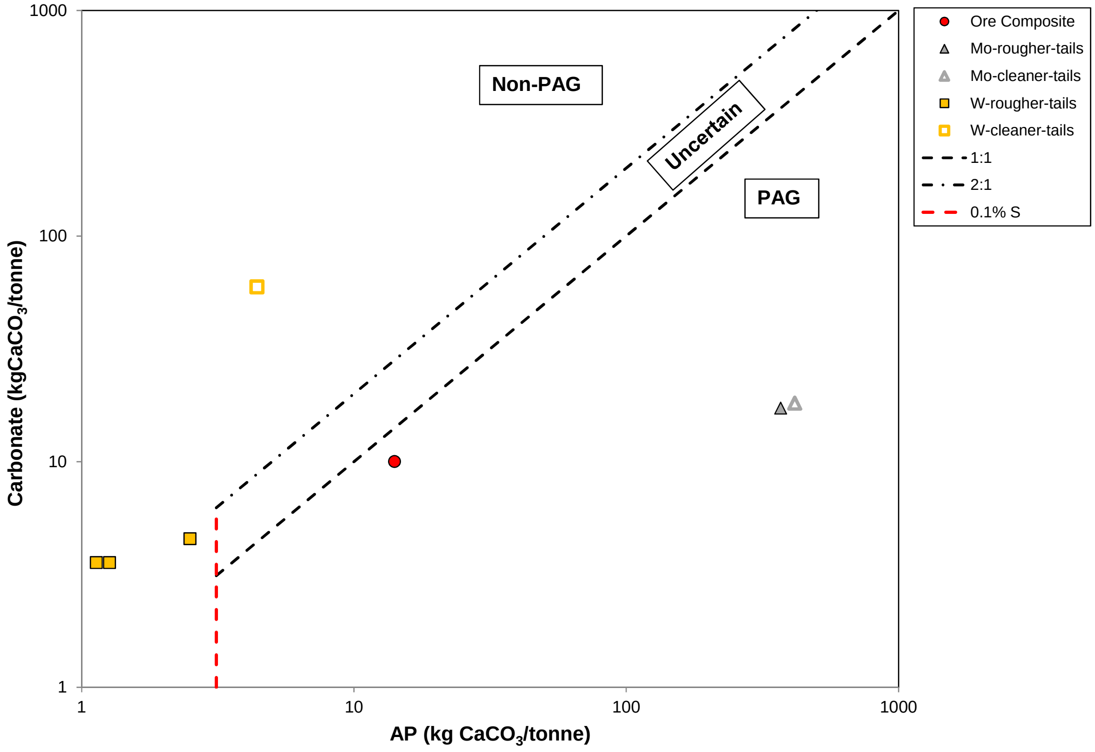

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Figure 7.5.4 Tailings NP Versus AP Comparison

Metallurgical concentration of molybdenite produced tailings enriched in iron sulphides and tailings were classified as PAG. Metal leaching potential exists for arsenic, cadmium, copper, lead, molybdenum, selenium, silver, uranium and zinc due to sulphide oxidation. Sub-aqueous storage of molybdenite tailings in the TSF will effectively inhibit sulphide oxidation and metal leaching.

Concentration of tungsten is performed after sulphide removal and as a result, the tailings were classified as NPAG based on NPRs greater than 2 and low sulphur concentrations (*e.g.,* < 0.1%). In addition to the samples tested herein, results from metallurgical lock cycle testing also revealed very low sulphur concentrations (*e.g.,* < 0.1%) in tungsten tailings. Based on static testing, 61 weeks of humidity cell testing, and mineralogical characterization, ARD is not expected from the tungsten rougher or cleaner tailings. Leaching of trace elements and other parameters (*e.g.,* fluoride) are not expected to exceed background concentrations.

The TSF pond water (*i.e.*, process water) for Sisson is expected to initially be alkaline and dominated by sulphate, thiosalts, carbonate, bicarbonate, sodium, and potassium. As the pond water ages, pH is predicted to decrease to approximately 8 due to equilibration with atmospheric carbon dioxide (formation of carbonic acid), conversion of carbonate to bicarbonate and oxidation of thiosalts to sulphate.

7.5.3 Drainage Chemistry Predictions

For each mine waste component, drainage chemistry was predicted in the form of waste material source terms. The suite of parameters predicted were inclusive of *Metal Mining Effluent Regulations* (*MMER*) and calculated as follows.

- Full scale waste facility leaching rates were generated by applying geochemical scaling factors to humidity cell leaching rates to account for the effects of temperature, particle size and contact factor. For all waste materials except tailings, the applied scaling factor was 0.07 based on rates obtained from field barrel tests. For tailings, the scaling factor was 0.2 as test material and full-scale material was assumed to have the same particle size.

- Scaled rates were inherently conservative for two reasons: based on experience, the scaling rate from barrel tests is likely overestimated as no consideration was given to decreased gas exchange in full scale facilities and laboratory rates used 95th percentile concentrations for sulphur and trace elements wherever possible.

- Scaled leaching rates in mg/kg/week were applied to various mine components and concentrations calculated based on estimated waste composition, volume, net precipitation, and infiltration.

- The majority of tailings will be submerged with sulphide oxidation effectively inhibited. Small portions of the beaches will be unsaturated and source terms for these areas were calculated assuming oxygen only penetrates up to 10 m.

- Waste materials classified as PAG were assumed to be submerged in water prior to onset of ARD.

- Although it is predicted that, under average hydrometeorological conditions, the pit will be filled by Year 39, approximately 12 years after the completion of Operation, the pit was conservatively assumed to fill within 20 years post-Closure. After the pit is filled, only a small hanging wall (*e.g.,* average height estimated at 20 m) will remain exposed.

- Concentrations were assessed with respect to mineral solubility limits determined using the equilibrium modeling program Phreeqc (Parkhurst et al. 1999). Any minerals oversaturated were allowed to saturate and concentrations set to equal the maximum concentration of the individual mineral’s solubility. For example, the mineral ferrihydrite was used to limit the concentration of iron at neutral pH.

- Predictions for leaching of explosive residues from barren rock and pit walls leading to soluble nitrate, nitrite, and ammonia was calculated using the Ferguson and Leask (1988) method.

- Solubility-adjusted concentrations for each waste facility were provided to Knight Piésold to model water quality expected from the Project (Section 7.6). Detailed results are provided in SRK (2013).

7.6 WATER QUALITY AND WATER BALANCE MODELLING

Information presented in this sub-section has been provided by Knight Piésold Ltd. (Knight Piésold 2013c and 2014).

7.6.1 Water Management Plan

7.6.1.1 General

The following sections outline the mine site water balance and the water management plan for the Project from pre-production (Year -2) through Post-Closure. The mine site water balance forms the basis for the predictive water quality modelling (Section 7.6.3).

7.6.1.1.1 Water Management during Construction

The Construction water management plan will commence approximately 24 months prior to mill commissioning (*i.e.,* 24 months before the commencement of Operation). Construction is characterized by:

- extensive clearing, grubbing, and stripping;
- development of a site access road and internal haul roads; and
- establishing water management and sediment control structures including coffer dams, pumping systems, run-off collection ditches, and diversion channels.

Some of the temporary works such as coffer dams and by-pass diversion channels will be decommissioned once the initial tailings storage facility (TSF) starter embankments have been constructed. Sediment collection ponds and collection channels will remain in place throughout the life of the Project.

7.6.1.1.2 Water Management during Operation

All water that has been in contact with mine facilities or associated construction areas (referred to as mine contact water), including the open pit, ore processing plant site and soil stockpiles, will be controlled and managed. The operational water management plan for the site includes the following components.

- Diversion channels upstream of the Project facilities, including the TSF, plant site, and other infrastructure, will direct non-contact water back to the natural environment to the extent possible. This water may be collected to control sediment before discharge if needed.
- All un-diverted run-off from within the footprints of the project facilities (*e.g.,* plant site) will be collected in channels and routed to water management ponds.
- All un-diverted run-off from within the TSF catchment will be directed to the TSF.

- Water from the open pit will be pumped to a collection pond near the pit rim, and subsequently pumped to the TSF.

- Tailings will be selectively deposited from the crest of the TSF embankments to develop tailings beaches, which will function as an extensive low permeability zone to mitigate seepage through the embankments. The operational supernatant pond will be managed to reduce the potential for dust generation and to ensure that sufficient storage exists for operational flexibility and storm inflow storage.

- Process water contained in the tungsten and molybdenum tailings will be discharged into the TSF with the tailings slurry at an average rate of approximately 2,022 m^3/h at full production.

- Tailings supernatant water will be reclaimed, treated, and pumped back to the mill to the extent possible to meet the average process water requirement of approximately 2,003 m^3/h at full production.

- Water will be discharged from the TSF to a water treatment plant (WTP) when the facility is operating in a water surplus condition, likely starting in Year 8 of the mine life under average climatic conditions, to maintain an acceptable TSF operating pond volume.

- Water management ponds (WMPs) at low points around the TSF perimeter will collect seepage and run-off from the TSF embankments. This water will be pumped back to the TSF unless the water quality is suitable for discharge.

- Groundwater monitoring wells will be located below the WMPs. Groundwater pump-back wells will be developed and operated as necessary to return groundwater to the WMPs and TSF if seepage quality may jeopardize downstream water quality.

7.6.1.1.3 Water Management during Decommissioning, Reclamation and Closure

Water Management during Closure

Closure includes the period between the end of active mining and processing operations and the time at which the open pit has filled with water. It is estimated that closure will begin in Year 28 and the open pit will be filled by about Year 39. The water management plan for the site during the Decommissioning, Reclamation and Closure phase includes the following elements.

- Diversion channels will be maintained upstream of the Project facilities that have not yet been removed or reclaimed to direct non-contact water back to the natural environment to the extent possible. This water may be collected to control sediment before discharge if needed. Once Project-affected areas have been fully reclaimed and stabilized, surface drainage will be re-directed to mimic the pre-Project regime wherever possible.

- All un-diverted run-off from within the footprints of the Project facilities (*e.g.,* TSF embankments) will be collected in channels and directed to water management ponds until water quality is suitable for discharge. Once water quality from reclaimed areas meets applicable discharge criteria, the water management structures (*i.e.,* collection channels and water management ponds) will be decommissioned.

- All un-diverted run-off from within the TSF catchment will flow to the TSF.
- The tailings beaches will be reshaped to enhance drainage towards the TSF pond and to meet the end land use objectives for the site. The tailings surface will be capped with rock and soil to minimize erosion by water and wind, provide a trafficable surface, and allow re-vegetation.
- The TSF quarry area will be connected to the TSF pond with a channel excavated in rock.
- An outlet channel will be constructed between the TSF pond and the open pit to allow excess water from the TSF to flow into the open pit. This will help fill the open pit more quickly during Closure.
- Water management ponds at low points around the TSF perimeter will continue to collect seepage and run-off from the TSF embankments. This water will be pumped back to the TSF until the water quality is suitable for discharge.
- Groundwater monitoring wells will be maintained below the water management ponds. Groundwater pump-back wells will be operated as necessary.

Water Management during Post-Closure

The Post-Closure period begins when the open pit has completely filled with water and discharge begins to the downstream environment. The water management plan for the site in Post-Closure includes the following.

- The diversion channel on the southeast side of the open pit will be maintained to continue providing flow to the McBean Brook watershed.
- All water management features that are no longer needed will be reclaimed as open water features, wetlands, and/or other appropriate end land uses.
- The outlet channel between the TSF pond and the open pit will continue to allow excess water from the TSF to flow into the open pit.
- The water level in the pit lake will be maintained by pumping the water to the WTP, and treating it as necessary prior to discharge. The lake level will be maintained at an elevation that ensures all groundwater flows into it. All water that needs to be discharged will be treated for as long as is necessary to meet the Project’s permit conditions for discharge water quality. It is expected that the water treatment facility used during Operation will be re-mobilized for this purpose, although it may need to be refurbished and/or reconfigured to suit Post-Closure water treatment requirements.

- When the pit lake water is of sufficient quality to allow its discharge into downstream drainages, pumping and treatment will cease, the pit will be allowed to fill completely, and the pit lake will discharge to Sisson Brook through an engineered channel at the low point on the pit rim.
- Groundwater monitoring wells will be maintained below the water management ponds. Groundwater pump-back wells will be operated as necessary.

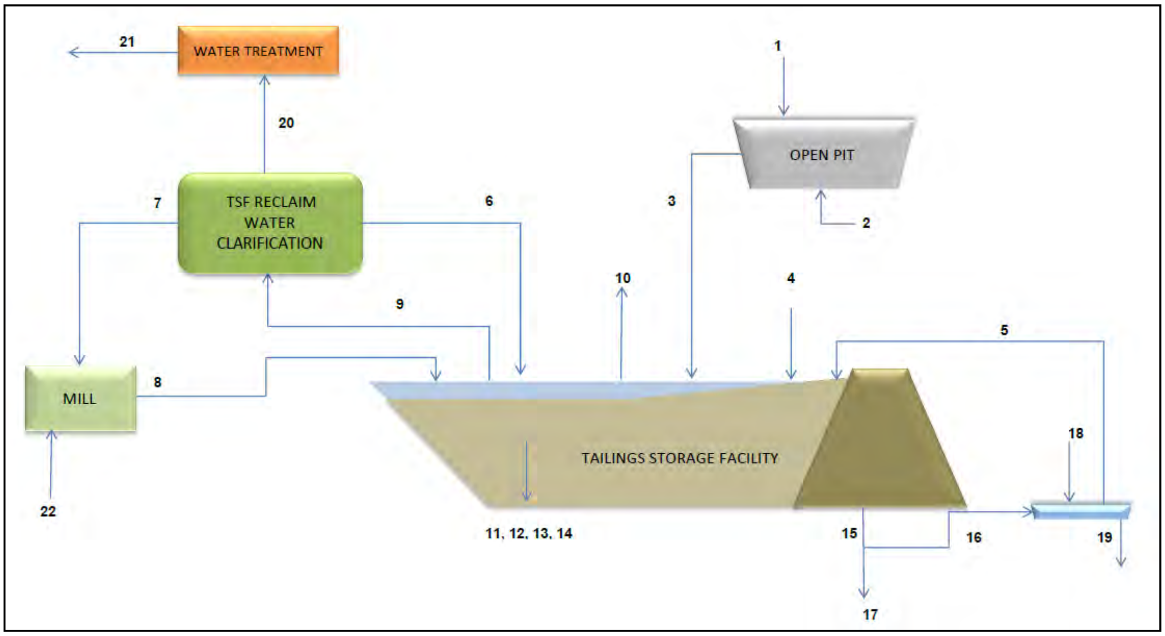
7.6.2 Operational Water Balance Model

7.6.2.1 General

A stochastic analysis was carried out on the base case monthly operational mine site water balance using the GoldSim© software package. The intent of the modelling was to estimate the magnitude and extent of the water surplus and/or deficit conditions in the TSF based on a range of possible climatic conditions. The modelling timeline includes one pre-production year (Year -1), and 27 years of mine operation (Years 1 to 27) at an average rate of 30,000 dry metric tonnes per day. The model incorporates the following major mine components:

- Open Pit;
- Mill;
- TSF;
- Barren Rock and Mid-Grade Ore stored in the TSF (collectively referred to as Waste Rock);
- Reclaim Water Clarification Plant; and
- Water Treatment Plant (WTP).

The model is shown schematically on Figure 7.6.1 and descriptions of each flow path are provided in Table 7.6.1.



NOTES:
1. WATER BALANCE SCHEMATIC IS NOT DRAWN TO SCALE.
2. SOLID LINE DENOTES WATER ROUTING ASSUMPTION →

Figure 7.6.1 Operational Water Balance Model Schematic Flow Sheet (Operation phase)

Table 7.6.1 Operational Water Balance Flow Path Descriptions

Number	Description
1	Open Pit Direct Precipitation and Catchment Run-off
2	Open Pit Groundwater Inflows
3	Open Pit Dewatering to TSF
4	TSF Catchment & Beach Run-off, Direct Precipitation on Pond
5	Water Management Pond Recycle
6	Water from Clarification Plant to TSF Pond
7	Water From Clarification Plant to Mill
8	Water in Tailings to TSF
9	TSF Reclaim Water to Clarification Plant
10	TSF Pond Evaporation
11	Water Retained in Tailings Void Spaces
12	Water Retained in Clarification Slurry Void Spaces
13	Water Retained in Barren Rock Void Spaces
14	Water Retained Mid-Grade Stockpile Void Spaces
15	TSF Embankment Seepage – Total
16	TSF Embankment Seepage – Captured by Seepage Collection System/WMPs
17	TSF Embankment Seepage – Lost
18	Water Management Pond Embankment and Catchment Run-off
19	Water Management Pond Seepage
20	Excess Clarified Water to Treatment
21	Treated Water Discharge to Environment
22	Fresh Water Make-up to Mill

Model assumptions and parameters are discussed in the following sections, and additional details are presented in Samuel Engineering (2013).

7.6.2.2 Model Inputs and Assumptions

7.6.2.2.1 Climatic Conditions

The base case monthly operational water balance model was developed using the estimated monthly values shown in Table 7.6.2. The mean annual unit run-off (MAUR) for undisturbed basins in the Project area was estimated to be approximately 827 mm based on the long-term MAUR for the Project site station B-2 on Bird Brook at Napadogan. The mean annual precipitation (MAP) was estimated to be 1,350 mm, with 75% of the annual precipitation falling as rain and the remainder as snow. The annual average potential evapotranspiration (PET) for the Project site was estimated to be 500 mm. PET was assumed to equal lake evaporation and was applied to the TSF pond surface to estimate evaporation losses.

Table 7.6.2 Average Hydrometeorological Inputs

Parameter	Monthly Value (mm)												Annual (mm)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Precipitation	115	83	107	96	111	114	127	122	119	117	116	123	1,350
Rainfall	34	21	45	70	110	114	127	122	119	114	85	51	1,012
Snowfall	81	62	62	26	1	0	0	0	0	3	31	72	338
Sublimation	15	15	15	15	0	0	0	0	0	0	0	15	75
Snowmelt	0	0	28	113	121	1	0	0	0	0	0	0	263
Available Precipitation	34	21	73	183	231	115	127	122	119	114	85	51	1275
Lake Evaporation	0	0	0	15	68	100	119	104	65	29	0	0	500
Available Run-off	41	28	65	213	138	49	33	26	25	54	82	73	827

Notes:
1) The precipitation values were estimated for Sisson climate station, which is at an approximate elevation of 305 m.
2) Surface run-off was estimated by multiplying the available precipitation values by the corresponding run-off coefficient for each Project area.
3) The lake evaporation values were applied to TSF pond area to estimate evaporative losses.
4) Available run-off values were applied to undisturbed areas within the mine footprint to estimate run-off.

7.6.2.2.1.1 Run-off Coefficients for Disturbed Areas

Natural run-off values are not directly applicable for mine site disturbed areas because of the substantial changes in run-off caused by altering the ground cover. Therefore, the quantities of water (run-off/infiltration) generated from the mine affected areas (open pit, TSF embankments, barren rock, mid-grade ore, and TSF beaches) and open water (TSF supernatant pond) were estimated by multiplying rainfall and snowmelt by the following assumed run-off coefficients:

- TSF Beaches: 0.7;
- TSF Embankments, Mid-Grade Ore, and Barren Rock: 0.8;
- TSF Pond: 1.0; and

- Open Pit Walls: 0.9.

7.6.2.2.1.2 Stochastic Inputs

The variability of climatic conditions was addressed using a stochastic version of the water balance model that included Monte Carlo-type simulation techniques. The monthly climate parameters were modeled as probability distributions rather than simply as mean values. The year-to-year variability of monthly run-off was quantified using coefficient of variation (C_v) values that were derived from regional datasets. The monthly mean and standard deviation values were used to develop monthly probability distributions that are required for a Monte Carlo simulation. The distributions of monthly precipitation were modelled assuming an underlying Gamma distribution.

7.6.2.2.1.3 TSF Embankment Drainage and Seepage Collection

Steady-state seepage analyses were completed using the finite element computer program SEEP/W to estimate the amount of seepage through the TSF embankments. It was assumed that a portion the embankment drainage and seepage will be captured by the embankment seepage collection system or intercepted and collected by groundwater pump-back wells downstream of the TSF. A small fraction of the total seepage was assumed to bypass the seepage collection systems and be lost to the environment downstream of the TSF.

It should be noted that a more conservative (higher) estimated TSF seepage values were used in the water quality modelling as compared to the Operational Water Balance Model that was carried out for engineering purposes. The estimated seepage losses from the TSF in each phase of the predictive water quality model are shown in Table 7.6.3 along with the estimated seepage capture rates of the water management ponds and the corresponding capture efficiencies.

Table 7.6.3 Estimated Seepage Rates by Project Phase

	Operation	Closure and Post-Closure
TSF Seepage (L/month)	2.8×10^8 (106 L/s)	6.3×10^7 (24 L/s)
Seepage Capture (L/month)	2.3×10^8 (87 L/)	4.2×10^7 (16 L/s)
Capture Efficiency (%)	82%	67%

7.6.2.2.1.4 TSF Reclaim Clarification Plant

Reclaim water pumped from the TSF will be sent to a clarification plant for removal of suspended solids prior to being pumped to the mill for use in the process. The settled solids produced from the clarification treatment system will include a lime underflow and calcium carbonate precipitate, both of which will be pumped back to the TSF as slurries.

7.6.2.2.1.5 Pumping to Water Treatment Plant

Water will be directed to a WTP from the TSF reclaim clarification plant at a rate of approximately 6 million m^3/a to maintain an acceptable operating pond volume in the TSF and to supplement the stream flow in the downstream environment. Pumping to treatment is assumed to commence as of approximately Year 8 and will continue until the end of Operation in Year 27, under average climatic conditions.

7.6.2.2.1.6 Mill Requirements

Water requirements at the mill were calculated based on the specified mill production rate and the expected solids content (% by weight) of the tailings. All of the process water will be supplied by the TSF reclaim system. The freshwater requirement for the mill is approximately 14 m^3/h. This fresh water requirement is assumed to be in addition to any process water make-up extracted from the TSF reclaim system.

7.6.2.2.1.7 Pit Dewatering System

The water pumped from the open pit by the dewatering system includes pit wall run-off, undisturbed pit catchment run-off entering the pit, and groundwater inflows. Groundwater inflows to the open pit were estimated to be approximately 40 L/s at the maximum extent of the pit. The inflow rate was assumed to increase linearly during the 27 years of Operation, from 0 L/s in Year 1, up to 40 L/s in Year 27. It was assumed that pit dewatering flows will be pumped to the TSF during Operation.

7.6.2.2.1.8 Water Retained in Voids in TSF

The amount of water retained in the tailings, clarification plant solids, barren rock and mid-grade ore stored in the TSF is a function of the production schedule and the dry density and specific gravity of the solids.

Approximately 209 million tonnes of barren rock and mid-grade ore will be stored in the TSF from Year 1 through to Year 20; from Year 21, the barren rock will be stored in the open pit and flooded during Closure along with the pit. Within the TSF, the mid-grade ore is assumed to be partially submerged by the supernatant pond starting in Year 15, with approximately 17 million tonnes submerged by Year 25. The barren rock will start to be submerged by the pond in Year 3, and will then be progressively saturated until Year 21.

7.6.2.2.1.9 Reclaim Water

The volume of water available for reclaim to the mill was estimated using the TSF water balance.

The primary TSF inflows are:

- water pumped to the TSF from the mill with the tailings slurry;
- water in the clarification plant slurries;
- direct precipitation and run-off to the TSF, which includes run-off from the exposed mid-grade ore stockpile, barren rock, and quarry; and
- embankment seepage recycle.

The primary TSF outflows are:

- pumping of excess water to the WTP;
- water retained in tailings and rock void spaces;
- evaporation; and
- embankment seepage.

The water available for process use is assumed to be 100% of the difference between these inflows and outflows.

7.6.2.3 Water Balance Results

The water balance model results were used to estimate the likelihood of having a surplus or deficit of water in the TSF. The TSF pond is predicted to be in a net surplus condition for the entire operating life of the mine, indicating that the system (including the TSF and contributing catchments) is able to supply more than enough water to meet the mill process water requirements, even under dry conditions. Surplus conditions mean that water either needs to be stored in the TSF or discharged.

The water balance model assumed that the TSF start-up pond is allowed to accumulate over one freshet season prior to the start of mine Operation and that the minimum operating pond volume is 3 million m^3. The TSF pond volume will then increase over the first eight years of Operation as the aerial extent of the TSF increases and surplus water is collected in the pond; no surface water discharge is expected until Year 8 under average climatic conditions. Approximately 6 million m^3/year of TSF pond water will be pumped to the WTP during Operation starting in Year 8 under average conditions. Surplus water in the TSF will be routed to the open pit after closure (starting in Year 28) to fill the pit lake more quickly. Water will be discharged from the pit lake through the WTP starting in Year 40. The model timeline is summarized below in Table 7.6.4.

Table 7.6.4 Summary of Water Balance Model Timeline

Mine/Model Year	Milestone
Year -1	Start-up – run-off collects in the TSF for initial operation of the mill up to approximately 3 million m^3.
Year 1 to Year 7	Operation – TSF pond grows as the facility expands.
Year 8 to Year 27	Operation – TSF pond reaches steady-state operating volume and discharge to the WTP begins.
Year 28 to Year 39	Closure – surplus water from the TSF is routed to the open pit to increase the rate of filling.
Year 40 Onward	Post-Closure – the open pit is full and water is discharged from the pit lake to a WTP.

7.6.3 Predictive Water Quality Model

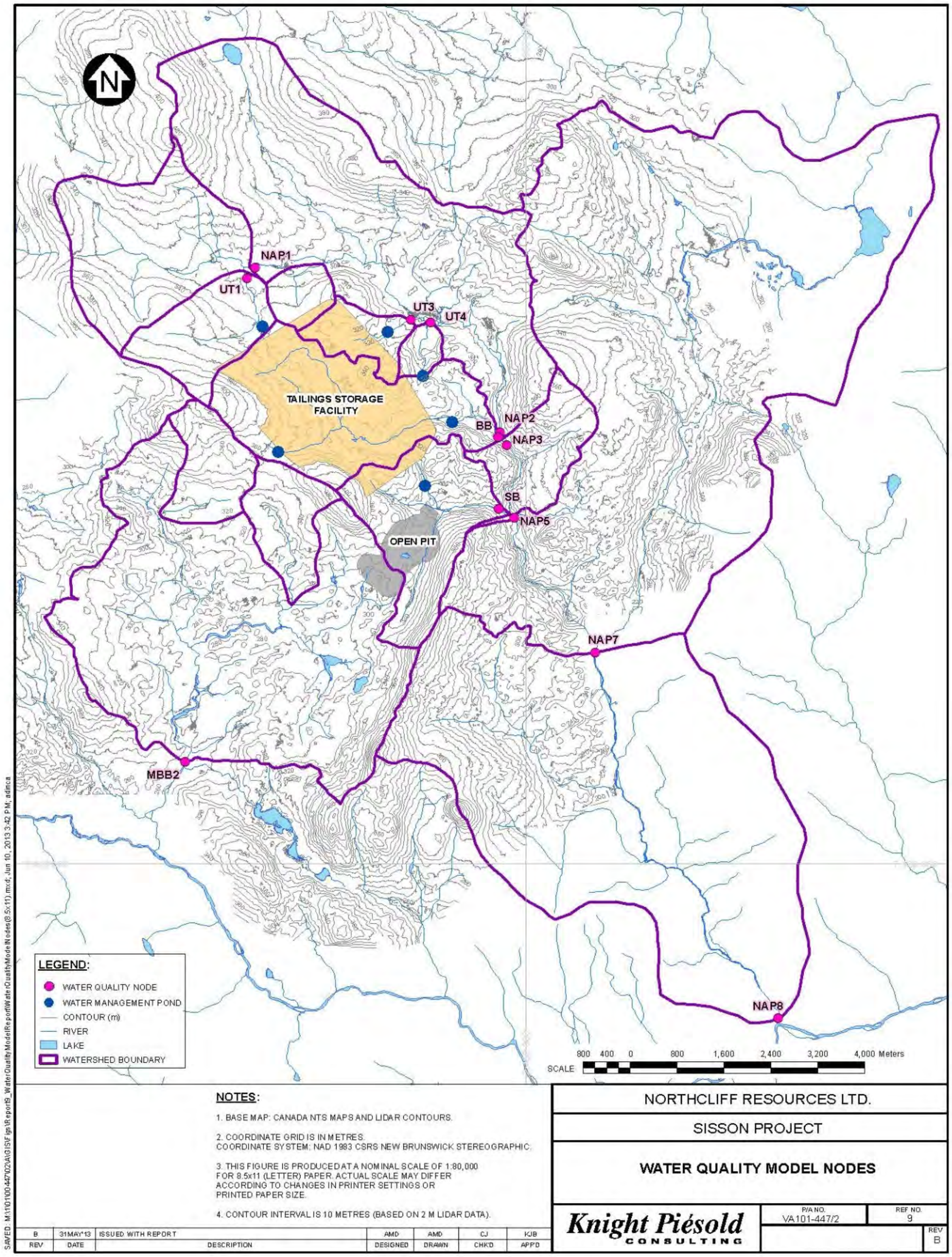
7.6.3.1 Introduction and Modelling Objectives

The water quality predictions for the Project were modelled using GoldSim© from baseline through to Post-Closure, with average monthly outputs over a 100 year period. The model is generally based on the design and operating strategies employed in the Technical Report for the feasibility study (Samuel Engineering 2013). The results of the model were used in an iterative process to help optimize the

Project design and reduce the potential Project induced changes on downstream water quality. This optimization process resulted in several changes to the assumed design and Operation of the Project when compared to the feasibility study.

The objective of the predictive modelling was to quantitatively estimate the environmental effects of the Project on the water quality in the downstream environment including Napadogan Brook, McBean Brook, and their tributaries. The complete details of the methods and results are presented in the Predictive Water Quality Modelling report (Knight Piésold 2013c) and as updated in Knight Piésold (2014).

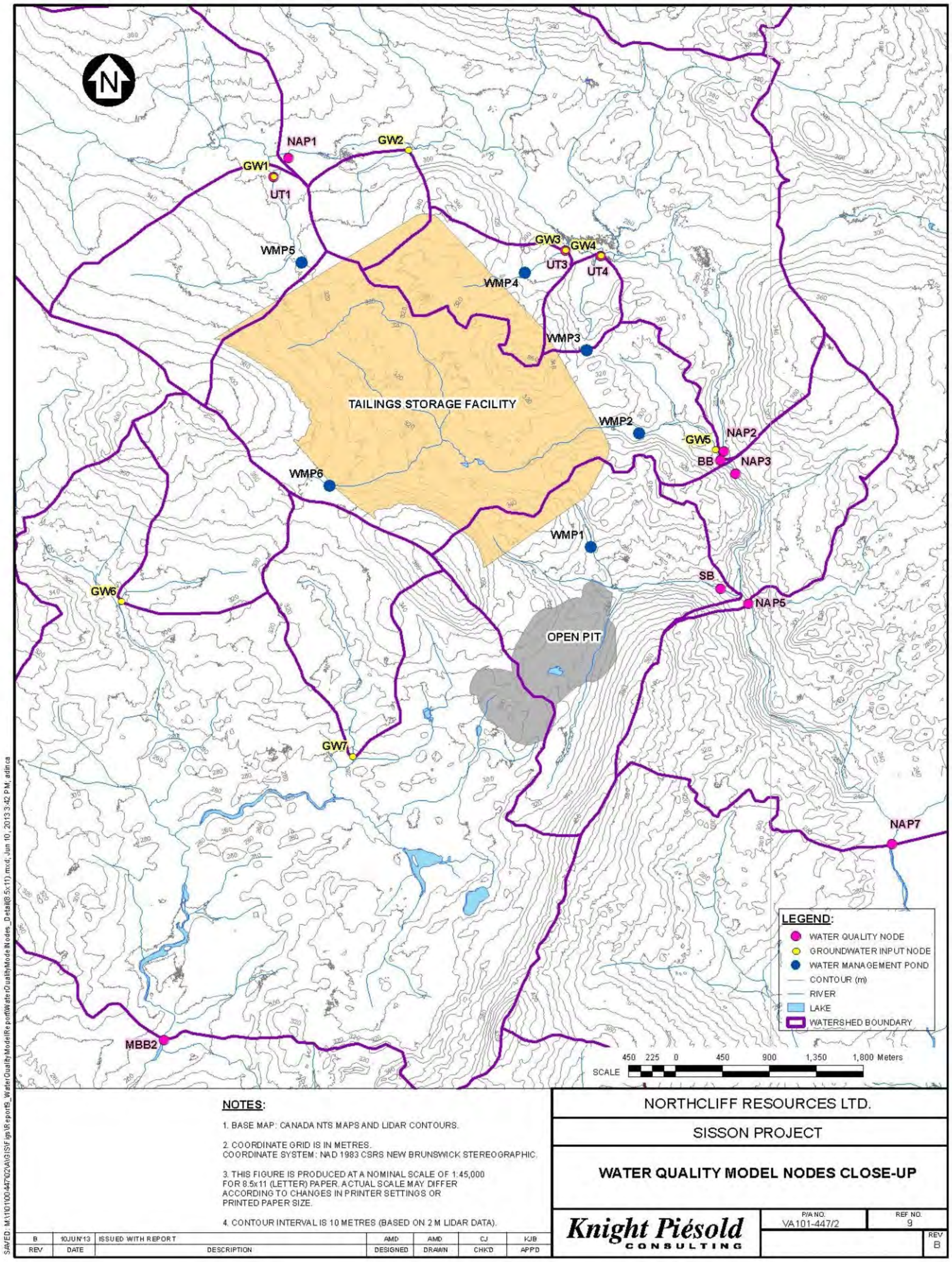
Water quality results were predicted for seven nodes along Napadogan Brook (NAP1, NAP2, NAP3, NAP5, NAP7, and NAP8), and one node along McBean Brook (MBB2). Water quality predictions have also been calculated for three unnamed tributaries (UT1, UT3, and UT4). The location of the model nodes are shown on Figure 7.6.2, and a close-up view of the mine site area is shown on Figure 7.6.3.



NOTES:

1. BASE MAP: CANADA NTS MAPS AND LIDAR CONTOURS.
2. COORDINATE GRID IS IN METRES.
COORDINATE SYSTEM: NAD 1983 CSRS NEW BRUNSWICK STEREOGRAPHIC.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:80,000 FOR 8.5x11 (LETTER) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. CONTOUR INTERVAL IS 10 METRES (BASED ON 2 M LIDAR DATA).

Figure 7.6.2 Water Quality Model Nodes



NOTES:

1. BASE MAP: CANADA NTS MAPS AND LIDAR CONTOURS.

2. COORDINATE GRID IS IN METRES.
COORDINATE SYSTEM: NAD 1983 CSRS NEW BRUNSWICK STEREOGRAPHIC.

3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:45,000 FOR 8.5x11 (LETTER) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

4. CONTOUR INTERVAL IS 10 METRES (BASED ON 2 M LIDAR DATA).

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
B	10JUN'13	ISSUED WITH REPORT	AMD	AMD	CJ	KJB

NORTHCLIFF RESOURCES LTD.

SISSON PROJECT

WATER QUALITY MODEL NODES CLOSE-UP

Knight Piésold
CONSULTING

P/A NO. VA101-447/2
REF NO. 9
REV B

Figure 7.6.3 Water Quality Model Nodes Close-Up

7.6.3.2 Project Timeline

The model timeline encompasses all phases of the Project (Operation, Closure, and Post-Closure) as well as two years prior to Operation (*i.e.,* Construction, model Years -2 and -1), which represent baseline conditions at the downstream water quality nodes. Following the two baseline years, the model runs continuously from Year 1 (beginning of Operation) to Year 100 (the predicted water quality during Post-Closure is assumed to reach a steady state prior to Year 100). Predicted water quality changes are driven by the water management strategy in each of the following Project phases.

7.6.3.2.1 Operation (Years 1-27)

Operation begins with commissioning of the mill and ends when ore processing is complete, during which time the water management strategy includes the following.

- Diversion ditches are constructed around the open pit area to convey non-contact water from the upslope catchments to McBean Brook and Sisson Brook. This results in some water that would have naturally run-off to Sisson Brook being discharged to McBean Brook.

- Contact water and un-diverted non-contact water from within the TSF and open pit footprints report to the TSF and to the open pit, respectively.

- TSF embankment seepage is collected in the water management ponds (WMPs) and is continuously pumped back into the TSF. Water will not be stored in the WMPs under normal operating conditions.

- TSF basin seepage that bypasses the WMPs mixes with groundwater in the receiving environment and reports to the nearest creek after a five-year lag time.

- A seepage recovery system is modelled along the northern extent of the TSF downgradient of WMP 5 that is assumed to recover 30% of TSF basin seepage in that portion of the catchment.

- All contact and non-contact water collected in the open pit is pumped to the TSF.

- Beginning in Year 8, approximately 6 million m^3/a of excess water from the TSF is pumped to a water treatment plant (WTP) and discharged post-treatment to Napadogan Brook at the confluence with Sisson Brook. The WTP discharge rate is generally proportional to the baseline hydrograph of at the point of discharge. The discharge is further reduced during low flow months in late summer and mid-winter to minimize the impact on receiving water quality.

- Mill inputs (tailings deposition) to the TSF cease at the end of Year 27.

7.6.3.2.2 Closure (Years 28-39)

Closure begins when the mill shuts down and ends when the open pit has filled to the point where controlled discharge of excess water is required. During Closure, the water management strategy includes the following.

- Open pit dewatering ceases and the pit begins to fill with water.

- Pumping from the TSF to the WTP ceases and WTP effluent discharge to Sisson Brook stops; this causes a change in the predicted water quality in Napadogan Brook downstream of Sisson Brook.
- Inputs from the mill to the TSF cease at the end of Year 27 causing changes in water quality in the TSF starting in Year 28. Changes in predicted chemistry at the downstream nodes along Napadogan Brook are evident in Year 33; these nodes are affected by seepage from the TSF, which arrives with a five-year delay.
- Water collected in the TSF and quarry flows to the open pit through an engineered channel starting in Year 31.
- Water collected in the WMPs is continuously pumped back to the TSF.
- In Year 34, ferric sulphate batch treatment of the open pit water begins.

7.6.3.2.3 Post-Closure (Years 40 Onward)

Post-Closure begins when the open pit is full and discharge to the receiving environment begins.

- The open pit water is pumped to a WTP that discharges to Sisson Brook beginning in Year 40. The pit lake is maintained at an elevation that ensures it is a groundwater sink.
- Water collected in the WMPs is continuously pumped back to the TSF until water quality is suitable for discharge.

7.6.3.3 Mass Balance and Water Quality Model Description

7.6.3.3.1 Water Quality Calculations

The water quality model was developed using a mass balance calculation approach in GoldSim© to predict average monthly water chemistry at select locations within and downstream of the Project area. The mass balance method assumes that the incoming flows at any modelled node are thoroughly mixed at that point. The generalized mass balance equation for mixing points on natural streams is:

$$C_{New} = \frac{C_A \times Q_A + C_B \times Q_B}{(Q_A + Q_B)}$$

where:

C_{New} = mixed concentration (mg/L);

C_A = concentration of Stream A (mg/L);

Q_A = flow rate of Stream A (m^3/s);

C_B = concentration of Stream B (mg/L); and

Q_B = flow rate of Stream B (m^3/s).

A conservative approach was adopted for the prediction of water quality in the reservoir components of the model including the TSF, WMPs, and open pit. The monthly concentrations within each reservoir are equal to the sum of the stored load and input loads from the current time step (monthly loading), divided by the reservoir volume determined by the water balance model. Loads removed from each reservoir were determined using this concentration multiplied by the volume of water being removed from the reservoir in that time step.

The generalized mass balance equation for reservoirs is:

$$C_{New} = \frac{(C_A \times V_A) + (C_B \times V_B) - (C_A \times V_C)}{(V_A + P - E)}$$

where:

C_{New} = mixed concentration (mg/L)

C_A = concentration of reservoir A at the previous time step (mg/L);

V_A = volume of reservoir A (m^3);

C_B = concentration of stream B (mg/L);

V_B = monthly inflow volume of stream B (m^3);

V_C = monthly outflow volume of outlet stream C (m^3);

P = monthly precipitation (m^3); and

E = monthly evaporation (m^3).

7.6.3.3.2 Parameters

A total of 77 parameters were modelled, including hardness, alkalinity, organic carbon, major ions, and 33 metals (both total and dissolved). Several metals were reported as below the method detection limit (MDL) in both the source terms and the baseline data (beryllium, tellurium, and tin) and have therefore not been modelled. Metals were only modelled in the dissolved form within the proposed mine facilities, and in the total and dissolved form at downstream locations.

7.6.3.4 Inputs and Assumptions

7.6.3.4.1 General

The water quality modeling involved a series of studies and analyses including: a) characterizing the geochemical properties of waste materials (waste rock and tailings), open pit walls and borrow materials; b) based on these properties, generating geochemical source terms for these materials; c) developing the operational water balance model for the Project; and d) applying the source terms within the water balance model to predict consequent water quality characteristics at various nodes in the model. In each case, the analyses incorporated assumptions based on experience and best professional judgment. More conservative assumptions were used where the inputs to the analyses included higher uncertainty.

The model results are considered the best estimates based on the available information. It is expected that as more data are collected, the model inputs and assumptions will be refined, thereby reducing the level of conservativeness inherent in the results. It is expected that this will tend to result in lower predictions of chemical concentrations at each node in the model.

7.6.3.4.2 Climate, Hydrology, and Groundwater

Flow inputs for the mass balance water quality model were derived using the base case monthly operational mine site water balance that was previously developed for the feasibility study engineering using the GoldSim© software package. The original intent of this modelling was to estimate the magnitude and extent of any water surplus and/or deficit conditions in the TSF based on a range of possible climatic conditions. This model was modified to include the various contact water flow pathways defined between the Project and the downstream environment, and incorporated into the mass balance predictive water quality model.

The mean monthly hydrometeorological parameters were based on the values used in the operational water balance model. Catchment areas were calculated using the LiDAR topographic data where possible and National Topographic System (NTS) mapping where LiDAR data were not available (*e.g.,* in the upper reaches of East Branch Napadogan Brook).

Groundwater baseflow inputs were estimated based on the Bird Brook hydrologic data using a visual qualitative hydrograph separation approach. Flow data were estimated on a monthly basis using 40 years of data from which monthly averages were generated from the data set.

7.6.3.4.3 Geochemical Source Terms

Geochemical source terms were provided by SRK Consulting (Canada) Inc. (SRK) for the following:

- Open Pit Sump: mg/day;
- Milled Ore: mg/L (based on ~18.5 Mm3/y of process water);
- Process Reagents: mg/tonne of ore processed;
- Low-Grade Stockpile Run-off/Infiltration: mg/L;
- Barren Rock Run-off/Infiltration: mg/L;
- Barren Rock Flooding: mg/tonne of rock submerged;
- TSF Beach Run-off: mg/m^2/week;
- TSF Unsaturated Beach Infiltration: mg/L;

- TSF Embankment Run-off/Infiltration: mg/L;
- TSF Quarry Sump: mg/L;
- Pit Walls: mg/L; and
- Water Treatment Plant Effluent: mg/L.

Details regarding the development of the contact water source terms are provided in SRK (2013).

7.6.3.4.4 Water Treatment Plant

It was determined early in the predictive water quality modelling process that water treatment may be required to mitigate the effects of the Project on receiving waters. A water treatment plant (WTP) concept that could be incorporated into the mass balance model was subsequently developed by SRK. The estimated removal efficiency by the WTP for each parameter was applied to discharge from the TSF during Operation and from the open pit in Post-Closure. Estimated WTP discharge concentrations were provided by SRK (2013).

The WTP was represented in the mass balance model by limiting the maximum parameter concentrations in the discharge to estimated WTP discharge concentrations. It was assumed that the WTP would not remove constituents in the influent water when those concentrations were below the estimated WTP discharge concentrations. A water clarification system is also included in the Project design to pre-treat water recycled to the mill from the TSF. However, water quality improvements were not credited to this clarification plant, which is a conservative assumption. Additional test work and analysis is underway to better understand the potential contribution of the clarification system to water quality improvements. Additional water treatment has been applied to the model for the open pit, in the form of a batch treatment process that will be implemented in Closure (approximately Model Year 34).

7.6.3.4.5 Baseline Water Quality

7.6.3.4.5.1 Baseline Water Quality Data

The baseline water quality program for the Project began in 2007 with samples collected on a monthly or quarterly (seasonal) basis. The baseline surface water data collected until December 2011 were included for the development of monthly average background water quality inputs for the model, consistent with the baseline water quality. In cases where no data were available for a particular month or where data were collected seasonally and not monthly, parameter concentrations were assumed to equal the average concentrations of the previous month.

Groundwater quality data for samples collected between December 2011 and June 2012 were used to generate the background water quality for the mass balance model. Groundwater quality data were generally not applied to the model directly, but were used for comparison to low flow surface water quality data for nearby sites. Piper tri-linear diagrams were used to assess the similarity of geochemical facies for the groundwater to low flow surface water quality. The facies were similar and as a result the mid-winter water chemistry data for the nearby surface water sites were assumed to equal the groundwater chemistry. Many parameters are higher in groundwater than in nearby streams during low flow conditions, though it can be assumed that the majority of the flows are generated from groundwater inflows. Complex and simple geochemical processes can occur in the shallow groundwater/surface water environment which can result in some parameters precipitating out of solution. Assuming that low flow surface water chemistry is equivalent to new groundwater inflow chemistry accounts for these processes without the need for additional modelling. Parameter concentrations measured in all samples from each monitoring well location (shallow and deep wells) were averaged and used as baseline groundwater concentrations for each well location. Groundwater quality at nodes without groundwater monitoring wells was assumed to be the same as that of the closest groundwater monitoring site.

It should be noted that surface water and groundwater sample collection is ongoing, but the end dates specified above are the cut-off points for data used in the development of the baseline input terms for the model. The baseline conditions provided in this report refer to the average monthly data for each model node that were used as inputs to the model. These data under-represent the measured range for some of the parameters but are consistent with the model results, which are predicted monthly average concentrations.

7.6.3.4.5.2 Baseline Water Quality Calibration Model

Baseline water quality at the modelled nodes was assumed to be equal to the observed average monthly surface water quality at those points during the period of record. However, several key data inputs to the water quality model required further estimation and calculation. A calibration model was developed in GoldSim© to provide estimates for the following information that was not available in the baseline dataset:

- separation of the surface water and groundwater components of the resulting measured water quality;
- calculation of parameter concentrations in tributaries and modelled nodes for which no baseline data were available;
- estimation of parameter loads attenuated under baseline conditions when groundwater surfaces; and
- estimation of parameter loads attenuated under baseline conditions between modelled nodes for which baseline data are available.

Inputs to the calibration model included groundwater data from sites in close proximity to each node, groundwater flow data, averaged surface water data from sites in close proximity to each node, and surface water flow data.

Parameters that were predicted to decrease between the nodes in the calibration model shown on Figure 7.6.2, in at least one month each year under baseline conditions, include:

- NAP1 to NAP2: ammonia, nitrate, dissolved manganese, and total copper, lead, phosphorous, tin, vanadium, and zinc;

- BB to NAP3: nitrate, dissolved molybdenum, and total molybdenum;
- NAP3 to NAP4: hardness, alkalinity, ammonia, nitrate, phosphate, sulphate, chloride, fluoride, and dissolved and total aluminum, arsenic, boron, cadmium, calcium, copper, iron, lead, lithium, manganese, magnesium, mercury, molybdenum, phosphorous, potassium, rubidium, silicon, sodium, strontium, and tungsten;
- SB to NAP5: dissolved and total molybdenum; and
- NAP5 to NAP7: ammonia, phosphate, sulphate, dissolved aluminum, arsenic, cadmium, lead, molybdenum, phosphorous, silicon, uranium, and zinc, and total aluminum, antimony, arsenic, cadmium, chromium, cobalt, lead, lithium, molybdenum, phosphorous, silicon, tin, uranium, vanadium, and zinc.

The calibrated baseline model was used as basis for the predictive mass balance model for Operation, Closure, and Post-Closure.

7.6.3.5 Results

7.6.3.5.1 General

The following milestones in the model timeline strongly influence the model results and are key to interpreting the water chemistry predictions:

- water treatment has been applied to the model for mine site discharge to Sisson Brook during Operation and Post-Closure (Model Years 8 through 27 and Year 40 onward);
- TSF water quality is strongly affected by mill inputs (milled ore and process reagents) during Operation; and
- TSF seepage rates are lower in Closure and Post-Closure than during Operation.

Water chemistry changes at the downstream model nodes along Napadogan Brook are attributed to loading from contact water through two main pathways: (1) seepage from the TSF and Water Management Ponds, and (2) discharge of surplus treated water through the water treatment plant (WTP) in Operation and Post-Closure. The seasonality of the predicted changes is directly proportional to receiving water flow conditions, with higher modelled concentrations in response to lower surface water flow conditions.

Changes in predicted downstream chemistry that are driven by seepage chemistry are observed to increase from baseline concentrations at all of the modelled nodes that are located upstream of NAP5 (Napadogan Brook at the confluence with Sisson Brook) but downstream of the Project. Parameters that change as a result of treated water discharge from the Project are marked by an increase in concentration at NAP5 that coincides with WTP discharge in Model Year 8 and Post-Closure WTP discharge in Year 40. There are no additional Project-generated loads downstream of NAP5 and concentrations of all mine affected parameters subsequently decrease with distance downstream.

7.6.3.5.2 Guidelines for Comparison

Water quality predictions have been compared with the CCME Canadian Environmental Quality Guidelines for the Protection of Aquatic Life (Freshwater) (CCME FAL guidelines) and the Health Canada Guidelines for Canadian Drinking Water Quality (GCDWQ). The guidelines are presented in Table 7.6.5 along with the *Metal Mining Effluent Regulations* (*MMER*) for relevant metals. The predicted water quality was compared with the guidelines and regulations for the model nodes points along Napadogan Brook (NAP1, NAP2, NAP3, NAP5, NAP7, and NAP8), McBean Brook (MBB2) and an unnamed tributary (UT1). Water quality in other areas of the Project was also modelled, but is not compared with the guidelines. These areas include the Tailings Storage Facility (TSF), Open Pit, Water Treatment Plant (WTP), three unnamed tributaries (UT3, and UT4), Bird Brook, and Sisson Brook.

While water quality predictions are compared to these guidelines below, it must be noted that consequent risks to human, ecological or fish health cannot be directly inferred from any guideline exceedances. These risks are assessed in Chapter 8 of this EIA Report as they relate to the consideration of specific Valued Environmental Components. The results presented below do not, in and of themselves, necessarily infer the deterioration or protection of environmental quality. The results are meant to provide an indication of the issues that would require further study and confirmation as the Project advances.

Table 7.6.5 Applicable Water Quality Guidelines and Regulations

Parameter	Guidelines		Regulations
	CCME FAL Guidelines (mg/L)	GCDWQ (mg/L)	*MMER* - Column 2 (mg/L)
pH	pH 6.5 to 9	pH 6.5 to 8.5	
Ammonia	0.499 [a]		
Nitrate	3	10	
Sulphate		500	
Bromide (Br)		0.01	
Chloride (Cl)	640		
Fluoride (F)	0.12	1.5	
Aluminum (Al)	0.005 to 0.1 [b]	0.2*	
Antimony (Sn)		0.006	
Arsenic (As)	0.005	0.01	0.50
Barium (Ba)		1	
Boron (B)		5	
Cadmium (Cd)	$10^{(0.86*(\log(H)-3.2)}$/1000 to 0.000055 [c]	0.005	
Chromium (Cr)	0.0089	0.05	
Copper (Cu)	$e^{(0.8545*\ln(H)-1.465)}$ 0.2/1000 to 0.004 [c]	1	0.30
Iron (Fe)	0.3	0.3	
Lead (Pb)	$e^{((1.273*\ln(H)-4.705))}$ /1000 to 0.007 [c]	0.01	0.20
Manganese (Mn)		0.05	
Mercury (Hg)	0.000026	0.001	
Molybdenum (Mo)	0.073		
Nickel (Ni)	$e^{((0.76*\ln(H)+1.06))}$ /1000 to 0.15 [c]		0.50
Phosphorous (P)	Narrative		
Selenium (Se)	0.001	0.01	
Silver (Ag)	0.0001		

Table 7.6.5 Applicable Water Quality Guidelines and Regulations

Parameter	Guidelines		Regulations
	CCME FAL Guidelines (mg/L)	GCDWQ (mg/L)	*MMER* - Column 2 (mg/L)
Sodium (Na)		200	
Thallium (Tl)	0.0008		
Uranium (U)	0.015	0.02	
Zinc (Zn)	0.03	5	0.50

Notes:

1) Units are in mg/L unless otherwise specified.
2) Metals guidelines were applied to both total and dissolved concentrations generated in the model.

[a] CCME FAL guidelines for ammonia ranges from 0.017 to 192 mg/l; the guideline is inversely proportional to both pH and temperature. The guideline value used for comparison was based on the 90th percentile baseline pH and temperature.

[b] CCME FAL guidelines for Al are pH dependent; guideline is 0.005 mg/L for pH < 6.5 and 0.1 mg/L for pH > 6.5.

[c] Hardness (H) dependent guidelines; guidelines are calculated using predicted hardness. Maximum hardness specified is generally based upon an assumed hardness of 180 mg/L $CaCO_3$.

* The GCDWQ guideline for aluminum is an “operational guidance value” established for operational considerations in drinking water treatment, and therefore is not applicable for the water quality in Napadogan Brook or its tributaries

7.6.3.5.3 Results

Predicted water quality is discussed in this section for the nodes along Napadogan Brook (NAP1 through NAP8), McBean Brook (MBB2), and the unnamed tributary immediately upstream of NAP1 (UT1).

Since completion of the Draft EIA Report in July 2013, geochemical ML/ARD testing of site materials continued. In particular, further humidity cell testing of quarry rock by SRK demonstrated the need to revise the water quality modelling source terms for embankment runoff and infiltration. A correction was also made to the treatment levels that can be conservatively assumed for chromium in the water treatment plant discharge at the current stage of Project planning. The previous model results were based on the incorrect assumption of water treatment for chromium to 0.001 mg/L and the new results are based upon the corrected assumption of 0.01 mg/L. All other assumptions, background data and source terms used in the previous modelling remain valid and have not been updated. The results of the updated predictive water quality modelling are presented below. The most notable change from the previous model results is the significant reduction in predicted copper concentrations at modelled nodes.

While the results for the modelled location on the unnamed tributary to Napadogan Brook (UT1) are presented in the graphs along with results for nodes on Napadogan and McBean brooks, the degree of uncertainty for the UT1 results is greater than for the other nodes due to a lack of baseline water quality, hydrological, and hydrogeological information in this area. It is important to note that the UT1 results are indicative only and do not have the same level of accuracy or confidence as the results at other nodes. They represent a conservative assumption that all modelled seepage that bypasses the TSF water management systems becomes surface water before it enters Napadogan Brook and is accounted for at the NAP1 node, when some of it may well enter the brook as groundwater.

The focus of the discussion for the predicted Project surface water chemistry is on those parameters that are predicted to increase to levels that exceed one or both of the CCME FAL guidelines or GCDWQ at model nodes in Napadogan Brook. Predicted effluent discharge from the WTP does not exceed the *MMER* for any parameter. The discussion pertains to the dissolved concentrations for these parameters, as only solutes are modelled for the Project facilities. The results for the receiving water quality nodes include predicted total metals concentrations, but these only change from baseline concentrations with the addition of the dissolved loads from the mine site seepage and discharge. The seasonality of the predicted data is summarized for each key parameter along with the duration (or time frame) over which the elevated concentrations are predicted to occur and how the concentrations vary with distance from the source. The parameters of interest have been determined based upon the predicted results exceeding one or more of the guidelines for any of the mine phases; these parameters are sodium (Na), manganese (Mn), fluoride (F), aluminum (Al), arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), and selenium (Se).[1] For brevity, parameters that did not exceed either the CCME FAL guidelines or GCDWQ are not discussed here; only those parameters that exceeded either or both of these guidelines are discussed.

All of the key parameter concentration changes are affected by seepage. Concentrations of Na, F, Cd, and Se are also influenced by discharge of excess treated water from the TSF and the open pit. Some similarities are evident in the seasonality of the model results for these parameters that are driven by changes in receiving water flow conditions. Seepage rates from the TSF and WMPs are constant set rates for each year in the model and do not follow a seasonal pattern within each year; as a result, concentrations at the downstream surface water quality nodes are predicted to increase in response to seasonal low surface water flow conditions. The mean annual hydrograph for the Project area is bi-modal with the lowest stream flows observed in February, August, and September. The majority of the parameters remain below guidelines for the remainder of the year, but rise to levels that exceed guidelines during these months due to the influence of seepage.

The changes in chemistry that result from treated water discharge are also predicted to follow the same seasonal trend as seepage affected changes. However, there are a few parameters (Al, As, Cd, Cr, Cu, and Mn) for which water treatment is applied and this seasonal trend is not as pronounced.

The predicted McBean Brook water chemistry is not altered by mine seepage; however, changes are modelled as a result of water diverted around the open pit from the Sisson Brook catchment to McBean Brook. Surface water diversion structures will route run-off that would naturally have drained through Sisson Brook into the McBean Brook catchment. The modelled data for McBean Brook have been included herein, but a detailed discussion of the results has not been provided since no parameters were noted to increase to a point where guidelines were encroached upon, except for those that were observed to exceed guidelines in the baseline data.

7.6.3.5.3.1 Sodium (Na)

The annual distribution of predicted sodium concentrations for one year in each Project phase are provided on Figure 7.6.4. The use and interpretation of these predictions in considering the consequent risks to human, ecological or aquatic environment health are found in the HHERA (Section 7.7), Aquatic Environment (Section 8.5), and Public Health and Safety (Section 8.9).

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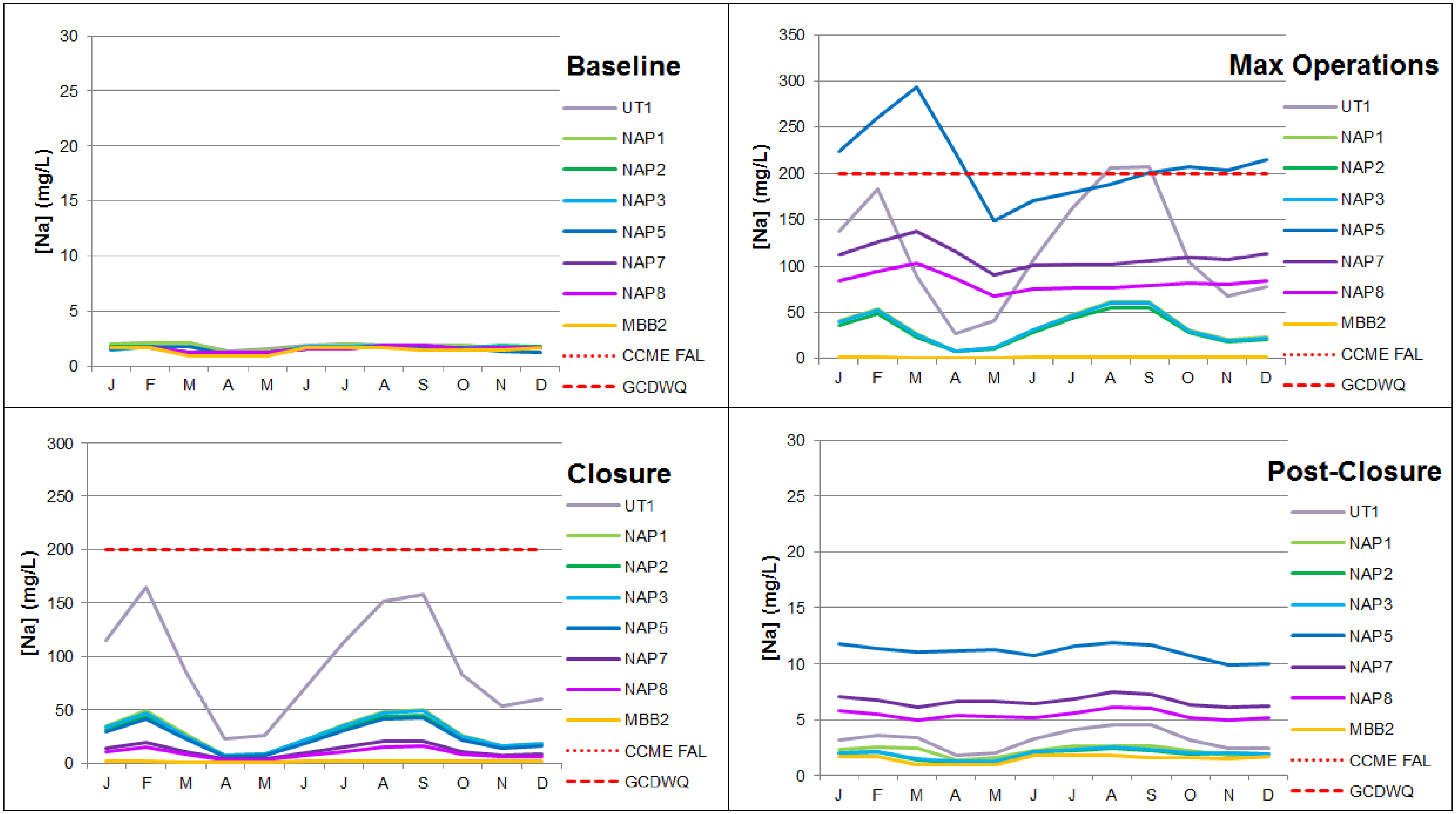
[1] The EIA Report of July 2013 showed lead concentrations in excess of lead guidelines at UT1, while the updated model results do not. Thus, lead is not discussed in this section.

Sodium concentrations are predicted to exceed the GCDWQ 200 mg/L aesthetic objective at NAP5 and at UT1 only during Operation; there is no CCME FAL guideline for this parameter. Sodium is used as a mill reagent, which is the primary loading source for this parameter; therefore, concentrations of sodium in the TSF and at the modelled nodes in the receiving environment decrease at the beginning of Closure, when mill inputs no longer contribute to the system. The objective exceedance at NAP5 is a result of treated water discharge from the TSF to Sisson Brook during Operation (Years 8 through 27); concentrations are predicted to decrease below the objectives at the next model node (NAP7). Sodium is predicted to exceed the GCDWQ objective at NAP5 year-round from Years 8 through 14 (Operation) and then seasonally in association with lower receiving water flow conditions from Years 15 through 27 (generally from September through April). The maximum sodium concentration of 293 mg/L is predicted at NAP5 in Model Year 17 (Operation). The predicted chemistry at UT1 is primarily affected by seepage water from the TSF. At this location sodium concentrations are highest during Operation. Concentrations decrease below the objective at the next model node (NAP1). Sodium exceeds the GCDWQ objective seasonally from Years 10 through 15 (generally in August and September). The maximum sodium concentration of 207 mg/L is predicted at UT1 in Model Year 14 (Operation).



Notes:

1. "Baseline" refers to Model Years -1 and -2; "Closure" refers to Year 30; "Post-Closure" refers to Year 50.
2. "Maximum Operations" refers to the year for which sodium reaches its maximum value (Year 14 for NAP1, NAP2, NAP3, and MBB2; Year 16 for NAP5, NAP7, and NAP8).
3. ***There is no CCME FAL Guideline for sodium.***
4. The GCDWQ for sodium is an aesthetic guideline based on taste and is not within the scale of the baseline and Post-Closure graphs.
5. CCME FAL refers to the CCME Canadian Environmental Quality Guidelines for the Protection of Freshwater Aquatic Life.
6. GCDWQ refers to the Health Canada Guidelines for Canadian Drinking Water Quality.

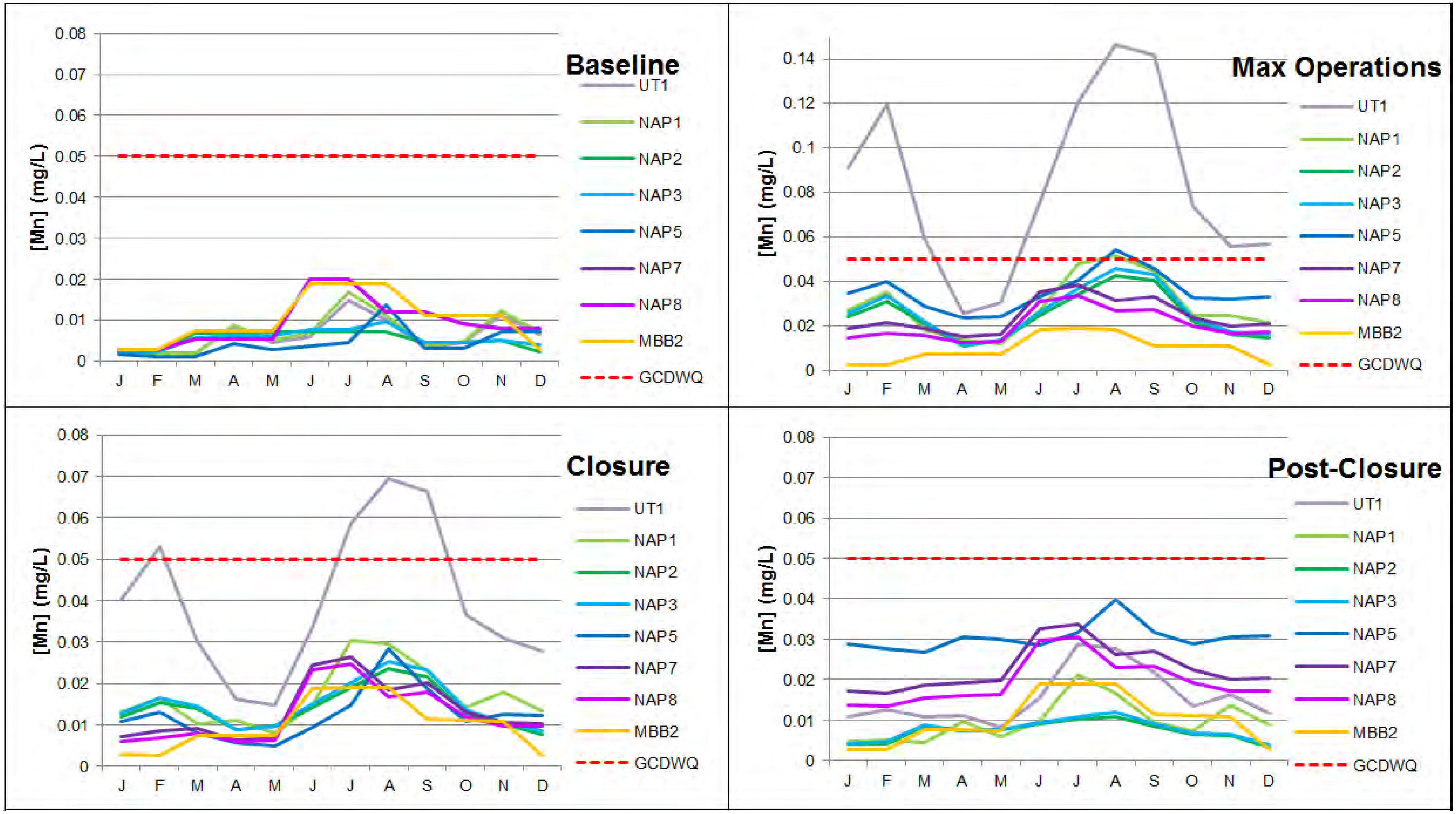
Figure 7.6.4 Predicted Sodium Concentrations at Downstream Nodes by Project Phase

7.6.3.5.3.2 Manganese (Mn)

The annual distribution of predicted manganese concentrations for one year in each Project phase are provided on Figure 7.6.5. The use and interpretation of these predictions in considering the consequent risks to human, ecological or aquatic environment health are found in the HHERA (Section 7.7), Aquatic Environment (Section 8.5), and Public Health and Safety (Section 8.9).

Manganese concentrations are predicted to exceed the GCDWQ 0.05 mg/L aesthetic objective on a seasonal basis at UT1, NAP1, and NAP5 during Operation and at UT1 during Closure; there is no CCME FAL guideline for manganese. Maximum annual concentrations occur in August in association with low surface water flows; predicted concentrations remain below the objective for the remainder of the year with few exceptions. Maximum annual concentrations are predicted to exceed the objective during Operation in Years 10 through 25 at NAP5, and in Years 13 through 19 at NAP1; however, average annual concentrations at these sites remain below the objective. Maximum annual concentrations are predicted to exceed the objective at UT1 during Operation and Closure in Years 7 through 33; the annual average concentrations are predicted to exceed this objective at UT1 during Operation in Years 9 through 26.

The highest predicted value downstream of UT1 is 0.055 mg/L for NAP5 in Model Year 16 (Operation), followed by 0.052 mg/L for NAP1 in Model Year 14 (Operation). At UT1, the highest predicted value is 0.147 mg/L, occurring in Year 16 (Operation). Changes in manganese concentrations at NAP5 and downstream result from TSF seepage, embankment runoff, and WTP discharge, though WTP discharge does not result in a notable change at NAP5 compared to the upstream nodes affected by seepage and embankment runoff. Concentrations decrease below the guideline at the next downstream model node from both NAP1 and NAP5 (NAP2 and NAP7, respectively). It is noted that the seasonal distribution of manganese concentrations is slightly different at NAP7 and NAP8 compared to NAP5 due to manganese loading from background sources downstream of the Project area.



Notes:

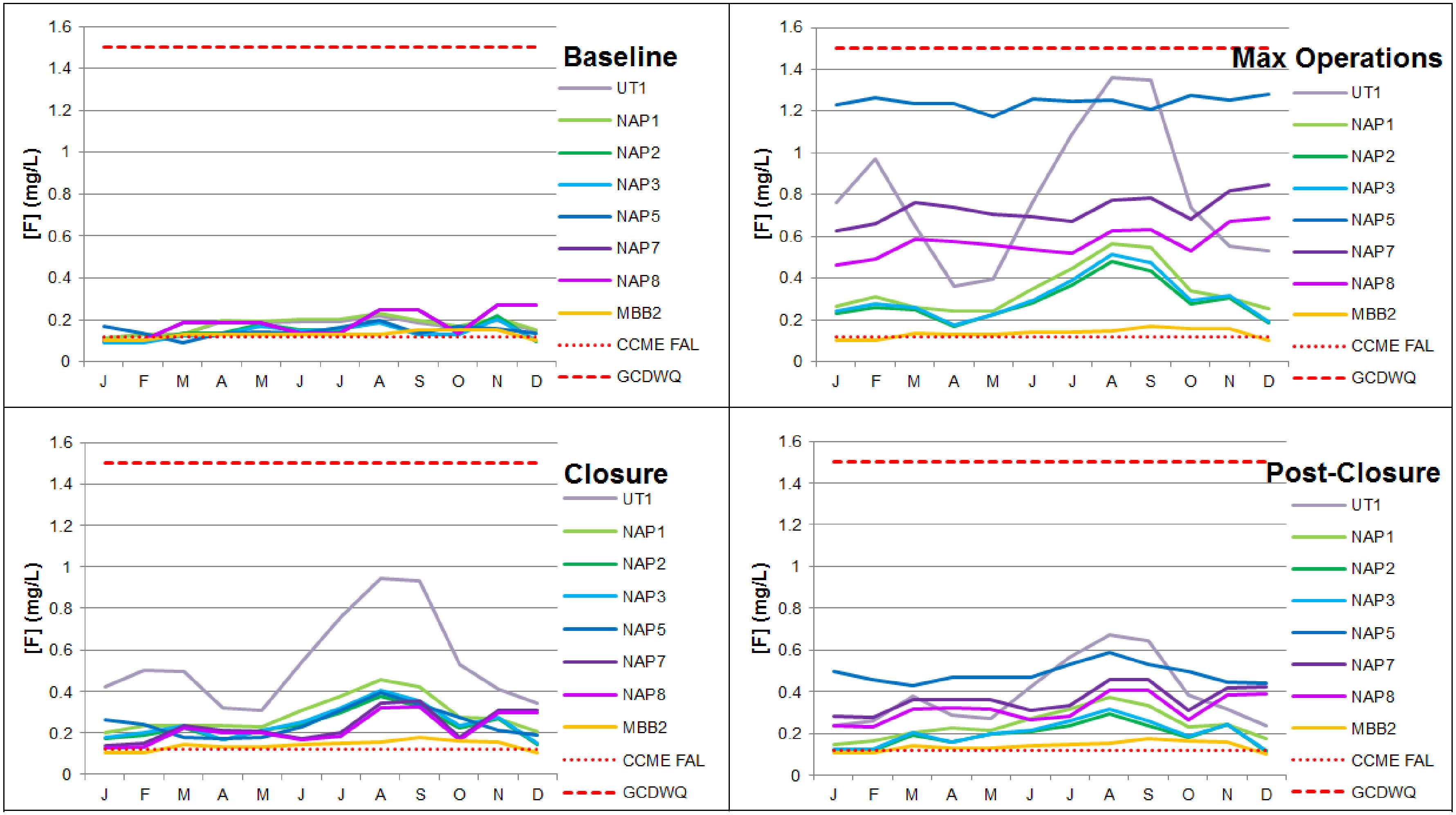
1. "Baseline" refers to Model Years -1 and -2; "Closure" refers to Year 30; "Post-Closure" refers to Year 50.
2. " Max Operations" refers to the year for which manganese reaches its maximum value (Year 14 for all nodes).
3. ***There is no CCME FAL guideline for manganese.***
4. GCDWQ refers to the Health Canada Guidelines for Canadian Drinking Water Quality.

Figure 7.6.5 Predicted Manganese Concentrations at Downstream Nodes by Project Phase

7.6.3.5.3.3 Fluoride (F)

The annual distribution of predicted fluoride concentrations for one year in each Project phase are provided on Figure 7.6.6. The use and interpretation of these predictions in considering the consequent risks to human, ecological or aquatic environment health are found in the HHERA (Section 7.7), Aquatic Environment (Section 8.5), and Public Health and Safety (Section 8.9).

Fluoride concentrations are not predicted to exceed the 1.5 mg/L GCDWQ, but are predicted to exceed the 0.12 mg/L CCME FAL guideline at each node for the duration of the modelled Project life. Baseline fluoride concentrations are elevated throughout the Project area and average levels generally exceeded the CCME FAL guideline. Changes in fluoride concentrations are predicted as a result of seepage and point source discharge from the WTP. The greatest increase is noted at UT1 due to seepage from the TSF and Water Management Pond 5 (WMP5), reaching a maximum concentration of 1.4 mg/L in Year 17 (Operation). Peak concentrations decrease at NAP 1 (maximum concentration of 0.57 mg/L in Year 17) and continue to decrease downstream along Napadogan Brook, upstream of the discharge point for the WTP effluent in Sisson Brook. The predicted variability at each of these nodes is seasonal with the highest concentrations in the lower flow months in late-summer. Peak concentrations of fluoride increase at NAP5 when compared to the upstream nodes (maximum concentration of 1.3 mg/L in Year 12) due to the treated water discharge from the WTP during Operation, and to a lesser degree in Post-Closure. The concentration of fluoride in the WTP effluent is higher during Operation than in Post-Closure because ore processing, which is the main loading source for fluoride, ceases at the end of Operation.



Notes:

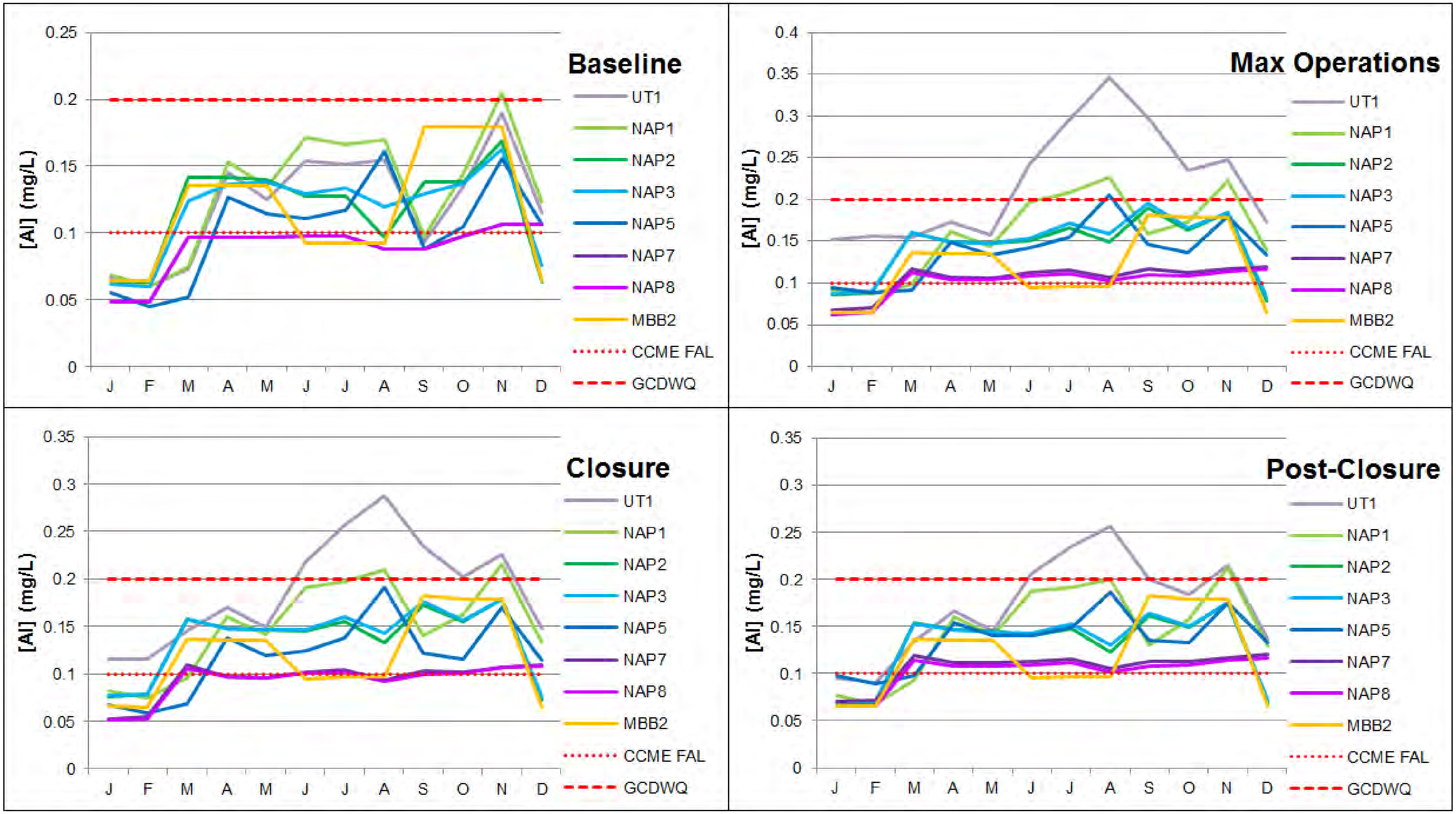
1. "Baseline" refers to Model Years -1 and -2; "Closure" refers to year 30; "Post-Closure" refers to Year 50.
2. "Max Operations" refers to the year for which fluoride reaches its maximum value (Year 24 for NAP1, NAP2, NAP3, and MBB2; Year 11 for NAP5, NAP7, and NAP8).
3. CCME FAL refers to the CCME Canadian Environmental Quality Guidelines for the Protection of Freshwater Aquatic Life.
4. GCDWQ refers to the Health Canada Guidelines for Canadian Drinking Water Quality.

Figure 7.6.6 Predicted Fluoride Concentrations at Downstream Nodes by Project Phase

7.6.3.5.3.4 Aluminum (Al)

The annual distribution of predicted dissolved aluminum concentrations for one year in each Project phase are provided on Figure 7.6.7. The use and interpretation of these predictions in considering the consequent risks to human, ecological or aquatic environment health are found in the HHERA (Section 7.7), Aquatic Environment (Section 8.5), and Public Health and Safety (Section 8.9).

Aluminum concentrations are naturally elevated in the Project area, particularly in samples collected from the upper portion of the Napadogan Brook watershed, decreasing with distance downstream. Average baseline dissolved aluminum concentrations exceeded the CCME FAL guideline at all sites except in lower Napadogan Brook and seasonally exceeded the GCDWQ at NAP1, UT1 and NAP5 (baseline values are from the average monthly dataset used for the model inputs for each of the nodes and measured maximum and minimum concentrations are under-represented). The GCDWQ guideline for aluminum is an operational guidance value for water treatment plants and is therefore not directly applicable to potential water quality effects on human health; reference to the guideline has been included in this assessment for completeness (Mackie, J. Personal communication, October 27, 2014). The predicted aluminum concentrations resulting from the Project are slightly higher than the baseline concentrations, but follow the same seasonal distribution. Aluminum concentrations are predicted to exceed the 0.1 mg/L CCME FAL guideline (pH > 6.5) on a regular basis at all modelled nodes for the duration of the model and are predicted to exceed the 0.2 mg/L GCDWQ operational guidance value on occasion, but only at NAP1, UT1, and NAP5 (maximum concentrations of 0.227 mg/L, 0.346 mg/L, and 0.206 mg/L respectively). Maximum concentrations are predicted to occur in Model Year 24 (Operation) for all nodes in Napadogan Brook.



Notes:

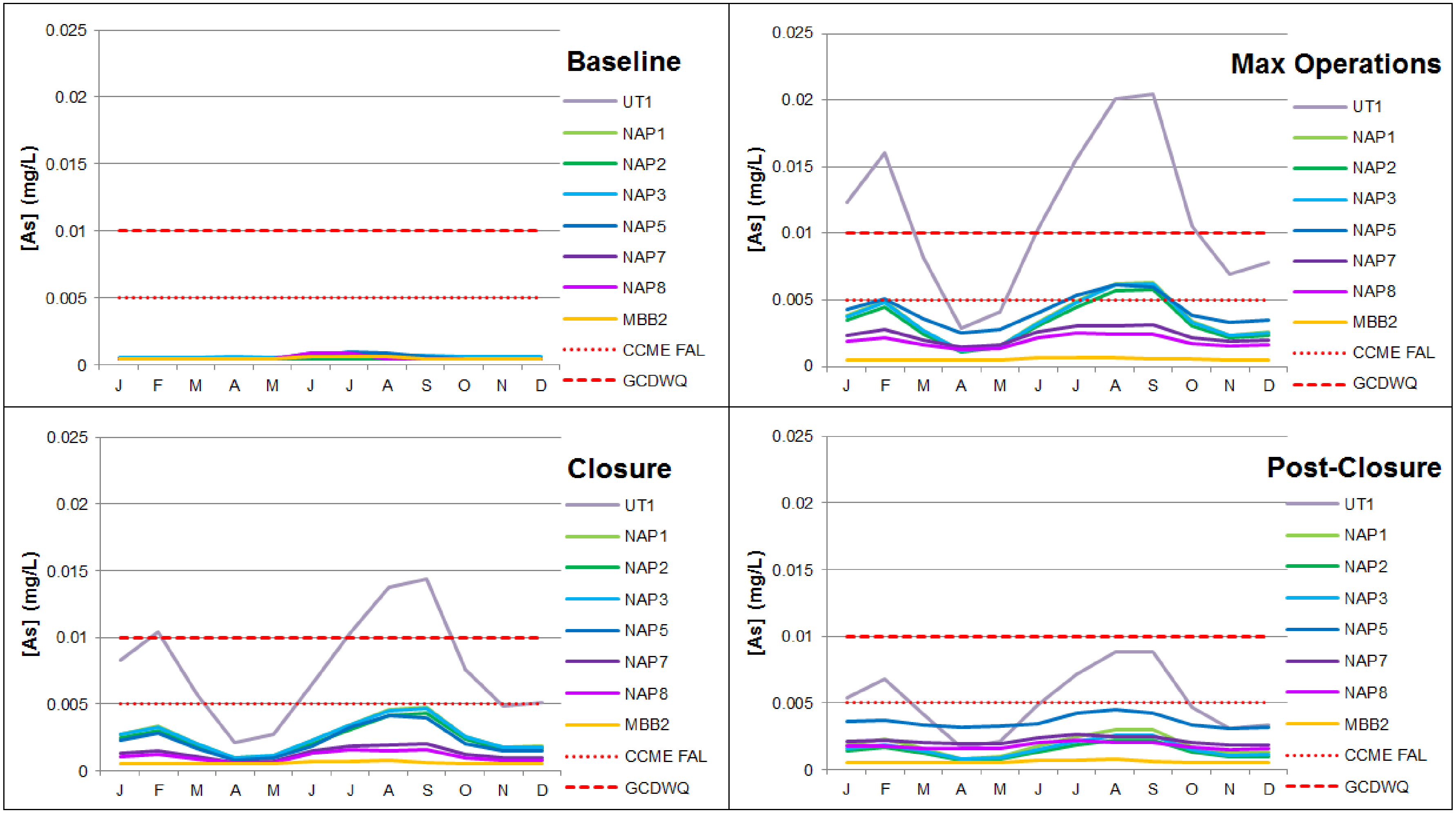
1. "Baseline" refers to Model Years -1 and -2; "Closure" refers to Year 30; "Post-Closure" refers to Year 50.
2. "Max Operations" refers to the year for which aluminum reaches its maximum value (Year 24 for all nodes).
3. CCME FAL refers to the CCME Canadian Environmental Quality Guidelines for the Protection of Freshwater Aquatic Life.
4. GCDWQ refers to the Health Canada Guidelines for Canadian Drinking Water Quality.

Figure 7.6.7 Predicted Aluminum Concentrations at Downstream Nodes by Project Phase

7.6.3.5.3.5 Arsenic (As)

The annual distribution of predicted dissolved arsenic concentrations for one year in each Project phase is provided on Figure 7.6.8. The use and interpretation of these predictions in considering the consequent risks to human, ecological or aquatic environment health are found in the HHERA (Section 7.7), Aquatic Environment (Section 8.5), and Public Health and Safety (Section 8.9).

Arsenic concentrations are predicted to increase during Operation and seasonally exceed guidelines at several nodes. These guideline exceedances are driven mainly by seepage from the TSF, with minor increases in concentrations due to WTP effluent, and are predicted to decrease below guidelines at all nodes along Napadogan Brook at the start of Closure. Arsenic is predicted to exceed the 0.01 mg/L GCDWQ and the 0.005 mg/L CCME FAL guideline at UT1 on a seasonal basis from Year 10 to Year 13 (during Operation). After which arsenic seasonally exceeds the CCME FAL guideline for the duration of the model. Annual average concentrations at UT1 also exceed the GCDWQ guideline from Year 13 to 16 (Operation) and exceed the CCME FAL guideline from Year 10 onward. The predicted concentrations are highest at UT1; however, the results for this node have a lesser degree of certainty than those for other nodes. Downstream from UT1, arsenic is predicted to exceed the CCME FAL guidelines on a seasonal basis at NAP1 through NAP5 during Operation only. The predicted concentrations do not exceed the CCME FAL guidelines at the nodes downstream of NAP5 (NAP7 and NAP8). Changes in arsenic concentrations upstream of NAP5 are related to seepage from the TSF and Water Management Ponds (WMPs) as well as runoff from the embankment. The changes at NAP5 are also affected by WTP effluent during Operation and in Post-Closure. The predicted arsenic concentrations are higher under low flow conditions and are highest in the summer months (July, August, and September). Predicted arsenic concentrations peak at all sites in Model Year 14 (Operation) with a maximum concentration of 0.020 mg/L predicted at UT1. The next highest predicted concentration of arsenic downstream of UT1 is 0.0063 mg/L at NAP1.



Notes:

1. "Baseline" refers to Model Years -1 and -2; "Closure" refers to Year 30; "Post-Closure" refers to Year 50.
2. "Max Operations" refers to the year for which arsenic reaches its maximum value (Year 14 for all nodes).
3. CCME FAL refers to the CCME Canadian Environmental Quality Guidelines for the Protection of Freshwater Aquatic Life.
4. GCDWQ refers to the Health Canada Guidelines for Canadian Drinking Water Quality.

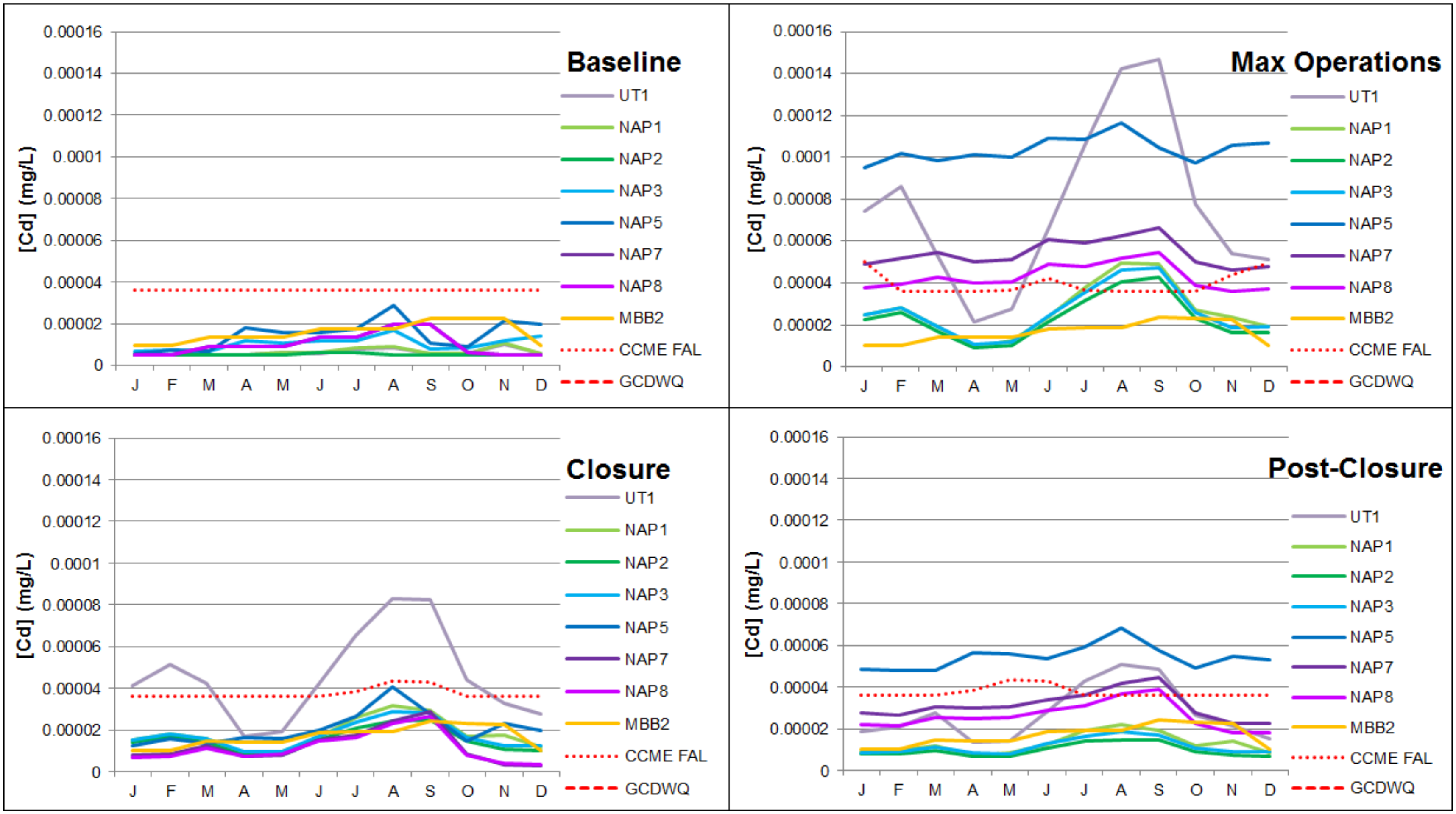
Figure 7.6.8 Predicted Arsenic Concentrations at Downstream Nodes by Project Phase

7.6.3.5.3.6 Cadmium (Cd)

The annual distribution of predicted dissolved cadmium concentrations for one year in each Project phase is provided on Figure 7.6.9. The use and interpretation of these predictions in considering the consequent risks to human, ecological or aquatic environment health are found in the HHERA (Section 7.7), Aquatic Environment (Section 8.5), and Public Health and Safety (Section 8.9).

It is noted that baseline cadmium concentrations are elevated and generally exceeded the hardness-dependent CCME FAL guideline throughout the Project area.

The predicted cadmium concentrations do not exceed the short-term cadmium CCME FAL guideline at any node, but several exceedances of the long-term guideline have been noted. Annual minimum, average, and maximum concentrations predicted at NAP5 during Operation and Post-Closure exceed the long-term guideline (the baseline annual maximum concentration also exceeds this guideline). At NAP7, cadmium concentrations exceed the guideline year-round during Operation and the annual maximum exceeds the guideline during Post-Closure. Upstream from NAP5, cadmium concentrations are predicted to exceed the guideline seasonally during Operation, Closure, and Post-Closure at UT1 and during Operation only at NAP1 and NAP3. Changes in cadmium concentrations upstream of NAP5 are related to seepage from the TSF and WMPs as well as runoff from the embankment. The changes at NAP5 are also affected by WTP effluent during Operation and in Post-Closure. The predicted cadmium concentrations are higher under low flow conditions and are highest in the summer months (July, August, and September).



Notes:

1. "Baseline" refers to Model Years -1 and -2; "Closure" refers to Year 30; "Post-Closure" refers to Year 50.
2. "Max Operations" refers to the year for which cadmium reaches its maximum value (Year 24 for NAP1, NAP2, NAP3, and MBB2; year 20 for NAP5, NAP7, and NAP8).
3. The CCME FAL guideline is hardness-dependent; the guideline shown is for long-term exposure and is calculated for hardness at NAP1; the CCME FAL guideline for short-term exposure is above the scale of these graphs.
4. ***The GCDWQ guideline of 0.005 mg/l is not shown on these graphs.***
5. CCME FAL refers to the CCME Canadian Environmental Quality Guidelines for the Protection of Freshwater Aquatic Life.
6. GCDWQ refers to the Health Canada Guidelines for Canadian Drinking Water Quality.

Figure 7.6.9 Predicted Cadmium Concentrations at Downstream Nodes by Project Phase

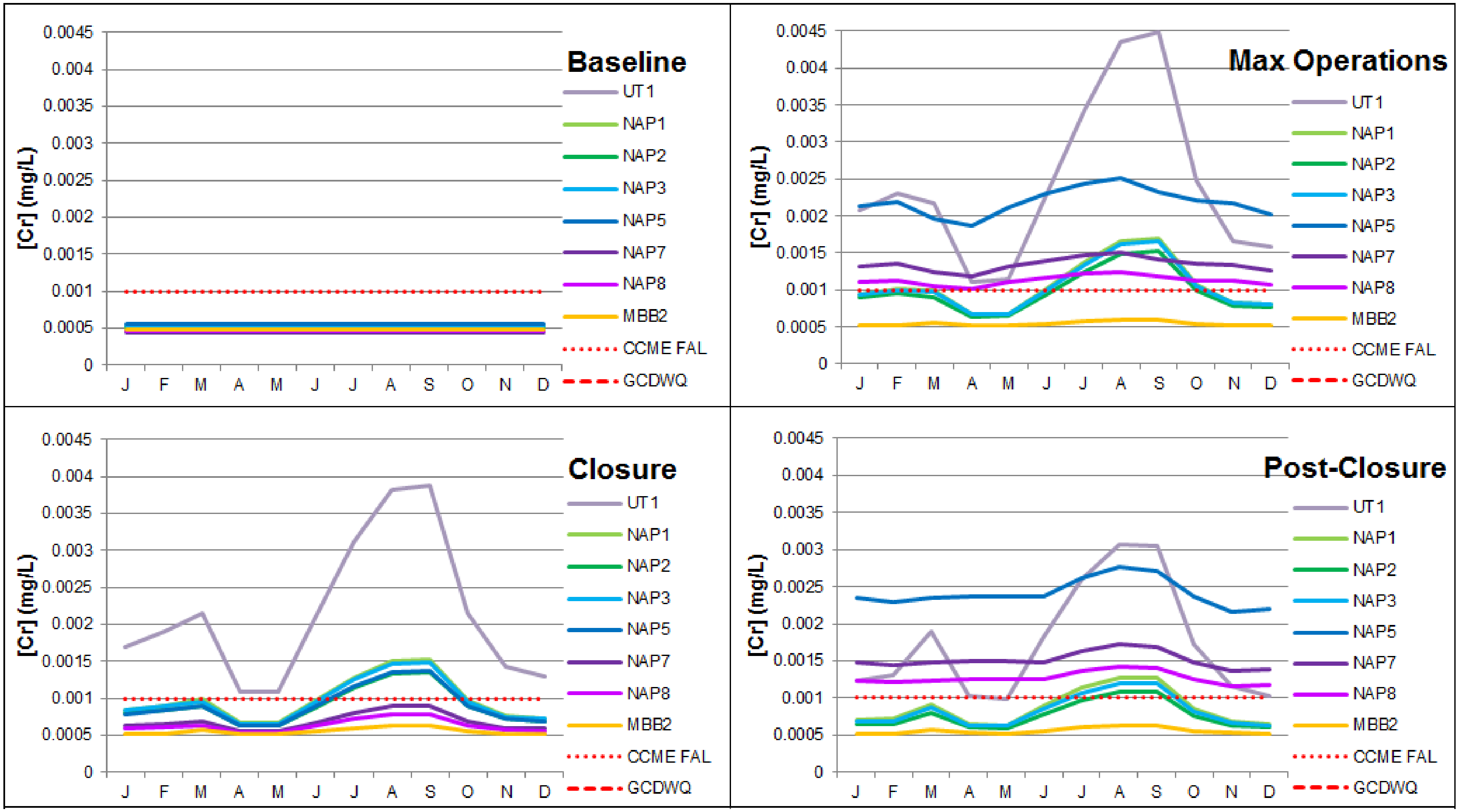
7.6.3.5.3.7 Chromium (Cr)

The annual distribution of predicted dissolved chromium concentration for one year in each Project phase is provided on Figure 7.6.10. The use and interpretation of these predictions in considering the consequent risks to human, ecological or aquatic environment health are found in the HHERA (Section 7.7), Aquatic Environment (Section 8.5), and Public Health and Safety (Section 8.9).

The hexavalent chromium (Cr VI) guideline has been used for comparison instead of the trivalent chromium guideline (CCME FAL guideline of 0.0089 mg/L), as Cr VI is the principal species found in surface waters (CCME 1999). Chromium concentrations are predicted to be equal to or greater than the 0.001 mg/L CCME FAL guideline for Cr VI year-round at UT1 from Year 6 of Operation, though Closure and Post-Closure. The predicted chromium concentrations exceed this guideline on a seasonal basis, concurrent with lower receiving water stream flow, at all model nodes from NAP1 to upstream of NAP5. The same seasonal variability is predicted at NAP5 for Closure, with similar seasonal exceedances of the CCME FAL. Chromium concentrations are predicted to decrease below the guideline at NAP7, and downstream, during Closure. Chromium concentrations are predicted to increase at NAP5, NAP7, and NAP8 during Operation and Post-Closure as a result of discharge from the WTP. Prior to Year 8 of Operation, the chromium concentrations are predicted to exceed the CCME FAL seasonally at NAP5 and are the result of seepage from the TSF. However, chromium is predicted to continuously exceed the CCME FAL for the remainder of Operation and in Post-Closure. The WTP influent chromium concentrations are below the water treatment threshold of 0.01 mg/L during Closure, and as a result, there is no removal of this parameter in the model for this phase; this is a conservative assumption. Chromium concentrations decrease downstream of NAP5 (at nodes NAP7 and NAP8), though they are predicted to remain above the CCME FAL during Operation (after Year 8), and through Post-Closure.

The changes upstream of NAP5 are predominantly driven by seepage and runoff from the embankment which results in season influences on downstream water quality, with higher concentrations occurring during periods of lower stream flow. These lower flow periods are from June through October, and a second lower peak is also evident in February. These seasonal influences continue to affect predicted water quality at NAP5 and downstream, but the predicted concentrations are more consistent throughout the year due to continuous discharge (seasonally variable) from the WTP in Operation and Post-Closure. Chromium concentrations are predicted to be highest during Operation at UT1 (0.0045 mg/L); seasonal peak concentrations are also predicted to be higher at this node for Closure and Post-Closure that the other model nodes. The maximum predicted concentrations for NAP5 and downstream are occur in Post-Closure under steady-state conditions (after model Year 50). The predicted concentrations in Post-Closure range from 0.0021 mg/L to 0.0028 mg/L with an average of 0.0023 mg/L.

Predicted concentrations remain well below the 0.05 mg/L GCDWQ at all nodes.



Notes:

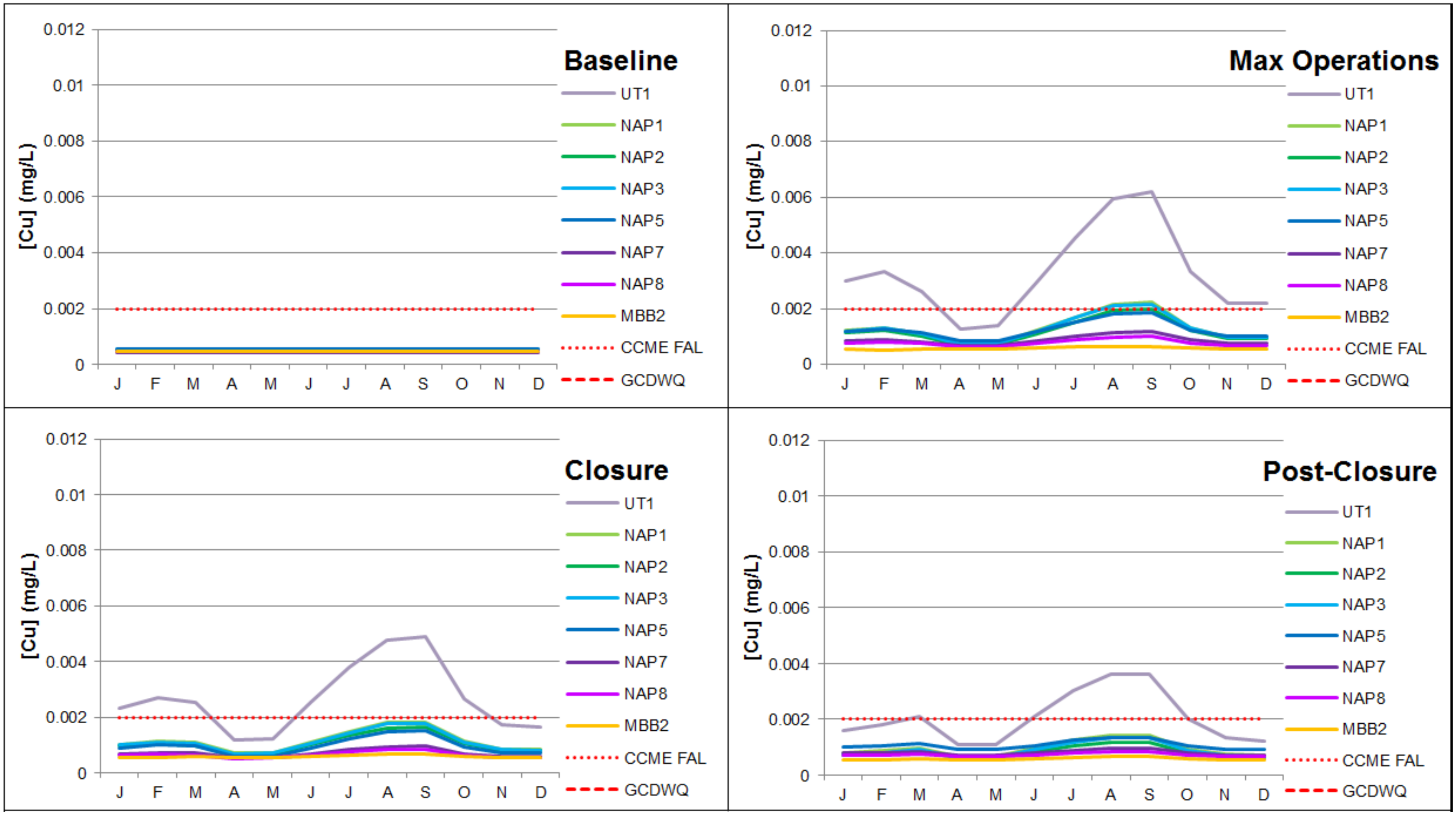
1. "Baseline" refers to Model Years -1 and -2; "Closure" refers to Year 30; "Post-Closure" refers to Year 50.
2. "Max Operations" refers to the year for which chromium reaches its maximum value (Year 26 for all nodes).
3. The CCME FAL guideline for trivalent chromium is 0.0089 mg/l; the CCME FAL guideline for hexavalent chromium is 0.001 mg/l.
4. ***The GCDWQ guideline of 0.05 mg/l is not shown on these graphs.***
5. The current conditions indicate that chromium is below the method detection limit at all nodes.
6. CCME FAL refers to the CCME Canadian Environmental Quality Guidelines for the Protection of Freshwater Aquatic Life.
7. GCDWQ refers to the Health Canada Guidelines for Canadian Drinking Water Quality.

Figure 7.6.10 Predicted Chromium Concentrations at Downstream Nodes by Project Phase

7.6.3.5.3.8 Copper (Cu)

Annual distributions of predicted dissolved copper concentrations for one year in each Project phase are provided on Figure 7.6.11. The use and interpretation of these predictions in considering the consequent risks to human, ecological or aquatic environment health are found in the HHERA (Section 7.7), Aquatic Environment (Section 8.5), and Public Health and Safety (Section 8.9).

Maximum copper concentrations are predicted to exceed the hardness dependent CCME FAL guideline at UT1, and marginally at NAP1 and NAP3. Average annual concentrations exceed the guideline only at UT1. The applicable guideline for all model nodes is 0.002 mg/L for hardness of < 83 mg/L CaCO3. Predicted concentrations remain well below the 1 mg/L GCDWQ at all nodes. Copper concentrations are influenced by seepage and by WTP effluent (effluent discharge limit of 0.002 mg/L); however, the point source effluent does not affect the trend to lower predicted concentrations moving from UT1 and NAP1 downstream. The predicted changes to copper concentrations for all sites are predominantly driven by seepage and embankment runoff and are therefore seasonal, with higher concentrations occurring in during periods of lower stream flow. Concentrations at UT1 are predicted to exceed the CCME FAL guideline from June through November, and again from January to March during Operation and Closure. During Post-Closure, concentrations of copper are predicted to exceed the CCME FAL guideline at UT1 from June to October and again in March. Seasonal fluctuations follow the same trends at the nodes downstream from UT1, but maximum concentrations (during August and September) are predicted to marginally exceed the CCME FAL guideline only during Operation at NAP1 and NAP3. Maximum copper concentrations are reached in late-Operation and early-Closure with a predicted peak concentration of 0.0062 mg/L at UT1. The next highest concentration is predicted at NAP1, with a maximum (rather than annual average) concentration of 0.0022 mg/L. Predicted copper concentrations decrease to levels at or below the CCME FAL guidelines in lower Napadogan Brook (NAP5 to NAP8) during all project Phases.



Notes:

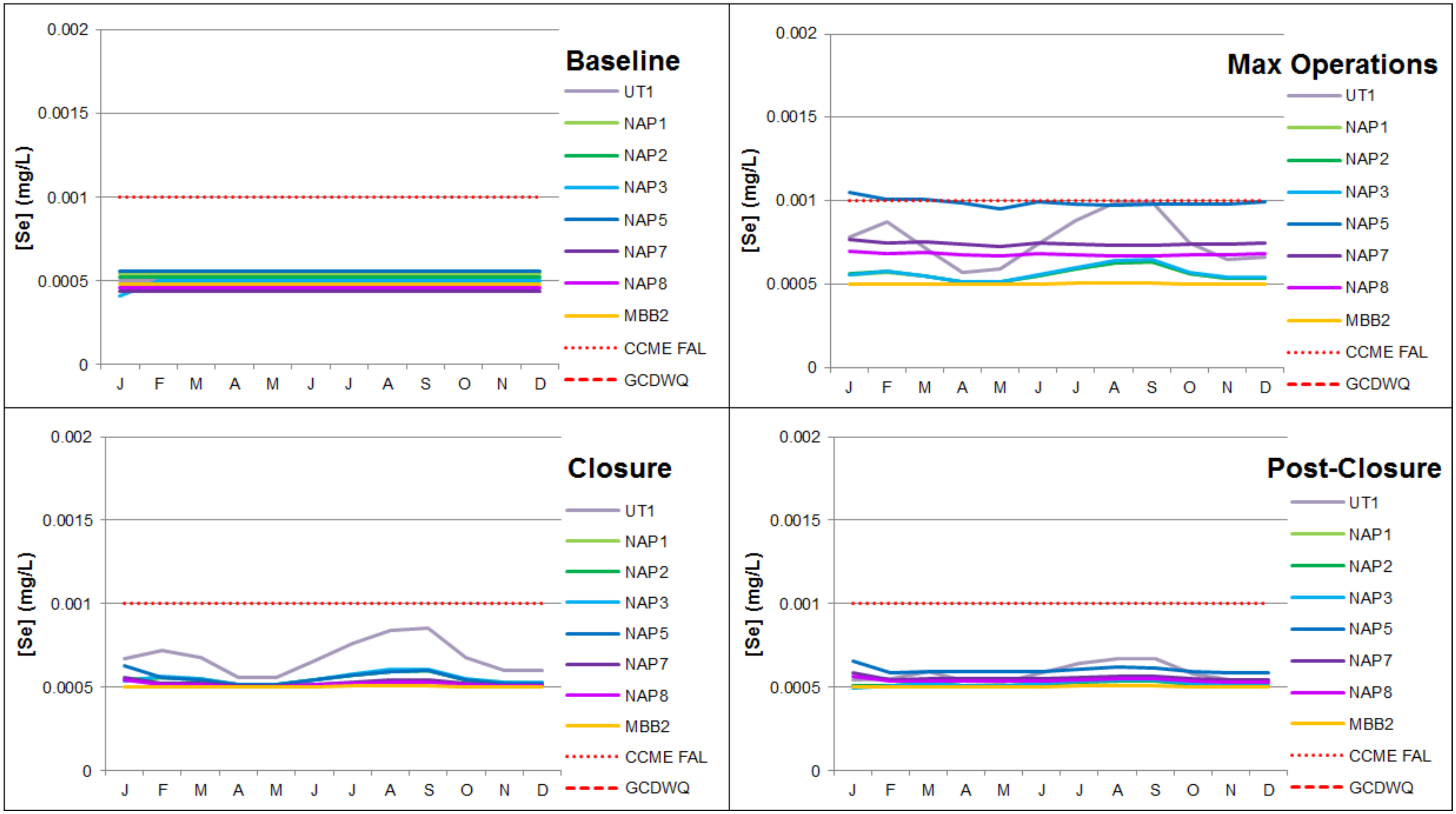
1. "Baseline" refers to Model Years -1 and -2; "Closure" refers to Year 30; "Post-Closure" refers to Year 50.
2. "Max Operations" refers to the year for which copper reaches its maximum value (Year 26 for all nodes).
3. ***The GCDWQ guideline is 1.0 mg/l and is not within the scale of these graphs.***
4. CCME FAL guideline is hardness-dependent, with a minimum of 0.002 mg/l for hardness <83 mg/l.
5. CCME FAL refers to the CCME Canadian Environmental Quality Guidelines for the Protection of Freshwater Aquatic Life.
6. GCDWQ refers to the Health Canada Guidelines for Canadian Drinking Water Quality.

Figure 7.6.11 Predicted Copper Concentrations at Downstream Nodes by Project Phase

7.6.3.5.3.9 Selenium (Se)

The annual distribution of predicted dissolved selenium concentrations for one year in each Project phase is provided on Figure 7.6.12. The use and interpretation of these predictions in considering the consequent risks to human, ecological or aquatic environment health are found in the HHERA (Section 7.7), Aquatic Environment (Section 8.5), and Public Health and Safety (Section 8.9).

Selenium concentrations are predicted to fluctuate seasonally around the CCME FAL guideline at NAP5 during Operation as a result of WTP effluent being discharged via Sisson Brook, starting in Model Year 8 (Operation). Concentrations at this node are predicted to remain well below the 0.01 mg/L GCDWQ and to drop below the CCME FAL guideline by Year 17 (Operation phase). The predicted concentrations at NAP5 during Operation are effectively at the guideline (range of 0.00097 mg/L to 0.00105 mg/L).



Notes:

1. "Baseline" refers to Model Years -1 and -2; "Closure" refers to Year 30; "Post-Closure" refers to Year 50.
2. "Max Operations" refers to the year for which selenium reaches its maximum value (Year 24 for NAP1, NAP2, NAP3, and MBB2; Year 11 for NAP5, NAP7, and NAP8).
3. ***The GCDWQ guideline is 0.01 mg/l and is not within the scale of these graphs.***
4. The current conditions indicate that selenium is below the method detection limit at all nodes.
5. CCME FAL refers to the CCME Canadian Environmental Quality Guidelines for the Protection of Freshwater Aquatic Life.
6. GCDWQ refers to the Health Canada Guidelines for Canadian Drinking Water Quality.

Figure 7.6.12 Predicted Selenium Concentrations at Downstream Nodes by Project Phase

7.7 HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT (HHERA)

As outlined in Sections 3.4.1.6 and 3.4.2.5, activities being carried out during the Construction, Operation, Decommissioning, Reclamation and Closure phases will release contaminants of potential concern (COPCs) to which humans and ecological receptors may potentially be exposed. Specifically:

- emissions of criteria air contaminants (CACs) from Project activities have the potential to affect human health through inhalation;
- deposition of COPCs in dust from extraction and transport of the ore has the potential to affect soil quality, thereby also affecting vegetation, wildlife, and consumers of country foods; and
- treated surplus water release from the water treatment plant, and release of seepage from the TSF, may release COPCs into groundwater or surface water which may affect water quality in nearby streams and thereby affect drinking water, aquatic life, and consumers of fish or aquatic plants.

A Human Health and Ecological Risk Assessment (HHERA) is the most appropriate mechanism to quantify the potential risks to human and ecological health that could result from Project activities. An HHERA consists of two main components: a Human Health Risk Assessment (HHRA) and an Ecological Risk Assessment (ERA). An HHRA is an assessment of the potential toxicological risks on human receptors. An ERA is an assessment of the potential ecotoxicological risks on ecological receptors. Section 4.13 of the Final Guidelines (NBENV 2009) and Section 4.8 of the Terms of Reference (Stantec 2012a) require that an HHERA of the Project be conducted as part of the environmental impact assessment (EIA) of the Project.

All chemicals, whether from human-made or natural sources, have an inherent toxicity and thus can result in a potential to cause a toxicological health risk to living organisms. The nature and magnitude of the health risk associated with a chemical depends upon:

- the type of receptor being exposed (*e.g*., human or wildlife);
- the duration and route of exposure (*e.g*., acute versus chronic exposure; with dermal, inhalation or ingestion routes of exposure); and
- the hazard represented by the chemical (*i.e*., its inherent toxicity).

If all three components (*i.e.,* receptor, exposure, and hazard) are present, then the possibility exists that a health risk may result (Figure 7.7.1). If, however, one or more of these three components is not present, then there is no risk. For example, a human or ecological receptor could be exposed to a contaminant, but if that contaminant has a very low toxicity or is present at very low levels, then no unacceptable risk would be expected. Alternatively, a contaminant present or released into the environment may be very toxic, but if there is no route of exposure by which a receptor could be exposed to the contaminant, again there is no risk to the receptor.

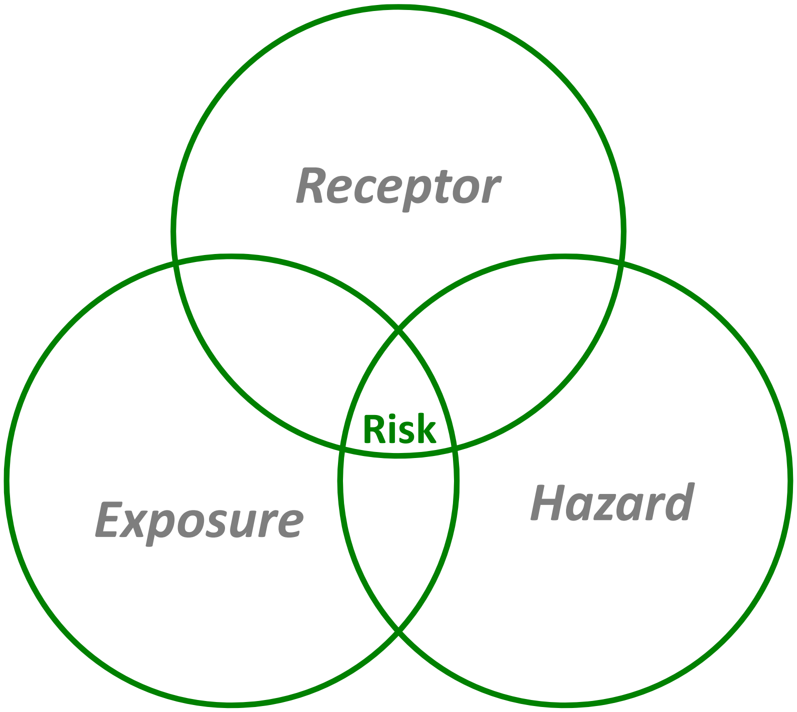


Figure 7.7.1 Health Risk Components

7.7.1 Human Health and Ecological Risk Assessment Methodology

This assessment of risks to human and ecological health was conducted according to widely-accepted risk assessment methodologies and follows guidance published and endorsed by regulatory agencies, including the following publications:

- "Federal Contaminated Sites Risk Assessment in Canada, Part I: Guidance on Human Health Risk Preliminary Quantitative Risk Assessment (PQRA), Version 2.0" (Health Canada 2010a);
- "Federal Contaminated Sites Risk Assessment in Canada, Part II: Health Canada Toxicological Reference Values (TRVs) and Chemical-Specific Factors Version 2.0" (Health Canada 2010b);
- "Federal Contaminated Sites Risk Assessment in Canada, Part V: Guidance on Complex Human Health Detailed Quantitative Risk Assessment For Chemicals ($DQRA_{CHEM}$)" (Health Canada 2010c); and
- "A Framework for Ecological Risk Assessment—Canadian Council of Ministers of the Environment" (CCME 1996).

The HHERA framework (Figure 7.7.2) is composed of the following major components, which are the same for the characterization of risks to both human and ecological receptors.

- **Project Site Characterization and Modelled Predictions:** This component includes a review and compilation of existing information including the Project components and related activities, and biophysical and land use studies completed in support of this EIA.

- **Problem Formulation:** Problem formulation includes the identification of the potential Project-related environmental hazards that may pose a health risk (*i.e.*, COPC), potential receptors (human and ecological), and relevant exposure pathways (*e.g.*, inhalation of COPC in air). The problem formulation component ensures that the HHERA focuses on the key areas and issues of concern.

- **Hazard (Toxicity) Assessment**: The hazard (toxicity) assessment includes the identification of published, scientifically-reviewed toxicity information for each COPC, against which the receptor exposures can be compared.

- **Exposure Assessment:** The exposure assessment is the qualitative or quantitative evaluation of the degree to which the receptors will be exposed to the COPC, generally expressed as a dose (*e.g.*, mg of COPC per kg body weight per day). Generally, human and ecological receptors can be exposed to these contaminants by directly inhaling them, coming into dermal contact with them, or ingesting them along with food and water.

- **Risk Characterization**: Risk characterization is a qualitative or quantitative assessment of the health risk of each COPC to each receptor, based on the degree of exposure. The potential for Project activities to affect the health of a receptor can then be assessed based on the magnitude of the predicted risk.

- **Uncertainty Assessment:** A review of the assumptions and uncertainties associated with the risk estimation is completed. If, upon review, one or more of the assumptions used to estimate the exposure (and risk) is found to be unreliable, the assumption may be revised and the risk calculations repeated until the results are considered to be reliable, but not unduly conservative in its approach. A conservative assessment or assumption is one that is likely to over-state the actual risk or consequence, rather than under-stating it.

- **Recommendations:** If required, recommendations are provided for mitigation and/or monitoring that would reduce the potential risk.

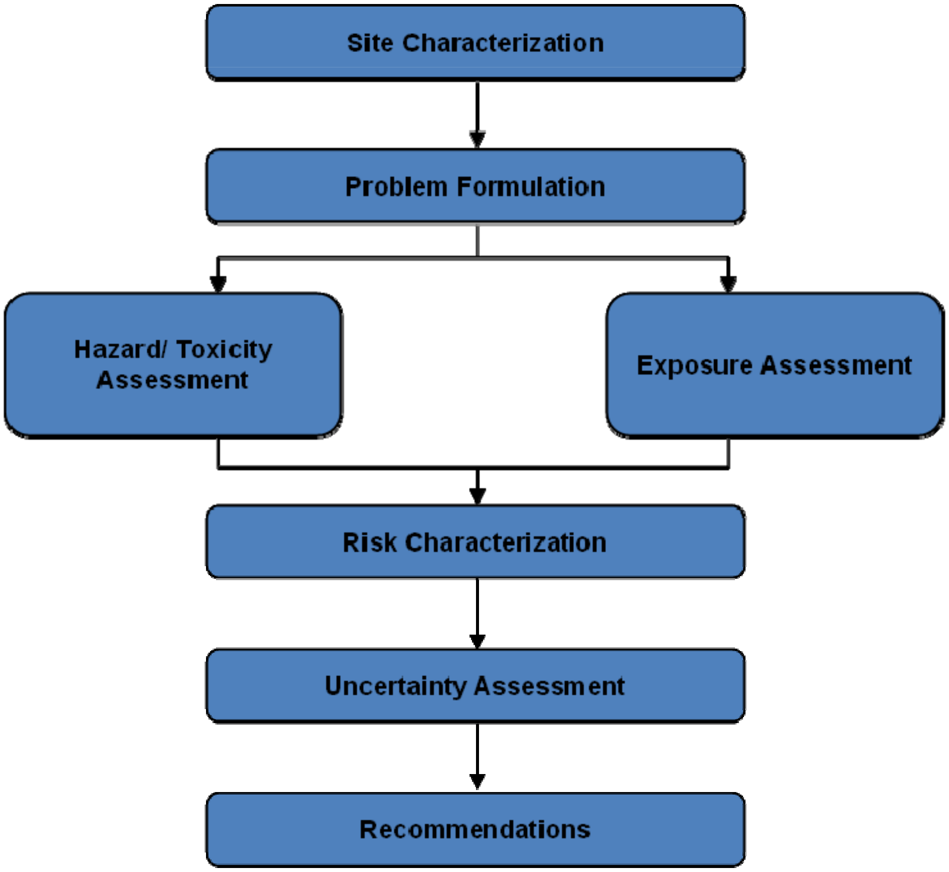


Figure 7.7.2 Human Health and Ecological Risk Assessment Framework

To assess the potential human and ecological health risks, the HHERA considered how the Project activities may result in the release of contaminants to the environment. Details of the activities associated with each of the Project phases of Construction (the time during which the Project would be constructed), Operation (the time period after the Construction phase during which the mine would operate), and Decommissioning, Reclamation and Closure (*i.e.,* the time following the completion of Operation of the Project) are provided in Section 3.4. The HHERA considered the potential risks from the Project alone and in the context of the existing environmental conditions as follows.

- The “Baseline Case” evaluates potential health risks presently existing at and near the Project site, and is based upon measured data for COPC concentrations in air, soil, plants, water, soil invertebrates, small mammals, and fish. COPC concentrations for wild game (*e.g*., moose) were estimated based upon measured concentrations of COPCs in other media.

- The “Project Alone Case” evaluates potential future health risks arising from changes in air quality and the burden of metal deposition to soils and vegetation caused by dust fall near the Project site, and changes to water quality in downstream watercourses (*i.e.,* Napadogan Brook) caused by the Project.

- As implied by the name, the “Project + Baseline Case” evaluates the health risks associated with the predicted environmental concentrations, which incorporate both the health risks potentially arising from existing conditions and those from predicted changes in the environment that may be caused by Project activities.

7.7.2 Project Site Characterization and Environmental Quality Model Predictions

In order to complete the HHERA, it was necessary to understand the area within which Project-related environmental effects can be predicted or measured with a reasonable degree of accuracy and confidence. For the HHERA, this includes an area of 20 x 20 km centred on the Project Development Area (PDA, defined as the physical footprint of Project components; see Figure 1.2.1). Referred to herein as the HHERA Study Area, this 20 km x 20 km area encompasses the open pit; the ore processing plant; storage areas; the TSF; and the quarry and areas directly adjacent to the PDA (Figure 7.7.3).

The area of the Project straddles a topographical divide that separates the headwaters of the McBean Brook and Napadogan Brook watersheds. Both brooks drain to the Nashwaak River, which enters the St. John River at Fredericton. The majority of the Project facilities lie within the small Bird and Sisson brook tributary watersheds to West Branch Napadogan Brook, which drains via Napadogan Brook to the Nashwaak River. The southwestern portion of the open pit does, however, partially intersect small headwater tributaries to McBean Brook. These watersheds support both warm and cold water fish species. The main aquatic species of interest in Napadogan Brook and the headwaters of the Nashwaak River are Atlantic salmon, American eel, and brook trout. A detailed description of water quality, and fish and fish habitat is provided in Sections 7.6, 8.4, and 8.5.

Most of the Project is located near the southwestern border of the Central Uplands Ecoregion within the Beadle Ecodistrict, a lake-filled region of rolling hills separated by broad valleys. This area is typically well-drained, forested upland, separated by rolling valleys. The HHERA Study Area includes tolerant hardwood forest at higher elevations, transitioning to black spruce/balsam fir dominated forest in the valley bottoms. As will be discussed in Section 8.7.2 (Vegetated Environment), over 400 vascular plant species were identified in the HHERA Study Area, including an S2/sensitive species (Nodding ladies’-tresses, *Spiranthes cernua*) at one location outside the PDA. Further information on existing vegetation communities in the PDA and parts of the HHERA Study Area are presented in Section 8.7.

As will be discussed in Section 8.6.2 (Terrestrial Environment), wildlife within the PDA and parts of the HHERA Study Area consists of up to 22 mammalian species, approximately 146 songbird species that use every type of habitat in the area, and 11 herpetile (reptiles and amphibian) species. A total of 13 Species at Risk (SAR) may potentially be present in the region including: Canada lynx, Tricolored Bat, Northern Myotis, Little Myotis, Wood turtle, Bald Eagle, Common Nighthawk, Chimney Swift, Olive-sided Flycatcher, Eastern Wood-pewee, Barn Swallow, Canada Warbler, and Rusty Blackbird. More details regarding wildlife and wildlife habitats in the PDA and parts of the HHERA Study Area are provided on Section 8.6.

Like much of central New Brunswick, the general area of the Project is sparsely populated but supports a variety of land uses including hunting, fishing, ATV, snowmobile, and commercial forestry. There is a long history of active commercial logging, and thus there are many forestry roads, in the general area of the Project. A number of active recreational campsite leases (some containing privately-owned cabins) are located near the PDA. The closest of these recreational campsites is approximately 1.5 km to the east of the open pit location (Figure 7.7.3). There are no permanent residences located in the immediate vicinity of the Project; the closest permanent residences are located in Napadogan, a small community on Highway 107, approximately 9 km to the northeast of the Project site (Figure 7.7.3).

An Indigenous Knowledge Study (Moccasin Flower Consulting 2013) (IKS) was conducted by the St. Mary's First Nation (SMFN), Woodstock First Nation (WFN), and Madawaska Maliseet First Nation (MMFN). The IKS identified a number of plant and animal species of importance to First Nations in the general area of the Project, including berries, nuts (*e.g.,* butternuts, hazelnuts), fiddleheads, moose and deer, muskrat, beaver, rabbit, grouse, and fish including Atlantic salmon. The IKS also provided information on specific areas of traditional land use (*e.g.,* areas where vegetation is collected for food and medicinal uses, drinking water springs, and fishing and hunting areas).

7.7.2.1 Contaminants of Potential Concern (COPCs)

As noted previously, sources of contaminants from Project activities include emissions of criteria air contaminants (CACs, *i.e.,* SO_2, NO_2, CO, PM, PM_{10}, and $PM_{2.5}$) from combustion sources, emissions of non-criteria air contaminants (non-CACs) from fugitive ore dust during extraction and transport, and release of treated surplus water or seepage containing trace metals into groundwater and surface water in the receiving environment. For brevity, these contaminants are referred to below as contaminants of potential concern, or COPCs. Environmental media potentially directly affected by these releases include air, soil, and surface water. Changes in COPC concentrations in soil and surface water may also result in changes in COPC concentrations in plants, game, and fish.

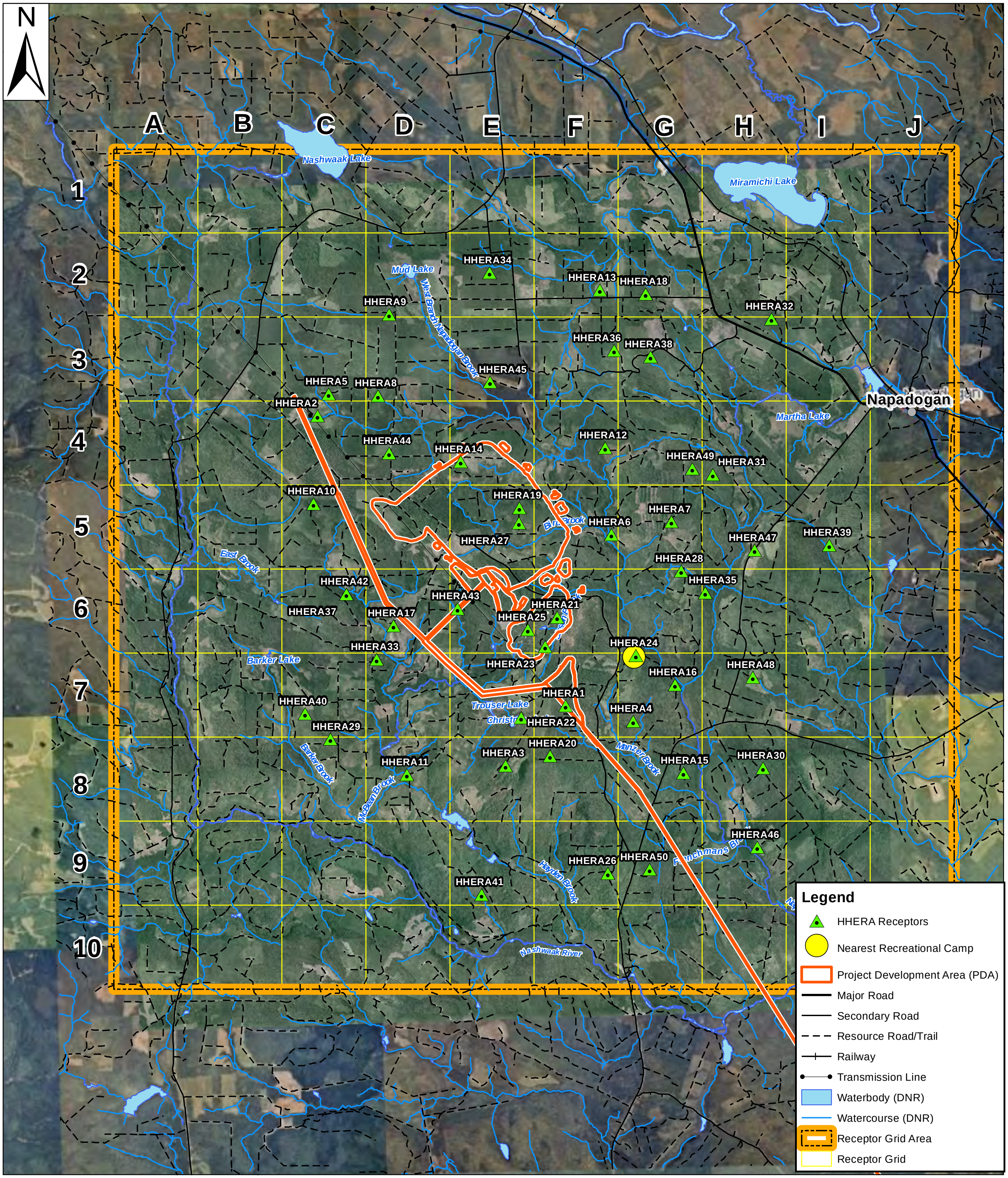
Exposure point concentration (EPC) values are concentrations of COPCs in relevant environmental media that are selected to represent the conditions to which human and ecological receptors may be exposed.

7.7.2.1.1 COPC Identification

A multi-step screening process was used to identify the COPCs for the HHERA. For air, the CACs identified in Section 7.1 (*i.e.,* SO_2, NO_2, CO, PM, PM_{10}, and $PM_{2.5}$) were carried forward as COPCs in the HHERA.

For terrestrial and aquatic environments, the trace metals contained in the ore (shown in Table 3.4.33) were identified as possible COPCs; however, a screening process was applied to select which of these metals should be carried forward as COPCs. For terrestrial (soil related) exposures, the screening considered: whether the contaminant was already present in the environment at concentrations above guidelines, the toxic potential of the metal constituents in the ore dust, and the potential for levels of metals in dust to be lower than the existing soil conditions.

For aquatic (surface water related) exposures, the selection of COPCs considered the model-predicted concentrations of various trace metals in surface water associated with Operation and Decommissioning, Reclamation and Closure phases (Section 7.6) screened against drinking water guidelines and guidelines for the protection of freshwater aquatic life.



Receptor Grid for HHERA Sisson Project: Environmental Impact Assessment (EIA) Report, Napadogan, N.B.	Scale: NTS 0 0.5 1 1.5 Kilometres	Project No.: 121810356		Data Sources: NBDNR, SNB Imagery Provided By: NBDNR	Fig. No.: 7.7.3
	Date: (dd/mm/yyyy) 12/07/2013	Dwn. By: JAB	Appd. By: DLM		
Client: Sisson Mines Ltd.					

7.7.2.1.2 COPC Screening Based on Soil Quality Guidelines

For soil, if existing concentrations of a contaminant in soil (as measured in the baseline sampling program, Stantec 2012h) were higher than existing regulatory guidelines, the contaminant was carried forward as a COPC, for further evaluation. The measured baseline soil data obtained as part of the baseline sampling program (Stantec 2012h) were compared to applicable environmental quality standards or guidelines for soil. The soil data were sufficient to determine a 95 percent upper confidence limit of the mean (95 percent UCLM). The use of a 95 percent UCLM for comparing site concentrations to clean-up standards or establishing background levels is recommended by the USEPA (2002). Where the 95 percent UCLM soil concentrations exceeded the screening level guidelines, the contaminant was carried forward as a COPC. The 95 percent UCLM of arsenic, manganese, and selenium in measured soil data were higher than the applicable human health and ecological screening guideline values found in:

- Canadian Council of Ministers of the Environment (CCME) “Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health 1999, updated 2011” (CCME 1999);
- Ontario Ministry of the Environment (OMOE) “Table 3 Site Condition Standards of Soil, Groundwater and Sediment Standards for Use Under Part XV.1 of the *Environment Protection Act*, 2009” (OMOE 2009); and
- United States Environmental Protection Agency (USEPA) “Ecological Soil Screening Levels, 2007” (USEPA 2007).

7.7.2.1.3 COPC Screening Based on Relative Toxic Potential of Ore

Following the initial identification of potential COPCs described above, the total metal concentration of each COPC was then assessed based on the relative toxic potential (RTP) to human health, mammals, birds, and plant and soil invertebrates (Alberta Health and Wellness 2011). To evaluate the potential for ore dust to affect environmental quality through air dispersion and subsequent deposition onto soil, the RTP was calculated by dividing the concentration of each metal in the ore (as shown in Table 3.4.31), by the appropriate toxicity reference value (TRV, mg/kg body weight-day for oral ingestion for humans, mammals and birds; mg/kg for direct contact for plants and soil invertebrates). Consistent with USEPA (1989) guidance, parameters accounting for more than one percent of the RTP were selected as COPCs that would be further evaluated in the HHERA.

Parameters accounting for more than one percent of the relative toxic potential included: aluminum, arsenic, boron, chromium, cobalt, copper, lead, manganese, molybdenum, nickel, thallium, titanium, uranium, vanadium, and zinc; these COPCs were carried forward in the HHERA. Very limited toxicological data are available for a number of metals (*e.g.*, bismuth, calcium, iron, magnesium, potassium, rubidium, sodium, sulphur, and titanium), and thus these metals were omitted from the HHERA. Although the soil and tap water guidelines for lithium from the USEPA Regional Screening Tables were developed using a provisional peer reviewed toxicity value (PPRTV) developed for a Superfund site, the PPRTV number provides very little information about the adverse environmental effects of a contaminant, or the quality of evidence on which the toxicity assessment was based (USEPA 2012). A literature review (Aral and Vecchio-Sadus 2008) has indicated that lithium is not expected to bioaccumulate and its human and environmental toxicity are low. Based on the results of the literature review, it was concluded that neither lithium intake from food and water nor from occupational exposure presents a toxicological hazard (Aral and Vecchio-Sadus 2008).. As none of the Health Canada (2010a) recommended resources have developed a toxicological reference value for lithium, and given the findings of the published literature review, lithium was not carried forward as a COPC.

A third step, consisting of comparison of concentrations of metals in the ore to the background soil concentrations (based on the median of soil sample results), was completed. Parameters for which ore concentrations were less than or equal to the background soil concentrations were not carried forward for further analysis, since ore deposition would not increase the existing background soil total metal concentrations. This sub-set includes selenium.

7.7.2.1.4 COPC Screening Based on Water Quality Guidelines

Existing (measured) and predicted future metal concentrations in surface water were screened by comparison to provincial and federal guidelines for the protection of aquatic life, and for drinking water, as found in:

- CCME Water Quality Guidelines for the Protection of Aquatic Life (Freshwater) (CCME 1999 and updates);
- British Columbia approved water quality guidelines (BC Ministry of Environment 2010b); and
- Health Canada “Guidelines for Canadian Drinking Water Quality” (GCDWQ; Health Canada 2012b).

7.7.2.1.5 Summary of COPC Screening

The non-CAC COPC selection process therefore includes screening of trace elements in a series of steps (Table 7.7.1), as follows.

- In Step 1, it is determined whether measured concentrations in soil exceed guidelines.
- In Step 2, the toxic potential of trace elements in the ore for human and ecological receptors is considered.
- In Step 3, trace element concentrations in the ore are higher than local soil background values is confirmed.
- In Step 4, water is screened against guidelines for drinking water and aquatic life. Elements that are flagged as COPCs in this step get added to the list derived by screening soils.

In addition, mercury was added to the list of COPCs as being inherently of interest. Also, sodium was screened out as it was flagged by aesthetic objectives for drinking water quality, not by health-based guidelines.

Table 7.7.1 Summary of Non-CAC Contaminant of Potential Concern Screening

Parameter	Step 1	Step 2 - Toxic Potential by Receptor				Step 3		Step 4 - Screening Water			
	Guideline Exceedance	HH	Bird	Small Animal Prey	Plant/Soil Invertebrates	Is ore concentration higher than background?	List of Soil-based COPCs	Drinking Water Guideline Screening	Freshwater Aquatic Life Screening	Final List of HHRA COPCs	Final List of ERA COPCs
Aluminum		X		X			Aluminum			Aluminum	Aluminum
Antimony											
Arsenic	X	X		X	X		Arsenic			Arsenic	Arsenic
Barium											
Bismuth											
Boron					X		Boron		X	Boron	Boron
Cadmium											
Calcium											
Chromium		X	X	X			Chromium			Chromium	Chromium
Cobalt			X		X		Cobalt			Cobalt	Cobalt
Copper			X	X	X		Copper			Copper	Copper
Iron											
Lead		X					Lead			Lead	Lead
Lithium											
Magnesium											
Manganese	X	X		X	X		Manganese			Manganese	Manganese
Mercury						no				Mercury (IOI)	Mercury (IOI)
Molybdenum		X	X	X	X		Molybdenum			Molybdenum	Molybdenum
Nickel				X			Nickel			Nickel	Nickel
Phosphorus											
Potassium											
Rubidium											
Selenium	X					no					
Silver											
Sodium								X			
Strontium											
Sulphur											
Thallium		X			X		Thallium	X	X	Thallium	Thallium

Table 7.7.1 Summary of Non-CAC Contaminant of Potential Concern Screening

Parameter	**Step 1**	**Step 2 - Toxic Potential by Receptor**				**Step 3**		**Step 4 - Screening Water**			
	Guideline Exceedance	**HH**	**Bird**	**Small Animal Prey**	**Plant/Soil Invertebrates**	**Is ore concentration higher than background?**	**List of Soil-based COPCs**	**Drinking Water Guideline Screening**	**Freshwater Aquatic Life Screening**	**Final List of HHRA COPCs**	**Final List of ERA COPCs**
Titanium					X		Titanium			Not measured in baseline and will thus only be assessed for plants exposed to soil dusted for 27 years; baseline soil is assumed to have zero concentration.	
Tungsten	X						Tungsten		X	Tungsten	Tungsten
Uranium		X			X		Uranium		X	Uranium	Uranium
Vanadium		X	X	X	X		Vanadium	X	X	Vanadium	Vanadium
Zinc					X		Zinc			Zinc	Zinc

Notes:
Iron and manganese are omitted from the COPC list since their guideline is based on aesthetic objectives and not health effects.

Legend:

IOI	Inherently of Interest
HH	Human Health
COPC	contaminant of potential concern
HHRA	Human Health Risk Assessment
ERA	Ecological Risk Assessment

The final list of non-CAC COPCs for the HHRA and ERA includes (Table 7.7.1):

- Aluminum (Al);
- Arsenic (As);
- Boron (B);
- Chromium (Cr);
- Cobalt(Co);
- Copper
- Lead (Pb);
- Manganese (Mn);
- Mercury (Hg);
- Molybdenum (Mo);
- Nickel (Ni);
- Thallium (Tl);
- Tungsten (W);
- Uranium (U);
- Vanadium (V); and
- Zinc (Zn).

In addition, CACs (*i.e.,* SO_2, NO_2, CO, PM, PM_{10}, and $PM_{2.5}$) were carried forward as COPCs for the HHRA.

7.7.2.2 Existing and Predicted Future Contaminant Concentrations in the Environment

In order to evaluate the potential health risks associated with COPCs from the Project, the HHERA relied on the results of the predictive air dispersion and deposition modelling (Section 7.1) and the predictive water quality modelling (Section 7.6). These predictive models provide estimates of COPCs in air and surface water under future conditions (*i.e.*, Project + Baseline Case). Future COPC concentrations in vegetation, soil invertebrates, and small mammals were estimated based upon future (*i.e.*, Project + Baseline Case) soil concentrations as predicted by the air dispersion and deposition modelling. Future COPC concentrations for fish, benthic invertebrates, and sediment were estimated using predicted future (*i.e.*, Project + Baseline Case) COPC concentrations in surface water as predicted by the predictive water quality modelling.

The equation used to calculate a COPC concentration in a biological tissue from a soil or water concentration (hereinafter referred to as the “generalized equation”) is as follows:

$$EPC_j = EPC_i \text{ x } UP_{ij}$$

where:

EPC_j = Exposure point concentration in target biotic tissue *j* (*e.g.*, plants or fish, mg/kg wet weight);

EPC_i = Exposure point concentration in measured media *i* (*e.g.*, soil and surface water, in mg/kg dry weight or in mg/L); and

UP*ij* = Uptake Factor from environmental medium *i* to target biota tissue *j* (environmental medium and biotic tissue dependent).

However, another important aspect of the HHERA is to assess the risk from the Project in the context of existing or background exposures. Given the importance of existing concentrations to both the prediction of future concentrations and for providing context for the health risk estimates, both the existing contaminant concentrations in the environment (*i.e.*, the concentrations that are present currently, prior to any Project activities) are presented along with the predicted future (*i.e.*, Project + Baseline) contaminant concentrations.

Where measured baseline data were available for biological tissues, these values are considered to be more reliable than a model-estimated value would be. However, for Project + Baseline Case predictions, it is always necessary to rely upon model-estimated values. In order to reconcile measured and model-estimated values, the following approach was taken.

The expected magnitude of change introduced by the project was estimated by calculating both Baseline Case and Project + Baseline Case predictions for metal concentrations in biological tissues. The ratio of the two predictions (*i.e.*, (predicted Project + Baseline Case) / (predicted Baseline Case)) was calculated to provide an estimate of the expected magnitude of change to be introduced as a result of the Project going forward. The measured baseline tissue concentrations were then multiplied by this ratio in order to estimate the expected future concentration in tissues.

As a more concrete example of this approach, the 95 percent UCLM value for arsenic in brook trout fillet that would be consumed by humans was measured and found to be 0.89 mg/kg wet weight for the fish carcass in West Branch Napadogan Brook for the Baseline Case. Williams *et al.* (2006) provided a review of arsenic bioaccumulation by a variety of fish species, and gave an equation relating the bioaccumulation factor for arsenic in fish tissue to the arsenic concentration in water. Using the equation of Williams *et al.* (2006), the expected ratio of Project + Baseline Case to Baseline Case arsenic concentrations in fish tissue was estimated using measured and predicted future case arsenic concentrations in the water for each of the assessment locations on West Branch Napadogan Brook and McBean Brook. The baseline fish tissue arsenic concentration was then multiplied by these site-specific ratio values to estimate future fish tissue arsenic concentrations.

The same process was applied, using appropriate bioaccumulation models or uptake factors for each of the COPCs, and for each of the biological tissue types used as a potential food source by humans or ecological receptors (*i.e.*, fish tissue, benthic invertebrates, plant tissues, soil invertebrates, animal prey tissues, *etc.*), to predict Project + Baseline Case tissue metal concentrations where measured baseline data were available. In the absence of measured baseline tissue data, then both Baseline Case and Project + Baseline Case tissue metal concentrations were simply predicted from measured or expected metal concentrations in water, soil or sediment, using published uptake factors or bioaccumulation models.

HHERA receptor locations were established within 2 km x 2 km grids within the larger 20 km x 20 km HHERA Study Area, in order to assess potential exposures within each grid square. These HHERA locations generally correspond to the baseline soil sample locations (Stantec 2012h), of which ten represented biota sampling locations where vegetation, soil invertebrates, and small game samples were also collected. These locations were selected to provide appropriate coverage of the HHERA Study Area, thereby incorporating the expected locations of sensitive human and ecological receptors into the assessment. In the event that multiple samples (or HHERA receptor locations) were collected within the same grid, the maximum value was carried forward for assessment. Figure 7.7.3 shows the HHERA receptor locations and grid squares considered in the assessment.

Additional details regarding the COPC concentrations used in the HHERA are provided below.

7.7.2.2.1 Air

Air COPCs are detailed in Section 7.1 and Section 8.2, and include the following CACs: particulate matter (PM) (including $PM_{2.5}$ and PM_{10}), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), and carbon monoxide (CO). Non-CAC concentrations in air were also assessed.

To characterize baseline concentrations of COPCs in ambient air, as discussed in Section 8.2.2, Northcliff conducted an ambient air quality monitoring program at the Project site over a six month period to cover three seasons (summer, fall and winter). The monitoring was carried out from August 2011 to February 2012, at a site in Napadogan that was selected because it is the nearest residential area to the Project. Additional air quality data collected by the Province of New Brunswick was used to further describe the ambient air quality generally found in central New Brunswick

Particulate matter (dustfall) concentrations in air were measured at Napadogan as part of the ambient air quality monitoring. The average particulate matter concentration measured was 17.0 $\mu g/m^3$, with concentrations ranging from a low of 7.1 $\mu g/m^3$ in February 2012 to a high of 35.3 $\mu g/m^3$ in August 2011. These levels were assumed to represent existing conditions for the Baseline Case.

Predicted CAC concentrations for the Project + Baseline Case were provided in Table 7.1.8. Note that these CAC concentrations represent the maximum overall ground-level concentrations (GLCs) during Operation. As indicated in Section 8.2, maximum GLCs of CAC during Construction were lower than those during Operation, and emissions of CAC during Decommissioning, Reclamation and Closure are expected to be similar to or less than those during Construction.

Maximum metals concentrations in air were determined using the results of chemical analysis of the ore and the air dispersion model results for PM_{10} emitted during Project activities that are associated with the ore dust generation. Details of how the concentrations of metals from the ore samples (provided in Table 3.4.31) were determined, and how dust emissions from ore and overburden were estimated, are provided in Section 3.4.1.5 (Construction) and 3.4.2.5 (Operation). A summary of the air deposition modelling is provided in Section 7.1. The resulting maximum predicted GLCs of metals from air dispersion during Operation are provided in Tables 7.7.2 to 7.7.4.

Table 7.7.2 Maximum 1-hour COPC Concentrations in Ambient Air (mg/m^3)

COPC	Maximum Ground-level 1-h Air Exposure Point Concentrations (EPCs) (mg/m^3)	
	Baseline Case	Project + Baseline Case
Aluminum (Al)	7.00E-04	1.13E-01
Arsenic (As)	5.99E-06	2.72E-04
Boron (B)	6.08E-06	6.37E-06
Chromium (Cr)	2.52E-06	4.44E-04
Cobalt (Co)	2.00E-06	8.18E-05
Copper (Cu)	6.57E-04	1.19E-03
Lead (Pb)	6.62E-06	2.98E-04
Manganese (Mn)	2.56E-05	8.63E-03
Mercury (Hg)	1.95E-08	2.53E-07
Molybdenum (Mo)	3.04E-06	9.74E-05
Nickel (Ni)	2.99E-06	1.33E-04
Thallium (Tl)	1.01E-05	6.11E-06
Tungsten (W)	3.67E-06	1.72E-04

Table 7.7.2 Maximum 1-hour COPC Concentrations in Ambient Air (mg/m^3)

COPC	Maximum Ground-level 1-h Air Exposure Point Concentrations (EPCs) (mg/m³)	
	Baseline Case	Project + Baseline Case
Uranium (U)	6.46E-05	1.76E-05
Vanadium (V)	2.01E-06	5.04E-04
Zinc (Zn)	5.72E-05	9.94E-04

Table 7.7.3 Maximum 24-hour COPC Concentrations in Ambient Air (mg/m^3)

COPC	Maximum Ground-level 24-h Air Exposure Point Concentrations (EPCs) (mg/m³)	
	Baseline Case	Project + Baseline Case
Aluminum (Al)	2.88E-04	4.75E-03
Arsenic (As)	2.46E-06	1.14E-05
Boron (B)	2.50E-06	1.29E-06
Chromium (Cr)	1.03E-06	1.86E-05
Cobalt (Co)	8.20E-07	3.43E-06
Copper (Cu)	2.70E-04	5.00E-05
Lead (Pb)	2.72E-06	1.25E-05
Manganese (Mn)	1.05E-05	3.61E-04
Mercury (Hg)	8.01E-09	6.24E-08
Molybdenum (Mo)	1.25E-06	1.97E-05
Nickel (Ni)	1.23E-06	5.55E-06
Thallium (Tl)	4.16E-06	2.56E-07
Tungsten (W)	1.51E-06	3.48E-05
Uranium (W)	2.65E-05	7.39E-07
Vanadium (V)	8.27E-07	2.11E-05
Zinc (Zn)	2.35E-05	4.17E-05

Table 7.7.4 Maximum Annual Average COPC Concentrations in Ambient Air (mg/m^3)

COPC	Annual Average Air Exposure Point Concentrations (EPC) at Grid G8 (mg/m³)		
	Baseline Case	Project Alone Case	Project + Baseline Case
Aluminum (Al)	1.64E-04	1.51E-04	3.16E-04
Arsenic (As)	2.16E-06	3.51E-07	2.51E-06
Boron (B)	2.47E-06	1.59E-07	2.63E-06
Chromium (Cr)	8.13E-07	5.66E-07	1.38E-06
Cobalt (Co)	7.19E-07	1.08E-07	8.27E-07
Copper (Cu)	1.93E-04	1.55E-06	1.94E-04
Lead (Pb)	1.75E-06	3.83E-07	2.13E-06
Manganese (Mn)	6.53E-06	6.78E-06	1.33E-05
Mercury (Hg)	6.95E-09	5.87E-09	1.28E-08
Molybdenum (Mo)	1.24E-06	2.40E-06	3.64E-06
Nickel (Ni)	1.10E-06	1.68E-07	1.27E-06
Thallium (Tl)	4.12E-06	8.12E-09	4.13E-06
Tungsten (W)	1.45E-06	4.25E-06	5.70E-06
Uranium (U)	2.28E-05	2.33E-08	2.28E-05
Vanadium (V)	7.59E-07	6.69E-07	1.43E-06
Zinc (Zn)	1.52E-05	1.27E-06	1.65E-05

7.7.2.2.2 Soil

As reported in Stantec (2012h), soil samples were collected from the HHERA receptor locations identified in Figure 7.7.3. To predict the future soil concentrations (*i.e.*, Project + Baseline Case), the mass loading associated with deposition of ore dust during Operation as predicted by the air deposition modelling was added to the measured existing metal concentrations in soil at each of the HHERA receptor locations. During the Construction and Decommissioning, Reclamation and Closure phases, the mine would not be producing, processing, or handling ore, and hence there would not be atmospheric deposition of ore dust.

Ore dust deposition rates were obtained on a site-specific basis as annual average values from the air dispersion and deposition model (Section 7.1). To estimate the deposition of ore dust on soil concentration, it was assumed that 100 percent of the deposited ore dust and associated COPCs are incorporated into the surface layer of soil (*i.e.,* the top 10 cm) within the HHERA receptor grid. For example, for the soil concentrations at grid location G8 (see Figure 7.7.3), the concentrations in soil for the Baseline Case are the measured concentrations in the soil sample from location HHERA15, the Project Alone Case concentrations are based on the results of deposition modelling for HHERA15, and the Project + Baseline Case is the sum of the measured soil concentration and the modelled deposition. As an example, the results for Grid G8 are shown in Table 7.7.5, for illustrative purposes. This same process was repeated at each of the receptor grid squares in Figure 7.7.3.

Table 7.7.5 Concentrations in Soil at HHERA Grid G8 (mg/kg dry weight)

COPC	Soil Exposure Point Concentrations (EPC) at Grid G8 (mg/kg dry weight)		
	Baseline Case	Project Alone Case	Project + Baseline Case
Aluminum (Al)	6.24E+03	1.24E-04	6.24E+03
Arsenic (As)	1.00E+01	3.34E-07	1.00E+01
Boron (B)	2.00E+00	7.36E-08	2.00E+00
Chromium (Cr)	7.00E+00	5.37E-07	7.00E+00
Cobalt (Co)	1.10E+00	9.04E-08	1.10E+00
Copper (Cu)	5.00E+00	1.45E-06	5.00E+00
Lead (Pb)	1.16E+01	3.73E-07	1.16E+01
Manganese (Mn)	4.80E+01	1.32E-05	4.80E+01
Mercury (Hg)	6.00E-02	5.20E-09	6.00E-02
Molybdenum (M0)	2.00E-01	1.11E-06	2.00E-01
Nickel (Ni)	3.00E+00	1.63E-07	3.00E+00
Thallium (Tl)	5.00E-02	6.70E-09	5.00E-02
Tungsten (W)	2.00E-01	1.96E-06	2.00E-01
Uranium (U)	5.00E-01	1.93E-08	5.00E-01
Vanadium (V)	3.20E+01	5.53E-07	3.20E+01
Zinc (Zn)	1.40E+01	1.20E-06	1.40E+01

7.7.2.2.3 Surface Water

For the HHERA, exposure to surface water for the existing (Baseline Case) conditions was based on annual average metal concentrations in surface water samples from the Napadogan River watershed collected between the June 2007 and April 2012 (Section 8.4 and Knight Piésold 2012e). Samples were variously collected by Rescan between 2007 and 2008 and by Northcliff between 2009 and 2012.

Water quality modelling (Section 7.6) was used to predict surface water quality during the Construction, Operation, and Decommissioning, Reclamation and Closure phases at seven locations along Napadogan Brook (NAP1, NAP2, NAP3, NAP5, NAP7, and NAP8), and one location along McBean Brook (MBB2), as shown in Figure 7.6.2. The modelling also predicted surface water quality at locations in three unnamed tributaries to Napadogan Brook (UT1, UT3, and UT4), though with reduced levels of confidence. For the purposes of establishing surface water concentrations for the Project + Baseline Case to be used in the HHERA, the maximum annual average COPC concentration during any of the phases was selected for the Project + Baseline Case, and thus represents a conservative estimate of water quality in consideration of all Project phases and activities. Project Alone concentrations were estimated as the Project + Baseline Case concentration minus the Baseline Case concentration.

For those HHERA receptor grids that contained one of the above-noted watercourses, the results of surface water quality monitoring and water quality modelling that best represented that particular reach of watercourse was applied to the grid. For example, for Grid G8 (see Figure 7.7.3), the results at NAP5 best represents the Napadogan Brook in this area. As an example, the water quality data for Baseline, Project Alone, and Project + Baseline Cases for Grid G8 are provided in Table 7.7.6, for illustrative purposes. This same process was repeated at each of the receptor grid squares in Figure 7.7.3. Note that if a grid square did not contain a watercourse, no surface water (or fish) exposures were assigned to that grid location.

Table 7.7.6 Concentrations in Surface Water at HHERA Grid G8 (mg/L)

COPC	Surface Water Exposure Point Concentrations (EPC) at Grid G8 (mg/L)		
	Baseline Case	Project Alone Case	Project + Baseline Case
Aluminum (Al)	1.34E-01	1.39E-01	2.73E-01
Arsenic (As)	6.90E-04	3.86E-03	4.55E-03
Boron (B)	1.69E-03	2.15E-01	2.16E-01
Chromium (Cr)	5.42E-04	5.17E-04	1.06E-03
Cobalt (Co)	6.02E-05	1.26E-03	1.32E-03
Copper (Cu)	5.00E-04	1.40E-03	1.90E-03
Lead (Pb)	1.30E-04	1.67E-04	2.97E-04
Manganese (Mn)	8.64E-03	3.22E-02	4.08E-02
Mercury (Hg)	1.31E-05	3.88E-07	1.35E-05
Molybdenum (Mo)	2.08E-04	1.40E-02	1.43E-02
Nickel (Ni)	5.00E-04	1.99E-03	2.49E-03
Thallium (Tl)	5.00E-05	1.63E-04	2.13E-04
Tungsten (W)	2.19E-03	1.79E-02	2.01E-02
Uranium (U)	1.96E-04	1.91E-03	2.10E-03
Vanadium (V)	6.37E-04	1.20E-02	1.27E-02
Zinc (Zn)	1.56E-03	1.11E-02	1.26E-02

7.7.2.2.4 Groundwater

Human and ecological receptors are not expected to be directly exposed to potential increases in the identified COPCs in groundwater. Several recreational campsites (some including cabins) are believed to collect water flowing from springs (this will be confirmed prior to Construction); these springs were also identified as drinking water sources by First Nations. As shown on Figure 8.4.11, the recreational campsites are located no closer than 1.5 km from the eastern edge open pit, and any springs or wells that might be present at the camps are not expected to be affected by pit dewatering (see Section 8.4). The closest known well users identified through NBDELG are in the community of Napadogan, more than 9 km from the Project, and would not be affected by seepage from the Project (Section 8.4). Although a series of groundwater wells will be installed to supply fresh water during Operation, they will be sited to avoid migration of potential contaminants from the TSF to the well (Section 8.4). As result, further assessment of groundwater is not considered in the HHERA.

7.7.2.2.5 Vegetation

Because metals are ubiquitous in the environment, a determination of existing concentrations of metals in vegetation is required to evaluate current exposures to COPC in vegetation. As described in Stantec (2012h), a total of 16 vegetation samples, including shrubs (8 samples, referred to below as “browse”) and grasses (8 samples, referred to below as “forage”), and 9 wild berry samples (referred to below as “berries”) were collected from key sampling locations shown on Figure 7.7.3. These data were used to estimate 95 percent UCLM for leafy vegetation and berries, which were then used as exposure concentrations for ingestion of vegetation for the Baseline Case (*i.e.*, prior to Project activities).

Concentrations of COPCs in plant tissues for the future Project + Baseline Case were estimated based upon the predicted concentrations of COPCs in soil for Project + Baseline Case, using the generalized equation relating elemental concentrations in vegetation to soil concentrations, and using published uptake factors (Baes *et al*. 1984; Bechtel Jacobs 1998; Bechtel Jacobs 1998 in USEPA 2007; CSA 1987; Davis *et al*. 1993; EcoMatters *et al*. 2004; Garn *et al*. 2001; Hamilton *et al*. 2002; Haus *et al.* 2007; Holdway *et al.* 1983; IAEA 1994; Koutsospyros *et al.* 2006; Lijzen *et al.* 2001; McGeer *et al.* 2003; ORNL 1998; Sample *et al.* 1998a; Sample *et al.* 1998b; Sheppard and Evenden 1988; Sheppard and Evenden 1990; Sheppard *et al.* 2010; Strigul *et al.* 2010; Torres and Johnson 2001; USEPA 2007; Williams *et al.* 2006; Zach *et al.* 1998). Project Alone Case concentrations in vegetation were estimated as the difference between the Project + Baseline Case concentrations and the Baseline Case concentrations. As an example, the COPC concentrations in browse, forage, and berries for Grid G8 are provided in Tables 7.7.7 to 7.7.9, for illustrative purposes. This same process was repeated at each of the receptor grid squares in Figure 7.7.3.

Table 7.7.7 Concentrations in Browse at HHERA Grid G8 (mg/kg wet weight)

COPC	Browse Exposure Point Concentrations (EPC) at Grid G8 (mg/kg wet weight)		
	Baseline Case	Project Alone Case	Project + Baseline Case
Aluminum (Al)	2.43E+01	4.83E-07	2.43E+01
Arsenic (As)	3.71E-02	1.24E-09	3.71E-02
Boron (B)	1.14E+01	4.19E-07	1.14E+01
Chromium (Cr)	8.88E-02	6.81E-09	8.88E-02
Cobalt (Co)	2.24E+00	1.84E-07	2.24E+00
Copper (CU)	3.71E+00	4.24E-07	3.71E+00
Lead (Pb)	2.18E-01	3.93E-09	2.18E-01
Manganese (Mn)	9.63E+02	2.64E-04	9.63E+02
Mercury (Hg)	2.35E-02	1.11E-09	2.35E-02
Molybdenum (Mo)	5.01E-02	2.78E-07	5.01E-02
Nickel (Ni)	2.23E+00	9.06E-08	2.23E+00
Thallium (Tl)	6.25E-03	8.37E-10	6.25E-03
Tungsten (W)	1.48E-01	5.47E-07	1.48E-01

Table 7.7.7 Concentrations in Browse at HHERA Grid G8 (mg/kg wet weight)

COPC	Browse Exposure Point Concentrations (EPC) at Grid G8 (mg/kg wet weight)		
	Baseline Case	Project Alone Case	Project + Baseline Case
Uranium (U)	2.00E-03	2.87E-11	2.00E-03
Vanadium (V)	7.00E-02	1.21E-09	7.00E-02
Zinc (Zn)	1.76E+02	8.37E-06	1.76E+02

Table 7.7.8 Concentrations in Forage at HHERA Grid G8 (mg/kg wet weight)

COPC	Forage Exposure Point Concentrations at Grid G8 (mg/kg wet weight)		
	Baseline Case	Project Alone Case	Project + Baseline Case
Aluminum (Al)	5.24E+01	1.04E-06	5.24E+01
Arsenic (As)	5.13E-02	1.71E-09	5.13E-02
Boron (B)	1.81E+00	6.65E-08	1.81E+00
Chromium (Cr)	3.10E-01	2.38E-08	3.10E-01
Cobalt (Co)	1.27E-01	1.04E-08	1.27E-01
Copper (Cu)	3.33E+00	3.80E-07	3.33E+00
Lead (Pb)	6.61E-01	1.19E-08	6.61E-01
Manganese (Mn)	6.56E+02	1.80E-04	6.56E+02
Mercury (Hg)	2.72E-02	1.28E-09	2.72E-02
Molybdenum (Mo)	5.79E-01	3.21E-06	5.79E-01
Nickel (Ni)	6.09E-01	2.48E-08	6.09E-01
Thallium (Tl)	8.50E-03	1.14E-09	8.50E-03
Tungsten (W)	5.50E-02	2.03E-07	5.50E-02
Uranium (U)	4.00E-03	5.74E-11	4.00E-03
Vanadium (V)	1.35E-01	2.33E-09	1.35E-01
Zinc (Zn)	2.17E+01	1.03E-06	2.17E+01

Table 7.7.9 Concentrations in Berries at HHERA Grid G8 (mg/kg wet weight)

COPC	Berries Exposure Point Concentrations (EPC) at Grid G8 (mg/kg wet weight)		
	Baseline Case	Project Alone Case	Project + Baseline Case
Aluminum (Al)	3.50E+01	6.96E-07	3.50E+01
Arsenic (As)	6.00E-03	2.00E-10	6.00E-03
Boron (B)	1.76E+00	6.49E-08	1.76E+00
Chromium (Cr)	6.55E-02	5.03E-09	6.55E-02
Cobalt (Co)	1.35E-02	1.11E-09	1.35E-02
Copper (Cu)	7.66E-01	8.75E-08	7.66E-01
Lead (Pb)	7.90E-02	1.42E-09	7.90E-02
Manganese (Mn)	1.70E+02	4.66E-05	1.70E+02
Mercury (Hg)	5.00E-03	2.36E-10	5.00E-03
Molybdenum (Mo)	5.00E-02	2.77E-07	5.00E-02
Nickel (Ni)	2.27E-01	9.24E-09	2.27E-01
Thallium (Tl)	4.00E-03	5.36E-10	4.00E-03
Tungsten (W)	5.00E-03	1.85E-08	5.00E-03
Uranium (U)	2.00E-03	2.87E-11	2.00E-03
Vanadium (V)	1.10E-01	1.90E-09	1.10E-01
Zinc (Zn)	5.84E+00	2.77E-07	5.84E+00

7.7.2.2.6 Soil Invertebrates

Soil invertebrates represent an important food source for many small mammals and birds. Because soil invertebrates accumulate COPCs from their environment, a determination of existing concentrations of metals in soil invertebrates is important to the evaluation of health risks to wildlife. As reported in Stantec (2012h), concentrations of metals in soil invertebrate tissues were analysed in nine samples (*i.e.,* seven slug samples and two earth worm samples) collected from selected HHERA receptor locations shown on Figure 7.7.3. The soil invertebrate concentration for the Baseline Case is an average of the existing slug concentration (based on a 95 percent UCLM of the seven slug samples) and the existing worm concentrations (based on an average of the two earthworm samples). These concentrations were then used as representative exposure concentrations for ingestion of metals by wildlife for the Baseline Case (*i.e.*, prior to Project activities).

Concentrations of COPCs in soil invertebrates for the Project + Baseline Case were estimated based upon the predicted concentrations of COPCs in soil for Project + Baseline Case, using the generalized equation relating elemental concentrations in biota to soil concentrations and using published uptake factors (Baes *et al*. 1984; Bechtel Jacobs 1998; Bechtel Jacobs 1998 in USEPA 2007; CSA 1987; Davis *et al*. 1993; EcoMatters *et al*. 2004; Garn *et al*. 2001; Hamilton *et al*. 2002; Haus *et al.* 2007; Holdway *et al.* 1983; IAEA 1994; Koutsospyros *et al.* 2006; Lijzen *et al.* 2001; McGeer *et al.* 2003; ORNL 1998; Sample *et al.* 1998a; Sample *et al.* 1998b; Sheppard and Evenden 1988; Sheppard and Evenden 1990; Sheppard *et al.* 2010; Strigul *et al.* 2010; Torres and Johnson 2001; USEPA 2007; Williams *et al.* 2006; Zach *et al.* 1998). Project Alone Case concentrations in soil invertebrates were estimated as the difference between the Project + Baseline Case concentrations and the Baseline Case concentrations. As an example, the COPC concentrations in soil invertebrates for Grid G8 are provided in Table 7.7.10, for illustrative purposes. This same process was repeated at each of the receptor grid squares in Figure 7.7.3.

Table 7.7.10 Concentrations in Soil Invertebrates at HHERA Grid G8 (mg/kg wet weight)

COPC	Terrestrial Invertebrates Exposure Point Concentrations (EPC) at Grid G8 (mg/kg wet weight)		
	Baseline Case	Project Alone Case	Project + Baseline Case
Aluminum (Al)	2.22E+02	4.41E-06	2.22E+02
Arsenic (As)	1.22E+00	2.87E-08	1.22E+00
Boron (B)	1.75E+00	6.45E-08	1.75E+00
Chromium (Cr)	4.28E-01	3.28E-08	4.28E-01
Cobalt (Co)	7.93E-01	6.52E-08	7.93E-01
Copper (Cu)	7.68E+00	5.87E-07	7.68E+00
Lead (Pb)	6.14E+00	1.59E-07	6.14E+00
Manganese (Mn)	1.71E+03	4.69E-04	1.71E+03
Mercury (Hg)	7.51E-02	6.50E-09	7.51E-02
Molybdenum (Mo)	1.85E-01	1.03E-06	1.85E-01
Nickel (Ni)	3.93E-01	2.14E-08	3.93E-01
Thallium (Tl)	3.24E-02	4.33E-09	3.24E-02
Tungsten (W)	2.30E-02	2.26E-07	2.30E-02
Uranium (U)	2.85E-02	1.10E-09	2.85E-02
Vanadium (V)	5.48E-01	9.46E-09	5.48E-01
Zinc (Zn)	1.45E+02	4.06E-06	1.45E+02

7.7.2.2.7 Small Mammals

Small mammals are consumed as prey by other wildlife receptors. As reported in Stantec (2012h), a total of 30 small mammal samples were collected at selected HHERA receptor locations (Figure 7.7.3). These data were used to estimate 95 percent UCLM, considered to represent existing concentrations of metals in small mammals prior to any Project activities, which were then used as the Baseline Case exposure concentrations for ingestion of metals in small mammals by wildlife.

Concentrations of COPCs in small mammals for the Project + Baseline Case were estimated based upon the predicted concentrations of COPCs in soil for Project + Baseline Case, using the generalized equation relating elemental concentrations in biota to soil concentrations and using published uptake factors (Baes *et al*. 1984; Bechtel Jacobs 1998; Bechtel Jacobs 1998 in USEPA 2007; Davis *et al*. 1993; EcoMatters *et al*. 2004; IAEA 1994; Koutsospyros *et al.* 2006; Sheppard and Evenden 1988; Torres and Johnson 2001; USEPA 2007; Zach *et al.* 1998). Project Alone Case concentrations in small mammals were estimated as the difference between the Project + Baseline Case concentrations and the Baseline Case concentrations. As an example, the COPC concentrations in small mammals for Grid G8 are provided in Table 7.7.11, for illustrative purposes. This same process was repeated at each of the receptor grid squares in Figure 7.7.3.

Table 7.7.11 Concentrations in Small Mammals at HHERA Grid G8 (mg/kg wet weight)

COPC	Small Animal Prey Exposure Point Concentrations (EPC) at Grid G8 (mg/kg wet weight)		
	Baseline Case	Project Alone Case	Project + Baseline Case
Aluminum (Al)	8.36E+00	1.66E-07	8.36E+00
Arsenic (As)	4.90E-02	1.34E-09	4.90E-02
Boron (B)	7.24E-01	2.66E-08	7.24E-01
Chromium (Cr)	3.11E-01	2.39E-08	3.11E-01
Cobalt (Co)	3.52E-02	2.89E-09	3.52E-02
Copper (Cu)	3.82E+00	1.11E-06	3.82E+00
Lead (Pb)	1.82E-01	2.59E-09	1.82E-01
Manganese (Mn)	3.32E+01	9.10E-06	3.32E+01
Mercury (Hg)	1.88E-02	1.63E-09	1.88E-02
Molybdenum (Mo)	1.47E-01	8.15E-07	1.47E-01
Nickel (Ni)	2.11E-01	5.35E-09	2.11E-01
Thallium (Tl)	2.33E-02	3.12E-09	2.33E-02
Tungsten (W)	9.48E-03	9.30E-08	9.48E-03
Uranium (U)	1.00E-03	3.87E-11	1.00E-03
Vanadium (V)	2.43E-02	4.20E-10	2.43E-02
Zinc (Zn)	3.15E+01	1.99E-07	3.15E+01

7.7.2.2.8 Game

Consumption of wild game is considered an important pathway for human exposures, and consumption of moose was a specific concern of First Nations. As moose tissue samples were not available for analysis, concentrations of COPCs in wild game for both the Baseline and Project + Baseline cases were estimated. Wild game (*i.e.*, moose) is assumed to consume vegetation as both forage and browse, and to consume incidental COPC-affected soil as well as COPC-affected surface water. The generalized equation used to calculate moose tissue concentrations for human health consumption is as follows:

$$C_{game} = [(F_V \times Q_{V(game)} \times C_V) + (B_S \times Q_{S(game)} \times C_S) + (F_W \times Q_{W(water)} \times C_W)] \times Ba_{(game)} \times MF$$

where:

C_{game} = Concentration of COPC in wild game tissue (mg/kg wet weight);

F_V = Fraction of vegetation from site (conservatively set at 100%; unitless);

$Q_{V(game)}$ = Quantity of vegetation ingested by wild game (kg dry weight/day);

C_V = Concentration of COPC in vegetation (mg/kg dry weight);

B_S = Fraction of soil from site (conservatively set at 100%; unitless);

$Q_{S(game)}$ = Quantity of soil ingested by wild game (kg dry weight/day);

C_S = Concentration of COPC in soil (mg/kg dry weight);

F_W = Fraction of water from site (conservatively set at 100%; unitless);

$Q_{W(game)}$ = Quantity of water ingested by wild game (L/day);

C_W = Concentration of COPC in surface water (mg/L);

$B_{a(game)}$ = COPC-specific bio-transfer factor for wild game (day/kg wet weight); and

MF = Metabolic factor (set at 1.0; unitless).

Wild game are conservatively assumed to spend an entire lifetime in the vicinity of the Project, within the grid locations shown in Figure 7.7.3, and not range into other areas that would be subject to different regimes of deposition. As such, fractions of vegetation, soil and water from the site are set at 100%. It is also conservatively assumed that all COPC are 100% bioavailable to wild game and not metabolized (*i.e.*, metabolic factor of 1.0). Vegetation eaten by wild game (*i.e.*, moose) was estimated to be 2.8 kg/dry weight of vegetation per day and assumed to comprise 80% browse and 20% forage. As aquatic vegetation is not generally available in the vicinity of the Project, the vegetation diet of wild game was assumed to be made up entirely of terrestrial vegetation. Primary literature uptake factors for predicting animal tissue concentrations are available for beef. In accordance with USEPA (2005) guidance, to predict the uptake of COPC into wild game, the beef uptake factor is adjusted based on the relative lipid content of the game animal (assumed 10% fat content for the moose, in contrast to 19% for the beef as per Shultz *et al.* (1994); Stephenson (2003); and Knott *et al.* (2005)). As an example, the COPC concentrations in wild game for Grid G8 are provided in Table 7.7.12, for illustrative purposes. This same process was repeated at each of the receptor grid squares in Figure 7.7.3.

Table 7.7.12 Concentrations in Wild Game at HHERA Grid G8 (mg/kg wet weight)

COPC	Wild Game Exposure Point Concentrations (EPC) at Grid G8 (mg/kg wet weight)		
	Baseline Case	Project Alone Case	Project + Baseline Case
Aluminum (Al)	2.79E+00	2.47E-03	2.80E+00
Arsenic (As)	4.55E-03	2.64E-04	4.81E-03
Boron (B)	7.43E-02	1.10E-03	7.54E-02
Chromium (Cr)	2.26E-02	1.16E-04	2.27E-02
Cobalt (Co)	6.88E-01	2.00E-04	6.88E-01
Copper (Cu)	6.87E-01	5.99E-04	6.88E-01
Lead (Pb)	2.42E-03	1.95E-06	2.42E-03
Manganese (Mn)	6.73E+00	4.04E-04	6.73E+00
Mercury (Hg)	2.43E-03	1.02E-06	2.43E-03
Molybdenum (Mo)	1.86E-02	9.90E-04	1.96E-02
Nickel (Ni)	2.19E-01	1.04E-04	2.19E-01
Thallium (Tl)	5.71E-03	7.34E-05	5.79E-03
Tungsten (W)	5.99E-02	5.54E-03	6.54E-02
Uranium (U)	2.06E-05	1.76E-06	2.24E-05
Vanadium (V)	1.45E-02	3.18E-04	1.48E-02
Zinc (Zn)	2.44E-01	1.10E-05	2.44E-01

7.7.2.2.9 Fish Tissue

Fish tissue samples were collected from brook trout greater than 9 cm in length from Sisson Brook, Bird Brook, McBean Brook, and the West Branch Napadogan Brook (see Section 8.5). Samples were collected from nine locations (two in Bird Brook, two in Sisson Brook, one in McBean Brook, and three in the West Branch Napadogan Brook). These results were used to determine 95 percent UCLMs for detected contaminants. For COPC that were not detected in the tissue samples, the EPCs were assumed to be at one half of the reported detection limit. The measured fish tissue concentrations were incorporated into the assessment as site-specific existing data for the assessment of fish ingestion exposure pathways for humans and for ecological receptors for the Baseline Case; whole fish concentrations were used for the assessment of ecological receptors, while only the concentrations in the carcass (*i.e.*, cleaned fish – head and entrails removed) were used to assess human exposures. These fish concentrations, used in the Baseline Case, represent the current or existing conditions, prior to any of the Project activities.

For each HHERA receptor grid locations, concentrations of COPCs in fish tissue for the future (Project + Baseline Case) were estimated based upon the modelled future (Project + Baseline Case) concentrations of COPCs in water for that grid location, as described in Section 7.7.2.2.3, and the generalized equation for estimating fish tissue concentrations from surface water concentrations. Uptake factors for surface water to fish were obtained from CSA (1987); Davis *et al*. (1993); Holdway *et al.* (1983); Lijzen *et al.* (2001); McGeer *et al.* (2003); Sheppard *et al.* (2010); Strigul *et al.* (2010); and Williams *et al.* (2006). Project Alone Case concentrations in fish tissues were estimated as the difference between the Project + Baseline Case concentrations and the Baseline Case concentrations. As an example, the COPC concentrations in whole fish tissues and fish carcass for Grid G8 are provided in Tables 7.7.13 and 7.7.14, for illustrative purposes. This same process was repeated at each of the receptor grid squares in Figure 7.7.3.

Table 7.7.13 Concentrations in Whole Fish Tissues at HHERA Grid G8 (mg/kg wet weight)

COPC	Fish Tissue Exposure Point Concentrations (EPC) at Grid G8 (mg/kg wet weight)		
	Baseline Case	Project Alone Case	Project + Baseline Case
Aluminum (Al)	2.59E+01	2.68E+01	5.28E+01
Arsenic (As)	7.24E-01	5.04E-01	1.23E+00
Boron (B)	2.66E-02	3.38E+00	3.41E+00
Chromium (Cr)	1.09E-01	1.04E-01	2.13E-01
Cobalt (Co)	7.86E-02	1.64E+00	1.72E+00
Copper (Cu)	8.00E-01	6.02E-01	1.40E+00
Lead (Pb)	4.94E-02	1.66E-02	6.60E-02
Manganese (Mn)	7.11E+00	2.65E+01	3.36E+01
Mercury (Hg)	1.13E-01	3.36E-03	1.16E-01
Molybdenum (Mo)	1.56E-02	1.05E+00	1.07E+00
Nickel (Ni)	4.66E-02	7.15E-02	1.18E-01
Thallium (Tl)	1.68E-02	5.48E-02	7.16E-02
Tungsten (W)	7.19E-03	5.86E-02	6.57E-02
Uranium (U)	8.94E-03	8.68E-02	9.58E-02
Vanadium (V)	4.76E-02	9.01E-01	9.49E-01
Zinc (Zn)	2.58E+01	4.70E+00	3.05E+01

Table 7.7.14 Concentrations in Fish Carcass Tissues at HHERA Grid G8 (mg/kg wet weight)

COPC	Fish Carcass Exposure Point Concentrations (EPC) at Grid G8 (mg/kg wet weight)		
	Baseline Case	Project Alone Case	Project + Baseline Case
Aluminum (Al)	3.16E+00	3.27E+00	6.43E+00
Arsenic (As)	8.90E-01	6.19E-01	1.51E+00
Boron (B)	2.50E-02	3.18E+00	3.20E+00
Chromium (Cr)	3.48E-02	3.32E-02	6.80E-02
Cobalt (Co)	4.01E-02	8.39E-01	8.79E-01
Copper (Cu)	4.06E-01	3.05E-01	7.11E-01
Lead (Pb)	2.40E-02	8.05E-03	3.20E-02
Manganese (Mn)	2.82E+00	1.05E+01	1.33E+01
Mercury (Hg)	1.28E-01	3.80E-03	1.32E-01
Molybdenum (Mo)	6.36E-03	4.29E-01	4.35E-01
Nickel (Ni)	2.85E-02	4.37E-02	7.22E-02
Thallium (Tl)	1.41E-02	4.60E-02	6.01E-02
Tungsten (W)	3.54E-03	2.88E-02	3.24E-02
Uranium (U)	2.95E-03	2.87E-02	3.16E-02
Vanadium (V)	2.50E-02	4.73E-01	4.98E-01
Zinc (Zn)	1.64E+01	2.99E+00	1.94E+01

7.7.2.2.10 Sediment

As part of the qualitative and quantitative baseline surveys, sediment samples were collected from Sisson Brook, Bird Brook, McBean Brook, and West Branch Napadogan Brook. Eight samples were collected from McBean Brook and eleven samples were collected from West Branch Napadogan Brook.

These results were used to determine 95 percent UCLMs for detected contaminants. For COPC that were not detected in the sediment samples, the EPCs were assumed to be at one half of the reported detection limit. These sediment concentrations, used in the Baseline Case, represent the current or existing conditions, prior to any of the Project activities.

For each HHERA receptor grid locations, concentrations of COPCs in sediment for the future (Project + Baseline Case) were estimated based upon the modelled future (Project + Baseline Case) concentrations of COPCs in water for that grid location, as described in Section 7.7.2.2.3, and the generalized equation for estimating fish tissue concentrations from surface water concentrations. Where available, uptake factors for water-to-sediment were based on concentration ratios from Sheppard *et al.* (2010) which were adjusted to consider site-specific sediment characteristics (*e.g.,* organic carbon and grain size) and provide the quantity of the available and mineralized metal content in the sediment. For the Project Alone Case, increases in sediment concentrations for the non-mineralized portion of the sediment were calculated as the product of the increases in water concentrations and the adjusted site-specific concentration ratios. For the Project + Baseline Case, metal sediment concentrations were calculated as the sum of the measured Baseline sediment concentrations and their corresponding predicted increase. For metals not covered by Sheppard *et al.* (2010), sediment-to-water partition coefficients were obtained from other sources as follows: boron from Lemarchand (2005), mercury from CSA (2011 update), and tungsten from Clausen *et al.* (2010). As an example, the COPC concentrations in sediment for Grid G8 are provided in Table 7.7.15, for illustrative purposes. This same process was repeated at each of the receptor grid squares in Figure 7.7.3.

Table 7.7.15 Concentrations in Sediment at HHERA Grid G8 (mg/kg dry weight)

COPC	Sediment Exposure Point Concentrations (EPC) at Grid G8 (mg/kg dry weight)		
	Baseline Case	Project Alone Case	Project + Baseline Case
Aluminum (Al)	7.87E+03	1.01E+04	1.80E+04
Arsenic (As)	3.25E+01	8.82E-01	3.34E+01
Boron (B)	2.00E+00	8.58E+00	1.06E+01
Chromium (Cr)	9.86E+00	1.43E-01	1.00E+01
Cobalt (Co)	1.19E+01	9.05E+00	2.10E+01
Copper (Cu)	1.93E+01	1.19E+00	2.05E+01
Lead (Pb)	2.94E+01	1.31E+00	3.07E+01
Manganese (Mn)	1.82E+03	2.78E+01	1.85E+03
Mercury (Hg)	7.59E-02	6.22E-05	7.60E-02
Molybdenum (Mo)	4.70E+00	3.44E+00	8.14E+00
Nickel (Ni)	1.64E+01	4.22E+00	2.06E+01
Thallium (Tl)	3.09E-01	1.07E+00	1.37E+00
Tungsten (W)	2.50E+00	8.04E+00	1.05E+01
Uranium (U)	5.11E+00	3.42E+00	8.53E+00
Vanadium (V)	2.03E+01	1.08E+01	3.12E+01
Zinc (Zn)	6.30E+01	1.81E+00	6.48E+01

7.7.2.2.11 Benthic Invertebrates

Benthic invertebrates represent an important food source for many small mammals and birds. Because soil invertebrates accumulate COPCs from their environment, a determination of existing concentrations of metals in benthic invertebrates is important to the evaluation of health risks to wildlife.

Benthic invertebrate samples were not analyzed for COPCs; however, concentrations of COPCs in benthic invertebrates for both the Baseline Case and the Project + Baseline Case were estimated.

Concentrations of COPCs in benthic invertebrates for the Project + Baseline Case were estimated based upon the predicted concentrations of COPCs in soil for the Project + Baseline Case, using the generalized equation relating elemental concentrations in biota to sediment concentrations and using published uptake factors (Garn *et al*. 2001; Hamilton *et al*. 2002; Haus *et al.* 2007; ORNL 1998). The Project Alone Case concentrations in benthic invertebrates were estimated as the difference between the Project + Baseline Case concentrations and the Baseline Case concentrations. As an example, the COPC concentrations in benthic invertebrates for Grid G8 are provided in Table 7.7.16, for illustrative purposes. This same process was repeated at each of the receptor grid squares in Figure 7.7.3.

Table 7.7.16 Concentrations in Benthic Invertebrates at HHERA Grid G8 (mg/kg wet weight)

COPC	Benthic Invertebrates Exposure Point Concentrations (EPC) at Grid G8 (mg/kg wet weight)		
	Baseline Case	Project Alone Case	Project + Baseline Case
Aluminum (Al)	3.59E+02	4.61E+02	8.20E+02
Arsenic (As)	7.78E-02	4.35E-01	5.13E-01
Boron (B)	4.58E-01	1.97E+00	2.42E+00
Chromium (Cr)	5.50E-02	5.25E-02	1.08E-01
Cobalt (Co)	1.04E-03	2.17E-02	2.28E-02
Copper (Cu)	2.09E+00	5.87E+00	7.96E+00
Lead (Pb)	1.16E-01	1.49E-01	2.66E-01
Manganese (Mn)	1.13E+00	4.22E+00	5.36E+00
Mercury (Hg)	9.32E-03	7.64E-06	9.33E-03
Molybdenum (Mo)	2.66E-02	1.79E+00	1.82E+00
Nickel (Ni)	1.50E-01	5.97E-01	7.47E-01
Thallium (Tl)	1.86E-02	1.22E-01	1.40E-01
Tungsten (W)	9.12E-02	2.93E-01	3.84E-01
Uranium (U)	5.92E-03	5.75E-02	6.35E-02
Vanadium (V)	1.03E-02	1.96E-01	2.06E-01
Zinc (Zn)	2.24E+00	1.59E+01	1.82E+01

7.7.3 Human Health Risk Assessment (HHRA)

A human health risk assessment (HHRA) is a scientific study that estimates the nature and magnitude of potential adverse health risks in humans following exposure to contaminants released by a project. The scope of the HHRA is to assess interactions between predicted or measured levels of COPC in environmental media (*i.e*., air, soil, water, and food items) that may occur as a result of Project-related emissions or releases, and the potential for these interactions to result in adverse health risks to human receptors exposed to these media.

7.7.3.1 Problem Formulation

The problem formulation step defines the nature and scope of the work to be conducted, permits practical boundaries to be placed on the overall scope of work, and focuses the assessment on the key areas and issues of concern. As the relevant receptor locations for the HHERA have been identified elsewhere, as have the relevant COPCs for the assessment, the key tasks that comprise the problem formulation step of this HHRA include the following:

- receptor identification and characterization; namely the identification of “receptors of concern”, which includes those persons with the greatest probability of exposure to contaminants and/or those that have the greatest sensitivity to these contaminants; and
- identification of exposure pathways and routes.

7.7.3.1.1 Receptor Identification and Characterization

A human receptor is a hypothetical person, inclusive of all life stages (*i.e.*, an infant, toddler, child, adolescent, adult) who is potentially exposed to the COPC while in the HHERA Study Area. General physical and behavioural characteristics specific to the receptor type (*e.g.*, body weight, breathing rate, food consumption rate) are used to obtain an amount of contaminant exposure (*i.e.,* dose) received by each receptor. The HHRA must be sufficiently comprehensive to ensure inclusion of those receptors with the greatest potential for exposure to COPC, and those who have the greatest sensitivity, or potential for developing adverse health outcomes from these exposures.

Based on current and anticipated future land use, the human receptors considered for the assessment include traditional, recreational, or commercial users of the land surrounding the Project. Health Canada (2009; 2010a) has provided food ingestion characteristics for fish and game that are specific to Canadian Aboriginal populations, and higher than the fish ingestion characteristics for the general Canadian population as shown in Table 7.7.17 (Health Canada does not provide wild game ingestion rates for the Canadian general population). As indicated in Health Canada (2010a), all other characteristics (e.g., soil ingestion, body weight) should be assumed to be equivalent to the general population. For this HHRA, the physical characteristics for each of the human receptor life stages (infant, toddler, child, teen, adult) were obtained from Health Canada (2010a), with the exception of fish ingestion rates, which were obtained from Health Canada (2009).

A First Nations receptor, inclusive of all life stages, was selected for the assessment, as all other receptors (*e.g.,* recreational, commercial) were considered to have potentially lesser exposures than members of local Aboriginal communities who may use the land or resources in or near the PDA for traditional uses such as fishing, hunting, and collecting plants for food and medicinal use. Although consumption rates for local plants are not known, it has been conservatively assumed that a First Nations receptor would consume vegetation that they collected from natural areas in an amount equivalent to the total vegetable consumption rate of the Canadian general population. It was conservatively assumed that the First Nations receptor would be present in the HHERA Study Area, on average, two days per week, every week, each year. This is considered conservative, and reflects comments made by a member of local First Nations who indicated that he would spend about 10% of his time (*i.e*., less than 1 day per week) in the general area of the PDA for hunting (Polchies, P. Personal communication, September 26, 2012).

In accordance with Health Canada guidance, carcinogenic and non-carcinogenic COPCs are evaluated differently. Non-carcinogenic COPCs are assumed to act via a threshold mechanism and exposures are assessed within specific life stages. The toddler life stage is defined as six months to four years (3.5 years total life stage) (Health Canada 2010a). As determined by Health Canada, toddlers are generally more susceptible to oral exposures than other age groups due to their generally higher ratio of ingestion rate to body weight. If the toddler assessment finds acceptable risk levels, then by default the risks to people in other life stages are also assumed to be acceptable. Both a First Nations adult and a First Nations toddler life stage were considered in the HHRA for non-carcinogenic COPCs; however, as the health risk estimates for the toddler were confirmed to be higher than the adult, only the results for a toddler are reported herein.

Carcinogenic COPCs are assumed to act via a non-threshold mechanism and exposures are assessed over a lifetime. Carcinogenic risks from COPC exposures were assessed assuming a composite (or lifetime) receptor.

Table 7.7.17 Human Receptor Characteristics

Assumed Characteristic	Receptor Values			Units for Lifetime
	Toddler	Adult	Lifetime	
Canadian General Population				
Body weight (kg)	16.5	70.7	--	--
Incidental soil ingestion rate (kg/d)	0.08	0.02	0.047	g soil-a/kg bw-d
Inhalation rate (m^3/d)	8.3	16.6	21.7	m^3 air-a/kg bw-d
Water ingestion rate (L/d)	0.6	1.5	1.76	L water-a/kg bw-d
Vegetable ingestion (kg/d)	0.172	0.325	0.4	kg vegetation-a/kg bw-d
Fish ingestion (kg/d) *	0.056	0.111		kg fish-a/kg bw-d
Canadian Aboriginal Populations (First Nations)				
Fish ingestion (kg/d)	0.095	0.22	0.276	kg fish-a/kg bw-d
Wild game ingestion (kg/d)	0.085	0.27	0.302	kg game meat-a/kg bw-d

Notes:

"--" lifetime body weight is not used; body weight in accounted for in the adjusted lifetime ingestion rates.

" * " Fish ingestion rate of Canadian general population not used in the HHRA (HHRA used First Nations consumption rates for fish).

Legend:

kg	kilogram	bw	body weight
a	annum (*i.e.*, year)	d	day
L	litre	m^3	cubic metre

Source: Health Canada (2009) (fish ingestion rates only) and Health Canada (2010a).

The fraction of fish originating from the HHERA Study Area was assumed to represent 20% of the total fish consumption shown in Table 7.7.17. This assumption was made in consideration of the annual fish ingestion for a family of four that is considered representative of Canadian Aboriginal populations (Health Canada 2009) and the fish stream productivity within the HHERA Study Area. Based on fish ingestion rates presented in Health Canada (2009), a total of 230 kilograms of fish would be required on an annual basis to meet the dietary fish requirements of a family of four (two adults and two toddlers). Based on the measured average weight of fish of length 15 cm and greater from the HHERA Study Area (as measured during field studies, Section 8.5.2), this would represent approximately 4,580 fish. However, based on fish density observations from sampling programs carried out for the Aquatic Environment (see Section 8.5.2), neither McBean nor West Branch Napadogan brooks have the capacity to supply these many fish. In addition, the variety of species that are usually assumed to be included in the fish ingestion category (including both finfish and shellfish) is far greater than that found in the HHERA Study Area. For example, the Indigenous Knowledge Study (IKS) noted that many participants fish for salmon in the Southwest Miramichi River. As such, a realistic, yet still conservative exposure scenario for fish ingestion, based on 20% of the fish originating from the HHERA Study Area, was selected.

The fraction of vegetation originating from the HHERA Study Area was assumed to represent 10% of the total vegetation consumption by a human receptor. This assumption was made in consideration of the estimated time spent in the HHERA Study Area as well as the realistic assumption that a variety of species stemming from various locations would be included within the vegetation ingestion pathway.

For game ingestion, it was assumed that 100% of the game would originate from the HHERA Study Area. This assumption was made in consideration that one large game animal (*i.e.*, a moose) could represent a large portion of a family's game consumption for a one-year period, and also considers that individuals tend to return of hunting areas year after year. This same one-year period would represent a substantive portion of the toddler life stage. As such, the assumption of 100% of game being obtained from the HHERA Study Area is considered a conservative but potentially realistic scenario for the First Nation receptor.

7.7.3.1.2 Exposure Pathway Screening and Conceptual Site Model

Relevant receptor locations for the HHERA and the relevant COPCs for the assessment were identified in Section 7.7.2. It remains to identify the key linkages or exposure pathways through which human receptors might be significantly exposed to COPCs under the Baseline and future (Project + Baseline) cases.

In the exposure assessment, the likelihood that human receptors may come into contact with a COPC is evaluated by examining the potential pathway for the movement of a COPC from its source to the eventual point of intake (exposure) by the receptor. For the purpose of this assessment, the exposure media and pathways are:

- inhalation of COPCs from air contaminant emissions released by the Project;
- direct contact with soil, including incidental ingestion of soil, inhalation of dust from soil and dermal contact with soil;
- ingestion of plants, fish, and game that have accumulated contaminants from the soil and other media; and
- ingestion of water.

A summary of potential exposure media for human receptors and a pathway-specific rationale for inclusion or exclusion from this HHRA is shown in Table 7.7.18.

Table 7.7.18 Rationale for Exposure Pathway Inclusion in the HHRA

Exposure Pathway	Included in HHRA?	Rationale
Inhalation of COPCs from air emissions	Yes	COPCs will be released from the Operation of the Project. Potential environmental effects on local air quality have been raised by stakeholders. This pathway was carried through the assessment.
Dermal contact with soil	Yes	Dermal absorption of COPC through contact with soil was assessed, as dispersed ore dust from activities at the PDA may affect soil quality and since the current soil concentrations in the HHERA Study Area (Figure 7.7.3) already exceed the soil quality guidelines for some COPCs. This pathway was carried through the assessment.
Incidental ingestion and inhalation of soil	Yes	Through the activity of traditional plant and vegetation collection, there exists a potential for the incidental ingestion of soil, and inhalation of particulate matter from soil. For this reason, this pathway was carried through the assessment.
Surface Water Ingestion	Yes	Water bodies may receive COPC input via transport from terrestrial media. Although surface water has not been identified as a potable water source, human receptors may be exposed to COPC concentrations in surface water if they drink from these sources. This pathway was carried through the assessment.
Ingestion of Country Foods (vegetation, game and fish)	Yes	Potential accumulation of COPC in country foods is a concern for First Nations. Deposition of dust and metals on soils, and subsequent accumulation in country foods (vegetation and game), may occur from Project activities. Similarly, changes in local water quality due to Project activities may result in higher concentrations of COPCs in fish tissues. This pathway was carried through the assessment.
Groundwater Ingestion or Contact	No	The closest known well users identified through NBDELG are in the community of Napadogan, more than 9 km from the Project, and would not be affected by seepage or releases from the Project. Although a series of groundwater wells will be installed to supply fresh water during Operation, these wells will be sited to avoid migration of potential contaminants from the TSF to the wells. This pathway was not carried through the assessment.

Beginning with the source media (*e.g*., air, soil, water), the key exposure pathways through which potential dietary items can accumulate COPCs, and human receptors can become exposed to COPCs, are summarized the conceptual HHRA model shown in Figure 7.7.4.

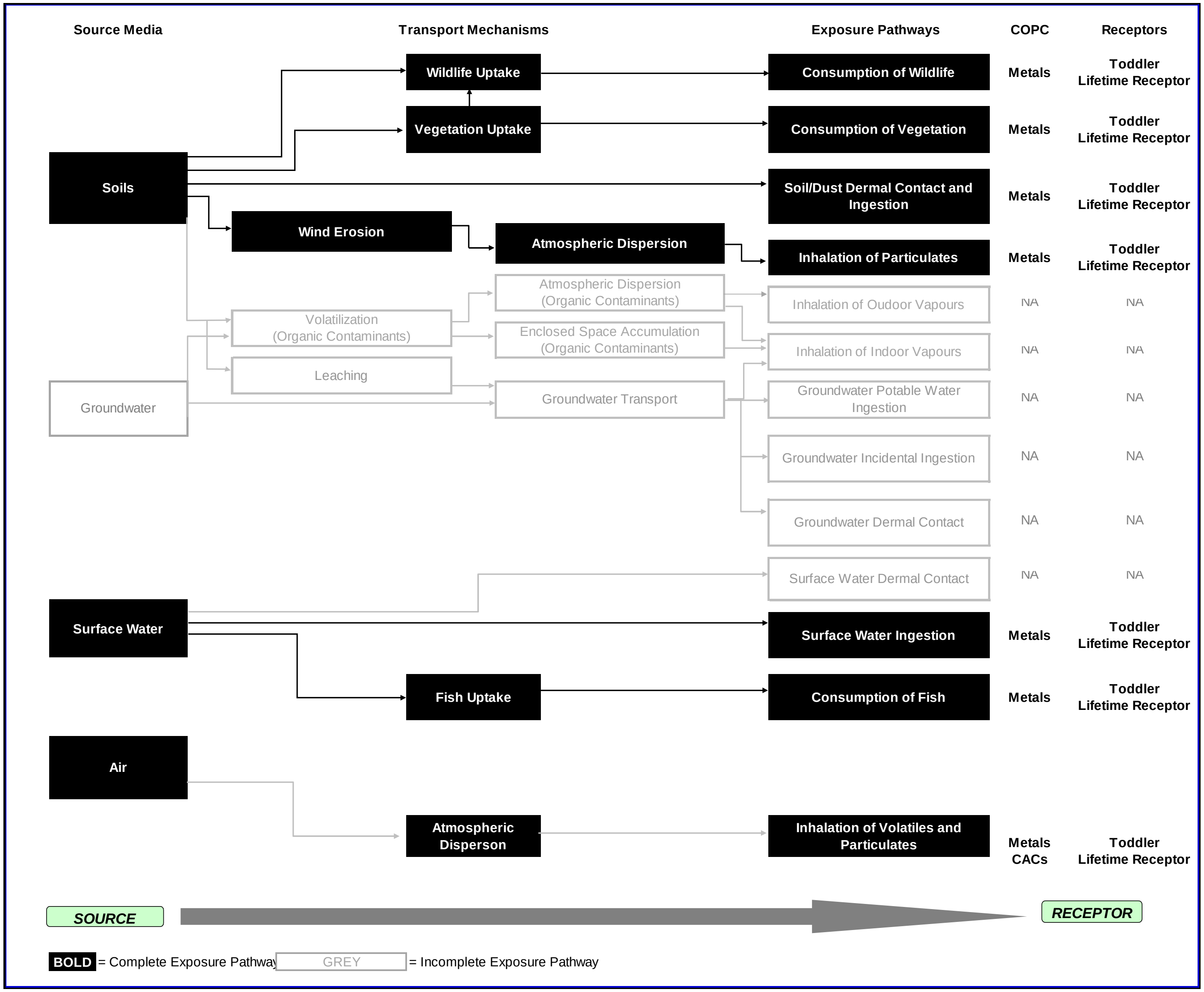


Figure 7.7.4 **Conceptual Site Model for Human Health Receptors**

7.7.3.2 Hazard Assessment

The hazard assessment (also known as a toxicity assessment) involves the selection of toxicological reference values (TRVs), also referred to as exposure limits, for each contaminant. Toxicity is the potential for a contaminant to produce any type of damage (whether permanent or temporary) to the structure or functioning of any part of the receptor's body. The toxicity of a contaminant depends on the amount taken into the body (referred to as the "dose") and the duration of exposure (*i.e.*, the length of time the receptor is exposed to the contaminant). For each contaminant, there is a specific dose and duration of exposure necessary to produce a toxic environmental effect in a given receptor. This is referred to as the "dose-response relationship" of a contaminant. The toxic potency of a contaminant (*i.e.*, its ability to produce any type of damage to the structure or function of any part of the body) is dependent on the inherent properties of the contaminant itself (*i.e.*, its ability to cause a biochemical or physiological response at the site of action within the receptor's body) as well as the ability of the contaminant to reach the site of action. This dose-response principle is central to the risk assessment methodology.

7.7.3.2.1 Toxicological Reference Values (TRVs)

Two basic categories of contaminants are commonly recognized by regulatory agencies (depending on the contaminant's mode of toxic action) and applied when estimating TRVs for human health (USEPA 1989). These are the "threshold" approach (typically used to evaluate non-carcinogens) and the "non-threshold" approach (typically used for carcinogenic compounds).

In the case of threshold contaminants, a threshold level must be exceeded for toxicity to occur. A no observable adverse effect level (NOAEL) can be identified for threshold contaminants, which is the dose or amount of the contaminant that results in no obvious response in the most sensitive test species and test endpoint. The application of uncertainty factors to the NOAEL provides an added level of protection, allowing for derivation of a TRV that is expected to be safe to the general public following exposure for a prescribed period of time. Generic nomenclature for TRVs for threshold contaminants includes Reference Concentration (RfC), which refers to the acceptable concentration of an airborne contaminant for which the primary route of exposure is inhalation, and Reference Dose (RfD), which refers to the acceptable dose of a contaminant and is most commonly expressed in terms of the total intake of the contaminant per unit of body weight per day (mg/kg-day).

Non-threshold contaminants are capable of producing cancer by altering genetic material. Regulatory agencies such as Health Canada and the USEPA assume that any level of long-term exposure to carcinogenic contaminants is associated with some "hypothetical cancer risk". As a result, regulatory agencies have typically employed acceptable Incremental Lifetime Cancer Risk (ILCR) levels (*i.e.*, levels over and above those that one would expect to be exposed to from background sources other than related to the Project). Generic nomenclature for TRVs for non-threshold contaminants includes Unit Risk (UR), defined as the upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent at a unit concentration of 1 µg/L in water, or 1 $\mu g/m^3$ in air (USEPA 1989), and cancer Slope Factor (SF), which is generally defined as the upper-bound increased cancer risk from a lifetime exposure to an agent usually expressed in units of proportion (of a population) affected per mg/kg-day (USEPA 1989).

7.7.3.2.2 Selection of TRVs

An essential part of the risk assessment process is the identification of toxicity reference values (TRV) against which exposures can be compared. These values are based on scientifically reviewed, published toxicological assessments from Canadian and American sources. TRVs have been established by several regulatory agencies including Health Canada, the United States Environmental Protection Agency (US EPA), the World Health Organization (WHO), Canadian Council of Ministers of the Environment (CCME), the Netherlands National Institute for Public Health and Environment (RIVM), and the Agency for Toxic Substances and Disease Registry (ATSDR). In the selection of toxicity values, Health Canada guidance was followed. Specifically, as per Health Canada (2010a), preference was given to the Health Canada values and, for substances with no Health Canada TRVs, alternative TRVs were obtained from the following agencies, in order of preference:

- Other Health Canada TRVs;
- US EPA Integrated Risk Information System (IRIS);
- World Health Organization (WHO);
- Netherlands National Institute of Public Health and the Environment (RIVM);
- Agency for Toxic Substances and Disease Registry (ATSDR); and
- California Environmental Protection Agency (Cal EPA).

The toxicity reference values and oral slope factors used in this HHRA for non-carcinogen and carcinogen oral exposure are summarized in Table 7.7.19, Table 7.7.20, and Table 7.7.21.

Table 7.7.19 Acute Inhalation Toxicological Reference Values

COPC	Toxicological Reference Value (TRV) (mg/m^3)	Health Endpoint	Source
1-hour Acute Exposure			
Sulphur dioxide (SO_2)	0.90	not available	GNB (1997), CCME (1996)
Nitrogen oxides (NO_x as NO_2)	0.40	not available	GNB (1997), Health Canada (2006)
Carbon monoxide (CO)	35	not available	GNB (1997), CCME (1996)
Total particulate matter (PM)	--	--	--
Particulate matter less than 2.5 microns ($PM_{2.5}$)	--	--	--
Particulate matter less than 10 microns (PM_{10})	--	--	--
Aluminum (Al)	0.05	health	TCEQ (2013)
Arsenic (As)	0.0001	not available	AENV (2013)
Boron (B)	0.05	health	TCEQ (2013)
Chromium (Cr)	0.001	health (total chromium)	AENV (2011)
Cobalt (Co)	0.0002	health	TCEQ (2013)
Copper (Cu)	0.10	respiratory system	Cal EPA (2012)
Lead (Pb)	0.0015	not available	AENV (2011)
Manganese (Mn)	0.002	not available	AENV (2011)

Table 7.7.19 Acute Inhalation Toxicological Reference Values

COPC	Toxicological Reference Value (TRV) (mg/m^3)	Health Endpoint	Source
Mercury (Hg) - total	--	--	--
Molybdenum (Mo)	0.03	health	TCEQ (2013)
Nickel (Ni)	0.006	not available	AENV (2011)
Thallium (Tl)	0.001	health	TCEQ (2013)
Tungsten (W)	0.01	health	TCEQ (2013)
Uranium (U)	0.0005	health	TCEQ (2013)
Vanadium (V)	--	--	--
Zinc (Zn)	--	--	--
24-hour Acute Exposure			
Sulphur dioxide (SO_2)	0.30	not available	GNB (1997), Health Canada (2006)
Nitrogen oxides (NO_x as NO_2)	0.20	not available	GNB (1997), Health Canada (2006)
Carbon monoxide (CO)	--	--	--
Total particulate matter (PM)	0.12	not available	GNB (1997)
Particulate matter less than 2.5 microns ($PM_{2.5}$)	0.03	health	OMOE (2012)
Particulate matter less than 10 microns (PM_{10})	0.05	interim value provided as guide	OMOE (2012)
Aluminum (Al)	--	--	--
Arsenic (As)	0.0003	health	OMOE (2012)
Boron (B)	0.12	particulate	OMOE (2012)
Chromium (Cr)	0.0005	health	OMOE (2012)
Cobalt (Co)	0.0001	health	OMOE (2012)
Copper (Cu)	0.05	health	OMOE (2012)
Lead (Pb)	0.0005	health	OMOE (2012)
Manganese (Mn)	0.0002	health	OMOE (2012)
Mercury (Hg) - total	0.003	health	OMOE (2012)
Molybdenum (Mo)	0.12	particulate	OMOE (2012)
Nickel (Ni)	0.0001	particulate	OMOE (2012)
Thallium (Tl)	--	--	--
Tungsten (W)	--	--	--
Uranium (U)	0.0001	particulate	OMOE (2012)
Vanadium (V)	0.002	health	OMOE (2012)
Zinc (Zn)	0.12	particulate	OMOE (2012)

Notes:
"--" indicates that TRV is not available

Table 7.7.20 Chronic Inhalation Toxicological Reference Values (Non-Carcinogens)

COPC	Toddler Toxicological Reference Value (TRV) (mg/m^3)	Adult Toxicological Reference Value (TRV) (mg/m^3)	Health Endpoint	Source
Inhalation (mg/m^3)				
Aluminum (Al)	1.99	1.99	provisional	ATSDR (2008)
Arsenic (As)	Not applicable	Not applicable	assessed as a carcinogen	Health Canada (2010b)

Table 7.7.20 Chronic Inhalation Toxicological Reference Values (Non-Carcinogens)

COPC	Toddler Toxicological Reference Value (TRV) (mg/m^3)	Adult Toxicological Reference Value (TRV) (mg/m^3)	Health Endpoint	Source
Boron (B)	0.0348	0.0348	derived from oral	Health Canada (2010b)
Chromium (Cr)	0.000008	0.000008	nasal septum atrophy	US EPA IRIS (1998)
Cobalt (Co)	0.0001	0.0001	respiratory effects	ATSDR (2004)
Copper (Cu)	0.001	0.001	lung and immune system effects	RIVM (2001)
Lead (Pb)	0.00368	0.00368	provisional – derived from oral	OMOE (1994)
Manganese (Mn)	0.00005	0.00005	impairment of neuro-behavioral function	US EPA IRIS (1993)
Mercury (Hg) - total	0.0003	0.0003	hand tremors and increases in memory disturbance	US EPA IRIS (1995)
Molybdenum (Mo)	0.012	0.012	no observed adverse effect concentration	RIVM (2001)
Nickel (Ni)	0.022	0.022	provisional – derived from oral	Health Canada (2010b)
Thallium (Tl)	0.000028	0.000028	provisional – derived from oral	Cal EPA (1999)
Tungsten (W)	0.0033	0.0033	not specified	NIOSH (1994)
Uranium (U)	0.0012	0.0012	provisional – derived from oral	Health Canada (2010b)
Vanadium (V)	0.0001	0.0001	respiratory effects	ATSDR (2009)
Zinc (Zn)	0.95	0.95	provisional – derived from oral	Health Canada (2010b)
Oral (mg/kg-day)				
Aluminum (Al)	1	1	neurotoxic	ATSDR (2008)
Arsenic (As)	Not applicable	Not applicable	assessed as a carcinogen	Health Canada (2010b)
Boron (B)	0.0175	0.0175	testicular atrophy	Health Canada (2010b)
Chromium (Cr)	0.001	0.001	hepatotoxicity (liver effects)	Health Canada (2010b)
Cobalt (Co)	0.01	0.01	polycythemia (blood disease)	ATSDR (2004)
Copper (Cu)	0.091	0.141	hepatotoxicity (liver effects)	Health Canada (2010b)
Lead (Pb)	0.0019	0.0019	behavioral effects and learning disabilities in children	OMOE (1994)
Manganese (Mn)	0.136	0.156	Parkinsonian-like neurotoxicity	Health Canada (2010b)
Mercury (Hg) - inorganic	0.0003	0.0003	nephrotoxicity (kidney effects)	Health Canada (2010b)
Methyl mercury (MeHg)	0.0002	0.0002 (women of childbearing years)	neurotoxicity	Health Canada (2010b)
Molybdenum (Mo)	0.023	0.028	reproductive effects	Health Canada (2010b)
Nickel (Ni)	0.011	0.011	perinatal lethality	Health Canada (2010b)

Table 7.7.20 Chronic Inhalation Toxicological Reference Values (Non-Carcinogens)

COPC	Toddler Toxicological Reference Value (TRV) (mg/m^3)	Adult Toxicological Reference Value (TRV) (mg/m^3)	Health Endpoint	Source
Thallium (Tl)	0.000014	0.000014	alopecia (hair loss)	Cal EPA (1999)
Tungsten (W)	0.0075	0.0075	body weight	Schroeder and Mitchener (1975)
Uranium (U)	0.0006	0.0006	nephrotoxicity (kidney effect) and hepatotoxicity (liver effects)	Health Canada (2010b)
Vanadium (V)	0.009	0.009	decreased hair cystine	US EPA IRIS (1988)
Zinc (Zn)	0.48	0.57	decreased growth of infants	Health Canada (2010b)

Table 7.7.21 Chronic Inhalation Toxicological Reference Values (Carcinogens)

COPC	Lifetime Toxicological Reference Value (TRV) (mg/m^3)	Health Endpoint	Source
Inhalation [1/(mg/m^3)]			
Arsenic (As)	6.4	bladder, lung, and liver cancer	Health Canada (2010b)
Chromium (Cr)	11	lung cancer	Health Canada (2010b)
Nickel (Ni)	1.3	lung and nasal cancer	Health Canada (2010b)
Oral [1/(mg/kg-day)]			
Arsenic (As)	1.8	lung cancer	Health Canada (2010b)

7.7.3.3 Exposure Assessment

The main objective of the exposure assessment is to develop a quantitative estimate of exposure for the human receptors to each COPC, based on the media concentrations and the receptor characteristics.

7.7.3.3.1 Exposure Point Concentrations (EPCs)

Section 7.7.2.2 presented the EPCs used in the risk assessment for the air, soil, water, vegetation, fish tissue, and game for the Baseline Case, the Project Alone Case, and the Project + Baseline Case. The HHRA used these EPCs in the assessment of human health risk at each of the HHERA receptor locations. For fish and moose, the concentrations used in the HHERA were calculated as an average for the HHERA Study Area, since no one location could support the consumption rates.

For the purposes of this assessment, receptors were conservatively assumed to harvest their country foods (*i.e.*, vegetation, game, and fish) from the HHERA Study Area over the exposure time (2 days/week), and consume the food collected throughout the year.

Although speciation of metals was not completed, existing guidance for the assessment of mercury and arsenic in fish tissues have been applied. For the purposes of the HHRA, it has been assumed that all mercury in fish occurs as the more toxic methyl mercury, consistent with US EPA (2005) guidance. The Canadian Ministry of the Environment performed studies analyzing concentrations of organic and inorganic arsenic in freshwater fish, determining that 10% of total arsenic is inorganic (Weiler 1987), while the other 90% appears to occur as organic arsenic, which is considered non-toxic. Therefore, it has been assumed that 10% of the total arsenic in fish from the HHERA Study Area occurs as inorganic arsenic.

7.7.3.3.2 Calculation of Average Daily Dose

Daily intakes from each type of food are determined for each individual COPC. In the absence of community specific consumption and use details for traditional foods in the HHERA Study Area, the Health Canada (2010) recommended consumption quantities were used in the assessment, with assumptions regarding what portion of the total consumption would originate from the HHERA Study Area. The consumption quantities are included in Section 7.7.3.1.1.

Daily intakes are calculated in the form of chronic daily intakes (CDIs) (to assess non-carcinogenic endpoints) and lifetime average daily doses (LADDs) (to assess carcinogenic endpoints), using the equations presented below.

$$\mathrm{CDI}_i = \mathrm{Intake}_{nc} \ \mathrm{x}\ \mathrm{EPC}_i$$

$$\mathrm{LADD}_i = \mathrm{Intake}_c \,\mathrm{x}\, \mathrm{EPC}_i$$

where:

CDI_i = chronic daily intake via pathway *i*, mg/kg bw-day (Note: bw means body weight);

LADD_i = lifetime average daily dose via pathway *i*, mg/kg bw-day;

Intake_{nc} = intake rate for medium *i* (*e.g*., game) (non-carcinogenic), kg medium/kg bw-day;

Intake_c = intake rate for medium *i* (*e.g*., game) (carcinogenic), kg medium/kg bw-day; and

EPC_i = Exposure concentration of contaminant in medium *i* (*e.g*., game), mg COPC/kg medium.

7.7.3.4 Risk Characterization

The final step in the HHERA is risk characterization. This involves the estimation, description, and evaluation of risk associated with exposure to COPC by comparing the estimated exposure to the appropriate TRV. For human receptors, the benchmark is different depending on whether or not the COPC are possibly cancer-causing.

7.7.3.4.1 Non-Cancer Causing Contaminants

The assessment of human health risks from non-cancer causing contaminants is conducted using Concentration Ratios (CR) for the inhalation pathway, and Hazard Quotients (HQ) for all other pathways.

Concentration Ratios (CR) were used to evaluate the health risks from short-term and long-term exposure of all life stages to contaminants in air. CRs were calculated by dividing the predicted ground-level air concentration (*i.e.,* 1-hour, 24-hour, or annual average) as predicted by air dispersion modelling by the appropriate TRV. Note that the TRVs for non-cancer causing contaminants are considered protective of the general population, including all life stages. For assessment of non-carcinogenic health risks due to short- and long-term direct inhalation of COPC by people, a benchmark of CR<1.0 was used for comparison of calculated CR, consistent with guidance from Alberta Health and Wellness (2011). In general, the risks associated with direct inhalation are distinct from those associated with oral and dermal exposures and are therefore assessed separately.

Hazard Quotients (HQ) were calculated by dividing the predicted exposure (or dose) by the TRV for a specific COPC. People are potentially exposed to contaminants through five main media (*i.e*., air, water, soil, food, and consumer products), and Health Canada and the Canadian Council of Ministers of the Environment (CCME) assume that no more than 20% of a person's daily intake comes from any one medium (*i.e*., 100% divided by 5 media is 20%). This translates into an HQ where the benchmark is HQ<0.2. For this HHRA, the potential health risks associated with water, soil, and country foods was undertaken, and the health risks associated with each source compared to the benchmark of HQ<0.2.

When predicted human health risks are less than the benchmark (*e.g*., CR<1.0, HQ<0.2), adverse human health outcomes are not expected. If predicted human health risks are higher than the benchmark, it does not necessarily indicate a health problem, but rather triggers a more in-depth review. Review of such HQ and CR values is important since both the exposure estimates and the toxicological criteria are based on a series of conservative assumptions, including multiple predictive models and reasonable "worst case" exposure scenarios.

7.7.3.4.2 Cancer-Causing Contaminants

The assessment or comparison for potential health risks from cancer-causing COPC was expressed as Incremental Lifetime Cancer Risks (ILCRs), and represents the increased risk of a person within a given population developing cancer over his or her lifetime as a result of the Project. ILCR consider the increase in risk over and above background risk. ILCR estimates resulting from direct air inhalation were calculated by multiplying the concentration in air resulting from the Project by the TRV (for any cancer-causing contaminants in air, also known as a UR).

For those cancer-causing COPC evaluated as part of the soil, water, or food pathway assessment, ILCR estimates resulting from a lifetime of exposure through multiple pathways were calculated by estimating a lifetime average daily dose (LADD) (over an assumed lifetime for a person of 80 years), and multiplying that LADD by the TRV (for cancer-causing contaminants in media other than air, also known as a SF). Consistent with Health Canada (2010a) and Atlantic PIRI (2007) guidance, the ILCR was compared to a benchmark of 1 person in a population of 100,000 (*i.e.,* 0.00001, or 1E-05) predicted to develop cancer as a result of their contaminant exposure from Project-related releases. It is noted that a risk estimate that exceeds an ILCR of 1E-05 would not, in and of itself, necessarily indicate that the proposed action or activity is not safe or presents an unacceptable risk (USEPA 2005). Rather, a risk estimate that exceeds a regulatory objective triggers careful consideration of the underlying scientific basis (USEPA 2005) and further monitoring to confirm the prediction and plan for adaptive management, as applicable.

The Lifetime Cancer Risk (LCR) is a measure used to assess risks related to contaminants that are capable of producing cancer, similar to the ILCR. Unlike ILCR, LCR includes the consideration of cancer risks from background or existing sources. Since regulators have not recommended an acceptable benchmark LCR for exposure to carcinogens associated with background or baseline conditions, interpretation of the significance of the LCR values is difficult. As such, the LCRs for the Baseline Case and the Project + Baseline Case are provided for reference and context only.

7.7.3.4.3 Risk Characterization Results

7.7.3.4.3.1 Human Health Risks via Inhalation – Criteria Air Contaminants (CACs)

The short-term (1-hour and 24-hour) and long-term (annual average) assessment of inhalation health risks for criteria air contaminants (CACs) at the location of the maximum ground-level concentration (GLC) within the LAA as predicted by the air dispersion modelling (Section 7.1) for the Baseline Case and the Project + Baseline Case are provided in Table 7.7.22.

Table 7.7.22 Maximum Acute and Chronic Inhalation Human Health Risks – Criteria Air Contaminants (CACs)

COPC (CACs)	Inhalation Human Health Risk, as measured by Concentration Ratio (CR dimensionless)					
	All Life Stages					
	Baseline Case			Project + Baseline Case		
	1-hour (CR)	24-hour (CR)	Annual Average (CR)	1-hour (CR)	24-hour (CR)	Annual Average (CR)
SO_2	0.0061	0.0075	-	0.0062	0.0078	-
NO_2	0.034	0.028	-	0.25	0.13	-
CO	0.052	-	-	0.053	-	-
PM	-	0.19	-	-	**7.0**	-
$PM_{2.5}$	-	0.21	-	-	0.95	-
PM_{10}	-	N/A	-	-	0.78	-

Notes:
- Indicates that a regulatory TRV for the selected averaging period is not available.
N/A Indicates that a predicted ground-level concentration for the selected averaging period is not available.
Bold indicates that the value exceeds the applicable benchmark (CR<1.0).

Results of the acute inhalation analyses indicate that the predicted maximum future GLCs of CACs were less than the benchmarks for acute inhalation (CR<1.0), with the exception of the maximum 24-hour PM (or total suspended particulate, TSP) concentration. The maximum predicted GLC for PM (837 $\mu g/m^3$) is above the regulatory guideline of 120 $\mu g/m^3$, as was discussed in Section 7.1, and consequent CR values exceed the benchmark. It is important to note that the location of the maximum GLC for PM is not at any of the HHRA locations. The PM predicted maximum concentration is located at the edge of the quarry and TSF area, as indicated in Section 7.1.

Given the low likelihood of a person being exposed to PM at the location of the maximum GLC where and when it occurs, it is important to evaluate the potential short-term risks related to exposures to PM at the locations where people currently reside, to gain a true understanding of human health risks to which people may be exposed at places where they are currently likely to be exposed. The CR values associated with the maximum predicted PM concentrations at the previously identified recreational cabins and nearest residences (Section 7.1), as well as each of the HHERA receptor locations were reviewed and are provided in Table 7.7.23.

Table 7.7.23 Acute and Chronic Inhalation Health Risks at Selected Receptor Locations – Criteria Air Contaminants (CACs)

COPC (CACs) (Exposure Period)	Location	Inhalation Human Health Risks (CRs, dimensionless)	
		All Life Stages	
		Baseline Case	Project + Baseline Case
PM (24-hour)	Maximum GLC (near quarry and TSF)	0.19	**7.0**
	Maximum at nearest recreational cabin or nearest residence	0.19	0.24
Notes: **Bold** indicates that the value exceeds the applicable benchmark (CR<1.0).			

With the exception of PM concentrations located within the quarry and TSF area, none of the PM concentrations are predicted to result in a CR value that exceeds the applicable benchmark (CR<1.0) at these locations (Table 7.7.23).

7.7.3.4.3.2 Human Health Risks via Inhalation – Non-Criteria Air Contaminants (non-CACs)

The CR values for exposures to predicted non-CAC COPC concentrations as predicted by the air dispersion modelling (Section 7.1) are presented in Table 7.7.24. The CR values for the 1-hour, 24-hour and annual average exposure periods are based on the maximum overall GLC predicted by the model within the entire HHERA Study Area.

Table 7.7.24 Maximum Acute and Chronic Inhalation Human Health Risks – Non-Criteria Air Contaminants (non-CACs)

COPC (non-CACs)	Inhalation Human Health Risk, as measured by Concentration Ratio (CR) , dimensionless					
	All Life Stages					
	Baseline Case			Project + Baseline Case		
	1-hour (CR)	24-hour (CR)	Annual Average (CR)	1-hour (CR)	24-hour (CR)	Annual Average (CR)
Aluminum (Al)	0.014	-	8.3E-05	**2.3**	-	1.6E-04
Arsenic (As)	0.060	0.0082	-	**2.7**	0.038	-
Boron (B)	1.2E-04	2.1E-05	7.1E-05	1.3E-04	1.1E-05	7.6E-05
Cadmium (Cd)	0.020	0.033	0.072	**1.3**	0.21	0.074
Chromium (Cr)	0.0025	0.0021	0.10	0.44	0.037	0.17
Cobalt (Co)	0.010	0.0082	0.0072	0.41	0.034	0.0083
Copper (Cu)	0.0066	0.0054	0.19	0.012	0.0010	0.19
Lead (Pb)	0.0044	0.0054	4.7E-04	0.20	0.025	5.8E-04
Manganese (Mn)	0.013	0.053	0.13	**4.3**	**1.8**	0.27

Table 7.7.24 Maximum Acute and Chronic Inhalation Human Health Risks – Non-Criteria Air Contaminants (non-CACs)

COPC (non-CACs)	Inhalation Human Health Risk, as measured by Concentration Ratio (CR) , dimensionless					
	All Life Stages					
	Baseline Case			Project + Baseline Case		
	1-hour (CR)	24-hour (CR)	Annual Average (CR)	1-hour (CR)	24-hour (CR)	Annual Average (CR)
Mercury (Hg)	-	4.0E-06	2.3E-05	-	3.1E-05	4.3E-05
Molybdenum (Mo)	1.0E-04	1.0E-05	1.0E-04	0.0032	1.6E-04	3.0E-04
Thallium (Tl)	0.010	-	0.15	0.0061	-	0.15
Tungsten (W)	3.7E-04	-	4.4E-04	0.017	-	1.7E-03
Uranium (U)	0.13	0.18	0.019	0.035	0.0049	0.019
Vanadium (V)	-	4.1E-04	0.0076	-	0.011	0.014
Zinc (Zn)	-	2.0E-04	1.6E-05	-	3.5E-04	1.7E-05

Notes:
- Indicates that a regulatory criteria or TRV for the selected averaging period is not available.
Bold indicates that the value exceeds the applicable benchmark (CR<1.0).

Results of the acute and chronic inhalation analyses indicate the following.

- Predicted maximum Project + Baseline Case GLCs of non-CACs were less than the regulatory guidelines (CR<1.0) for acute inhalation, with the following exceptions: the maximum 1-hour aluminum, arsenic, cadmium, and manganese as well as the maximum 24-hour manganese; these are generally only marginally above their respective regulatory guidelines.

- Predicted maximum Project + Baseline Case GLCs of non-CACs were less than the TRV for chronic inhalation (CR<1.0).

It is important to note that the location of the maximum GLCs for aluminum, arsenic, cadmium and manganese are not at any of the HHRA locations. The aluminum, arsenic, cadmium and manganese predicted maximum concentrations are located at the edge of the quarry and TSF area, as indicated in Section 7.1.

Given the low likelihood of a person being exposed to aluminum, arsenic, cadmium and manganese at the location of the maximum GLC where and when it occurs, it is important to evaluate the potential short-term risks related to exposures to aluminum, arsenic, cadmium and manganese at the locations where people currently reside, to gain a true understanding of human health risks to which people may be exposed at places where they are currently likely to be exposed. The CR values associated with the maximum predicted aluminum, arsenic, cadmium and manganese concentrations at the previously identified recreational cabins and nearest residences, as well as each of the HHERA receptor locations shown on Figure 7.7.3, were reviewed and are presented in Table 7.7.25. Only those human health risks that were predicted to exceed an applicable benchmark in Table 7.7.24 are provided, as there is no need for further analysis of those parameters and averaging periods that met the benchmark.

Table 7.7.25 Acute and Chronic Inhalation Human Health Risks at Selected Receptor Locations – Non-Criteria Air Contaminants (non-CACs)

COPC (non-CACs) (Exposure Period)	Location	Inhalation Human Health Risk (CR, dimensionless)	
		All Life Stages	
		Baseline Case	Project + Baseline Case
Aluminum (Al) (1-hour)	At the location of the Maximum predicted GLC	0.014	**2.3**
	Maximum at the nearest recreational cabin or nearest residence	0.014	0.035
	Maximum of the 46 HHERA Receptor Locations	0.014	0.28
Arsenic (As) (1-hour)	At the location of the Maximum predicted GLC	0.060	**2.7**
	Maximum at the nearest recreational cabin or nearest residence	0.060	0.084
	Maximum of the 46 HHERA Receptor Locations	0.060	0.33
Cadmium (Cd) (1-hour)	At the location of the Maximum predicted GLC	0.020	**1.3**
	Maximum at the nearest recreational cabin or nearest residence	0.020	0.032
	Maximum of the 46 HHERA Receptor Locations	0.020	0.15
Manganese (Mn) (1-hour)	At the location of the Maximum predicted GLC	0.013	**4.3**
	Maximum at the nearest recreational cabin or nearest residence	0.013	0.066
	Maximum of the 46 HHERA Receptor Locations	0.013	0.49
Manganese (Mn) (24-hour)	At the location of the Maximum predicted GLC	0.053	**1.8**
	Maximum at the nearest recreational cabin or nearest residence	0.053	0.10
	Maximum of the 46 HHERA Receptor Locations	0.053	0.26

Notes:
Bold indicates that the value exceeds the applicable benchmark (CR<1.0).

With the exception of concentrations located within the quarry and TSF area, none of the aluminum, arsenic, cadmium and manganese concentrations are predicted to result in a CR value that exceeds the benchmark (CR<1.0) at the nearest recreational cabin or nearest residence locations (Table 7.7.25).

In addition, cancer risks associated with three non-CACs that are considered carcinogens through the inhalation pathway were also evaluated for the chronic exposure scenario. These three metals include arsenic, chromium, and nickel. The results are provided in Table 7.7.26.

Table 7.7.26 Maximum Carcinogenic Human Health Risks Associated with Inhalation

COPC	Maximum Air Lifetime Cancer Risk (LCR or ILCR, dimensionless)		
	Lifetime		
	Baseline (LCR)	Project Alone (ILCR)	Project + Baseline (LCR)
Arsenic (As) (inhalation only)	1.4E-05	2.3E-06	1.6E-05
Chromium (Cr) (inhalation only)	8.9E-06	6.2E-06	1.5E-05
Nickel (Ni) (inhalation only)	1.4E-06	2.2E-07	1.7E-06

Notes:
Bold indicates that value exceeds applicable ILCR benchmark (ILCR<1E-05).

The Project-related ILCRs for all three metals are less than the benchmark of 1 in 100,000 (*i.e.*, ILCR<1E-05), indicating negligible health risks. As noted previously, the LCRs associated with the Baseline Case and the Project + Baseline Case have been provided for reference only as there are no benchmarks for the LCR values.

7.7.3.4.3.3 Human Health Risks via Ingestion and Dermal Contact with Soil

Hazard quotients (HQs) were determined for each of the HHERA receptor locations (as shown on Figure 7.7.3) based on incidental ingestion, inhalation of dust from soil, and direct dermal contact with soil. As noted in Section 7.7.3.3, people were assumed to spend two days per week, each week, in the HHERA Study Area. A summary of the maximum HQs for the toddler (*i.e.*, the most sensitive life stage for non-carcinogens) is provided in Table 7.7.27.

Table 7.7.27 Maximum Non-Carcinogenic Human Health Risks to Toddlers Associated with Soil Exposure

COPC[a]	Maximum Total Soil Hazard Quotient (HQ, dimensionless)		
	Toddler		
	Baseline Case	Project Alone Case	Project + Baseline Case
Aluminum (Al)	0.064	8.5E-08	0.064
Boron (B)	3.2E-04	6.8E-10	3.2E-04
Chromium (Cr)	0.066	2.2E-07	0.066
Cobalt (Co)	3.2E-03	3.4E-09	3.2E-03
Copper (Cu)	1.0E-03	6.3E-09	1.0E-03
Lead (Pb)	0.022	4.4E-08	0.022
Manganese (Mn)	0.14	4.3E-08	0.14
Mercury (Hg)	1.9E-03	6.5E-10	1.9E-03
Molybdenum (Mo)	1.0E-03	7.8E-09	1.0E-03
Nickel (Ni)	4.3E-03	5.5E-09	4.3E-03
Thallium (Tl)	0.030	1.8E-07	0.030
Tungsten (W)	1.7E-03	4.5E-08	1.7E-03
Uranium (U)	8.0E-03	1.3E-08	8.0E-03
Vanadium (V)	0.020	2.5E-08	0.020
Zinc (Zn)	3.7E-04	1.0E-09	3.7E-04

Notes:
Bold indicates that value exceeds applicable HQ benchmark (HQ<0.2).
[a] Arsenic assessed as a carcinogen only (see Table 7.7.28), consistent with Health Canada (2010b).

As indicated in Table 7.7.27, maximum HQs for the soil pathway were below the relevant benchmark of HQ<0.2 for Baseline Case, Project Alone Case, and Project + Baseline Case.

Cancer risks associated with the COPCs that are considered carcinogens were also assessed at each of the HHERA receptor locations. The results are provided in Table 7.7.28. As noted previously, the LCRs associated with the Baseline Case and the Project + Baseline Case have been provided for reference only as there are no benchmarks for the LCR values. It is noted that carcinogenic health endpoints are assessed over the lifetime of an individual, and not for any particular life stage.

Table 7.7.28 Maximum Carcinogenic Human Health Risks Associated with Soil Exposure

COPC	Maximum Soil Lifetime Cancer Risk (LCR or ILCR, dimensionless)		
	Lifetime		
	Baseline Case (LCR)	Project Alone Case (ILCR)	Project + Baseline Case (LCR)
Arsenic (As)	3.4E-05	2.9E-11	3.4E-05
Chromium (Cr) [a]	1.3E-09	4.3E-15	1.3E-09
Nickel (Ni) *	1.2E-10	1.5E-16	1.2E-10

Notes:
Bold indicates that value exceeds applicable ILCR benchmark (ILCR<1E-05).
[a] Potential carcinogenic effects for chromium and nickel associated with inhalation of dust from soil. Health risks associated with chromium and nickel from incidental ingestion of soil and dermal with soil are provided in Table 7.7.27.

The ILCRs associated with each of these metals at the HHERA receptor locations were less than the benchmark of 1 in 100,000 (*i.e.*, ILCR<1E-05). Based on these results, the potential health risks associated with predicted increases in COPC concentrations in soil associated with deposition of ore dust are negligible.

7.7.3.4.3.4 Human Health Risks via Ingestion of Water

Although there are no groundwater users in the immediate vicinity of the Project, and although streams in the HHERA Study Area have not been identified as sources of potable water, the HHERA considered the possibility that people may drink water from the streams while in the HHERA Study Area (assumed to be two days per week, a highly conservative assumption). A summary of the maximum HQs for the toddler (*i.e.*, the most sensitive life stage for non-carcinogens) is provided in Table 7.7.29.

Table 7.7.29 Maximum Non-Carcinogenic Human Health Risks Associated with Ingestion of Water

COPC [a]	Maximum Surface Water Ingestion Hazard Quotient (HQ, dimensionless)		
	Toddler		
	Baseline Case	Project Alone Case	Project + Baseline Case
Aluminum (Al)	1.5E-03	1.5E-03	2.8E-03
Boron (B)	1.2E-03	0.13	0.13
Chromium (Cr)	5.6E-03	5.8E-03	0.012
Cobalt (Co)	6.3E-05	1.3E-03	1.4E-03
Copper (Cu)	6.1E-05	2.0E-04	2.6E-04
Lead (Pb)	1.1E-03	1.6E-03	2.3E-03
Manganese (Mn)	9.8E-04	2.5E-03	3.1E-03
Mercury (Hg)	4.5E-04	1.4E-05	4.7E-04
Molybdenum (Mo)	1.7E-04	6.4E-03	6.4E-03
Nickel (Ni)	4.7E-04	1.9E-03	2.4E-03
Thallium (Tl)	0.037	0.12	0.16
Tungsten (W)	3.0E-03	0.025	0.028
Uranium (U)	3.4E-03	0.033	0.036
Vanadium (V)	7.4E-04	0.014	0.015
Zinc (An)	5.3E-05	2.4E-04	2.7E-04

Notes:
Bold indicates that value exceeds applicable HQ benchmark (HQ<0.2).
[a] Arsenic assessed as a carcinogen only (see Table 7.7.30), consistent with Health Canada (2010b)

As indicated in Table 7.7.29, maximum HQs for the ingestion of water pathway were below the benchmark of HQ<0.2.

The lifetime cancer risk associated with arsenic (the only COPC that is considered a potential carcinogen via oral exposure) was also assessed at each of the HHERA receptor locations. The resulting maximum health risks are provided in Table 7.7.30. As noted previously, the LCRs associated with the Baseline Case and the Project + Baseline Case have been provided for reference only as there are no benchmarks for the LCR values.

Table 7.7.30 Maximum Carcinogenic Human Health Risks Associated with Ingestion of Water

COPC	Maximum Surface Water Lifetime Cancer Risk (LCR or ILCR, dimensionless)		
	Lifetime		
	Baseline Case (LCR)	Project Alone Case (ILCR)	Project + Baseline Case (LCR)
Arsenic (As) (water ingestion)	7.8E-06	4.4E-05	5.1E-05

The maximum ILCRs associated with ingestion of arsenic in surface water at the HHERA receptor locations was greater than the benchmark of 1 in 100,000 (*i.e.*, ILCR<1E-05) for the Project Alone Case and the Project + Baseline Case. Based on these results, the predicted increases in COPC concentrations in surface water represent a non-negligible health risk to those who may occasionally drink from the streams while in the HHERA Study Area. Further information is as follows.

Health Risks Associated with Arsenic in Water

As per Alberta Health and Wellness (2011), exceedances of the threshold do not necessarily indicate that adverse health effects are expected to occur, or that the health risks are considered unacceptable. However, an exceedance is normally a trigger for further evaluation of the significance of the estimated risks, which usually incorporates locally validated data as opposed to reliance on default assumptions and models to better reflect local conditions, or it may indicate the need for risk management of the project.

The calculated ILCR is based on model predictions that annual average arsenic concentrations in surface water will increase from 0.00069 mg/L to 0.00455 mg/L. These annual average arsenic concentrations for the Project + Baseline case meet the Canadian Drinking Water Quality Guideline of 0.010 mg/L (Health Canada 2012); however, the estimated lifetime cancer risk associated with the ingestion of drinking water containing arsenic at 0.010 mg/L is greater than the risk level that is considered by Health Canada to be “essentially negligible”.

The oral slope factor of 1.8 $(mg/kg\text{-}day)^{-1}$ used in this assessment was derived by Health Canada based in the incidence of internal (lung, bladder, and liver) cancers in a population in southwestern Taiwan exposed to arsenic levels ranging from 0.35 to 1.14 mg/L of arsenic in their drinking water (Health Canada 2006). Health Canada (2006) acknowledged that the extrapolation method used to estimate the risks of internal organ cancers from exposure to low levels of arsenic, as well as confounding factors (*e.g.*, genetic differences, differences in health status, arsenic metabolism, and nutritional status of the southwestern Taiwanese study population), may lead to an overestimate of the risks of internal organ cancers.

Epidemiological studies conducted in the United States (Steinmaus *et al.* 2003, Lamm *et al.* 2004 and U.S. EPA and AWWA Research Foundation 2004) have not found a clear association between cancer risks and arsenic in drinking water at levels below 0.05 mg/L. More recently, a study of a prospective Danish cohort of 57,053 people that was followed from 1970 to 2003 found no association with lung, bladder, liver, kidney, prostate, colorectal, or skin melanoma cancers from exposure to arsenic drinking water concentrations up to 0.0253 mg/L (Baastrap *et al* 2008), .

Although water from small spring-fed tributaries to Napadogan Brook was observed to be used at recreational campsites, the Napadogan Brook is not a known to be a regular source of drinking water. Therefore, potential exposures to the water are expected to be intermittent, and the assumption that water from the brook would be the sole source of water to a person for two days a week for 80 years overstates the risk.

The maximum predicted annual average concentration of arsenic in Napadogan Brook of 0.00455 mg/L is very unlikely to result in health effects since:

- Napadogan Brook is not used as a regular supply of potable water;
- the predicted concentration meets the Canadian Drinking Water Quality Guideline for arsenic of 0.010 mg/L; and
- recent epidemiological studies have not found an association between cancer risks and arsenic in drinking water at concentrations less than 0.010 mg/L.

7.7.3.4.3.5 Human Health Risks via Ingestion of Food

For the diet exposure pathway, Hazard Quotients were determined for each of the HHERA receptor locations based on ingestion of game, fish and vegetation. A summary of the maximum total HQs for the toddler is provided in Table 7.7.31.

Table 7.7.31 Maximum Non-Carcinogenic Human Health Risks Associated with Ingestion of Food

COPC [a]	Maximum Total Diet Hazard Quotient (HQ, dimensionless)		
	Toddler		
	Baseline Case	Project Alone Case	Project + Baseline Case
Aluminum (Al)	0.069	0.0038	0.073
Boron (B)	0.13	**0.21**	**0.34**
Chromium (Cr)	**0.43**	0.042	**0.47**
Cobalt (Co)	**0.37**	0.097	**0.47**
Copper (Cu)	0.076	0.0045	0.081
Lead (Pb)	0.20	0.0045	0.20
Manganese (Mn)	**4.6**	0.089	**4.6**
Mercury (Hg)	0.12	1.7E-05	0.12
Methyl Mercury (fish only)	**0.74**	0.022	**0.76**
Molybdenum (Mo)	0.026	0.022	0.048
Nickel (Ni)	0.16	0.0046	0.16
Thallium (Tl)	**3.8**	**3.8**	**7.6**
Tungsten (W)	0.053	0.0082	0.059

Table 7.7.31 Maximum Non-Carcinogenic Human Health Risks Associated with Ingestion of Food

COPC [a]	**Maximum Total Diet Hazard Quotient (HQ, dimensionless)**		
	Toddler		
	Baseline Case	**Project Alone Case**	**Project + Baseline Case**
Uranium (U)	0.012	0.055	0.067
Vanadium (V)	0.026	0.061	0.087
Zinc (Zn)	0.082	0.007	0.089

Notes:
Bold indicates that value exceeds the applicable benchmark (HQ<0.2).
[a] Arsenic assessed as a carcinogen only (see Table 7.7.33), consistent with Health Canada (2010b)

HQs for the diet pathway were below a HQ of 0.2, with the following exceptions: boron, chromium, cobalt, lead, manganese, methyl mercury (fish only), and thallium.

Further breakdown for these metals that exceed the applicable HQ benchmark in Table 7.7.31 is provided in Table 7.7.32 according to game, fish, and vegetation HQs for the most sensitive life stage (*i.e.,* toddler).

Table 7.7.32 Maximum Non-Carcinogenic Human Health Risks Associated with Ingestion of Game, Fish, and Vegetation

Parameters	**Maximum Total Diet Hazard Quotient (HQ)**							
Scenario	**Baseline Case**				**Project + Baseline Case**			
Pathway	**Game**	**Fish**	**Vegetation**	**Total**	**Game**	**Fish**	**Vegetation**	**Total**
Boron (B)	0.020	0.0017	0.11	0.11	0.022	**0.21**	0.11	**0.34**
Chromium (Cr)	0.16	0.040	**0.27**	**0.43**	0.12	0.082	**0.27**	**0.47**
Cobalt (Co)	**0.35**	0.0046	0.011	**0.37**	**0.36**	0.10	0.011	**0.47**
Lead (Pb)	0.0041	0.010	0.18	0.20	0.0043	0.014	0.18	0.20
Manganese (Mn)	**0.26**	0.034	**4.3**	**4.6**	**0.26**	0.11	**4.3**	**4.7**
Methyl Mercury (fish only)	---	**0.74**	---	**0.74**	---	**0.76**	---	**0.76**
Thallium (Tl)	**2.1**	**1.2**	**0.57**	**3.8**	**2.1**	**4.9**	**0.57**	**7.6**

Notes:
--- = in fish, mercury is evaluated as methyl mercury.
Veg = vegetation.
Bold indicates that the value exceeds the applicable benchmark (HQ<0.2).

Results of this analysis indicate the following.

- The predicted future HQs (*i.e.,* the health risks for Project + Baseline Case) associated with chromium, lead, manganese, and methyl mercury (fish only) in food did not increase substantially relative to the health risks associated with the existing conditions (*i.e.*, Baseline Case), as indicated by a change in health risk that is less than 10% relative to existing conditions.

- The predicted future HQs (*i.e.,* the health risks for Project + Baseline Case) associated with boron, cobalt, and thallium in food increased compared to the existing conditions (*i.e.,* baseline case). The change in health risks is associated with the consumption of fish.

Additional discussion of the potential health risks associated with boron, cobalt, and thallium in food is provided later in this section.

The lifetime cancer risk associated with arsenic (*i.e.,* the only COPC that is considered a potential carcinogen via oral exposure) was also assessed at each of the HHERA receptor locations. The maximum health risks are provided in Table 7.7.33. As noted previously, the LCRs associated with the Baseline Case and the Project + Baseline Case have been provided for reference only as there are no benchmarks for the LCR values.

Table 7.7.33 Maximum Carcinogenic Health Risks Associated with Ingestion of Food

COPC	Maximum Diet Lifetime Cancer Risk (LCR or ILCR, dimensionless)		
	Lifetime		
	Baseline Case (LCR)	Project Alone Case (ILCR)	Project + Baseline Case (LCR)
Arsenic (As)	1.9E-04	**6.2E-04**	8.1E-04

Notes:
Bold indicates that the value exceeds the applicable ILCR benchmark (ILCR<1E-05).

The ILCRs associated with ingestion of arsenic in food at the HHERA receptor locations were higher than the benchmark of 1 in 100,000 (*i.e.*, ILCR<1E-05).

Table 7.7.34 Maximum Carcinogenic Human Health Risks Associated with Ingestion of Game, Fish, and Vegetation

COPC	Maximum Diet Lifetime Cancer Risk (LCR or ILCR, dimensionless)											
	Lifetime											
	Baseline Case (LCR)				Project Alone Case (ILCR)				Project+ Baseline Case (LCR)			
	Game	Fish	Veg	Total	Game	Fish	Veg	Total	Game	Fish	Veg	Total
Arsenic (As)	3.1E-05	1.1E-04	4.1E-05	1.8E-04	1.8E-06	**7.7E-05**	4.5E-10	**7.9E-05**	3.3E-05	1.9E-04	4.1E-05	2.6E-04

Notes:
Bold indicates that the value exceeds the applicable ILCR benchmark (ILCR<1E-05).

Further breakdown for these metals according to game, fish and vegetation ingestion cancer risks are provided in Table 7.7.34. As indicated in Table 7.7.34, the ILCR associated with Project contributions to arsenic in food are related almost entirely to consumption of fish. Additional discussion of the potential health risks associated with arsenic is provided below.

Health Risks Associated with Boron

Boron is a widely occurring element in minerals, and is the 51st most common element found in the earth's crust (ATSDR 2010). Human exposure to boron is typically through consumption of food (boron is an essential element in plants), and to a lesser extent, ingestion of water (ATSDR 2010).

The health risk estimate for boron relied on toxicological data from Health Canada. Health Canada (2010b) provided a tolerable daily intake (TDI) of 0.0175 mg/kg-day for boron, based on information used by Health Canada (1991) to develop the Guidelines for Canadian Drinking Water Quality. The TDI was derived following several studies in mice, dogs, and rats that indicated exposure to boron caused testicular atrophy; however, USEPA IRIS (2004) has published a more recent oral reference dose of 0.2 mg/kg-day for boron, based on developmental effects (*i.e.*, decreased birth weight).

There is very limited information regarding typical boron concentrations in fish tissue samples. In a study completed by Allen *et al.* (2001) of elemental concentrations in fish tissue collected from four different river sites in southeastern Kansas, boron was not detected (*i.e.*, was less than the laboratory detection limit of 2 to 4 mg/kg) in any of the fish tissue samples analyzed. The findings of Allen *et al.*

(2001) are consistent with the baseline sampling in the HHERA Study Area, where boron was not detected in any of the fish carcass samples analyzed (*i.e*., the baseline fish tissue concentration for boron in fish carcass provided in Table 7.7.14 is simply ½ of the laboratory detection limit).

The predicted boron concentration increases in fish tissue relies on both the baseline fish tissue concentrations and on water quality modelling results. Predictive water modelling results indicate that boron concentrations in surface water may increase from less than 0.002 mg/L in the baseline condition to approximately 0.2 mg/L, which is similar to the reported average surface water concentration in the United States of about 0.1 mg/L (ATSDR 2010).

Since boron was not detected in the fish tissue carcass samples from the HHERA Study Area, the use of the ½ detection limit as a basis for predicting future fish tissue concentrations introduces uncertainty. As boron was not detected in fish tissue samples from other areas (Allen *et al.* 2001), and the predicted future surface water concentrations of boron are similar to average surface water concentrations of boron, the fish tissue concentrations used to assess the potential health risks for the Project + Baseline Case may be highly conservative.

Given the conservativeness in the toxicological data and the predicted fish tissue concentrations, it is unlikely that exposure to boron in food will result in adverse health problems.

Health Risks Associated with Cobalt

Cobalt is a naturally occurring element found in rocks, soil, water, plants, and animals, and has properties similar to iron and nickel (ATSDR 2004). At low levels, it is part of vitamin B12, which is essential for good health; however, at high levels, it may harm the lungs and heart (ATSDR 2004). Neither Health Canada nor US EPA IRIS have developed a TRV for oral exposures to cobalt. For the purposes of this assessment, the intermediate minimal risk level of 0.01 mg/kg-day developed by ATSDR (2004) was used to assess the potential health risks (*i.e*., with increases in red blood cell numbers) associated with cobalt as adequate chronic studies of the oral toxicity of cobalt or cobalt compounds in humans and animals are not presently available.

Baseline health risks associated with consumption of cobalt in food (HQ=0.37) is already higher than the benchmark of 0.2. For those instances where the existing conditions (*i.e*., Baseline Case) result in a calculated health risk above the benchmark, Health Canada (2010a) recommended that health risks posed by the Project alone should not exceed 0.2. As indicated in Table 7.7.31, the health risks associated with consumption of food for the Project Alone Case are 0.097. Even when combined with the health risks associated with ingestion of cobalt in water (HQ=0.0013), and exposures to soil (HQ=3.4E-09), the increased health risks associated with Project are less than 0.2, and therefore meet the Health Canada (2010a) recommendation.

Health Risks Associated with Thallium

The available toxicity database for thallium contains studies that are generally of poor quality (USEPA 2009). The TRV for thallium of 0.000014 mg/kg-day used in this assessment was obtained from the California Environmental Protection Agency (Cal EPA 1999), and is based on alopecia (hair loss) in rats. Alopecia is characteristic of thallium toxicity in both animals and humans, and it appears that alopecia is part of a continuum of dermal morphological changes and is therefore an early sign of an adverse health effect (Cal EPA 1999).

The existing concentration of thallium (*i.e.,* Baseline case) in brook trout was 0.017 mg/kg wet weight (whole fish) and 0.014 mg/kg wet weight (carcass). As indicated in Table 7.7.13, predicted future concentrations of thallium in brook trout were up to 0.072 mg/kg wet weight (whole fish) and 0.060 mg/kg wet weight (carcass). These concentrations of thallium in brook trout are less than the thallium concentration in whole fish samples of lake trout collected from Lake Michigan of 0.1408 mg/kg ± 0.1105 mg/kg (Lin *et. al* 2001), and thallium concentrations in whole fish collected from a pristine unaltered ecosystem in Peru by Gutleb *et. al* (2002), that were determined to be within the same range as those reported by Lin *et. al* (2001). Since the maximum predicted concentrations of thallium in fish tissue are less than concentrations of thallium in fish tissue samples from reference or pristine locations, the predicted fish tissue concentrations appear to be within the range of natural variability.

Health Risks Associated with Arsenic

Health Canada reviewed arsenic in food and found it is present at very low levels (low parts per billion [ppb]) in many foods, including meat and poultry, milk and dairy products, bakery goods and cereals, vegetables, and fruits and fruit juices (Health Canada 2008). These trace levels of arsenic generally reflect normal accumulation from the environment.

Carcinogenicity is considered the critical endpoint for arsenic exposures. The oral slope factor of 1.8 $(mg/kg\text{-}day)^{-1}$ used in this assessment was derived by Health Canada based in the incidence of internal (lung, bladder, and liver) cancers in individuals in southwestern Taiwan, and is similar to the oral scope factor of 1.5 $(mg/kg\text{-}day)^{-1}$ developed by the USEPA (2004).

Although arsenic exposures via game ingestion in the HHERA for the Baseline Case were based on a theoretical model (see Section 7.7.2.2.8), the moose tissue concentrations used in the HHERA are similar to published values. Concentrations of arsenic in moose (*i.e.*, game) were studied by the Maliseet Nation Conservation Council (2012), and included 44 moose carcass samples from 12 hunting zones in New Brunswick. The arsenic concentrations of the moose carcass in all samples analyzed were less than 0.05 mg/kg, while the moose tissue concentrations used in the HHERA were 0.0046 mg/kg (Baseline Case) and 0.0048 mg/kg (Project + Baseline Case).

Similarly, the arsenic concentrations in vegetation used in the HHERA were similar to reported concentrations of arsenic in fiddleheads in New Brunswick (Maliseet Nation Conservation Council n.d.). Concentrations of arsenic in 25 fiddlehead samples collected from Jemseg, Sugar Island, Mactaquac and Naskwaaksis had arsenic concentrations of less than 2 mg/kg. The concentrations of arsenic in vegetation used in this HHERA were 0.037 mg/kg for both the Baseline Case and the Project + Baseline Case.

Baseline concentrations of arsenic in brook trout from the HHERA Study Area of 0.89 mg/kg were compared to published fish tissue concentrations obtained from reference locations or natural areas. Baseline concentrations of arsenic in brook trout from the Study Area are higher than the mean total arsenic in rainbow trout (n=100) of 0.15 mg/kg in fish sampled from 54 lakes throughout British Columbia (BC Environment 1992), as well as observed mean concentrations elsewhere in North and South America (Gutleb *et al*. 2002; Hinck *et al*. 2009; Schmitt 2004), suggesting that existing concentrations of arsenic in fish from the HHERA Study Area may be naturally enriched with arsenic. However, the arsenic concentrations in fish tissue of 0.89 mg/kg (Baseline Case) and 1.5 mg/kg

(Project + Baseline Case) are below the Canadian Guidelines for Chemical Contaminants and Toxins in Fish and Fish Products of 3.5 mg/kg for arsenic (CFIA 2007).

Given the similarity between the concentrations of arsenic in game and vegetation within the HHERA Study Area and concentrations found in moose and vegetation elsewhere in New Brunswick, and that the arsenic concentrations in fish tissues for both the Baseline Case and the Project + Baseline Case are below the Canadian guidelines for arsenic in fish tissues, the consumption of arsenic in food from the HHERA Study Area is considered very unlikely to result in adverse health problems.

7.7.3.5 Uncertainty Analysis

All HHRAs have inherent uncertainty, which are addressed by incorporating conservative assumptions into every aspect of the risk assessment. Although many factors contribute to a risk estimate, results are generally sensitive to only a few of these factors, which are described below.

7.7.3.5.1 Uncertainties in Toxicological Information

There is limited toxicological information on the effects associated with low-level chemical exposures to humans. Most information available is based on epidemiological studies of occupationally exposed workers. These are usually based on an 8 h/d or 40 h/week, higher level exposure regimes and do not apply well to low-level, chronic exposures. Additionally reference doses and cancer potency estimates for many contaminants are based on laboratory dose-response estimates in animals. The use of animals requires certain assumptions to be made, which introduces further uncertainty. Assumptions include:

- the toxicological effect in animals also occurs in humans;
- the short-term exposures used in animal studies can be extrapolated to chronic or long term human exposures;
- the toxicokinetic and toxicodynamic processes that occur in animals also occur in humans;
- the uptake of the contaminant from the test vehicle (the medium within which the test compound is delivered to the animals, *e.g.* water) will be representative of the uptake of the contaminant from real-world environmental media (*e.g.,* soil, biota); and
- the assumption that extrapolation from high-dose laboratory studies to low-dose environmental studies accurately reflects the shape of the dose response curve at the low dose-response range.

To account for these and other related uncertainties, regulatory agencies such as Health Canada and the USEPA adopt conservative assumptions to account for uncertainties. The use of Uncertainty Factors accounts for uncertainties by lowering the reference dose of the Hazard Quotient calculation well below the level where no effects were seen in animals. Uncertainty Factors are applied by factors of 10 to account for uncertainties such as, interspecies differences (*e.g.*, physiology), individual variation (*e.g.*, unusually sensitive individuals), limitations in toxicological information, and extrapolation from acute exposures to chronic exposures. Depending on the degree of uncertainty, typical factors will range from 100 to 10,000, with some being lower than 10 (in the case where solid human data is available). The incorporation of these factors results in risk estimates that are extremely conservative and ensure that limited exposures above reference doses or reference concentrations will not result in adverse human health outcomes.

7.7.3.5.2 Sensitive Populations

A susceptible population will exhibit a different or enhanced response to a COPC than will most persons exposed to the same level of the contaminant in the environment. Reasons may be genetic makeup, age (*e.g.*, children or seniors), health and nutritional status, behaviour and exposure to other toxic substances (*e.g.*, cigarette smoke) (ATSDR 2002). Human receptors are selected such that the most sensitive individuals and individuals having the greatest potential for exposure to COPCs and adverse responses from such exposures are represented. For these reasons, a First Nations receptor (toddler and lifetime) was selected. It is assumed that the First Nations receptor will rely exclusively on local wild game, and rely heavily on local fish and vegetation to supplement their diets and therefore represent a high level exposure scenario. The First Nations toddler will represent the most sensitive individual for non-carcinogens for reasons just mentioned plus the physiological (nutritional needs) and behavioural (frequent hand to mouth transfer) considerations associated with children of that age. The non-cancer TRVs used in this risk assessment are estimates of a continuous exposure to the human population, including sensitive subgroups, that are to be without appreciable risk of adverse non-cancer effects during a lifetime. Toxicity doses used in the assessment have accounted for sensitive populations by applying uncertainty factors (see Toxicity Assessment above).

7.7.3.5.3 Uncertainties in Exposure Assessment

As noted in Section 7.7.2.2, the air concentrations and deposition rates are obtained directly from the air dispersion and deposition modelling results while future surface water concentrations were obtained directly from water quality modelling results. Conservative assumptions were used in the development of the air dispersion and deposition model (Section 7.1) and the predictive water quality model (Section 7.6).

Maximum predicted 1-hour, 24-hour, and annual average concentrations in air at each HHERA receptor location were used to evaluate all acute and chronic inhalation risk estimates. In reality, the frequency with which the maximum concentration would occur at any one receptor location is relatively low for most COPC. Therefore, the risk estimates tend to overestimate, rather than underestimate, health risks.

Estimation of COPC uptake through the food chain involves the use of assumptions regarding many factors, including the various uptake factors. Typically, these uptake factors are conservative and tend to overestimate, rather than underestimate, concentrations in biota. In addition, these uptake factors were applied to the reasonable maximum concentrations (*e.g.*, soil concentrations at the end of Operation, maximum annual average surface water concentrations), and are assumed to remain constant throughout the lifetime of the receptor (*e.g.*, 80 years for lifetime exposure); thus, the resulting exposure predictions are conservative.

7.7.3.5.4 Receptor Characteristics

For each receptor scenario, published characteristics and professional judgment were used in determining exposure durations, consumption patterns and ingestion rates (*e.g.,* Health Canada 2009, 2010a). For this assessment, the fraction of the total diet that a First Nations receptor would obtain from the HHERA Study Area (*i.e*., 100% of game, 20% of fish, and 10% of vegetation) represents a reasonable maximum exposure, which likely overstates the potential risk.

7.7.3.5.5 Uncertainties in Risk Characterization

The risk assessment of contaminants is complicated by the reality that most toxicological studies are on single contaminants but exposures are rarely to single contaminants. Exposures generally involve more than one contaminant. Although contaminants in the environment are most often present in some sort of mixture, guidelines for the protection of human health are almost exclusively based on exposure to single contaminants. The lack of approaches to evaluate biological effects of chemical mixtures and the use of single-compound toxicity data makes their use highly speculative.

Chemicals in a mixture may interact in four general ways to elicit a response:

- **Non-interacting –** contaminants have no effect in combination with each other; the toxicity of the mixture is the same as the toxicity of the most toxic component of the mixture;
- **Additive –** contaminants have similar targets and modes of action but do not interact, the hazard for exposure to the mixture is simply the sum of hazards for the individual contaminants;
- **Synergistic –** there is a positive interaction among the contaminants such that the response is greater than would be expected if the contaminants acted independently; or
- **Antagonistic –** there is a negative interaction among contaminants such that the response is less than would be expected if the contaminants acted independently.

For human health exposures, quantitative information on interactions among chemicals in mixtures is rarely available. In the absence of information on the mixture, risk is sometimes based on the addition of the risks of the individual mixture components, unless there is information indicating that the interaction is other than additive in nature. However, this practice is only appropriate if the COPC in question have similar modes of action and similar toxic endpoints in the human body. There is uncertainty associated with any of the above approaches in that risk may be overestimated or underestimated.

In this risk assessment, the COPC-specific HQs, ILCRs and LCRs for a receptor have been characterized for single COPCs only. This approach has been accepted in past risk assessments by various provincial jurisdictions and Health Canada.

7.7.4 Ecological Health Assessment (ERA)

Risk Quotient (RQ) values are used to evaluate health risks to ecological receptors, similar to HQs for human health. However, for the assessment of potential risk to community-based receptors (*e.g.,* soil invertebrates, terrestrial plants), the RQ was calculated by dividing the contaminant concentration in the environmental medium by an appropriate toxicological benchmark concentration, rather than by a daily dose. Ecological health risks have been assessed using RQ in previous assessments accepted by various provincial jurisdictions and Environment Canada. The framework used for this Ecological Risk Assessment (ERA) considered environmental effects at the population level for common mammals and birds, and at the individual level for species identified as “Endangered”, “Threatened”, or “Extirpated” under the *Species at Risk Act* (*SARA*) or under the New Brunswick *Species at Rick Act* (NB *SARA*).

7.7.4.1 Ecological Receptor Identification and Characterization

Key indicators were chosen for the ERA by focusing on wildlife species that are:

- Indigenous to the general area within which the Project is located;
- Likely to be highly exposed to affected environmental media due to their habitat, behavioural traits, and/or home range; or
- Representative of various levels in the trophic web (*e.g.,* herbivore, omnivore, carnivore).

Key indicators are considered to be representative of other wildlife receptors that would have generally similar lifestyle or foraging habits, but may be less likely to be adversely affected. For example, due to their small home range, small herbivorous mammals such as voles or rabbits are expected to be more affected by changes in the local environment than larger herbivores such as moose or deer, which would have a larger home range, and which would average their exposure over a larger area. Likewise, a nesting bird such as the American robin, which must obtain all of the food required to raise a brood of young from within a small radius of the nest site is expected to be more exposed than migratory birds that are simply passing through the area. Therefore, if there is no significant risk to key indicators with smaller home ranges and/or high residency factors when exposed to COPCs in an area of high concern, then by extension there will be no risk to key indicators with larger home ranges, or migratory behaviour, as these organisms are much less exposed than species with a limited home range.

Air dispersion and deposition modelling shows that metal deposition from dust associated with mining activities will be concentrated in areas of high disturbance, near the Project site. Therefore, it is reasonable and conservative to focus the ERA on small mammals and birds that have a small home range or foraging radius. If there are no significant environmental effects on small mammals inhabiting areas of maximum metal deposition closest to the Project site, then there will be no significant environmental effects on larger mammals that forage over much larger areas (where metal deposition decreases with increasing distance from the Project site and at some extent is considered negligible) and/or that are likely to avoid areas of high metal deposition due to the high level of physical disturbance, noise, and/or presence of humans. The species selected as key indicators, and their foraging habits, are listed in Table 7.7.35.

Table 7.7.35 Ecological Receptors Identified as Key Indicators of Risk

Common Name of Species	Scientific Name (Genus and Species)	Foraging Type
Masked shrew	*Sorex cinereus*	Insectivorous mammal
Meadow vole	*Microtus pennsyvanicus*	Herbivorous mammal
Snowshoe hare	*Lepus americanus*	Herbivorous mammal
Red fox	*Vulpes vulpes*	Omnivorous mammal
American mink	*Mustela vison*	Piscivorous mammal
Moose	*Alces alces*	Herbivorous mammal
Black bear	*Ursus americanus*	Herbivorous mammal
American robin	*Turdus migratorius*	Omnivorous bird
Red-tailed hawk	*Buteo jamaicensis*	Carnivorous bird
American black duck	*Anas rubripes*	Insectivorous bird
Belted kingfisher	*Megaceryle alcyon*	Piscivorous bird
Ruffed grouse	*Bonasa umbellus*	Herbivorous bird
Bald eagle	*Haliaeetus leucocephalus*	Piscivorous bird

Several amphibian and reptile species have been identified as being potentially present within the PDA (Section 8.6.2). In order to perform a quantitative ERA, appropriate toxicological data must be available. However, there is a general lack of appropriate toxicological data for amphibians and reptiles. As per ERA guidance (Environment Canada 2010; USEPA 2011), amphibians and reptiles were assessed using a surrogate receptor approach (*i.e.,* if no unacceptable risk is present for fish and other aquatic life, or for mammals and birds, then it is assumed that there is also no unacceptable risk present for amphibian or reptilian receptors).

7.7.4.2 Ecological Receptor Profiles

7.7.4.2.1 Masked Shrew

The masked shrew (*Sorex cinereus*) is the most widely distributed shrew in North America, and is found throughout most of Canada (Lee 2001). It is common in moist environments and is found in open and closed forests, meadows, riverbanks, lakeshores, and willow thickets (Lee 2001). Home range sizes are 0.2 to 0.6 ha (Saunders 1988). Masked shrews, which weigh approximately 5 g (U.S. EPA 1993), are prey to many small predators such as weasels, hawks, falcons, owls, domestic cats, foxes, snakes, and short-tailed shrews (Lee 2001). The masked shrew does not hibernate (NWF 2007), but feeds year-round on invertebrates (Lee 2001; NWF 2007), including insect larvae, ants, beetles, crickets, grasshoppers, spiders, harvestmen, centipedes, slugs, and snails. It will also consume seeds and fungi (Lee 2001). It consumes approximately 3 g (wet weight) of food per day, and 1 mL of water (or its equivalent) per day. The masked shrew's diet is modelled as including 2.5% terrestrial plant material and 97.5% invertebrates. Based on its consumption of these foods, the masked shrew is estimated to incidentally ingest about 0.044 g/day of dry soil.

7.7.4.2.2 Meadow Vole

The meadow vole (*Microtus pennsylvanicus*) is a small rodent (approximately 42 g) which makes its burrows along surface runways in grasses or other herbaceous vegetation (USEPA 1993). It is active year-round and is the most widely distributed small grazing herbivore in North America, inhabiting moist to wet habitats including grassy fields, marshes, and bogs (USEPA 1993). Meadow voles are found throughout Canada, roughly to the limit of the tree line in the north. Home ranges vary considerably, from less than 0.0002 ha to greater than 0.083 ha (USEPA 1993). Meadow voles are a major prey item for predators such as hawks and foxes, and they feed primarily on vegetation such as grasses, leaves, sedges, seeds, roots, bark, fruits, and fungi, but will occasionally feed on insects and animal matter (USEPA 1993; Neuburger 1999). It consumes approximately 11 g (wet weight) of food per day and 6 mL of water (or its equivalent) per day. The meadow vole's diet is modelled as including 98% terrestrial plant material and 2% invertebrates. Based on its consumption of these foods, the meadow vole is estimated to incidentally ingest approximately 0.32 g/day of dry soil.

7.7.4.2.3 Snowshoe Hare

The snowshoe hare (*Lepus americanus*) is an herbivore weighing approximately 1.35 kg (USEPA 1993), which is found throughout Canada in every province and territory (CWS & CWF 2005a). The snowshoe hare tends to inhabit forests, swamps, and riverside thickets (USEPA 1993). Home ranges vary from 3 ha to 7 ha (Shefferly 1999). A frequent prey item, the snowshoe hare may be a keystone species in boreal forests, maintaining food webs (CWS & CWF 2005a). Active year-round, it feeds on herbaceous plants and leaves from shrubs in summer, and small twigs, buds, and bark in winter; it will eat meat occasionally, if available (CWS & CWF 2005a). The snowshoe hare consumes approximately 0.26 kg of wet weight food per day and 0.13 L of water (or its equivalent) per day. The snowshoe hare's diet is modelled as including 95% terrestrial plant material and 5% small mammal or bird carrion. Based on its consumption of these foods, the snowshoe hare is estimated to incidentally ingest 3.58 g/day of dry soil.

7.7.4.2.4 Red Fox

The red fox (*Vulpes vulpes*), which weighs approximately 4.5 kg, is found throughout continental Canada and is the most widely distributed carnivore in the world (USEPA 1993). It is found in habitats as diverse as the Arctic and the temperate desert, and prefers areas with broken and diverse upland habitats (USEPA 1993). Family territories, which consist of home ranges of individuals from the same family, vary from approximately 57 ha to more than 3,000 ha (USEPA 1993). Foxes are active year-round and prey heavily on small mammals such as voles, mice and rabbits, and will also consume birds, insects, fruits, berries, and nuts; they are also noted scavengers (USEPA 1993). Red foxes consume approximately 0.76 kg (wet weight) of food per day and 0.38 L of water (or its equivalent) per day. The red fox's diet is modelled as including 10%

terrestrial plant material, 5% invertebrates, and 85% small mammal and bird prey. Based on its consumption of these foods, the red fox is estimated to incidentally ingest approximately 3 g/day of dry soil.

7.7.4.2.5 American Mink

The mink (*Mustela vison*), which weighs approximately 0.85 kg, is a small member of the weasel family and is the most abundant and widely distributed carnivorous mammal in North America (USEPA 1993). Mink are found throughout the continental portion of Canada, including Newfoundland, except in the most barren portions of northwestern Quebec, and eastern Nunavut. Minks are active year round and are associated with aquatic habitats such as rivers, streams, lakes, ditches, swamps, marshes, and backwater areas (USEPA 1993). Home ranges vary considerably but are in the range of 7.8 to 380 ha (USEPA 1993). Feeding extensively on small mammals, fish, amphibians, and crustaceans, as well as birds, reptiles, and insects depending on the season (USEPA 1993), mink consume approximately 0.22 kg of wet weight food per day and 0.09 L of water (or its equivalent) per day. The mink's diet comprises mainly small mammals or birds, as well as freshwater fish and benthic invertebrates. For this ERA, the mink’s diet is assumed to comprise solely freshwater fish.

7.7.4.2.6 Moose

In Canada, moose (*Alces alces*) can be found inhabiting forests from the Alaskan boundary to the eastern tip of Newfoundland and Labrador (CWS & CWF 1997). Their geographic distribution follows, but is not confined to, the boundaries of the boreal forest. Moose are highly dimorphic between sexes, with cows weighing much less than bulls. The average body weight (for both sexes) is 435 kg, although bulls of the northern sub-species, *A. A. gigans*, can weigh as much as 800 kg (Dewey *et al.* 2000; NWF 2007; CWS & CWF 1997). Although seasonal home ranges are surprisingly small for a large herbivorous animal (500 to 1,000 ha), annual home ranges can be up to 4,000 ha or more depending on habitat and food availability (BC MOE 2000; Lawson & Rodgers 1997 in NaturServe 2006). Seasonal migration usually follows an elevational gradient, as moose seek higher grounds in summer and lower elevations in winter. Moose are entirely herbivorous, consuming an estimated 18.6 kg/day (wet weight) of food, comprised of a mixture of terrestrial and aquatic vegetation. The name “Moose” is derived from an Algonkian term meaning “eater of twigs”, and this appropriately reflected in their diet (Yukon DOE 2006). In winter, the diet consists primarily of confer and hardwood twigs and shrubs (CWS & CWF 1997; NatureServe 2006; Dewey *et al.* 2000). The summer diet is more variable, consisting of leaves, twigs, bark, roots, and shoots of woody plants, as well as some grasses. Additionally, a considerable portion of the summer diet is aquatic vegetation (*e.g.,* lilies, pondweed, *etc.*), which moose will occasionally dive underwater to retrieve (CWS & CWF 1997; NatureServe 2006; Dewey *et al.* 2000). Based on its consumption of these foods, the moose is estimated to incidentally ingest 0.14 kg/day of dry soil and 0.11 kg/day dry sediment. Water Intake is estimated to be approximately 23.5 L/day.

7.7.4.2.7 Black Bear

The American black bear (*Ursus americanus*) is smaller than the grizzly bear (*Ursus arctos*) or the polar bear (*Ursus maritimus*), weighing approximately 68 kg (Eder and Pattie 2001). Found throughout most of Canada (with the exception of the Arctic and southern portions of the prairies and Ontario), black bears prefer heavily wooded areas and dense bushland (CWS & CWF 2007). Not a true hibernator, the black bear enters its den in October to December and emerges in March to early May (Kronk 2007). Average home range sizes are approximately 1,000 to 4,000 ha for females and often more than 10,000 ha for males (CWS & CWF 2007). Although black bears will eat almost anything, their diets rely heavily on vegetation, consisting of berries and nuts, as well as insects such as ants which are also a favorite (CWS & CWF 2007). When available, they will supplement their diet with newborn ungulates, small mammals and birds, as well as fish (CWS & CWF 2007). Black bears consume approximately 14.0 kg of wet weight food per day and 4.1 L of water or its equivalent per day.

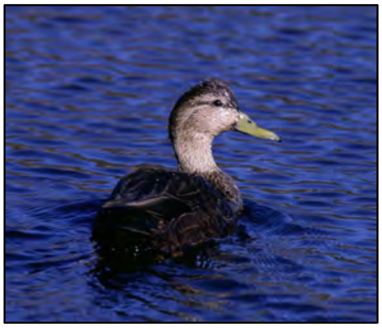
7.7.4.2.8 American Robin

The American robin (*Turdus migratorius*) is a medium-sized bird weighing approximately 80 g (USEPA 1993) that occurs throughout most of Canada during the breeding season and overwinters in mild areas of Canada (CWS & CWF 2005b). Access to fresh water, protected breeding habitat, and foraging areas are important to the American robin. Breeding habitat includes moist forest, swamps, open woodlands, orchards, parks, and lawns (USEPA 1993), and the American robin is well adapted to urban living, as well as having a summer range that extends up to the tundra. Foraging home range sizes (for fruit, earthworms, and insects) are approximately 0.15 to 0.81 ha (USEPA 1993). The American robin consumes approximately 65 g (wet weight) of food per day and 10 mL of water (or its equivalent) per day. The American robin diet is modelled as including 52.3% terrestrial plant material and 47.8% soil invertebrates. Based on its consumption of these foods, the American robin is estimated to incidentally ingest 0.49 g/day of dry soil.

7.7.4.2.9 Red-tailed Hawk

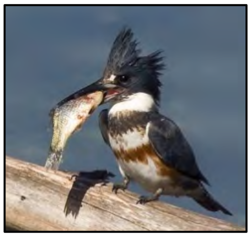
The red-tailed hawk (*Buteo jamaicensis*) is the most common and widespread hawk in North America (Cornell Lab of Ornithology 2003). The red-tailed hawk weighs approximately 1.1 kg (USEPA 1993). It breeds throughout southern Canada except in Newfoundland (Tufts 1986), where a similar niche is occupied by the short-eared owl. Northern populations of the red-tailed hawk are migratory, while populations from southern Canada may be year-round residents (USEPA 1993; Cornell Lab of Ornithology 2003). They are typically found in open areas with scattered, elevated perches in a wide range of habitats including scrub deserts, plains and montane grasslands, agricultural fields, pastures, urban parks, patchy coniferous and deciduous woodlands, and tropical rainforests (Arnold and Dewey 2002). Red-tailed hawks prefer a mixed landscape containing old fields, wetlands, and pastures for foraging, interspersed with groves of woodland, bluffs, or streamside trees for perching and breeding (USEPA 1993). Red-tailed hawk's home ranges vary in size from approximately 60 ha to greater than 2,400 ha, depending on the habitat (USEPA 1993, Arnold and Dewey 2002). They generally hunt from an elevated perch, foraging primarily (approximately 80 to 85% of diet) on small rodents such as mice, voles, shrews, rabbits, and squirrels, as well as birds and reptiles (Arnold and Dewey 2002). They consume approximately 190 g (wet weight) of food per day and 60 mL of water (or its equivalent) per day. The red-tailed hawk diet is modelled as including 100 percent terrestrial mammals. Based on its consumption of these foods, the red-tailed hawk is estimated to incidentally ingest approximately 0.66 g/day of dry soil.

7.7.4.2.10 American Black Duck



The American black duck (*Anas rubripes*) is found in wooded parts of northeastern and north central North America (*i.e.,* from Manitoba east in Canada), nesting near woodland lakes and streams, or in freshwater and tidal marshes (USEPA 1993). Although all ducks tend to return to the same feeding grounds every year, this tendency is most pronounced in the American black duck (CWS & CWF 1980). The American black duck weighs approximately 1.16 kg. Home range sizes for the American black duck are similar in size to the mallard duck using the same habitat varying in size from approximately 40 ha to 1,400 ha (USEPA 1993). The American black duck feeds primarily on aquatic invertebrates as ducklings and adults during the breeding season and on aquatic and terrestrial plants during the nonbreeding season (CWS & CWF 1980). Breeding females consume approximately 0.61 kg of wet weight food per day and 0.07 L of water (or its equivalent) per day. The duck's diet is modelled as including 12.5% terrestrial plant material, 12.5% aquatic plant material, and 75% benthic invertebrates. Based on its consumption of these foods, the duck is estimated to incidentally ingest 0.438 g/day of dry soil, and 12.4 g/day of dry sediment.

7.7.4.2.11 Belted Kingfisher



The belted kingfisher (*Ceryle alcyon*) occurs throughout southern Canada (as far north as James Bay, across the northern portions of the Prairie Provinces, into the Yukon in the west, and into northern Quebec and southern Labrador in the east). Belted kingfishers are typically found along rivers and streams, lake and pond edges, or on seacoasts and estuaries (USEPA 1993). They usually nest in burrows in a steep bank, preferably near water, and the tunnels may extend as far as 5 m before ending in a nest chamber. The belted kingfisher weighs approximately 0.15 kg. Foraging territory sizes range from approximately 2 ha to greater than 10 ha (assuming a watercourse width of 50 m), depending on the season (USEPA 1993). Feeding primarily on fish, they prefer stream riffles and waters that are free from thick vegetation in order to see their prey (USEPA 1993). Belted kingfisher will also consume aquatic invertebrates, insects, mammals, birds, reptiles and amphibians (USEPA 1993). They consume approximately 0.06 kg of wet weight food per day and 0.02 L of water (or its equivalent) per day. For this ERA, the belted kingfisher's diet is assumed to comprise solely freshwater fish.

7.7.4.2.12 Ruffed Grouse

The Ruffed Grouse (*Bonasa umbellus*) is frequently called the "partridge." The Ruffed grouse lives in treed areas, usually where birch and poplar are present (Centre d'Expertise en Analyse Environnementale du Quebec 2005). The approximate weight of a ruffed grouse is 500 g (Centre d'Expertise en Analyse Environnementale du Québec 2005; CWS & CWF 1986). Male ruffed grouse are larger than the females (males 500 to 750 g; females 450 to 600 g) (CWS & CWF 1986). It is difficult to determine if a grouse is male or female at a distance, but males are larger with larger ruffs and a longer tail. Ruffed grouse do not migrate and once established in an area, live all their life within a few hectares. During winter months, ruffed grouse burrow into the snow to protect themselves from the cold and predators. If the snow is deep and soft, the ruffed grouse can walk across the snow with the help of their "snowshoes", which are lateral extensions of the scales of the toes (CWS & CWF 1986). The home range of a ruffed grouse is approximately 2.1 ha. The ruffed grouse spend most of their lives on the ground and are mainly herbivorous, foraging on buds, leaves, twigs. In the winter, catkins and the buds of broad-leaved trees such as poplars, birch, and alders are the preferred food source. Ruffed grouse chicks will also feed on insects when they are available (CWS & CWF 1986). Ruffed grouse are estimated to consume approximately 65 g (wet weight) of food per day (Nagy 1987) and 37 mL of water (Calder and Braun 1983) (or its equivalent) per day. The grouse's diet is modelled as including 99.6% terrestrial plant material and 0.4% soil invertebrates. Based on its consumption of these foods, the ruffed grouse is estimated to incidentally ingest approximately 0.11 g/day of dry soil.

7.7.4.2.13 Bald Eagle

The bald eagle is the second largest bird of prey found in North America, and the largest found in Canada (CWS & CWF 1992). Adult birds are readily identified by their striking appearance, characterized by dark brown body plumage contrasting sharply with white head and tail plumage (Buehler 2000). The bald eagle is restricted in range entirely to North America, where it prefers sea coasts, lake shores, or riverine habitat possessing suitable nesting trees in which to breed. Female bald eagles are larger than males by up to 25%, and birds from northern latitudes (Canada and Alaska) are larger than their counterparts in the southeastern and southwestern United States (Buehler 2000). The typical body mass of the bald eagle ranges from 3,000 to 6,300 g (Palmer *et al.* 1988 in Buehler 2000), although masses of 7,000 g have been recorded (CWS & CWF 1992). Immature eagles grow rapidly owing to a voracious appetite. Bald eagles are opportunistic feeders, taking live prey when available but preferring to scavenge carrion or pirate freshly killed prey from other predators (CWS & CWF 1992; USEPA 1993). Their preferred food items include fish, aquatic birds, and mammals; however choice of prey is site-specific and may vary widely across their range (Buehler 2000). Adult birds are more likely to hunt and kill food items whereas immature birds are more prone to obtaining food through scavenging and piracy (CWS & CWF 1992). Bald eagles are modelled as consuming 45% terrestrial vertebrates (mammals and birds) and 55% freshwater fish. The bald eagle consumes 0.649 kg of wet weight food per day and 0.162 L of fresh water per day, and ingests 0.0879 g of soil and 1.02 g of sediment per day.

7.7.4.2.14 Soil Invertebrates and Terrestrial Plants

For soil invertebrates and terrestrial plants, it is more appropriate to assess potential risk at the community level (*i.e.*, all terrestrial plants living in a contaminated area), than to consider individual species. As shown in the conceptual site model (Figure 7.7.5), the primary exposure pathway to COPCs for these key indicators is from direct contact with soil. The toxicity of COPCs in this medium is of principal importance when assessing the potential risks to these key indicators. Therefore, toxicity benchmarks are commonly derived which relate COPC concentrations in various media to adverse effects thresholds for organisms that reside or rely on that medium. Additionally, these benchmarks are typically generated using toxicity data for not one, but several species that rely on that medium. They are intended to represent a COPC concentration that will be protective of species associated with that medium (*i.e.*, the soil invertebrate community).

7.7.4.2.15 Benthic Invertebrates

Similarly as for the terrestrial community, it is more appropriate to assess potential risk to benthic invertebrates at the community level (*i.e.*, all terrestrial plants living in a contaminated area), than to consider individual species. As shown in the conceptual site model (Figure 7.7.5), the primary exposure pathway to COPCs for these key indicators is from direct contact with sediment. Sediment concentrations were compared to the available Canadian Sediment Quality Guidelines for the Protection of Aquatic Life probable effect levels which are generated using toxicity data for a range of benthic invertebrates.

7.7.4.3 Ecological Receptor Locations

Forty-six terrestrial receptor locations were selected to be assessed in the ERA, based on a 2 km x 2 km grid distributed across the Project site. The receptor locations were selected to include areas of anticipated high dust deposition, as well as providing a gradient to background conditions. Of the forty-six receptor locations, twenty-seven were considered to contain only terrestrial habitat, whereas nineteen were traversed by watercourses, of which some portions will be exposed to mine effluent or to seepage from the tailings storage facility. Therefore, those nineteen receptor locations were modelled as including aquatic receptor locations, in addition to terrestrial receptor locations. The aquatic receptor locations include fifteen sites on West Branch Napadogan Brook or its tributaries upstream and downstream of the PDA, and four locations on McBean Brook downstream of the PDA.

7.7.4.3.1 Exposure Pathway Screening

Contaminant transport and exposure pathways are used to describe the movement of COPCs from a release point or source (*e.g.,* ore dust released by mining activity, and mine effluent or other releases to watercourses) to the eventual point of contact with key indicators (*e.g.,* direct exposure or ingestion). The exposure pathway screening incorporates information about Project-related COPC releases, activities in the area, receptor characteristics, and the exposure pathways. For this ERA, it is assumed that ecological receptors can be exposed to contaminants in the environment by:

- direct contact with contaminated soil or water;

- ingestion of soil and water (*e.g.,* as a result of foraging, drinking, or grooming); and/or
- ingestion of foods that have accumulated COPCs from soil or other media.

Identifying the potential exposure pathways involves consideration of several factors including the life history traits of each key indicator (*e.g.*, habitat, diet), features of the mine site (*e.g.*, biota, habitat suitability), and environmental fate and transport properties of each COPC. A summary of potential exposure pathways for ecological receptors and the rationale for inclusion or exclusion from this ERA is shown in Table 7.7.36.

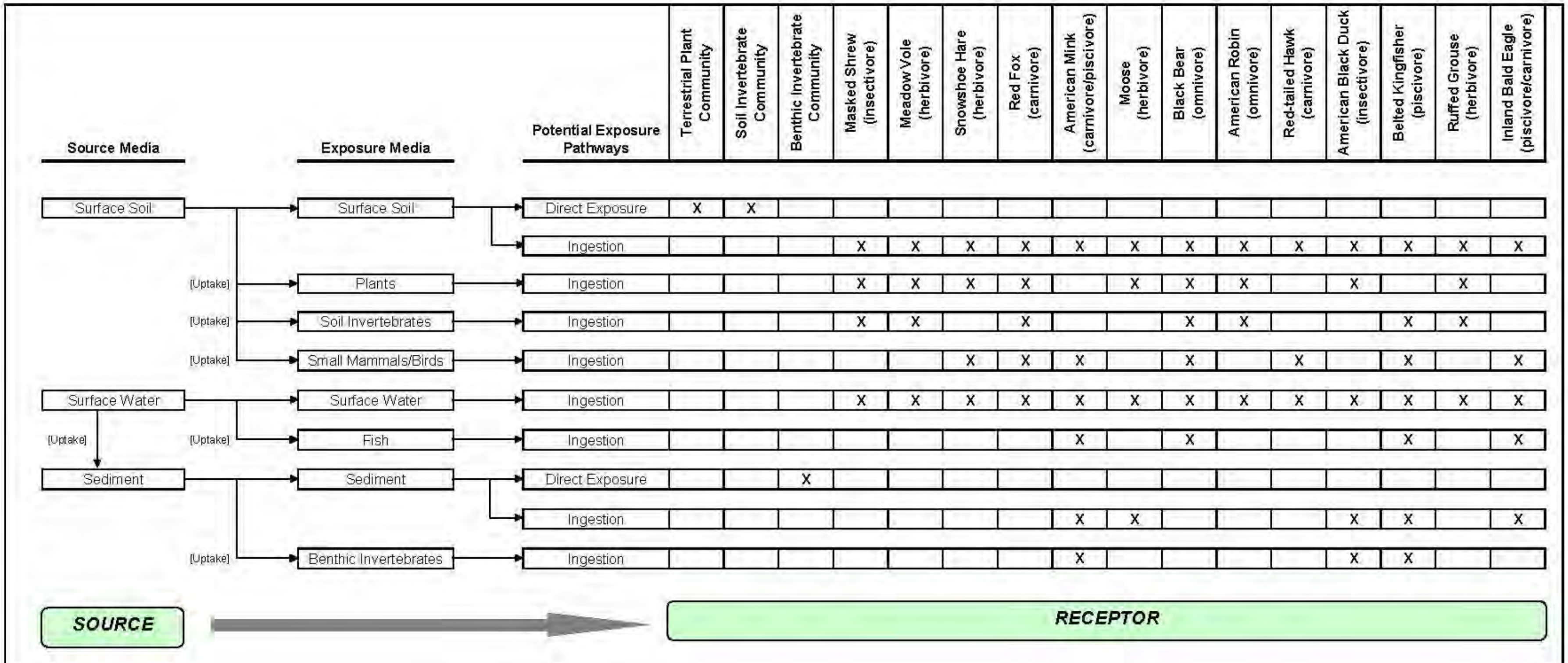
Table 7.7.36 Rationale for Exposure Pathway Inclusion in the ERA

Exposure Pathway	Included in the ERA?	Rationale
Soil Ingestion	Yes	Ecological receptors may ingest soil containing COPCs directly or indirectly as a result of consuming food items. Soil or dust may also be ingested as a result of grooming activity, nest or den construction and maintenance, or as a consequence of inhalation, if dust particles inhaled into the lung are coughed up and swallowed. Ingestion of soil, therefore, constitutes a potential source of exposure to mammalian and avian receptors.
Direct Contact with Soil	Yes	Direct contact with soil is the primary exposure pathway for soil invertebrates and plants. Direct (dermal) contact with soil could be a potential pathway for absorption of COPC by mammals and birds. It is not, however, expected to represent a major source of exposure for most mammalian and avian receptors due to the protection afforded by fur or feathers, which will significantly reduce soil contact with skin (Sample and Suter 1994). Soil adhering to fur and feathers may be ingested during grooming activity; however, this is captured as a component of incidental soil ingestion estimates.
Inhalation	No	Ecological receptors may be exposed to COPCs via inhalation of dust. However, this exposure pathway is believed to represent a relatively minor component of overall exposure. Toxicological dose/response models for inhaled COPCs are not necessarily the same as for ingested COPCs, and toxicological data to support the evaluation of inhalation as an exposure mechanism are generally lacking. Therefore, inhalation is not considered further in this ERA.
Ingestion of Foods from the Terrestrial Environment	Yes	The consumption of contaminated foods such as terrestrial plants, soil invertebrates, small mammals, birds or fish can be a source of exposure for mammalian and avian receptors.
Surface Water Ingestion	Yes	Ecological receptors may be exposed to COPCs present in surface water if they drink from these sources.
Ingestion of Foods from the Aquatic Environment	Yes	Some mammalian and avian receptors may consume foods (*e.g.*, fish) derived from the aquatic environment. Since the aquatic systems within and adjacent to the PDA are predominantly high- to medium-gradient streams, emphasis is placed on fish, rather than aquatic plants.
Direct Contact with Surface Water	No	Aquatic receptors (*e.g.*, fish, aquatic plants, and aquatic invertebrates) are addressed through the environmental effects assessment of the Aquatic Environment (Section 8.5), and are therefore not included in this ERA. This consideration is also assumed to extend to amphibians, which have an aquatic larval stage. For mammalian and avian receptors, direct contact with surface water is assumed to be a minor exposure pathway in comparison with direct ingestion of water, and ingestion of foods (*e.g.*, fish) from the aquatic environment.

Table 7.7.36 Rationale for Exposure Pathway Inclusion in the ERA

Exposure Pathway	Included in the ERA?	Rationale
Ingestion of Sediment	Yes	Ecological receptors may ingest sediment containing COPCs directly or indirectly as a result of consuming food items. Sediment may also be ingested as a result of grooming activity, nest or den construction and maintenance. Ingestion of sediment, therefore, constitutes a potential source of exposure to mammalian and avian receptors.
Ingestion of Foods from the Benthic Environment	Yes	Some mammalian and avian receptors may consume foods (*e.g.*, benthic invertebrates) derived from the benthic environment, therefore, this pathway was considered in the ERA.
Direct Contact with Sediment	Yes	Direct contact with sediment is the primary exposure pathway for benthic invertebrates. For mammalian and avian receptors, direct contact with sediment is assumed to be a minor exposure pathway in comparison with direct ingestion of sediment, and ingestion of foods (*e.g.*, fish) from the benthic environment.

The conceptual site model developed for this site, presented schematically in Figure 7.7.5, represents the interactions between the receptors and the COPCs, via the identified exposure pathways. In Figure 7.7.5, the relevant exposure pathways are designated by arrows leading from the contaminant source media to each receptor. The pathway is considered to be complete (*i.e.,* functioning) for a receptor when the exposure pathway box is marked with an “X”.



Source Media	Exposure Media	Potential Exposure Pathways	Terrestrial Plant Community	Soil Invertebrate Community	Benthic Invertebrate Community	Masked Shrew (insectivore)	Meadow Vole (herbivore)	Snowshoe Hare (herbivore)	Red Fox (carnivore)	American Mink (carnivore/piscivore)	Moose (herbivore)	Black Bear (omnivore)	American Robin (omnivore)	Red-tailed Hawk (carnivore)	American Black Duck (insectivore)	Belted Kingfisher (piscivore)	Ruffed Grouse (herbivore)	Inland Bald Eagle (piscivore/carnivore)
Surface Soil	Surface Soil	Direct Exposure	X	X														
		Ingestion				X	X	X	X	X	X	X	X	X	X	X	X	X
[Uptake]	Plants	Ingestion				X	X	X	X		X	X	X		X		X	
[Uptake]	Soil Invertebrates	Ingestion				X	X		X			X	X			X	X	
[Uptake]	Small Mammals/Birds	Ingestion						X	X	X		X		X		X		X
Surface Water	Surface Water	Ingestion				X	X	X	X	X	X	X	X	X	X	X	X	X
[Uptake]	Fish	Ingestion								X		X				X		X
Sediment	Sediment	Direct Exposure			X													
		Ingestion								X	X				X	X		X
[Uptake]	Benthic Invertebrates	Ingestion								X					X	X		

Note:
1) **X** - Indicates a potentially complete exposure pathway.
2) Aquatic Plants are not considered since these are of limited quantity in the study area. Birds and mammals are assumed to replace this portion of their diet with terrestrial plants.

Figure 7.7.5 Conceptual Site Model for Ecological Receptors

7.7.4.4 Exposure Assessment

The objective of the exposure assessment is to develop a quantitative estimate of the exposure of each key indicator to each COPC, based on empirical or modelled data.

7.7.4.4.1 Calculation of Average Daily Dose

In order to conduct a risk assessment, it is necessary to estimate the amount of a COPC a receptor organism might be exposed to on a mg/kg body weight/day basis (referred to as the average daily dose, or ADD). For each receptor, the ADD was calculated for each COPC by considering the intake from all applicable exposure pathways (*e.g.,* ingestion of water, soil, vegetation, soil invertebrates, small mammals, fish, sediment, and/or benthic invertebrates, as appropriate). For this ERA, it is conservatively assumed that all of an ingested quantity of COPC will be absorbed across the gut and enter the bloodstream of the receptor organism, and therefore the absorption factor (AF, unitless) has a default value of 1.0. The generalized form for ADD is as follows:

$$ADD_i = IF \text{ X } AF_i \text{ X } EPC_i$$

where:

ADD_i = Average daily dose for COPC *i* (mg COPC/kg body weight/day);

IF = Intake factor (kg medium/kg body weight/day);

AF_i = Absorption factor for COPC *i* (conservatively set at 1.0 which assumes that 100% of the COPC is absorbed; unitless); and

EPC_i = Exposure point concentration for COPC *i* (mg COPC/kg medium).

The IF is calculated for each exposure pathway using the media-specific ingestion rate (IR) appropriate to each receptor. The IF is also a function of the fraction of time each receptor spends at the site (f_{Site}), which was conservatively set at 1.0 for this ERA which assumes that receptor spends 100% of their time within the PDA, and a function of the receptor's body weight (BW), as follows:

$$IF = (IR \times f_{Site})/BW$$

The total ADD value for each receptor organism is then the sum of the individual ADD_i values representing its various exposure pathways.

7.7.4.5 Hazard Assessment

The hazard assessment (also known as a toxicity assessment) is the process by which the potential toxicity of each COPC is determined. The toxicity of a contaminant (*i.e.,* its ability to harm or cause damage to the functioning of the receptor) is an inherent property of the contaminant itself, although subject to potential modifying factors. Toxicity is usually evaluated by administering measured doses of a contaminant to a test organism. One modifying factor is the fraction of the dose that is absorbed, and toxicity studies usually address this by administering doses in a way, or using a particular contaminant form, that results in maximum absorption.

Chemical interactions can also modify toxicity, and contaminant mixtures may interact in four general ways to elicit a response:

- **Non-interacting –** contaminants do not produce a response in combination with each other; the toxicity of the mixture is the same as the toxicity of the most toxic component of the mixture;
- **Additive –** contaminants have similar targets and modes of action but do not interact, the hazard for exposure to the mixture is simply the sum of hazards for the individual contaminants;
- **Synergistic –** there is a positive interaction among the contaminants such that the response is greater than would be expected if the contaminants acted independently or in an additive manner; or
- **Antagonistic –** there is a negative interaction among the contaminants such that the response is less than would be expected if the contaminants acted independently or in an additive manner.

There are contaminant classes that have similar modes of action and target organs, and in these cases, a more appropriate characterization of risk is achieved by summing the RQ for each compound. The COPCs evaluated in this ERA are mainly trace metals. Few data are available to describe the toxicity of metal mixtures. Therefore, contaminant mixtures were not considered in this ERA, and the potential toxicity of each COPC is evaluated in isolation. This approach has been accepted in previous assessments by various provincial jurisdictions and Environment Canada.

7.7.4.6 Toxicological Reference Values

The amount of a substance that can be tolerated, below which adverse effects are not expected to be observed, is referred to as the toxicological reference value (TRV). The toxicological database in support of a TRV ideally includes a number of chronic or multi-generational exposure studies involving exposure of relevant test species (*i.e.,* the ecological receptor of interest or a phylogenetically similar species (*i.e.,* species of similar evolutionary relationships)) to appropriate contaminant forms of the substance of interest. Ideally, one or more relevant biological endpoints such as growth, reproductive effects, or survival would be measured in the study. Databases that meet this requirement are available for some contaminants, but in most cases, available toxicity data are limited to studies conducted with laboratory or domesticated animals (*e.g.,* mammals: mice, rats, rabbits; birds: quail, chicken, and ducks).

Toxicity reference values for this ERA are based on dose response studies, typically conducted with laboratory animals where the lowest observed adverse effects level (LOAEL) or no observed adverse effects level (NOAEL) has been quantified. The continued use of the LOAEL and NOAEL in toxicology has recently been criticized, and it is true that these measures can be influenced by methodological decisions (*e.g.,* the selection of specific concentrations and exposure sequences during study design). However, it remains that most available toxicity studies were conducted in an era when these were preferred endpoints, and such studies dominate the available literature. In addition, TRVs used in this ERA were determined from studies in which endpoints were derived from the administered doses, rather than the absorbed doses. This is a conservative approach because compounds are often administered in a more available form than would be found in the environment.

The preferred toxicity measure used for derivation of TRVs in this ERA is the LOAEL; however, in the absence of a suitable LOAEL, NOAEL-based TRVs were used. The LOAEL identifies the lowest exposure concentration or dose level at which some adverse effect was observed, and can therefore be considered a threshold for the onset of effects that could affect individual organisms (but not necessarily populations). Generally, LOAELs used towards TRV derivation are based on long-term growth or survival, or sub-lethal reproductive effects determined from chronic exposure studies. As such, these endpoints are relevant to the maintenance of wildlife populations. The LOAEL represents a threshold dose at which adverse outcomes are likely to become evident (Sample *et al.* 1996). This threshold is considered an appropriate endpoint for ERA since TRVs are used as the denominator in the risk quotient (RQ) calculation, and RQ values equal to or greater than 1.0 may be considered indicative of potential adverse environmental effects on ecological receptors.

Risk quotients calculated with NOAEL-based TRVs are more conservative since NOAELs relate to the threshold at which no individual effects from COPC exposure are observed. NOAEL-based TRVs can be used to provide a higher level of protection, as in the case where an endangered species is under evaluation, and affects at an individual level would be unacceptable.

Numerous sources were reviewed to obtain the most relevant TRVs for ecological receptors. Information sources included, but were not limited to:

- CCME Environmental Quality Guidelines; (CCME 1999 and updates);
- USEPA Ecological Soil Screening Level (Eco-SSL) documents;
- Oak Ridge National Laboratory Toxicity Benchmarks for Wildlife (Sample *et al.* 1996);
- Agency for Toxic Substances and Disease Registry (ATSDR) toxicity profiles;
- *Canadian Environmental Protection Act* (CEPA), Priority Substance List Assessment Reports; and
- Primary scientific literature.

7.7.4.7 Ecological Risk Characterization

The potential for adverse environmental effects on mammalian and avian receptors is quantified by comparing the amount of a substance that can be tolerated, below which adverse environmental effects are not expected (*i.e.*, the TRV) with the amount of a COPC an organism is expected to be exposed to on a daily basis (*i.e.,* the ADD). The quotient of the two (the risk quotient, or RQ) is used to make inferences about the possibility of ecological risks. The RQ is calculated as follows:

$$RQ = ADD/TRV.$$

When the ADD is less than the TRV associated with a potential for adverse environmental effects, the RQ value is less than 1.0. As such, RQ values less than 1.0 are taken to indicate that there is a negligible probability of adverse environmental effects occurring to ecological receptors. Where RQ values are greater than 1.0, there is a possibility (but not a certainty) of adverse environmental effects to ecological receptors. Such cases require a careful review of both predicted exposure levels and

TRV derivations, and more focused investigations may be required to reduce conservatism in the assessment to provide a more accurate assessment of the actual level of risk. If it is ultimately determined that the RQ is indicating unacceptable risk, then mitigation or remediation activities may be appropriate in order to reduce risks to ecological receptors.

The maximum risk quotients for mammalian and avian receptors are summarized in Tables 7.7.37 through 7.7.49. Maximum risk quotients presented in these tables correspond to the maximum values encountered and may not represent co-occurring values at the same location. COPCs demonstrating risk quotients higher than 1.0 are also presented spatially in Figures to 7.7.6 to 7.7.12.

For ease in interpreting Figures 7.7.6 to 7.7.12, grid squares in each figure correspond to grid squares as established in Figure 7.7.3. A particular grid square is identified by a letter and a number, corresponding to the letter on the x-axis of Figure 7.7.3 and the number on the y-axis of Figure 7.7.3 (*e.g.,* "Grid G8"). The grid squares are colour coded for quick identification of the resulting Risk Quotient (RQ) for that particular species in the grid square, with a green square corresponding to an RQ<1.0 and a red square corresponding to an RQ>1.0. Grey and white grid squares indicate that risk was not calculated for those particular grid squares either because there were no soil samples (grey squares) or, for the case of a semi-aquatic receptor, there is no watercourse at that location (white squares).

7.7.4.7.1 Risk Characterization for Terrestrial Ecological Receptors

Maximum risk quotients for terrestrial mammals (*i.e.,* masked shrew, meadow vole, snowshoe hare, red fox, moose and bear, Tables 7.7.37 to 7.7.42) were generally less than 1.0, with the exception of the masked shrew exposed to arsenic, copper, manganese and zinc for both the Baseline Case and Project + Baseline Case and the meadow vole exposed to arsenic for both the Baseline Case and Project + Baseline Case.

Table 7.7.37 Maximum Overall Risk Quotients for the Masked Shrew

COPC	Maximum Overall Risk Quotient (RQ, dimensionless)		
	Masked Shrew		
	Baseline Case	Project Alone Case	Project + Baseline Case
Aluminum (Al)	0.15	6.7E-04	0.15
Arsenic (As)	**2.9**	0.020	**2.9**
Boron (B)	0.012	1.6E-03	0.013
Chromium (total) (Cr)	0.26	7.0E-04	0.26
Cobalt (Co)	0.091	8.1E-05	0.091
Copper (Cu)	**1.63**	1.4E-03	**1.63**
Lead (Pb)	0.099	7.6E-06	0.099
Manganese (Mn)	**1.0**	1.4E-03	**1.0**
Mercury (Hg)	0.047	2.7E-06	0.047
Molybdenum (Mo)	0.099	4.3E-03	0.099
Nickel (Ni)	0.66	1.3E-03	0.66
Thallium (Tl)	0.088	4.5E-04	0.088
Tungsten (W)	0.047	7.2E-03	0.048

Table 7.7.37 Maximum Overall Risk Quotients for the Masked Shrew

COPC	Maximum Overall Risk Quotient (RQ, dimensionless)		
	Masked Shrew		
	Baseline Case	Project Alone Case	Project + Baseline Case
Uranium (U)	7.4E-03	1.5E-04	7.4E-03
Vanadium (V)	0.79	4.2E-03	0.79
Zinc (Zn)	**1.1**	8.9E-05	**1.1**

Notes:
Bold indicates that value exceeds the RQ target (1.0).

Table 7.7.38 Maximum Overall Risk Quotients for the Meadow Vole

COPC	Maximum Overall Risk Quotient (RQ, dimensionless)		
	Meadow Vole		
	Baseline Case	Project Alone Case	Project + Baseline Case
Aluminum (Al)	0.033	5.2E-04	0.033
Arsenic (As)	**1.4**	0.014	**1.4**
Boron (B)	5.3E-03	1.2E-03	6.2E-03
Chromium (total) (Cr)	0.15	5.0E-04	0.15
Cobalt (Co)	0.026	5.8E-05	0.026
Copper (Cu)	0.31	9.9E-04	0.31
Lead (Pb)	0.012	5.4E-06	0.012
Manganese (Mn)	0.24	1.0E-03	0.24
Mercury (Hg)	6.9E-03	1.9E-06	6.9E-03
Molybdenum (Mo)	0.080	3.4E-03	0.080
Nickel (Ni)	0.44	9.4E-04	0.44
Thallium (Tl)	0.016	3.2E-04	0.016
Tungsten (W)	0.037	5.2E-03	0.037
Uranium (U)	4.4E-03	1.2E-04	4.4E-03
Vanadium (V)	0.53	3.0E-03	0.53
Zinc (Zn)	0.063	6.3E-05	0.063

Notes:
Bold indicates that value exceeds the RQ target (1.0).

Table 7.7.39 Maximum Overall Risk Quotients for the Snowshoe Hare

COPC	Maximum Overall Risk Quotient (RQ, dimensionless)		
	Snowshoe Hare		
	Baseline Case	Project Alone Case	Project + Baseline Case
Aluminum (Al)	0.033	8.3E-04	0.033
Arsenic (As)	0.51	9.4E-03	0.51
Boron (B)	0.021	1.1E-03	0.022
Chromium (total) (Cr)	0.060	3.4E-04	0.060
Cobalt (Co)	0.043	3.9E-05	0.043
Copper (Cu)	0.26	6.7E-04	0.26
Lead (Pb)	4.7E-03	3.7E-06	4.7E-03
Manganese (Mn)	0.30	6.9E-04	0.30
Mercury (Hg)	5.8E-03	1.4E-06	5.8E-03
Molybdenum (Mo)	0.083	5.4E-03	0.083
Nickel (Ni)	0.46	6.3E-04	0.46

Table 7.7.39 Maximum Overall Risk Quotients for the Snowshoe Hare

COPC	Maximum Overall Risk Quotient (RQ, dimensionless)		
	Snowshoe Hare		
	Baseline Case	Project Alone Case	Project + Baseline Case
Thallium (Tl)	0.013	3.0E-04	0.013
Tungsten (W)	0.022	3.5E-03	0.023
Uranium (U)	3.8E-03	1.9E-04	3.8E-03
Vanadium (V)	0.27	2.8E-03	0.27
Zinc (Zn)	0.28	4.3E-05	0.28

Table 7.7.40 Maximum Overall Risk Quotients for the Red Fox

COPC	Maximum Overall Risk Quotient (RQ, dimensionless)		
	Red Fox		
	Baseline Case	Project Alone Case	Project + Baseline Case
Aluminum (Al)	0.019	9.9E-04	0.019
Arsenic (As)	0.16	8.3E-03	0.16
Boron (B)	3.1E-03	1.3E-03	4.3E-03
Chromium (total) (Cr)	0.033	3.0E-04	0.033
Cobalt (Co)	3.8E-03	3.4E-05	3.8E-03
Copper (Cu)	0.22	5.9E-04	0.22
Lead (Pb)	2.8E-03	3.2E-06	2.8E-03
Manganese (Mn)	0.039	6.1E-04	0.039
Mercury (Hg)	5.5E-03	1.6E-06	5.5E-03
Molybdenum (Mo)	0.051	6.5E-03	0.051
Nickel (Ni)	0.077	5.6E-04	0.077
Thallium (Tl)	0.030	3.6E-04	0.030
Tungsten (W)	4.1E-03	3.1E-03	4.4E-03
Uranium (U)	1.47E-03	2.29E-04	1.49E-03
Vanadium (V)	0.096	3.38E-03	0.096
Zinc (Zn)	0.079	3.78E-05	0.079

Table 7.7.41 Maximum Overall Risk Quotients for the Moose

COPC	Maximum Overall Risk Quotient (RQ, dimensionless)		
	Moose		
	Baseline Case	Project Alone Case	Project + Baseline Case
Aluminum (Al)	0.019	7.5E-04	0.019
Arsenic (As)	0.022	1.1E-03	0.023
Boron (B)	0.026	1.9E-04	0.026
Chromium (total) (Cr)	3.9E-03	1.9E-05	4.0E-03
Cobalt (Co)	0.011	4.4E-05	0.011
Copper (Cu)	0.073	1.3E-04	0.073
Lead (Pb)	4.6E-04	5.6E-06	4.6E-04
Manganese (Mn)	0.075	2.6E-05	0.075
Mercury (Hg)	4.9E-03	8.4E-07	4.9E-03
Molybdenum (Mo)	0.030	1.4E-03	0.031
Nickel (Ni)	0.10	2.2E-04	0.10
Thallium (Tl)	8.4E-03	1.3E-03	9.7E-03

Table 7.7.41 Maximum Overall Risk Quotients for the Moose

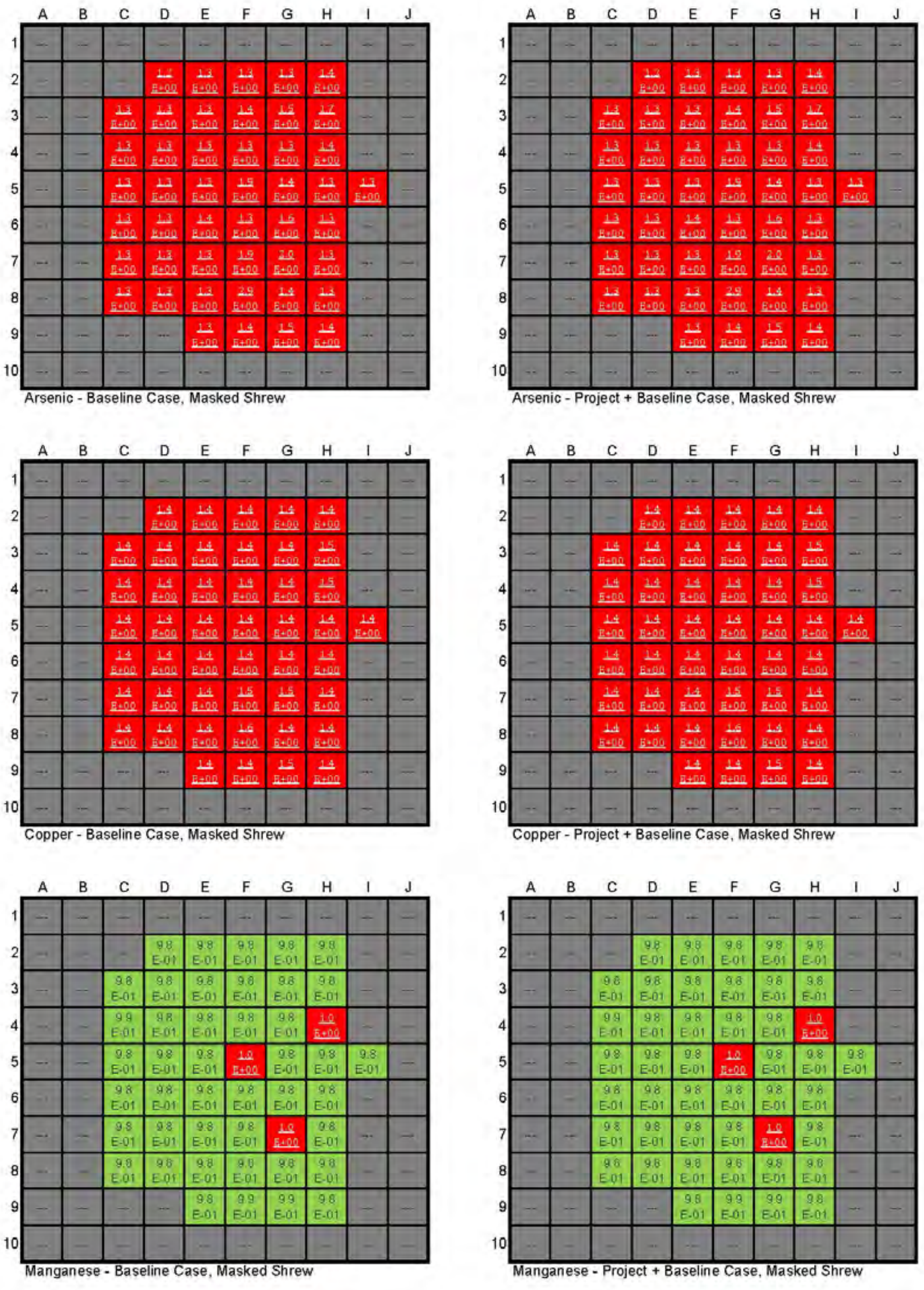
COPC	Maximum Overall Risk Quotient (RQ, dimensionless)		
	Moose		
	Baseline Case	Project Alone Case	Project + Baseline Case
Tungsten (W)	3.2E-03	3.6E-04	3.5E-03
Uranium (U)	8.5E-04	2.6E-04	1.1E-03
Vanadium (V)	0.047	2.2E-03	0.049
Zinc (Zn)	0.082	2.7E-06	0.082

Table 7.7.42 Maximum Overall Risk Quotients for the Black Bear

COPC	Maximum Overall Risk Quotient (RQ, dimensionless)		
	Black Bear		
	Baseline Case	Project Alone Case	Project + Baseline Case
Aluminum (Al)	0.076	5.1E-04	0.077
Arsenic (As)	0.11	5.2E-03	0.11
Boron (B)	0.013	4.0E-04	0.013
Chromium (total) (Cr)	0.025	3.3E-04	0.025
Cobalt (Co)	3.6E-03	3.1E-04	3.9E-03
Copper (Cu)	0.14	9.6E-04	0.15
Lead (Pb)	3.6E-03	2.3E-06	3.6E-03
Manganese (Mn)	0.13	3.0E-04	0.13
Mercury (Hg)	0.011	7.6E-05	0.011
Molybdenum (Mo)	0.13	6.3E-03	0.13
Nickel (Ni)	0.10	1.6E-04	0.10
Thallium (Tl)	0.030	1.7E-03	0.032
Tungsten (W)	2.8E-03	2.1E-04	3.0E-03
Uranium (U)	3.3E-03	1.7E-04	3.5E-03
Vanadium (V)	0.19	4.0E-03	0.19
Zinc (Zn)	0.054	1.4E-04	0.055

The spatial distributions of Risk Quotients (RQ) for the masked shrew and meadow vole are presented in Figures 7.7.6 and 7.7.7, respectively.

The primary pathway contributing to risk for the masked shrew was ingestion of terrestrial invertebrates, followed by ingestion of soil. For the meadow vole, the primary pathway contributing to risk was ingestion of soil, followed by ingestion of vegetation. The primary pathway contributing to risk for the American robin was ingestion of soil, followed by ingestion of terrestrial invertebrates. Due to the very small effect of ore dust deposition on the Project + Baseline Case concentrations arsenic, copper, manganese, vanadium and zinc in soil, there was no substantive difference between the risks of the Baseline Case and the Project + Baseline Case for terrestrial wildlife species exposed to these COPCs, as can be observed in Figures 7.7.6 to 7.7.8. In other words, the identified exceedances of the target RQ to the masked shrew, the meadow vole, and the American robin (which in some cases are localized) are related to pre-existing baseline metal concentrations in the environment, and the Project-related contribution to these environmental effects is negligible.



	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	1.2 E+00	1.3 E+00	1.3 E+00	1.3 E+00	1.4 E+00	---	---
3	---	---	1.3 E+00	1.3 E+00	1.3 E+00	1.4 E+00	1.5 E+00	1.7 E+00	---	---
4	---	---	1.3 E+00	1.3 E+00	1.3 E+00	1.3 E+00	1.3 E+00	1.4 E+00	---	---
5	---	---	1.3 E+00	1.3 E+00	1.3 E+00	1.9 E+00	1.4 E+00	1.3 E+00	1.3 E+00	---
6	---	---	1.3 E+00	1.3 E+00	1.4 E+00	1.3 E+00	1.6 E+00	1.3 E+00	---	---
7	---	---	1.3 E+00	1.3 E+00	1.3 E+00	1.9 E+00	2.0 E+00	1.3 E+00	---	---
8	---	---	1.3 E+00	1.3 E+00	1.3 E+00	2.9 E+00	1.4 E+00	1.3 E+00	---	---
9	---	---	---	---	1.3 E+00	1.4 E+00	1.5 E+00	1.4 E+00	---	---
10	---	---	---	---	---	---	---	---	---	---

Arsenic - Baseline Case, Masked Shrew

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	1.2 E+00	1.3 E+00	1.4 E+00	1.3 E+00	1.4 E+00	---	---
3	---	---	1.3 E+00	1.3 E+00	1.3 E+00	1.4 E+00	1.5 E+00	1.7 E+00	---	---
4	---	---	1.3 E+00	1.3 E+00	1.3 E+00	1.3 E+00	1.3 E+00	1.4 E+00	---	---
5	---	---	1.3 E+00	1.3 E+00	1.3 E+00	1.9 E+00	1.4 E+00	1.3 E+00	1.3 E+00	---
6	---	---	1.3 E+00	1.3 E+00	1.4 E+00	1.3 E+00	1.6 E+00	1.3 E+00	---	---
7	---	---	1.3 E+00	1.3 E+00	1.3 E+00	1.9 E+00	2.0 E+00	1.3 E+00	---	---
8	---	---	1.3 E+00	1.3 E+00	1.3 E+00	2.9 E+00	1.4 E+00	1.3 E+00	---	---
9	---	---	---	---	1.3 E+00	1.4 E+00	1.5 E+00	1.4 E+00	---	---
10	---	---	---	---	---	---	---	---	---	---

Arsenic - Project + Baseline Case, Masked Shrew

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	1.4 E+00	1.4 E+00	1.4 E+00	1.4 E+00	1.4 E+00	---	---
3	---	---	1.4 E+00	1.4 E+00	1.4 E+00	1.4 E+00	1.4 E+00	1.5 E+00	---	---
4	---	---	1.4 E+00	1.4 E+00	1.4 E+00	1.4 E+00	1.4 E+00	1.5 E+00	---	---
5	---	---	1.4 E+00	1.4 E+00	1.4 E+00	1.4 E+00	1.4 E+00	1.4 E+00	1.4 E+00	---
6	---	---	1.4 E+00	1.4 E+00	1.4 E+00	1.4 E+00	1.4 E+00	1.4 E+00	---	---
7	---	---	1.4 E+00	1.4 E+00	1.4 E+00	1.5 E+00	1.5 E+00	1.4 E+00	---	---
8	---	---	1.4 E+00	1.4 E+00	1.4 E+00	1.6 E+00	1.4 E+00	1.4 E+00	---	---
9	---	---	---	---	1.4 E+00	1.4 E+00	1.5 E+00	1.4 E+00	---	---
10	---	---	---	---	---	---	---	---	---	---

Copper - Baseline Case, Masked Shrew

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	1.4 E+00	1.4 E+00	1.4 E+00	1.4 E+00	1.4 E+00	---	---
3	---	---	1.4 E+00	1.4 E+00	1.4 E+00	1.4 E+00	1.4 E+00	1.5 E+00	---	---
4	---	---	1.4 E+00	1.4 E+00	1.4 E+00	1.4 E+00	1.4 E+00	1.5 E+00	---	---
5	---	---	1.4 E+00	1.4 E+00	1.4 E+00	1.4 E+00	1.4 E+00	1.4 E+00	1.4 E+00	---
6	---	---	1.4 E+00	1.4 E+00	1.4 E+00	1.4 E+00	1.4 E+00	1.4 E+00	---	---
7	---	---	1.4 E+00	1.4 E+00	1.4 E+00	1.5 E+00	1.5 E+00	1.4 E+00	---	---
8	---	---	1.4 E+00	1.4 E+00	1.4 E+00	1.6 E+00	1.4 E+00	1.4 E+00	---	---
9	---	---	---	---	1.4 E+00	1.4 E+00	1.5 E+00	1.4 E+00	---	---
10	---	---	---	---	---	---	---	---	---	---

Copper - Project + Baseline Case, Masked Shrew

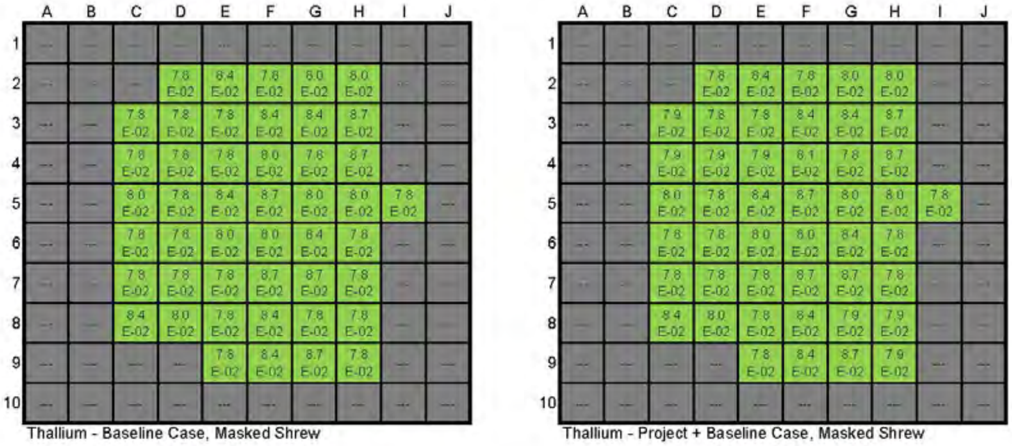
	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	9.8 E-01	9.8 E-01	9.8 E-01	9.8 E-01	9.8 E-01	---	---
3	---	---	9.8 E-01	9.8 E-01	9.8 E-01	9.8 E-01	9.8 E-01	9.8 E-01	---	---
4	---	---	9.9 E-01	9.8 E-01	9.8 E-01	9.8 E-01	9.8 E-01	1.0 E+00	---	---
5	---	---	9.8 E-01	9.8 E-01	9.8 E-01	1.0 E+00	9.8 E-01	9.8 E-01	9.8 E-01	---
6	---	---	9.8 E-01	9.8 E-01	9.8 E-01	9.8 E-01	9.8 E-01	9.8 E-01	---	---
7	---	---	9.8 E-01	9.8 E-01	9.8 E-01	9.8 E-01	1.0 E+00	9.8 E-01	---	---
8	---	---	9.8 E-01	9.8 E-01	9.8 E-01	9.8 E-01	9.8 E-01	9.8 E-01	---	---
9	---	---	---	---	9.8 E-01	9.9 E-01	9.9 E-01	9.8 E-01	---	---
10	---	---	---	---	---	---	---	---	---	---

Manganese - Baseline Case, Masked Shrew

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	9.8 E-01	9.8 E-01	9.8 E-01	9.8 E-01	9.8 E-01	---	---
3	---	---	9.8 E-01	9.8 E-01	9.8 E-01	9.8 E-01	9.8 E-01	9.8 E-01	---	---
4	---	---	9.9 E-01	9.8 E-01	9.8 E-01	9.8 E-01	9.8 E-01	1.0 E+00	---	---
5	---	---	9.8 E-01	9.8 E-01	9.8 E-01	1.0 E+00	9.8 E-01	9.8 E-01	9.8 E-01	---
6	---	---	9.8 E-01	9.8 E-01	9.8 E-01	9.8 E-01	9.8 E-01	9.8 E-01	---	---
7	---	---	9.8 E-01	9.8 E-01	9.8 E-01	9.8 E-01	1.0 E+00	9.8 E-01	---	---
8	---	---	9.8 E-01	9.8 E-01	9.8 E-01	9.8 E-01	9.8 E-01	9.8 E-01	---	---
9	---	---	---	---	9.8 E-01	9.9 E-01	9.9 E-01	9.8 E-01	---	---
10	---	---	---	---	---	---	---	---	---	---

Manganese - Project + Baseline Case, Masked Shrew

Figure 7.7.6 Distribution of Risk Quotients within the HHERA Study Area for the Masked Shrew

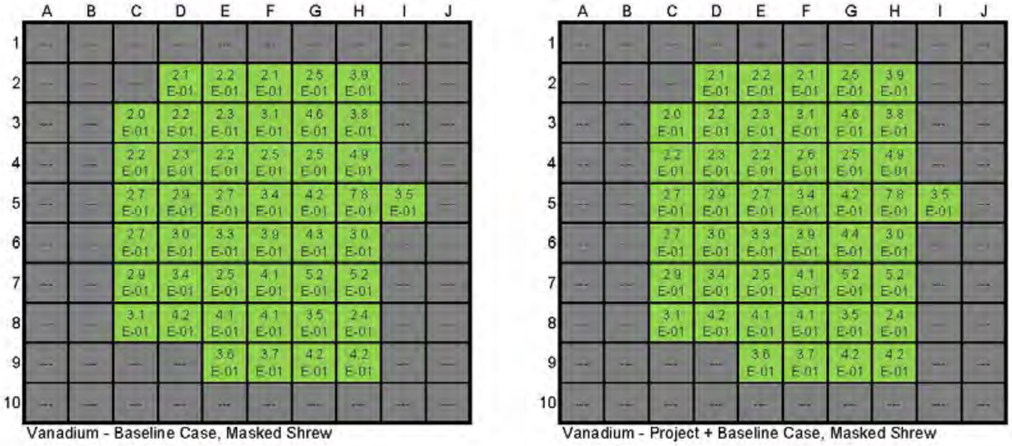


Thallium - Baseline Case, Masked Shrew

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	7.8 E-02	8.4 E-02	7.8 E-02	8.0 E-02	8.0 E-02	---	---
3	---	---	7.8 E-02	7.8 E-02	7.8 E-02	8.4 E-02	8.4 E-02	8.7 E-02	---	---
4	---	---	7.8 E-02	7.8 E-02	7.8 E-02	8.0 E-02	7.8 E-02	8.7 E-02	---	---
5	---	---	8.0 E-02	7.8 E-02	8.4 E-02	8.7 E-02	8.0 E-02	8.0 E-02	7.8 E-02	---
6	---	---	7.8 E-02	7.8 E-02	8.0 E-02	8.0 E-02	8.4 E-02	7.8 E-02	---	---
7	---	---	7.8 E-02	7.8 E-02	7.8 E-02	8.7 E-02	8.7 E-02	7.8 E-02	---	---
8	---	---	8.4 E-02	8.0 E-02	7.8 E-02	8.4 E-02	7.8 E-02	7.8 E-02	---	---
9	---	---	---	---	7.8 E-02	8.4 E-02	8.7 E-02	7.8 E-02	---	---
10	---	---	---	---	---	---	---	---	---	---

Thallium - Project + Baseline Case, Masked Shrew

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	7.8 E-02	8.4 E-02	7.8 E-02	8.0 E-02	8.0 E-02	---	---
3	---	---	7.9 E-02	7.8 E-02	7.8 E-02	8.4 E-02	8.4 E-02	8.7 E-02	---	---
4	---	---	7.9 E-02	7.9 E-02	7.9 E-02	8.1 E-02	7.8 E-02	8.7 E-02	---	---
5	---	---	8.0 E-02	7.8 E-02	8.4 E-02	8.7 E-02	8.0 E-02	8.0 E-02	7.8 E-02	---
6	---	---	7.8 E-02	7.8 E-02	8.0 E-02	8.0 E-02	8.4 E-02	7.8 E-02	---	---
7	---	---	7.8 E-02	7.8 E-02	7.8 E-02	8.7 E-02	8.7 E-02	7.8 E-02	---	---
8	---	---	8.4 E-02	8.0 E-02	7.8 E-02	8.4 E-02	7.9 E-02	7.9 E-02	---	---
9	---	---	---	---	7.8 E-02	8.4 E-02	8.7 E-02	7.9 E-02	---	---
10	---	---	---	---	---	---	---	---	---	---

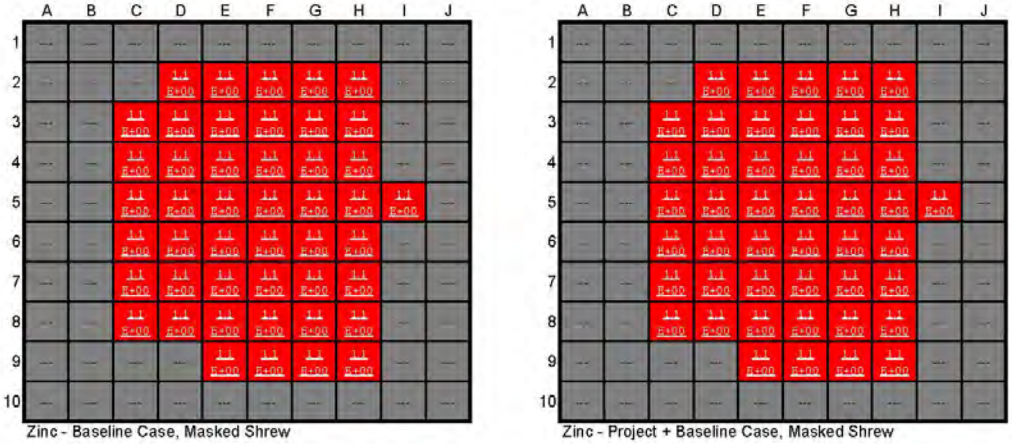


Vanadium - Baseline Case, Masked Shrew

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	2.1 E-01	2.2 E-01	2.1 E-01	2.5 E-01	3.9 E-01	---	---
3	---	---	2.0 E-01	2.2 E-01	2.3 E-01	3.1 E-01	4.6 E-01	3.8 E-01	---	---
4	---	---	2.2 E-01	2.3 E-01	2.2 E-01	2.5 E-01	2.5 E-01	4.9 E-01	---	---
5	---	---	2.7 E-01	2.9 E-01	2.7 E-01	3.4 E-01	4.2 E-01	7.8 E-01	3.5 E-01	---
6	---	---	2.7 E-01	3.0 E-01	3.3 E-01	3.9 E-01	4.3 E-01	3.0 E-01	---	---
7	---	---	2.9 E-01	3.4 E-01	2.5 E-01	4.1 E-01	5.2 E-01	5.2 E-01	---	---
8	---	---	3.1 E-01	4.2 E-01	4.1 E-01	4.1 E-01	3.5 E-01	2.4 E-01	---	---
9	---	---	---	---	3.6 E-01	3.7 E-01	4.2 E-01	4.2 E-01	---	---
10	---	---	---	---	---	---	---	---	---	---

Vanadium - Project + Baseline Case, Masked Shrew

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	2.1 E-01	2.2 E-01	2.1 E-01	2.5 E-01	3.9 E-01	---	---
3	---	---	2.0 E-01	2.2 E-01	2.3 E-01	3.1 E-01	4.6 E-01	3.8 E-01	---	---
4	---	---	2.2 E-01	2.3 E-01	2.2 E-01	2.6 E-01	2.5 E-01	4.9 E-01	---	---
5	---	---	2.7 E-01	2.9 E-01	2.7 E-01	3.4 E-01	4.2 E-01	7.8 E-01	3.5 E-01	---
6	---	---	2.7 E-01	3.0 E-01	3.3 E-01	3.9 E-01	4.4 E-01	3.0 E-01	---	---
7	---	---	2.9 E-01	3.4 E-01	2.5 E-01	4.1 E-01	5.2 E-01	5.2 E-01	---	---
8	---	---	3.1 E-01	4.2 E-01	4.1 E-01	4.1 E-01	3.5 E-01	2.4 E-01	---	---
9	---	---	---	---	3.6 E-01	3.7 E-01	4.2 E-01	4.2 E-01	---	---
10	---	---	---	---	---	---	---	---	---	---



Zinc - Baseline Case, Masked Shrew

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	---	---
3	---	---	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	---	---
4	---	---	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	---	---
5	---	---	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	---
6	---	---	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	---	---
7	---	---	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	---	---
8	---	---	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	---	---
9	---	---	---	---	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	---	---
10	---	---	---	---	---	---	---	---	---	---

Zinc - Project + Baseline Case, Masked Shrew

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	---	---
3	---	---	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	---	---
4	---	---	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	---	---
5	---	---	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	---
6	---	---	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	---	---
7	---	---	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	---	---
8	---	---	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	---	---
9	---	---	---	---	1.1 E+00	1.1 E+00	1.1 E+00	1.1 E+00	---	---
10	---	---	---	---	---	---	---	---	---	---

Figure 7.7.6 **(continued) Distribution of Risk Quotients within the HHERA Study Area for the Masked Shrew**

Arsenic - Baseline Case, Meadow Vole

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	2.9 E-02	7.6 E-02	3.6 E-02	9.0 E-02	1.3 E-01	---	---
3	---	---	3.6 E-02	4.9 E-02	4.9 E-02	1.1 E-01	2.2 E-01	3.7 E-01	---	---
4	---	---	5.0 E-02	5.0 E-02	5.0 E-02	3.6 E-02	1.0 E-01	1.8 E-01	---	---
5	---	---	6.3 E-02	7.6 E-02	1.0 E-01	5.3 E-01	1.4 E-01	1.0 E-01	1.0 E-01	---
6	---	---	4.9 E-02	6.3 E-02	1.5 E-01	6.3 E-02	3.6 E-01	7.6 E-02	---	---
7	---	---	4.9 E-02	6.3 E-02	4.9 E-02	5.3 E-01	7.0 E-01	9.0 E-02	---	---
8	---	---	7.6 E-02	1.0 E-01	6.3 E-02	1.4 E+00	1.5 E-01	5.0 E-02	---	---
9	---	---	---	---	6.3 E-02	1.5 E-01	2.8 E-01	1.4 E-01	---	---
10	---	---	---	---	---	---	---	---	---	---

Arsenic - Project + Baseline Case, Meadow Vole

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	2.9 E-02	7.6 E-02	3.6 E-02	9.0 E-02	1.3 E-01	---	---
3	---	---	3.7 E-02	4.9 E-02	4.9 E-02	1.1 E-01	2.2 E-01	3.7 E-01	---	---
4	---	---	5.0 E-02	5.3 E-02	5.0 E-02	5.0 E-02	1.0 E-01	1.8 E-01	---	---
5	---	---	6.3 E-02	7.6 E-02	1.0 E-01	5.3 E-01	1.4 E-01	1.0 E-01	1.0 E-01	---
6	---	---	4.9 E-02	6.3 E-02	1.5 E-01	6.4 E-02	3.6 E-01	7.6 E-02	---	---
7	---	---	4.9 E-02	6.3 E-02	5.0 E-02	5.3 E-01	7.0 E-01	9.0 E-02	---	---
8	---	---	7.6 E-02	1.0 E-01	6.3 E-02	1.4 E+00	1.5 E-01	5.0 E-02	---	---
9	---	---	---	---	6.3 E-02	1.5 E-01	2.8 E-01	1.4 E-01	---	---
10	---	---	---	---	---	---	---	---	---	---

Copper - Baseline Case, Meadow Vole

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	1.6 E-01	1.6 E-01	1.6 E-01	1.6 E-01	1.7 E-01	---	---
3	---	---	1.6 E-01	1.6 E-01	1.6 E-01	1.7 E-01	1.8 E-01	2.0 E-01	---	---
4	---	---	1.6 E-01	1.6 E-01	1.6 E-01	1.6 E-01	1.7 E-01	2.1 E-01	---	---
5	---	---	1.6 E-01	1.7 E-01	1.7 E-01	1.8 E-01	1.8 E-01	1.8 E-01	1.7 E-01	---
6	---	---	1.6 E-01	1.6 E-01	1.7 E-01	1.6 E-01	1.8 E-01	1.7 E-01	---	---
7	---	---	1.6 E-01	1.6 E-01	1.7 E-01	2.4 E-01	2.2 E-01	1.8 E-01	---	---
8	---	---	1.7 E-01	1.7 E-01	1.7 E-01	3.1 E-01	1.7 E-01	1.7 E-01	---	---
9	---	---	---	---	1.8 E-01	1.8 E-01	1.9 E-01	1.6 E-01	---	---
10	---	---	---	---	---	---	---	---	---	---

Copper - Project + Baseline Case, Meadow Vole

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	1.6 E-01	1.6 E-01	1.6 E-01	1.6 E-01	1.7 E-01	---	---
3	---	---	1.6 E-01	1.6 E-01	1.6 E-01	1.7 E-01	1.8 E-01	2.0 E-01	---	---
4	---	---	1.6 E-01	1.6 E-01	1.6 E-01	1.6 E-01	1.7 E-01	2.1 E-01	---	---
5	---	---	1.6 E-01	1.7 E-01	1.7 E-01	1.8 E-01	1.8 E-01	1.8 E-01	1.7 E-01	---
6	---	---	1.6 E-01	1.6 E-01	1.7 E-01	1.6 E-01	1.8 E-01	1.7 E-01	---	---
7	---	---	1.6 E-01	1.6 E-01	1.7 E-01	2.4 E-01	2.2 E-01	1.8 E-01	---	---
8	---	---	1.7 E-01	1.7 E-01	1.7 E-01	3.1 E-01	1.7 E-01	1.7 E-01	---	---
9	---	---	---	---	1.8 E-01	1.8 E-01	1.9 E-01	1.6 E-01	---	---
10	---	---	---	---	---	---	---	---	---	---

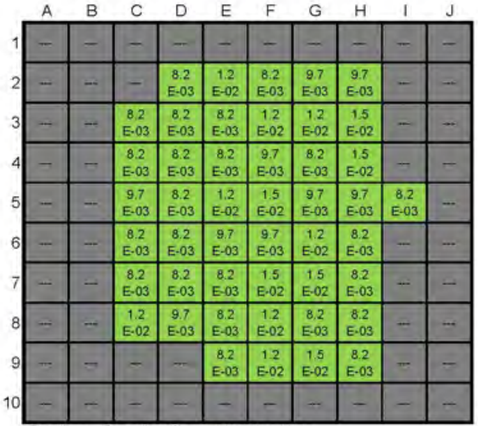
Manganese - Baseline Case, Meadow Vole

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	1.9 E-01	1.9 E-01	1.9 E-01	1.9 E-01	1.9 E-01	---	---
3	---	---	1.9 E-01	1.9 E-01	1.9 E-01	1.9 E-01	1.9 E-01	1.9 E-01	---	---
4	---	---	1.9 E-01	1.9 E-01	1.9 E-01	1.9 E-01	1.9 E-01	2.3 E-01	---	---
5	---	---	1.9 E-01	1.9 E-01	1.9 E-01	2.1 E-01	1.9 E-01	1.9 E-01	1.9 E-01	---
6	---	---	1.9 E-01	1.9 E-01	1.9 E-01	1.9 E-01	1.9 E-01	1.9 E-01	---	---
7	---	---	1.9 E-01	1.9 E-01	1.9 E-01	1.9 E-01	2.1 E-01	1.9 E-01	---	---
8	---	---	1.9 E-01	1.9 E-01	1.9 E-01	1.9 E-01	1.9 E-01	1.9 E-01	---	---
9	---	---	---	---	1.9 E-01	1.9 E-01	2.0 E-01	1.9 E-01	---	---
10	---	---	---	---	---	---	---	---	---	---

Manganese - Project + Baseline Case, Meadow Vole

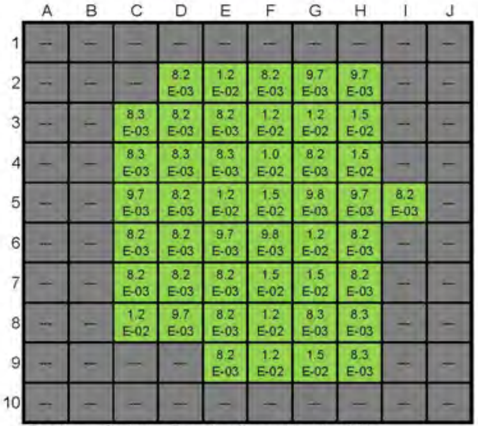
	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	1.9 E-01	1.9 E-01	1.9 E-01	1.9 E-01	1.9 E-01	---	---
3	---	---	1.9 E-01	1.9 E-01	1.9 E-01	1.9 E-01	1.9 E-01	1.9 E-01	---	---
4	---	---	1.9 E-01	1.9 E-01	1.9 E-01	1.9 E-01	1.9 E-01	2.3 E-01	---	---
5	---	---	1.9 E-01	1.9 E-01	1.9 E-01	2.1 E-01	1.9 E-01	1.9 E-01	1.9 E-01	---
6	---	---	1.9 E-01	1.9 E-01	1.9 E-01	1.9 E-01	1.9 E-01	1.9 E-01	---	---
7	---	---	1.9 E-01	1.9 E-01	1.9 E-01	1.9 E-01	2.1 E-01	1.9 E-01	---	---
8	---	---	1.9 E-01	1.9 E-01	1.9 E-01	1.9 E-01	1.9 E-01	1.9 E-01	---	---
9	---	---	---	---	1.9 E-01	1.9 E-01	2.0 E-01	1.9 E-01	---	---
10	---	---	---	---	---	---	---	---	---	---

Figure 7.7.7 **Distribution of Risk Quotients within the HHERA Study Area for the Meadow Vole**



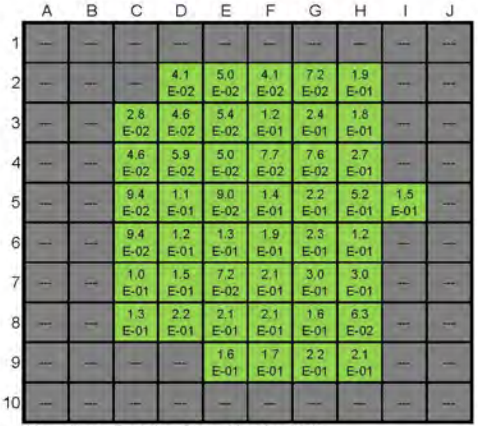
	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	8.2 E-03	1.2 E-02	8.2 E-03	9.7 E-03	9.7 E-03	---	---
3	---	---	8.2 E-03	8.2 E-03	8.2 E-03	1.2 E-02	1.2 E-02	1.5 E-02	---	---
4	---	---	8.2 E-03	8.2 E-03	8.2 E-03	9.7 E-03	8.2 E-03	1.5 E-02	---	---
5	---	---	9.7 E-03	8.2 E-03	1.2 E-02	1.5 E-02	9.7 E-03	9.7 E-03	8.2 E-03	---
6	---	---	8.2 E-03	8.2 E-03	9.7 E-03	9.7 E-03	1.2 E-02	8.2 E-03	---	---
7	---	---	8.2 E-03	8.2 E-03	8.2 E-03	1.5 E-02	1.5 E-02	8.2 E-03	---	---
8	---	---	1.2 E-02	9.7 E-03	8.2 E-03	1.2 E-02	8.2 E-03	8.2 E-03	---	---
9	---	---	---	---	8.2 E-03	1.2 E-02	1.5 E-02	8.2 E-03	---	---
10	---	---	---	---	---	---	---	---	---	---

Thallium - Baseline Case, Meadow Vole



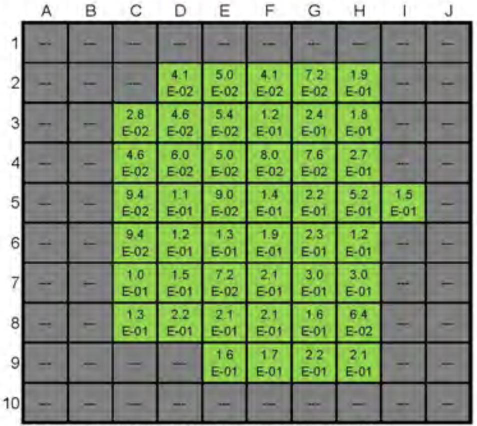
	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	8.2 E-03	1.2 E-02	8.2 E-03	9.7 E-03	9.7 E-03	---	---
3	---	---	8.3 E-03	8.2 E-03	8.2 E-03	1.2 E-02	1.2 E-02	1.5 E-02	---	---
4	---	---	8.3 E-03	8.3 E-03	8.3 E-03	1.0 E-02	8.2 E-03	1.5 E-02	---	---
5	---	---	9.7 E-03	8.2 E-03	1.2 E-02	1.5 E-02	9.8 E-03	9.7 E-03	8.2 E-03	---
6	---	---	8.2 E-03	8.2 E-03	9.7 E-03	9.8 E-03	1.2 E-02	8.2 E-03	---	---
7	---	---	8.2 E-03	8.2 E-03	8.2 E-03	1.5 E-02	1.5 E-02	8.2 E-03	---	---
8	---	---	1.2 E-02	9.7 E-03	8.2 E-03	1.2 E-02	8.3 E-03	8.3 E-03	---	---
9	---	---	---	---	8.2 E-03	1.2 E-02	1.5 E-02	8.3 E-03	---	---
10	---	---	---	---	---	---	---	---	---	---

Thallium - Project + Baseline Case, Meadow Vole



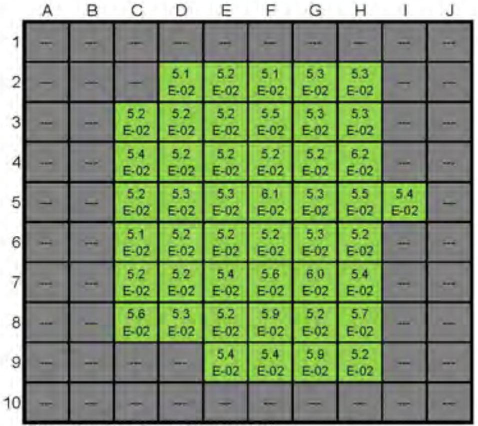
	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	4.1 E-02	5.0 E-02	4.1 E-02	7.2 E-02	1.9 E-01	---	---
3	---	---	2.8 E-02	4.6 E-02	5.4 E-02	1.2 E-01	2.4 E-01	1.8 E-01	---	---
4	---	---	4.6 E-02	5.9 E-02	5.0 E-02	7.7 E-02	7.6 E-02	2.7 E-01	---	---
5	---	---	9.4 E-02	1.1 E-01	9.0 E-02	1.4 E-01	2.2 E-01	5.2 E-01	1.5 E-01	---
6	---	---	9.4 E-02	1.2 E-01	1.3 E-01	1.9 E-01	2.3 E-01	1.2 E-01	---	---
7	---	---	1.0 E-01	1.5 E-01	7.2 E-02	2.1 E-01	3.0 E-01	3.0 E-01	---	---
8	---	---	1.3 E-01	2.2 E-01	2.1 E-01	2.1 E-01	1.6 E-01	6.3 E-02	---	---
9	---	---	---	---	1.6 E-01	1.7 E-01	2.2 E-01	2.1 E-01	---	---
10	---	---	---	---	---	---	---	---	---	---

Vanadium - Baseline Case, Meadow Vole



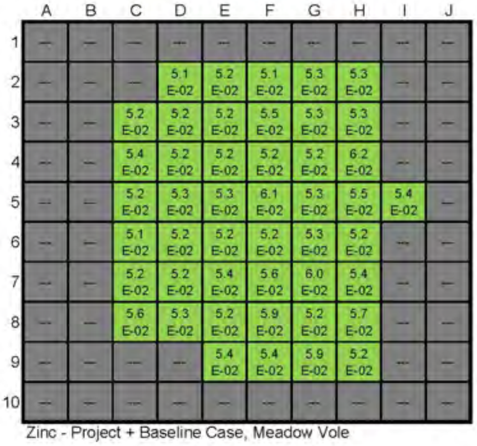
	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	4.1 E-02	5.0 E-02	4.1 E-02	7.2 E-02	1.9 E-01	---	---
3	---	---	2.8 E-02	4.6 E-02	5.4 E-02	1.2 E-01	2.4 E-01	1.8 E-01	---	---
4	---	---	4.6 E-02	6.0 E-02	5.0 E-02	8.0 E-02	7.6 E-02	2.7 E-01	---	---
5	---	---	9.4 E-02	1.1 E-01	9.0 E-02	1.4 E-01	2.2 E-01	5.2 E-01	1.5 E-01	---
6	---	---	9.4 E-02	1.2 E-01	1.3 E-01	1.9 E-01	2.3 E-01	1.2 E-01	---	---
7	---	---	1.0 E-01	1.5 E-01	7.2 E-02	2.1 E-01	3.0 E-01	3.0 E-01	---	---
8	---	---	1.3 E-01	2.2 E-01	2.1 E-01	2.1 E-01	1.6 E-01	6.4 E-02	---	---
9	---	---	---	---	1.6 E-01	1.7 E-01	2.2 E-01	2.1 E-01	---	---
10	---	---	---	---	---	---	---	---	---	---

Vanadium - Project + Baseline Case, Meadow Vole



	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	5.1 E-02	5.2 E-02	5.1 E-02	5.3 E-02	5.3 E-02	---	---
3	---	---	5.2 E-02	5.2 E-02	5.2 E-02	5.5 E-02	5.3 E-02	5.3 E-02	---	---
4	---	---	5.4 E-02	5.2 E-02	5.2 E-02	5.2 E-02	5.2 E-02	6.2 E-02	---	---
5	---	---	5.2 E-02	5.3 E-02	5.3 E-02	6.1 E-02	5.3 E-02	5.5 E-02	5.4 E-02	---
6	---	---	5.1 E-02	5.2 E-02	5.2 E-02	5.2 E-02	5.3 E-02	5.2 E-02	---	---
7	---	---	5.2 E-02	5.2 E-02	5.4 E-02	5.6 E-02	6.0 E-02	5.4 E-02	---	---
8	---	---	5.6 E-02	5.3 E-02	5.2 E-02	5.9 E-02	5.2 E-02	5.7 E-02	---	---
9	---	---	---	---	5.4 E-02	5.4 E-02	5.9 E-02	5.2 E-02	---	---
10	---	---	---	---	---	---	---	---	---	---

Zinc - Baseline Case, Meadow Vole



	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	5.1 E-02	5.2 E-02	5.1 E-02	5.3 E-02	5.3 E-02	---	---
3	---	---	5.2 E-02	5.2 E-02	5.2 E-02	5.5 E-02	5.3 E-02	5.3 E-02	---	---
4	---	---	5.4 E-02	5.2 E-02	5.2 E-02	5.2 E-02	5.2 E-02	6.2 E-02	---	---
5	---	---	5.2 E-02	5.3 E-02	5.3 E-02	6.1 E-02	5.3 E-02	5.5 E-02	5.4 E-02	---
6	---	---	5.1 E-02	5.2 E-02	5.2 E-02	5.2 E-02	5.3 E-02	5.2 E-02	---	---
7	---	---	5.2 E-02	5.2 E-02	5.4 E-02	5.6 E-02	6.0 E-02	5.4 E-02	---	---
8	---	---	5.6 E-02	5.3 E-02	5.2 E-02	5.9 E-02	5.2 E-02	5.7 E-02	---	---
9	---	---	---	---	5.4 E-02	5.4 E-02	5.9 E-02	5.2 E-02	---	---
10	---	---	---	---	---	---	---	---	---	---

Zinc - Project + Baseline Case, Meadow Vole

Figure 7.7.7 **(continued) Distribution of Risk Quotients within the HHERA Study Area for the Meadow Vole**

Maximum risk quotients for terrestrial birds (*i.e.,* American robin, red-tailed hawk, ruffed grouse and bald eagle, Tables 7.7.43 to 7.7.46) were less than 1.0, with the exception of the American robin exposed to vanadium for both the Baseline Case and the Project + Baseline Case. The spatial distribution of RQ for the American robin is presented in Figure 7.7.8.

No Baseline Case and Project + Baseline Case RQ values exceeded 1.0 for the snowshoe hare, red fox, moose, black bear, red-tailed hawk, ruffed grouse, or bald eagle. Differences in RQ values between the Baseline Case and the Project + Baseline Case scenarios were generally negligible for terrestrial mammalian and avian wildlife. Ore dust deposition is expected to negligibly affect soil quality, or COPC concentrations in terrestrial plants, soil invertebrates or small mammals, in areas that are not directly disturbed by mining activity.

Table 7.7.43 Maximum Overall Risk Quotients for the American Robin

COPC	Maximum Overall Risk Quotient (RQ, dimensionless)		
	American Robin		
	Baseline Case	Project Alone Case	Project + Baseline Case
Aluminum (Al)	---	---	---
Arsenic (As)	0.086	5.3E-04	0.086
Boron (B)	0.015	9.5E-04	0.015
Chromium (total) (Cr)	0.17	3.9E-04	0.17
Cobalt (Co)	0.18	1.5E-04	0.18
Copper (Cu)	0.20	1.5E-04	0.20
Lead (Pb)	0.25	1.8E-05	0.25
Manganese (Mn)	0.24	2.6E-04	0.24
Mercury (Hg)	0.037	1.9E-06	0.037
Molybdenum (Mo)	5.5E-03	2.0E-04	5.5E-03
Nickel (Ni)	0.068	9.9E-05	0.068
Thallium (Tl)	0.048	2.1E-04	0.048
Tungsten (W)	0.031	4.3E-03	0.031
Uranium (U)	5.9E-04	1.1E-05	5.9E-04
Vanadium (V)	**4.2**	0.019	**4.2**
Zinc (Zn)	0.66	4.7E-05	0.66

Notes:
"---" indicates not available or applicable.
There are insufficient data to define TRVs for avian receptors for aluminum; therefore, RQs are not calculated.
Bold indicates that value exceeds the RQ target (1.0).

Table 7.7.44 Maximum Overall Risk Quotients for the Red-tailed Hawk

COPC	Maximum Overall Risk Quotient (RQ, dimensionless)		
	Red-tailed Hawk		
	Baseline Case	Project Alone Case	Project + Baseline Case
Aluminum (Al)	---	---	---
Arsenic (As)	5.6E-03	2.4E-04	5.6E-03
Boron (B)	1.3E-03	4.3E-04	1.7E-03
Chromium (total) (Cr)	0.030	1.7E-04	0.030
Cobalt (Co)	7.7E-03	6.4E-05	7.7E-03
Copper (Cu)	0.038	6.3E-05	0.038
Lead (Pb)	5.6E-03	7.8E-06	5.6E-03
Manganese (Mn)	4.2E-03	1.1E-04	4.2E-03
Mercury (Hg)	6.4E-03	1.3E-06	6.4E-03
Molybdenum (Mo)	1.0E-03	8.7E-05	1.0E-03
Nickel (Ni)	8.5E-03	4.3E-05	8.5E-03
Thallium (Tl)	0.024	1.7E-04	0.024
Tungsten (W)	3.4E-03	1.9E-03	3.6E-03
Uranium (U)	3.9E-05	4.8E-06	4.0E-05
Vanadium (V)	0.55	0.015	0.55
Zinc (Zn)	0.062	2.1E-05	0.062

Notes:
"---" indicates not available or applicable.
There are insufficient data to define TRVs for avian receptors for aluminum; therefore, RQs are not calculated.

Table 7.7.45 Maximum Overall Risk Quotients for the Ruffed Grouse

COPC	Maximum Overall Risk Quotient (RQ, dimensionless)		
	Ruffed Grouse		
	Baseline Case	Project Alone Case	Project + Baseline Case
Aluminum (Al)	---	---	---
Arsenic (As)	4.0E-05	6.3E-06	4.0E-05
Boron (B)	2.1E-04	1.1E-05	2.2E-04
Chromium (total) (Cr)	1.5E-04	4.7E-06	1.5E-04
Cobalt (Co)	1.5E-03	1.7E-06	1.5E-03
Copper (Cu)	3.9E-04	1.7E-06	3.9E-04
Lead (Pb)	6.5E-05	2.1E-07	6.5E-05
Manganese (Mn)	1.0E-03	3.1E-06	1.0E-03
Mercury (Hg)	7.0E-05	2.9E-08	7.0E-05
Molybdenum (Mo)	5.7E-06	2.4E-06	6.1E-06
Nickel (Ni)	6.1E-04	1.2E-06	6.1E-04
Thallium (Tl)	7.5E-05	3.9E-06	7.5E-05
Tungsten (W)	1.5E-04	5.1E-05	1.8E-04
Uranium (U)	3.6E-07	1.3E-07	3.7E-07
Vanadium (V)	4.4E-03	3.3E-04	4.4E-03
Zinc (Zn)	3.4E-03	5.6E-07	3.4E-03

Notes:
"---" indicates not available or applicable.
There are insufficient data to define TRVs for avian receptors for aluminum; therefore, RQs are not calculated.

Table 7.7.46 Maximum Overall Risk Quotients for the Bald Eagle

COPC	Maximum Overall Risk Quotient (RQ, dimensionless)		
	Bald Eagle		
	Baseline Case	Project Alone Case	Project + Baseline Case
Aluminum (Al)	---	---	---
Arsenic (As)	2.8E-03	1.7E-03	4.4E-03
Boron (B)	7.1E-04	8.6E-04	1.6E-03
Chromium (total) (Cr)	0.010	2.3E-03	0.012
Cobalt (Co)	2.2E-03	7.3E-03	9.4E-03
Copper (Cu)	0.015	1.3E-03	0.016
Lead (Pb)	1.5E-03	8.1E-05	1.6E-03
Manganese (Mn)	1.4E-03	6.4E-04	2.0E-03
Mercury (Hg)	0.013	5.5E-04	0.013
Molybdenum (Mo)	3.9E-04	6.6E-04	1.0E-03
Nickel (Ni)	2.5E-03	1.6E-04	2.7E-03
Thallium (Tl)	0.017	7.4E-03	0.024
Tungsten (W)	7.0E-04	8.6E-04	1.5E-03
Uranium (U)	1.5E-05	3.1E-05	4.5E-05
Vanadium (V)	0.097	0.15	0.24
Zinc (Zn)	0.040	1.1E-03	0.041

Notes:

“---“ indicates not available or applicable.

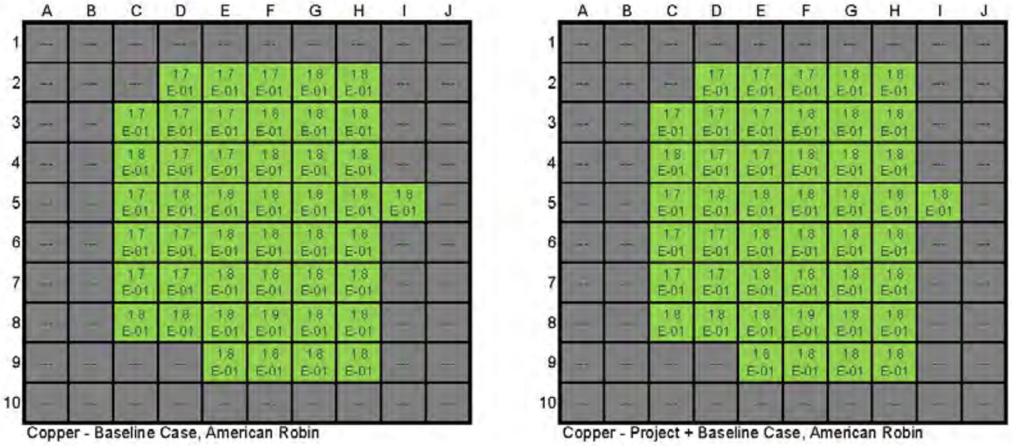
There are insufficient data to define TRVs for avian receptors for aluminum; therefore, RQs are not calculated.

	A	B	C	D	E	F	G	H	I	J
1	--	--	--	--	--	--	--	--	--	--
2	--	--	--	3.7 E-02	3.8 E-02	3.7 E-02	3.9 E-02	4.0 E-02	--	--
3	--	--	3.7 E-02	3.7 E-02	3.7 E-02	4.0 E-02	4.4 E-02	4.9 E-02	--	--
4	--	--	3.7 E-02	3.7 E-02	3.7 E-02	3.7 E-02	3.9 E-02	4.2 E-02	--	--
5	--	--	3.8 E-02	3.8 E-02	3.9 E-02	5.4 E-02	4.1 E-02	3.9 E-02	3.9 E-02	--
6	--	--	3.7 E-02	3.8 E-02	4.1 E-02	3.8 E-02	4.8 E-02	3.8 E-02	--	--
7	--	--	3.7 E-02	3.8 E-02	3.7 E-02	5.4 E-02	6.0 E-02	3.9 E-02	--	--
8	--	--	3.8 E-02	3.9 E-02	3.8 E-02	8.5 E-02	4.1 E-02	3.7 E-02	--	--
9	--	--	--	--	3.8 E-02	4.1 E-02	4.5 E-02	4.1 E-02	--	--
10	--	--	--	--	--	--	--	--	--	--

Arsenic - Baseline Case, American Robin

	A	B	C	D	E	F	G	H	I	J
1	--	--	--	--	--	--	--	--	--	--
2	--	--	--	3.7 E-02	3.8 E-02	3.7 E-02	3.9 E-02	4.0 E-02	--	--
3	--	--	3.7 E-02	3.7 E-02	3.7 E-02	4.0 E-02	4.4 E-02	4.9 E-02	--	--
4	--	--	3.7 E-02	3.8 E-02	3.7 E-02	3.6 E-02	3.9 E-02	4.2 E-02	--	--
5	--	--	3.8 E-02	3.8 E-02	3.9 E-02	5.4 E-02	4.1 E-02	3.9 E-02	3.9 E-02	--
6	--	--	3.7 E-02	3.8 E-02	4.1 E-02	3.8 E-02	4.8 E-02	3.8 E-02	--	--
7	--	--	3.7 E-02	3.8 E-02	3.7 E-02	5.4 E-02	6.0 E-02	3.9 E-02	--	--
8	--	--	3.8 E-02	3.9 E-02	3.8 E-02	8.5 E-02	4.1 E-02	3.7 E-02	--	--
9	--	--	--	--	3.8 E-02	4.1 E-02	4.5 E-02	4.1 E-02	--	--
10	--	--	--	--	--	--	--	--	--	--

Arsenic - Project + Baseline Case, American Robin

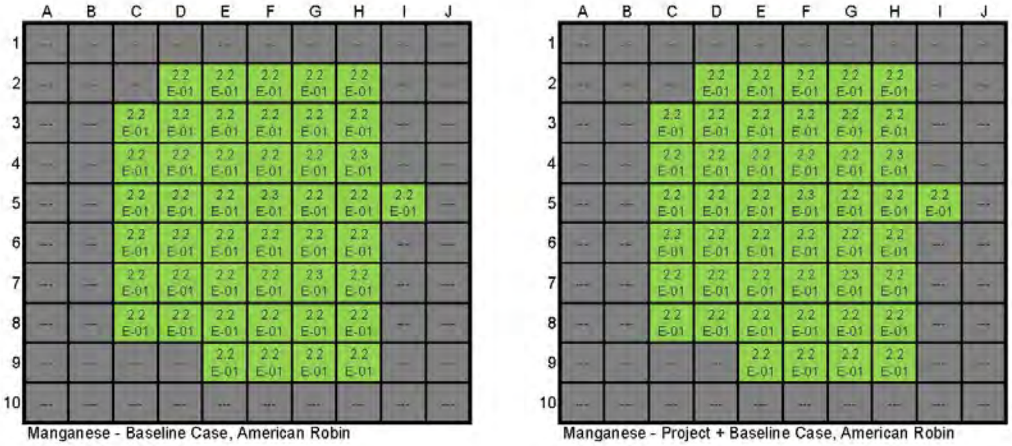


	A	B	C	D	E	F	G	H	I	J
1	--	--	--	--	--	--	--	--	--	--
2	--	--	--	1.7 E-01	1.7 E-01	1.7 E-01	1.8 E-01	1.8 E-01	--	--
3	--	--	1.7 E-01	1.7 E-01	1.7 E-01	1.8 E-01	1.8 E-01	1.8 E-01	--	--
4	--	--	1.8 E-01	1.7 E-01	1.7 E-01	1.8 E-01	1.8 E-01	1.8 E-01	--	--
5	--	--	1.7 E-01	1.8 E-01	1.8 E-01	1.8 E-01	1.8 E-01	1.8 E-01	1.8 E-01	--
6	--	--	1.7 E-01	1.7 E-01	1.8 E-01	1.8 E-01	1.8 E-01	1.8 E-01	--	--
7	--	--	1.7 E-01	1.7 E-01	1.8 E-01	1.8 E-01	1.8 E-01	1.8 E-01	--	--
8	--	--	1.8 E-01	1.8 E-01	1.8 E-01	1.9 E-01	1.8 E-01	1.8 E-01	--	--
9	--	--	--	--	1.8 E-01	1.8 E-01	1.8 E-01	1.8 E-01	--	--
10	--	--	--	--	--	--	--	--	--	--

Copper - Baseline Case, American Robin

	A	B	C	D	E	F	G	H	I	J
1	--	--	--	--	--	--	--	--	--	--
2	--	--	--	1.7 E-01	1.7 E-01	1.7 E-01	1.8 E-01	1.8 E-01	--	--
3	--	--	1.7 E-01	1.7 E-01	1.7 E-01	1.8 E-01	1.8 E-01	1.8 E-01	--	--
4	--	--	1.8 E-01	1.7 E-01	1.7 E-01	1.8 E-01	1.8 E-01	1.8 E-01	--	--
5	--	--	1.7 E-01	1.8 E-01	1.8 E-01	1.8 E-01	1.8 E-01	1.8 E-01	1.8 E-01	--
6	--	--	1.7 E-01	1.7 E-01	1.8 E-01	1.8 E-01	1.8 E-01	1.8 E-01	--	--
7	--	--	1.7 E-01	1.7 E-01	1.8 E-01	1.8 E-01	1.8 E-01	1.8 E-01	--	--
8	--	--	1.8 E-01	1.8 E-01	1.8 E-01	1.9 E-01	1.8 E-01	1.8 E-01	--	--
9	--	--	--	--	1.8 E-01	1.8 E-01	1.8 E-01	1.8 E-01	--	--
10	--	--	--	--	--	--	--	--	--	--

Copper - Project + Baseline Case, American Robin



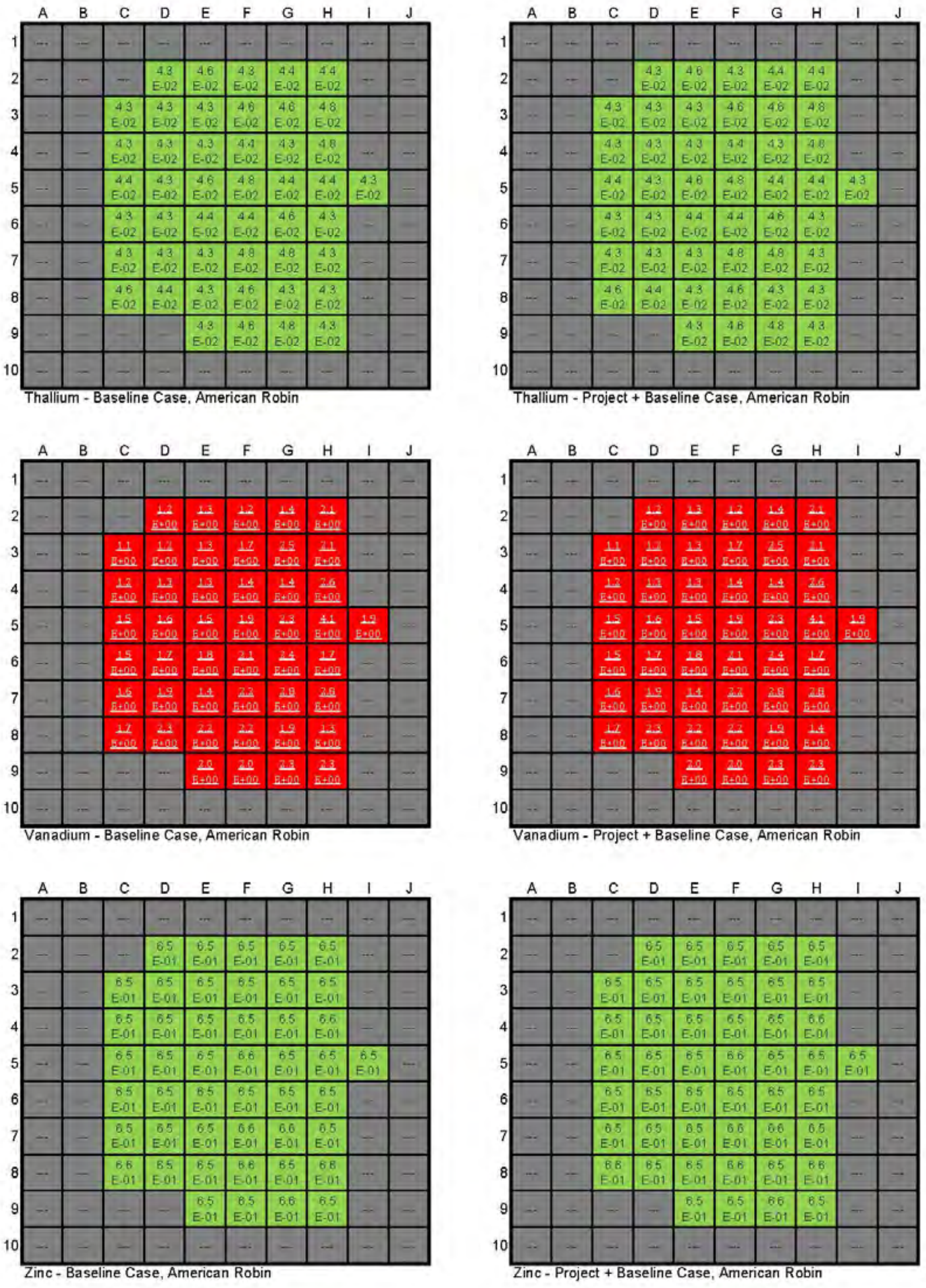
	A	B	C	D	E	F	G	H	I	J
1	--	--	--	--	--	--	--	--	--	--
2	--	--	--	2.2 E-01	2.2 E-01	2.2 E-01	2.2 E-01	2.2 E-01	--	--
3	--	--	2.2 E-01	2.2 E-01	2.2 E-01	2.2 E-01	2.2 E-01	2.2 E-01	--	--
4	--	--	2.2 E-01	2.2 E-01	2.2 E-01	2.2 E-01	2.2 E-01	2.3 E-01	--	--
5	--	--	2.2 E-01	2.2 E-01	2.2 E-01	2.3 E-01	2.2 E-01	2.2 E-01	2.2 E-01	--
6	--	--	2.2 E-01	2.2 E-01	2.2 E-01	2.2 E-01	2.2 E-01	2.2 E-01	--	--
7	--	--	2.2 E-01	2.2 E-01	2.2 E-01	2.2 E-01	2.3 E-01	2.2 E-01	--	--
8	--	--	2.2 E-01	2.2 E-01	2.2 E-01	2.2 E-01	2.2 E-01	2.2 E-01	--	--
9	--	--	--	--	2.2 E-01	2.2 E-01	2.2 E-01	2.2 E-01	--	--
10	--	--	--	--	--	--	--	--	--	--

Manganese - Baseline Case, American Robin

	A	B	C	D	E	F	G	H	I	J
1	--	--	--	--	--	--	--	--	--	--
2	--	--	--	2.2 E-01	2.2 E-01	2.2 E-01	2.2 E-01	2.2 E-01	--	--
3	--	--	2.2 E-01	2.2 E-01	2.2 E-01	2.2 E-01	2.2 E-01	2.2 E-01	--	--
4	--	--	2.2 E-01	2.2 E-01	2.2 E-01	2.2 E-01	2.2 E-01	2.3 E-01	--	--
5	--	--	2.2 E-01	2.2 E-01	2.2 E-01	2.3 E-01	2.2 E-01	2.2 E-01	2.2 E-01	--
6	--	--	2.2 E-01	2.2 E-01	2.2 E-01	2.2 E-01	2.2 E-01	2.2 E-01	--	--
7	--	--	2.2 E-01	2.2 E-01	2.2 E-01	2.2 E-01	2.3 E-01	2.2 E-01	--	--
8	--	--	2.2 E-01	2.2 E-01	2.2 E-01	2.2 E-01	2.2 E-01	2.2 E-01	--	--
9	--	--	--	--	2.2 E-01	2.2 E-01	2.2 E-01	2.2 E-01	--	--
10	--	--	--	--	--	--	--	--	--	--

Manganese - Project + Baseline Case, American Robin

Figure 7.7.8 **Distribution of Risk Quotients within the HHERA Study Area for the American Robin**



Thallium - Baseline Case, American Robin

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	4.3 E-02	4.6 E-02	4.3 E-02	4.4 E-02	4.4 E-02	---	---
3	---	---	4.3 E-02	4.3 E-02	4.3 E-02	4.6 E-02	4.6 E-02	4.8 E-02	---	---
4	---	---	4.3 E-02	4.3 E-02	4.3 E-02	4.4 E-02	4.3 E-02	4.8 E-02	---	---
5	---	---	4.4 E-02	4.3 E-02	4.6 E-02	4.8 E-02	4.4 E-02	4.4 E-02	4.3 E-02	---
6	---	---	4.3 E-02	4.3 E-02	4.4 E-02	4.4 E-02	4.6 E-02	4.3 E-02	---	---
7	---	---	4.3 E-02	4.3 E-02	4.3 E-02	4.8 E-02	4.8 E-02	4.3 E-02	---	---
8	---	---	4.6 E-02	4.4 E-02	4.3 E-02	4.6 E-02	4.3 E-02	4.3 E-02	---	---
9	---	---	---	---	4.3 E-02	4.6 E-02	4.8 E-02	4.3 E-02	---	---
10	---	---	---	---	---	---	---	---	---	---

Thallium - Project + Baseline Case, American Robin

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	4.3 E-02	4.6 E-02	4.3 E-02	4.4 E-02	4.4 E-02	---	---
3	---	---	4.3 E-02	4.3 E-02	4.3 E-02	4.6 E-02	4.6 E-02	4.8 E-02	---	---
4	---	---	4.3 E-02	4.3 E-02	4.3 E-02	4.4 E-02	4.3 E-02	4.8 E-02	---	---
5	---	---	4.4 E-02	4.3 E-02	4.6 E-02	4.8 E-02	4.4 E-02	4.4 E-02	4.3 E-02	---
6	---	---	4.3 E-02	4.3 E-02	4.4 E-02	4.4 E-02	4.6 E-02	4.3 E-02	---	---
7	---	---	4.3 E-02	4.3 E-02	4.3 E-02	4.8 E-02	4.8 E-02	4.3 E-02	---	---
8	---	---	4.6 E-02	4.4 E-02	4.3 E-02	4.6 E-02	4.3 E-02	4.3 E-02	---	---
9	---	---	---	---	4.3 E-02	4.6 E-02	4.8 E-02	4.3 E-02	---	---
10	---	---	---	---	---	---	---	---	---	---

Vanadium - Baseline Case, American Robin

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	1.2 E+00	1.3 E+00	1.2 E+00	1.4 E+00	2.1 E+00	---	---
3	---	---	1.1 E+00	1.2 E+00	1.3 E+00	1.7 E+00	2.5 E+00	2.1 E+00	---	---
4	---	---	1.2 E+00	1.3 E+00	1.3 E+00	1.4 E+00	1.4 E+00	2.6 E+00	---	---
5	---	---	1.5 E+00	1.6 E+00	1.5 E+00	1.9 E+00	2.3 E+00	4.1 E+00	1.9 E+00	---
6	---	---	1.5 E+00	1.7 E+00	1.8 E+00	2.1 E+00	2.4 E+00	1.7 E+00	---	---
7	---	---	1.6 E+00	1.9 E+00	1.4 E+00	2.2 E+00	2.8 E+00	2.8 E+00	---	---
8	---	---	1.7 E+00	2.3 E+00	2.2 E+00	2.2 E+00	1.9 E+00	1.3 E+00	---	---
9	---	---	---	---	2.0 E+00	2.0 E+00	2.3 E+00	2.3 E+00	---	---
10	---	---	---	---	---	---	---	---	---	---

Vanadium - Project + Baseline Case, American Robin

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	1.2 E+00	1.3 E+00	1.2 E+00	1.4 E+00	2.1 E+00	---	---
3	---	---	1.1 E+00	1.2 E+00	1.3 E+00	1.7 E+00	2.5 E+00	2.1 E+00	---	---
4	---	---	1.2 E+00	1.3 E+00	1.3 E+00	1.4 E+00	1.4 E+00	2.6 E+00	---	---
5	---	---	1.5 E+00	1.6 E+00	1.5 E+00	1.9 E+00	2.3 E+00	4.1 E+00	1.9 E+00	---
6	---	---	1.5 E+00	1.7 E+00	1.8 E+00	2.1 E+00	2.4 E+00	1.7 E+00	---	---
7	---	---	1.6 E+00	1.9 E+00	1.4 E+00	2.2 E+00	2.8 E+00	2.8 E+00	---	---
8	---	---	1.7 E+00	2.3 E+00	2.2 E+00	2.2 E+00	1.9 E+00	1.4 E+00	---	---
9	---	---	---	---	2.0 E+00	2.0 E+00	2.3 E+00	2.3 E+00	---	---
10	---	---	---	---	---	---	---	---	---	---

Zinc - Baseline Case, American Robin

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	6.5 E-01	6.5 E-01	6.5 E-01	6.5 E-01	6.5 E-01	---	---
3	---	---	6.5 E-01	6.5 E-01	6.5 E-01	6.5 E-01	6.5 E-01	6.5 E-01	---	---
4	---	---	6.5 E-01	6.5 E-01	6.5 E-01	6.5 E-01	6.5 E-01	6.6 E-01	---	---
5	---	---	6.5 E-01	6.5 E-01	6.5 E-01	6.6 E-01	6.5 E-01	6.5 E-01	6.5 E-01	---
6	---	---	6.5 E-01	6.5 E-01	6.5 E-01	6.5 E-01	6.5 E-01	6.5 E-01	---	---
7	---	---	6.5 E-01	6.5 E-01	6.5 E-01	6.6 E-01	6.6 E-01	6.5 E-01	---	---
8	---	---	6.6 E-01	6.5 E-01	6.5 E-01	6.6 E-01	6.5 E-01	6.8 E-01	---	---
9	---	---	---	---	6.5 E-01	6.5 E-01	6.6 E-01	6.5 E-01	---	---
10	---	---	---	---	---	---	---	---	---	---

Zinc - Project + Baseline Case, American Robin

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	6.5 E-01	6.5 E-01	6.5 E-01	6.5 E-01	6.5 E-01	---	---
3	---	---	6.5 E-01	6.5 E-01	6.5 E-01	6.5 E-01	6.5 E-01	6.5 E-01	---	---
4	---	---	6.5 E-01	6.5 E-01	6.5 E-01	6.5 E-01	6.5 E-01	6.6 E-01	---	---
5	---	---	6.5 E-01	6.5 E-01	6.5 E-01	6.6 E-01	6.5 E-01	6.5 E-01	6.5 E-01	---
6	---	---	6.5 E-01	6.5 E-01	6.5 E-01	6.5 E-01	6.5 E-01	6.5 E-01	---	---
7	---	---	6.5 E-01	6.5 E-01	6.5 E-01	6.6 E-01	6.6 E-01	6.5 E-01	---	---
8	---	---	6.6 E-01	6.5 E-01	6.5 E-01	6.6 E-01	6.5 E-01	6.6 E-01	---	---
9	---	---	---	---	6.5 E-01	6.5 E-01	6.6 E-01	6.5 E-01	---	---
10	---	---	---	---	---	---	---	---	---	---

Figure 7.7.8 **(continued) Distribution of Risk Quotients within the HHERA Study Area for the American Robin**

7.7.4.7.2 Risk Characterization for Aquatic Ecological Receptors

Maximum risk quotients for aquatic mammals (*i.e.,* mink) and for aquatic birds (*i.e.,* American black duck and belted kingfisher) are presented in Tables 7.7.47 to 7.7.49.

Table 7.7.47 Maximum Overall Risk Quotients for the Mink

COPC	Maximum Overall Risk Quotient (RQ, dimensionless)		
	Mink		
	Baseline Case	Project Alone Case	Project + Baseline Case
Aluminum (Al)	0.049	0.085	0.12
Arsenic (As)	0.17	0.47	0.61
Boron (B)	1.6E-03	1.8E-02	2.0E-02
Chromium (total) (Cr)	0.032	0.074	0.098
Cobalt (Co)	3.0E-03	5.1E-02	5.3E-02
Copper (Cu)	0.22	0.35	0.55
Lead (Pb)	1.4E-03	1.2E-03	2.1E-03
Manganese (Mn)	0.012	0.057	0.068
Mercury (Hg)	0.013	8.5E-04	0.014
Molybdenum (Mo)	0.025	0.52	0.54
Nickel (Ni)	0.066	0.081	0.13
Thallium (Tl)	0.029	0.16	0.18
Tungsten (W)	5.5E-03	0.045	0.048
Uranium (U)	1.1E-03	0.012	0.012
Vanadium (V)	0.038	0.21	0.22
Zinc (Zn)	0.091	0.025	0.12

Table 7.7.48 Maximum Overall Risk Quotients for the American Black Duck

COPC	Maximum Overall Risk Quotient (RQ, dimensionless)		
	American Black Duck		
	Baseline Case	Project Alone Case	Project + Baseline Case
Aluminum (Al)	---	---	---
Arsenic (As)	4.7E-03	0.12	0.12
Boron (B)	4.6E-03	0.032	0.037
Chromium (total) (Cr)	0.030	0.14	0.16
Cobalt (Co)	0.012	0.098	0.11
Copper (Cu)	0.069	0.66	0.70
Lead (Pb)	0.016	0.056	0.069
Manganese (Mn)	0.049	0.013	0.061
Mercury (Hg)	0.026	6.9E-06	0.026
Molybdenum (Mo)	2.7E-03	0.085	0.087
Nickel (Ni)	0.024	0.11	0.14
Thallium (Tl)	0.11	**1.2**	**1.2**
Tungsten (W)	0.037	0.39	0.42
Uranium (U)	1.5E-04	2.8E-03	2.9E-03

Table 7.7.48 Maximum Overall Risk Quotients for the American Black Duck

COPC	Maximum Overall Risk Quotient (RQ, dimensionless)		
	American Black Duck		
	Baseline Case	Project Alone Case	Project + Baseline Case
Vanadium (V)	0.47	**4.4**	**4.6**
Zinc (Zn)	0.047	0.22	0.26

Notes:
"---" indicates not available or applicable.
There are insufficient data to define TRVs for avian receptors for aluminum; therefore, RQs are not calculated.
Bold indicates that value exceeds the RQ target (1.0).

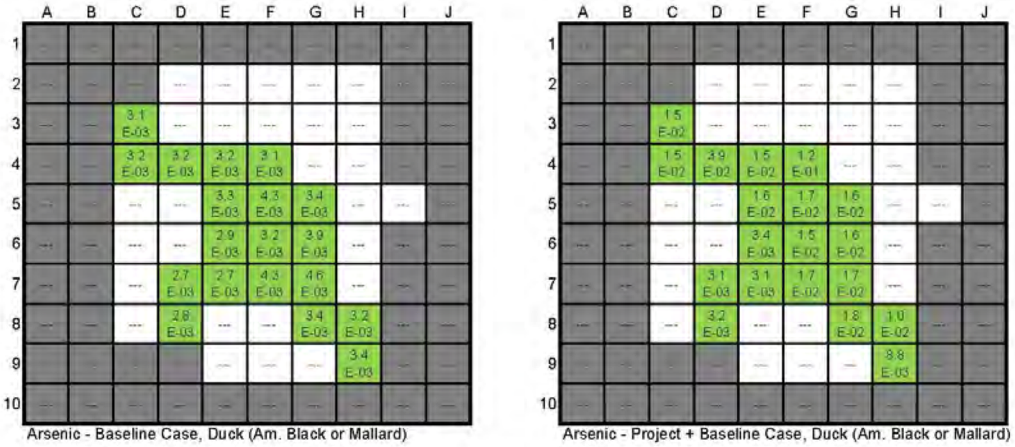
Table 7.7.49 Maximum Overall Risk Quotients for the Belted Kingfisher

COPC	Maximum Overall Risk Quotient (RQ, dimensionless)		
	Belted Kingfisher		
	Baseline Case	Project Alone Case	Project + Baseline Case
Aluminum (Al)	---	---	---
Arsenic (As)	0.047	0.057	0.075
Boron (B)	1.2E-03	0.040	0.041
Chromium (total) (Cr)	0.11	0.20	0.23
Cobalt (Co)	0.065	0.45	0.47
Copper (Cu)	0.045	0.15	0.18
Lead (Pb)	0.039	0.011	0.042
Manganese (Mn)	0.020	0.050	0.061
Mercury (Hg)	0.041	2.9E-03	0.043
Molybdenum (Mo)	2.9E-03	0.047	0.047
Nickel (Ni)	0.034	0.024	0.036
Thallium (Tl)	0.033	0.30	0.33
Tungsten (W)	0.031	0.11	0.11
Uranium (U)	4.2E-04	1.7E-03	1.8E-03
Vanadium (V)	**3.0**	**4.0**	**4.4**
Zinc (Zn)	0.14	0.056	0.19

Notes:
"---" indicates not available or applicable.
There are insufficient data to define TRVs for avian receptors for aluminum; therefore, RQs are not calculated.
Bold indicates that value exceeds the RQ target (1.0).

7.7.4.7.3 Risk Characterization for Semi-Aquatic Ecological Receptors

Maximum risk quotients for semi-aquatic mammals (*i.e.,* mink; Table 7.7.47) were less than 1.0. Maximum risk quotients for aquatic birds (*i.e.,* American black duck and belted kingfisher, Tables 7.7.48 and 7.7.49) were less than 1.0, with the exception of the American black duck exposed to thallium and vanadium for the Project + Baseline Case and the exception of the belted kingfisher exposed to vanadium for both the Baseline Case and the Project + Baseline Case. The spatial distributions of RQ for the American black duck and the belted kingfisher are presented in Figures 7.7.9 and 7.7.10, respectively.

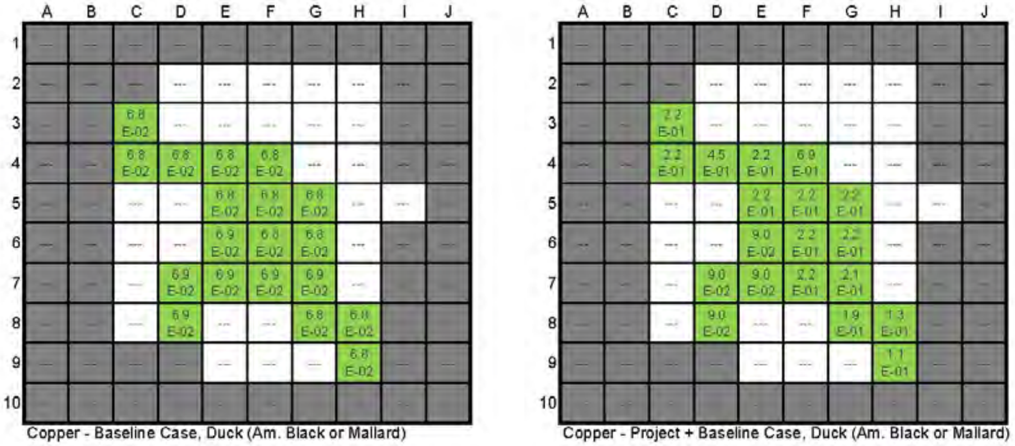


Arsenic - Baseline Case, Duck (Am. Black or Mallard)

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	---	---	---	---	---	---	---
3	---	---	3.1 E-03	---	---	---	---	---	---	---
4	---	---	3.2 E-03	3.2 E-03	3.2 E-03	3.1 E-03	---	---	---	---
5	---	---	---	---	3.3 E-03	4.3 E-03	3.4 E-03	---	---	---
6	---	---	---	---	2.9 E-03	3.2 E-03	3.9 E-03	---	---	---
7	---	---	---	2.7 E-03	2.7 E-03	4.3 E-03	4.6 E-03	---	---	---
8	---	---	---	2.8 E-03	---	---	3.4 E-03	3.2 E-03	---	---
9	---	---	---	---	---	---	---	3.4 E-03	---	---
10	---	---	---	---	---	---	---	---	---	---

Arsenic - Project + Baseline Case, Duck (Am. Black or Mallard)

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	---	---	---	---	---	---	---
3	---	---	1.5 E-02	---	---	---	---	---	---	---
4	---	---	1.5 E-02	3.9 E-02	1.5 E-02	1.2 E-01	---	---	---	---
5	---	---	---	---	1.6 E-02	1.7 E-02	1.6 E-02	---	---	---
6	---	---	---	---	3.4 E-03	1.5 E-02	1.6 E-02	---	---	---
7	---	---	---	3.1 E-03	3.1 E-03	1.7 E-02	1.7 E-02	---	---	---
8	---	---	---	3.2 E-03	---	---	1.8 E-02	1.0 E-02	---	---
9	---	---	---	---	---	---	---	8.8 E-03	---	---
10	---	---	---	---	---	---	---	---	---	---

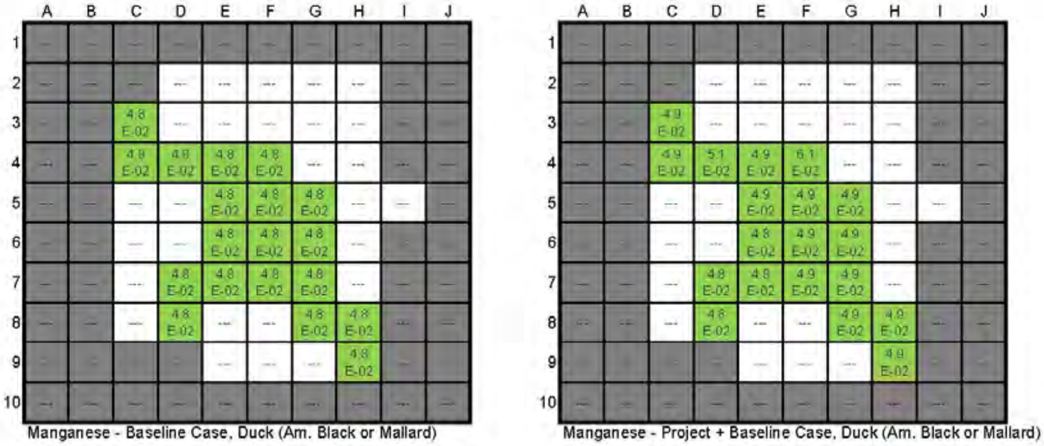


Copper - Baseline Case, Duck (Am. Black or Mallard)

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	---	---	---	---	---	---	---
3	---	---	6.8 E-02	---	---	---	---	---	---	---
4	---	---	6.8 E-02	6.8 E-02	6.8 E-02	6.8 E-02	---	---	---	---
5	---	---	---	---	6.8 E-02	6.8 E-02	6.8 E-02	---	---	---
6	---	---	---	---	6.9 E-02	6.8 E-02	6.8 E-02	---	---	---
7	---	---	---	6.9 E-02	6.9 E-02	6.9 E-02	6.9 E-02	---	---	---
8	---	---	---	6.9 E-02	---	---	6.8 E-02	6.8 E-02	---	---
9	---	---	---	---	---	---	---	6.8 E-02	---	---
10	---	---	---	---	---	---	---	---	---	---

Copper - Project + Baseline Case, Duck (Am. Black or Mallard)

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	---	---	---	---	---	---	---
3	---	---	2.2 E-01	---	---	---	---	---	---	---
4	---	---	2.2 E-01	4.5 E-01	2.2 E-01	6.9 E-01	---	---	---	---
5	---	---	---	---	2.2 E-01	2.2 E-01	2.2 E-01	---	---	---
6	---	---	---	---	9.0 E-02	2.2 E-01	2.2 E-01	---	---	---
7	---	---	---	9.0 E-02	9.0 E-02	2.2 E-01	2.1 E-01	---	---	---
8	---	---	---	9.0 E-02	---	---	1.9 E-01	1.3 E-01	---	---
9	---	---	---	---	---	---	---	1.1 E-01	---	---
10	---	---	---	---	---	---	---	---	---	---



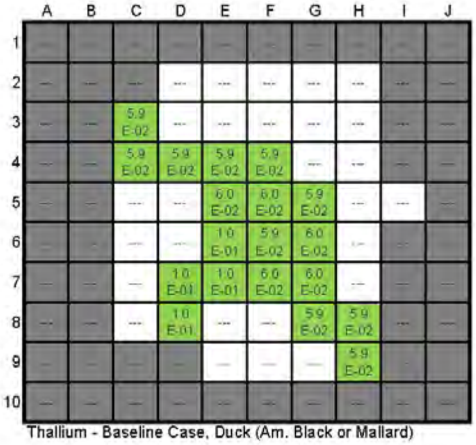
Manganese - Baseline Case, Duck (Am. Black or Mallard)

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	---	---	---	---	---	---	---
3	---	---	4.8 E-02	---	---	---	---	---	---	---
4	---	---	4.8 E-02	4.8 E-02	4.8 E-02	4.8 E-02	---	---	---	---
5	---	---	---	---	4.8 E-02	4.8 E-02	4.8 E-02	---	---	---
6	---	---	---	---	4.8 E-02	4.8 E-02	4.8 E-02	---	---	---
7	---	---	---	4.8 E-02	4.8 E-02	4.8 E-02	4.8 E-02	---	---	---
8	---	---	---	4.8 E-02	---	---	4.8 E-02	4.8 E-02	---	---
9	---	---	---	---	---	---	---	4.8 E-02	---	---
10	---	---	---	---	---	---	---	---	---	---

Manganese - Project + Baseline Case, Duck (Am. Black or Mallard)

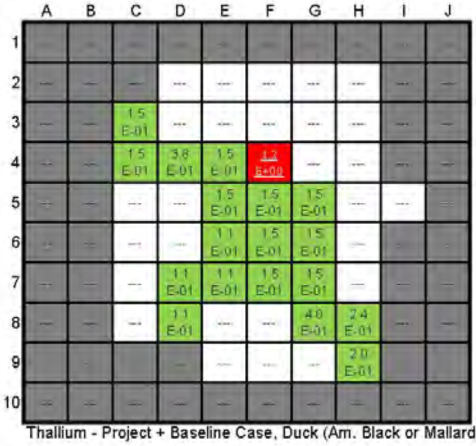
	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	---	---	---	---	---	---	---
3	---	---	4.9 E-02	---	---	---	---	---	---	---
4	---	---	4.9 E-02	5.1 E-02	4.9 E-02	6.1 E-02	---	---	---	---
5	---	---	---	---	4.9 E-02	4.9 E-02	4.9 E-02	---	---	---
6	---	---	---	---	4.8 E-02	4.9 E-02	4.9 E-02	---	---	---
7	---	---	---	4.8 E-02	4.8 E-02	4.9 E-02	4.9 E-02	---	---	---
8	---	---	---	4.8 E-02	---	---	4.9 E-02	4.9 E-02	---	---
9	---	---	---	---	---	---	---	4.9 E-02	---	---
10	---	---	---	---	---	---	---	---	---	---

Figure 7.7.9 **Distribution of Risk Quotients within the HHERA Study Area for the American Black Duck**



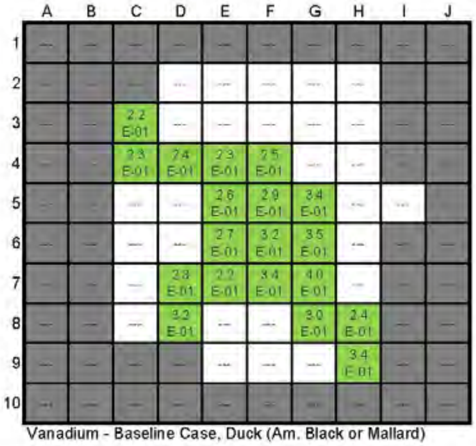
Thallium - Baseline Case, Duck (Am. Black or Mallard)

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	---	---	---	---	---	---	---
3	---	---	5.9 E-02	---	---	---	---	---	---	---
4	---	---	5.9 E-02	5.9 E-02	5.9 E-02	5.9 E-02	---	---	---	---
5	---	---	---	---	6.0 E-02	6.0 E-02	5.9 E-02	---	---	---
6	---	---	---	---	1.0 E-01	5.9 E-02	6.0 E-02	---	---	---
7	---	---	---	1.0 E-01	1.0 E-01	6.0 E-02	6.0 E-02	---	---	---
8	---	---	---	1.0 E-01	---	---	5.9 E-02	5.9 E-02	---	---
9	---	---	---	---	---	---	---	5.9 E-02	---	---
10	---	---	---	---	---	---	---	---	---	---



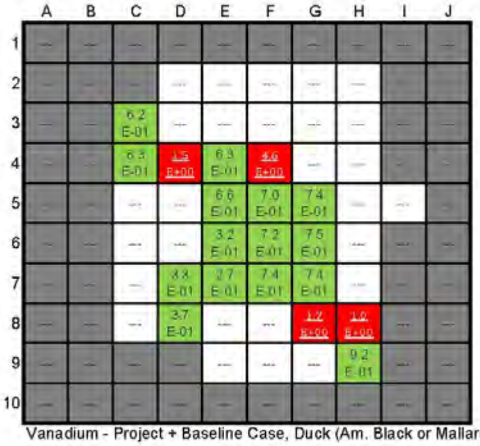
Thallium - Project + Baseline Case, Duck (Am. Black or Mallard)

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	---	---	---	---	---	---	---
3	---	---	1.5 E-01	---	---	---	---	---	---	---
4	---	---	1.5 E-01	3.8 E-01	1.5 E-01	1.2 E+00	---	---	---	---
5	---	---	---	---	1.5 E-01	1.5 E-01	1.5 E-01	---	---	---
6	---	---	---	---	1.1 E-01	1.5 E-01	1.5 E-01	---	---	---
7	---	---	---	1.1 E-01	1.1 E-01	1.5 E-01	1.5 E-01	---	---	---
8	---	---	---	1.1 E-01	---	---	4.0 E-01	2.4 E-01	---	---
9	---	---	---	---	---	---	---	2.0 E-01	---	---
10	---	---	---	---	---	---	---	---	---	---



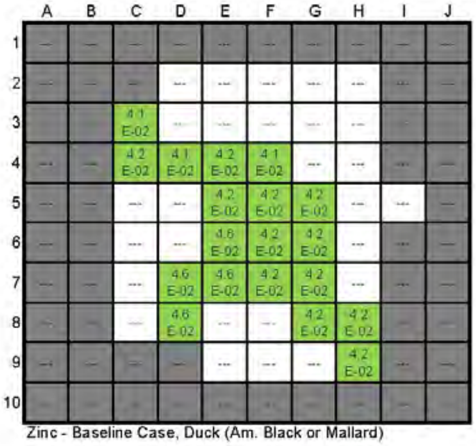
Vanadium - Baseline Case, Duck (Am. Black or Mallard)

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	---	---	---	---	---	---	---
3	---	---	2.2 E-01	---	---	---	---	---	---	---
4	---	---	2.3 E-01	2.4 E-01	2.3 E-01	2.5 E-01	---	---	---	---
5	---	---	---	---	2.6 E-01	2.9 E-01	3.4 E-01	---	---	---
6	---	---	---	---	2.7 E-01	3.2 E-01	3.5 E-01	---	---	---
7	---	---	---	2.8 E-01	2.2 E-01	3.4 E-01	4.0 E-01	---	---	---
8	---	---	---	3.2 E-01	---	---	3.0 E-01	2.4 E-01	---	---
9	---	---	---	---	---	---	---	3.4 E-01	---	---
10	---	---	---	---	---	---	---	---	---	---



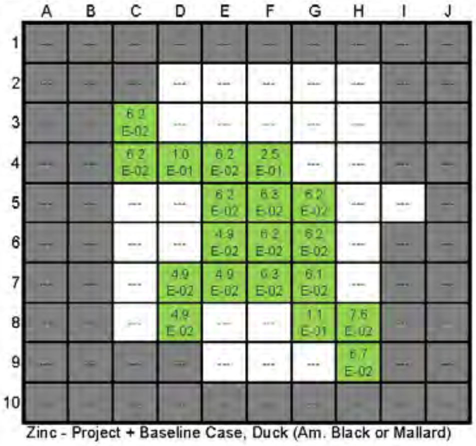
Vanadium - Project + Baseline Case, Duck (Am. Black or Mallard)

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	---	---	---	---	---	---	---
3	---	---	6.2 E-01	---	---	---	---	---	---	---
4	---	---	6.3 E-01	1.5 E+00	6.3 E-01	4.6 E+00	---	---	---	---
5	---	---	---	---	6.6 E-01	7.0 E-01	7.4 E-01	---	---	---
6	---	---	---	---	3.2 E-01	7.2 E-01	7.5 E-01	---	---	---
7	---	---	---	3.8 E-01	2.7 E-01	7.4 E-01	7.4 E-01	---	---	---
8	---	---	---	3.7 E-01	---	---	1.2 E+00	1.0 E+00	---	---
9	---	---	---	---	---	---	---	9.2 E-01	---	---
10	---	---	---	---	---	---	---	---	---	---



Zinc - Baseline Case, Duck (Am. Black or Mallard)

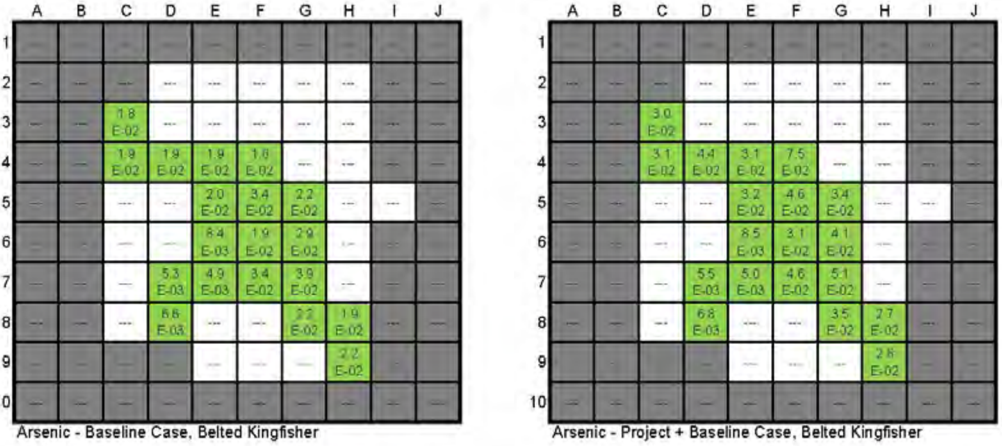
	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	---	---	---	---	---	---	---
3	---	---	4.1 E-02	---	---	---	---	---	---	---
4	---	---	4.2 E-02	4.1 E-02	4.2 E-02	4.1 E-02	---	---	---	---
5	---	---	---	---	4.2 E-02	4.2 E-02	4.2 E-02	---	---	---
6	---	---	---	---	4.6 E-02	4.2 E-02	4.2 E-02	---	---	---
7	---	---	---	4.6 E-02	4.6 E-02	4.2 E-02	4.2 E-02	---	---	---
8	---	---	---	4.6 E-02	---	---	4.2 E-02	4.2 E-02	---	---
9	---	---	---	---	---	---	---	4.2 E-02	---	---
10	---	---	---	---	---	---	---	---	---	---



Zinc - Project + Baseline Case, Duck (Am. Black or Mallard)

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	---	---	---	---	---	---	---
3	---	---	6.2 E-02	---	---	---	---	---	---	---
4	---	---	6.2 E-02	1.0 E-01	6.2 E-02	2.5 E-01	---	---	---	---
5	---	---	---	---	6.2 E-02	6.3 E-02	6.2 E-02	---	---	---
6	---	---	---	---	4.9 E-02	6.2 E-02	6.2 E-02	---	---	---
7	---	---	---	4.9 E-02	4.9 E-02	6.3 E-02	6.1 E-02	---	---	---
8	---	---	---	4.9 E-02	---	---	1.1 E-01	7.6 E-02	---	---
9	---	---	---	---	---	---	---	6.7 E-02	---	---
10	---	---	---	---	---	---	---	---	---	---

Figure 7.7.9 (continued) Distribution of Risk Quotients within the HHERA Study Area for the American Black Duck

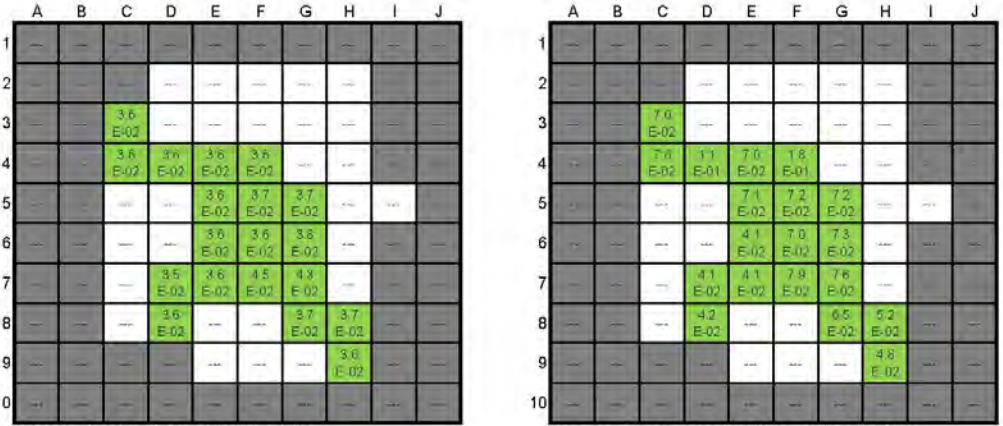


	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	---	---	---	---	---	---	---
3	---	---	1.8 E-02	---	---	---	---	---	---	---
4	---	---	1.9 E-02	1.9 E-02	1.9 E-02	1.8 E-02	---	---	---	---
5	---	---	---	---	2.0 E-02	3.4 E-02	2.2 E-02	---	---	---
6	---	---	---	---	8.4 E-03	1.9 E-02	2.9 E-02	---	---	---
7	---	---	---	5.3 E-03	4.9 E-03	3.4 E-02	3.9 E-02	---	---	---
8	---	---	---	6.6 E-03	---	---	2.2 E-02	1.9 E-02	---	---
9	---	---	---	---	---	---	---	2.2 E-02	---	---
10	---	---	---	---	---	---	---	---	---	---

Arsenic - Baseline Case, Belted Kingfisher

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	---	---	---	---	---	---	---
3	---	---	3.0 E-02	---	---	---	---	---	---	---
4	---	---	3.1 E-02	4.4 E-02	3.1 E-02	7.5 E-02	---	---	---	---
5	---	---	---	---	3.2 E-02	4.6 E-02	3.4 E-02	---	---	---
6	---	---	---	---	8.5 E-03	3.1 E-02	4.1 E-02	---	---	---
7	---	---	---	5.5 E-03	5.0 E-03	4.6 E-02	5.1 E-02	---	---	---
8	---	---	---	6.8 E-03	---	---	3.5 E-02	2.7 E-02	---	---
9	---	---	---	---	---	---	---	2.8 E-02	---	---
10	---	---	---	---	---	---	---	---	---	---

Arsenic - Project + Baseline Case, Belted Kingfisher

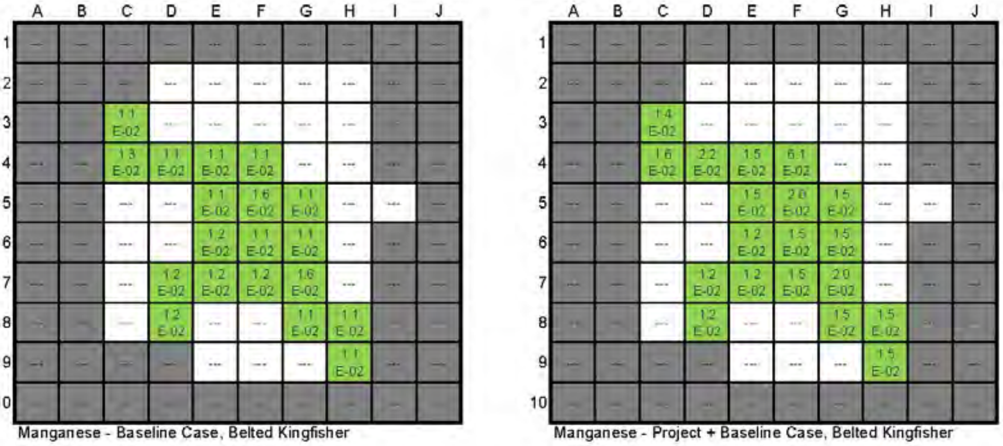


	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	---	---	---	---	---	---	---
3	---	---	3.6 E-02	---	---	---	---	---	---	---
4	---	---	3.6 E-02	3.6 E-02	3.6 E-02	3.6 E-02	---	---	---	---
5	---	---	---	---	3.6 E-02	3.7 E-02	3.7 E-02	---	---	---
6	---	---	---	---	3.6 E-02	3.6 E-02	3.8 E-02	---	---	---
7	---	---	---	3.5 E-02	3.6 E-02	4.5 E-02	4.8 E-02	---	---	---
8	---	---	---	3.6 E-02	---	---	3.7 E-02	3.7 E-02	---	---
9	---	---	---	---	---	---	---	3.6 E-02	---	---
10	---	---	---	---	---	---	---	---	---	---

Copper - Baseline Case, Belted Kingfisher

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	---	---	---	---	---	---	---
3	---	---	7.0 E-02	---	---	---	---	---	---	---
4	---	---	7.6 E-02	1.1 E-01	7.0 E-02	1.8 E-01	---	---	---	---
5	---	---	---	---	7.1 E-02	7.2 E-02	7.2 E-02	---	---	---
6	---	---	---	---	4.1 E-02	7.0 E-02	7.3 E-02	---	---	---
7	---	---	---	4.1 E-02	4.1 E-02	7.9 E-02	7.8 E-02	---	---	---
8	---	---	---	4.2 E-02	---	---	6.5 E-02	5.2 E-02	---	---
9	---	---	---	---	---	---	---	4.8 E-02	---	---
10	---	---	---	---	---	---	---	---	---	---

Copper - Project + Baseline Case, Belted Kingfisher



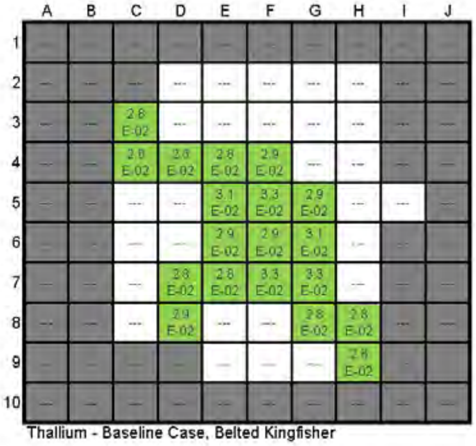
	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	---	---	---	---	---	---	---
3	---	---	1.1 E-02	---	---	---	---	---	---	---
4	---	---	1.3 E-02	1.1 E-02	1.1 E-02	1.1 E-02	---	---	---	---
5	---	---	---	---	1.1 E-02	1.6 E-02	1.1 E-02	---	---	---
6	---	---	---	---	1.2 E-02	1.1 E-02	1.1 E-02	---	---	---
7	---	---	---	1.2 E-02	1.2 E-02	1.2 E-02	1.6 E-02	---	---	---
8	---	---	---	1.2 E-02	---	---	1.1 E-02	1.1 E-02	---	---
9	---	---	---	---	---	---	---	1.1 E-02	---	---
10	---	---	---	---	---	---	---	---	---	---

Manganese - Baseline Case, Belted Kingfisher

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	---	---	---	---	---	---	---
3	---	---	1.4 E-02	---	---	---	---	---	---	---
4	---	---	1.6 E-02	2.2 E-02	1.5 E-02	6.1 E-02	---	---	---	---
5	---	---	---	---	1.5 E-02	2.0 E-02	1.5 E-02	---	---	---
6	---	---	---	---	1.2 E-02	1.5 E-02	1.5 E-02	---	---	---
7	---	---	---	1.2 E-02	1.2 E-02	1.5 E-02	2.0 E-02	---	---	---
8	---	---	---	1.2 E-02	---	---	1.5 E-02	1.5 E-02	---	---
9	---	---	---	---	---	---	---	1.5 E-02	---	---
10	---	---	---	---	---	---	---	---	---	---

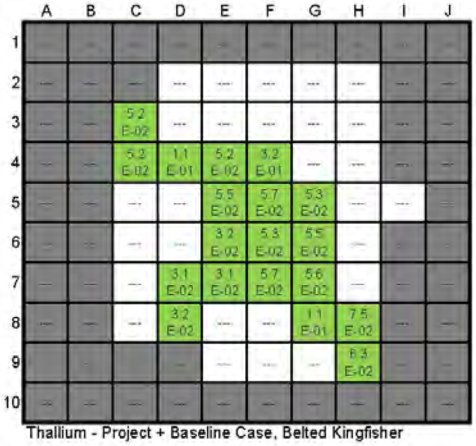
Manganese - Project + Baseline Case, Belted Kingfisher

Figure 7.7.10 **Distribution of Risk Quotients within the HHERA Study Area for the Belted Kingfisher**



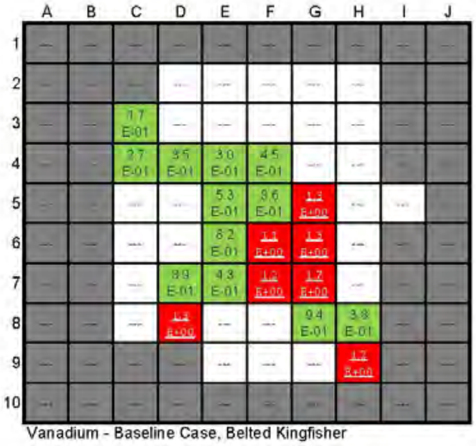
	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	---	---	---	---	---	---	---
3	---	---	2.8 E-02	---	---	---	---	---	---	---
4	---	---	2.8 E-02	2.8 E-02	2.8 E-02	2.9 E-02	---	---	---	---
5	---	---	---	---	3.1 E-02	3.3 E-02	2.9 E-02	---	---	---
6	---	---	---	---	2.9 E-02	2.9 E-02	3.1 E-02	---	---	---
7	---	---	---	2.8 E-02	2.8 E-02	3.3 E-02	3.3 E-02	---	---	---
8	---	---	---	2.9 E-02	---	---	2.8 E-02	2.8 E-02	---	---
9	---	---	---	---	---	---	---	2.8 E-02	---	---
10	---	---	---	---	---	---	---	---	---	---

Thallium - Baseline Case, Belted Kingfisher



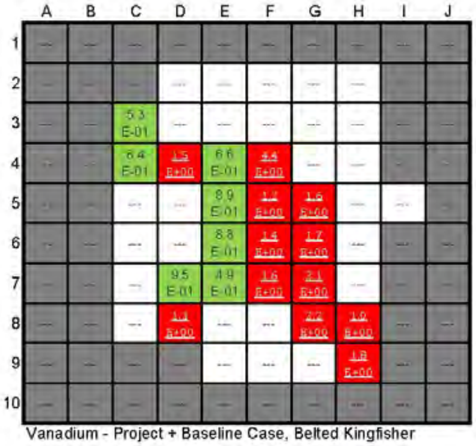
	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	---	---	---	---	---	---	---
3	---	---	5.2 E-02	---	---	---	---	---	---	---
4	---	---	5.2 E-02	1.1 E-01	5.2 E-02	3.2 E-01	---	---	---	---
5	---	---	---	---	5.5 E-02	5.7 E-02	5.3 E-02	---	---	---
6	---	---	---	---	3.2 E-02	5.3 E-02	5.5 E-02	---	---	---
7	---	---	---	3.1 E-02	3.1 E-02	5.7 E-02	5.6 E-02	---	---	---
8	---	---	---	3.2 E-02	---	---	1.1 E-01	7.5 E-02	---	---
9				---	---	---	---	8.3 E-02	---	---
10	---	---	---	---	---	---	---	---	---	---

Thallium - Project + Baseline Case, Belted Kingfisher



	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	---	---	---	---	---		
3	---	---	1.7 E-01	---	---	---	---	---	---	---
4	---	---	2.7 E-01	3.5 E-01	3.0 E-01	4.5 E-01	---	---	---	---
5	---	---	---	---	5.3 E-01	8.6 E-01	1.3 E+00	---	---	
6	---	---	---	---	8.2 E-01	1.1 E+00	1.3 E+00	---	---	---
7	---	---	---	8.9 E-01	4.3 E-01	1.2 E+00	1.7 E+00	---	---	---
8	---	---	---	1.3 E+00	---	---	9.4 E-01	3.8 E-01	---	---
9	---	---	---	---	---	---	---	1.7 E+00	---	---
10	---	---	---	---	---	---	---	---	---	---

Vanadium - Baseline Case, Belted Kingfisher

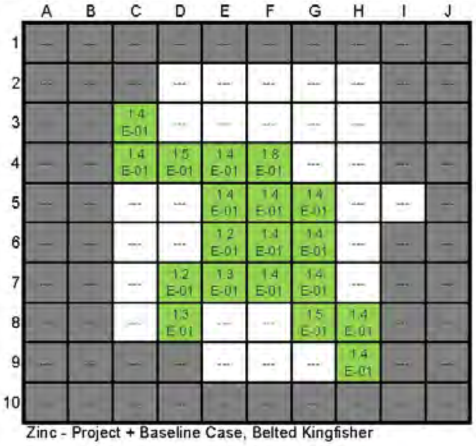


	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	---	---	---	---	---		
3	---	---	5.3 E-01	---	---	---	---	---	---	---
4	---	---	6.4 E-01	1.5 E+00	6.6 E-01	4.4 E+00	---	---	---	---
5	---	---	---	---	8.9 E-01	1.7 E+00	1.6 E+00	---	---	---
6	---	---	---	---	8.8 E-01	1.4 E+00	1.7 E+00	---	---	---
7	---	---	---	9.5 E-01	4.9 E-01	1.6 E+00	2.1 E+00	---	---	---
8	---	---	---	1.1 E+00	---	---	2.2 E+00	1.0 E+00	---	---
9	---	---	---	---	---	---	---	1.8 E+00	---	---
10	---	---	---	---	---	---	---	---	---	---

Vanadium - Project + Baseline Case, Belted Kingfisher

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	---	---	---	---	---	---	---
3			1.3 E-01	---	---	---	---	---		
4	---	---	1.3 E-01	1.3 E-01	1.3 E-01	1.3 E-01	---	---	---	---
5	---	---	---	---	1.3 E-01	1.3 E-01	1.3 E-01	---	---	---
6	---	---	---	---	1.2 E-01	1.3 E-01	1.3 E-01	---	---	---
7	---	---	---	1.2 E-01	1.2 E-01	1.3 E-01	1.3 E-01	---	---	---
8	---	---	---	1.2 E-01	---	---	1.3 E-01	1.3 E-01	---	---
9	---	---	---	---	---	---	---	1.3 E-01	---	---
10	---	---	---	---	---	---	---	---	---	---

Zinc - Baseline Case, Belted Kingfisher



	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	---	---	---	---	---	---	---
3			1.4 E-01	---	---	---	---	---		
4	---	---	1.4 E-01	1.5 E-01	1.4 E-01	1.8 E-01	---	---	---	---
5	---	---	---	---	1.4 E-01	1.4 E-01	1.4 E-01	---	---	---
6	---	---	---	---	1.2 E-01	1.4 E-01	1.4 E-01	---	---	---
7	---	---	---	1.2 E-01	1.3 E-01	1.4 E-01	1.4 E-01	---	---	---
8	---	---	---	1.3 E-01	---	---	1.5 E-01	1.4 E-01	---	---
9	---	---	---	---	---	---	---	1.4 E-01	---	---
10	---	---	---	---	---	---	---	---	---	---

Zinc - Project + Baseline Case, Belted Kingfisher

Figure 7.7.10 (continued) Distribution of Risk Quotients within the HHERA Study Area for the Belted Kingfisher

For the American black duck, risk quotients for thallium are generally less than 1.0, with one exception located in proximity of UT3&4 (corresponding to Grid F4 on Figure 7.7.3). The primary pathway contributing to thallium risk for the American black duck was ingestion of freshwater benthic invertebrates, followed by ingestion of freshwater sediments. Similarly, risk quotients for vanadium are generally less than 1.0, with four exceptions located in proximity of water prediction nodes UT3&4 (Grid F4), UT1 (Grid D4), NAP5 (Grid G8), and NAP7 (Grid H8) for vanadium. The primary pathway contributing to vanadium risk for the American black duck was ingestion of freshwater sediment followed by ingestion of freshwater benthic invertebrates. For both thallium and vanadium, the increase in RQ can be related to an increase in predicted surface water concentrations due primarily to modelled seepage from the TSF towards small tributaries of West Branch Napadogan Brook. These identified target RQ exceedances are generally only marginally higher than 1.0 and appear to be localized. As such, these are not expected to results in population-level effects for the American black duck.

For the belted kingfisher, risk quotients for vanadium exceeded the target RQ of 1.0 for both the Baseline Case and the Project + Baseline Case (Figure 7.7.10). The primary pathway contributing to risk for the belted kingfisher was ingestion of fish. Grids exhibiting exceedance of the target RQ with changes related to fish ingestion are localised in proximity of water prediction nodes UT3&UT4 (Grid F4) and UT1 (Grid D4), as well as within West Branch Napadogan Brook. As these are generally marginally higher than 1.0, these are not expected to result in population-level effects for the belted kingfisher.

7.7.4.7.4 Risk Characterization for Soil Invertebrates and Terrestrial Plants

Maximum risk quotients for soil invertebrates and terrestrial plants are provided in Tables 7.7.50 and 7.7.51, respectively. The tables provide Baseline Case, Project Alone Case and Project + Baseline Case RQ values using existing data for soils in the HHERA Study Area.

Maximum risk quotients for soil invertebrates were less than 1.0, with the exception of arsenic, boron and manganese for both the Baseline Case and the Project + Baseline Case. The spatial distribution of RQ for soil invertebrates is presented in Figure 7.7.11. Maximum risk quotients for terrestrial plants were less than 1.0, with the exception of arsenic, boron, manganese and vanadium for both the Baseline Case and the Project + Baseline Case. The spatial distribution of RQ for terrestrial plants is presented in Figure 7.7.12.

Due to the very small effect of ore dust deposition on the Project + Baseline Case concentrations of arsenic, boron, manganese and vanadium in soil, there was no substantive difference between the risks of the Baseline Case and the Project + Baseline Case for soil invertebrates and terrestrial plants exposed to these COPCs. The identified exceedances of the target RQ to (which in some cases are localized) are related to pre-existing baseline metal concentrations in the environment, and the Project-related contribution to these environmental effects is negligible.

Table 7.7.50 Maximum Overall Risk Quotients for Soil Invertebrates

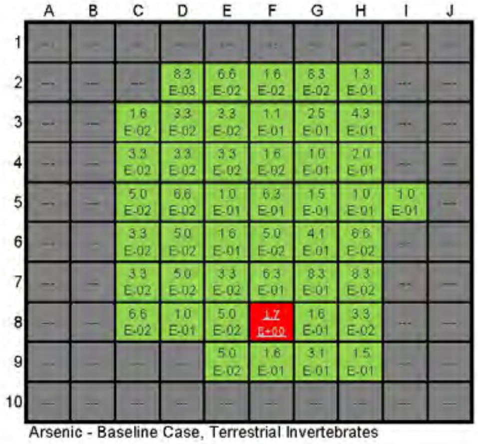
COPC	Maximum Overall Risk Quotient (RQ, dimensionless)		
	Soil Invertebrates		
	Baseline Case	Project Alone Case	Project + Baseline Case
Aluminum (Al)	---	---	---
Arsenic (As)	**1.7**	1.5E-06	**1.7**
Boron (B)	**2.7**	5.7E-06	**2.7**
Chromium (total) (Cr)	0.14	4.6E-07	0.14
Cobalt (Co)	0.56	6.0E-07	0.56
Copper (Cu)	0.44	2.8E-06	0.44
Lead (Pb)	0.029	5.7E-08	0.029
Manganese (Mn)	**14**	4.1E-06	**14**
Mercury (Hg)	0.040	1.4E-08	0.040
Molybdenum (Mo)	0.41	3.2E-06	0.41
Nickel (Ni)	0.12	1.5E-07	0.12
Thallium (Tl)	0.21	1.3E-06	0.21
Tungsten (W)	---	---	---
Uranium (U)	---	---	---
Vanadium (V)	0.58	7.3E-07	0.58
Zinc (Zn)	0.30	8.0E-07	0.30

Notes:
"---" indicates not available or applicable.
There are insufficient data to define a benchmark for aluminum, tungsten and uranium; therefore, RQs are not calculated.
Bold indicates that value exceeds the RQ target (1.0).

Table 7.7.51 Maximum Overall Risk Quotients for Terrestrial Plants

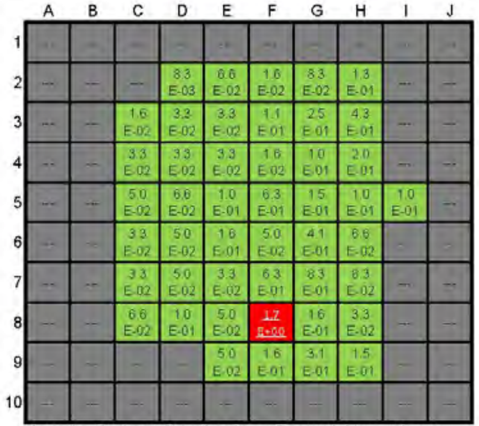
COPC	Maximum Overall Risk Quotient (RQ, dimensionless)		
	Terrestrial Plants		
	Baseline Case	Project Alone Case	Project + Baseline Case
Aluminum (Al)	---	---	---
Arsenic (As)	**5.2**	4.4E-06	**5.2**
Boron (B)	**2.7**	5.7E-06	**2.7**
Chromium (total) (Cr)	0.14	4.6E-07	0.14
Cobalt (Co)	0.56	6.0E-07	0.56
Copper (Cu)	0.44	2.8E-06	0.44
Lead (Pb)	0.20	3.9E-07	0.20
Manganese (Mn)	**28**	8.3E-06	**28**
Mercury (Hg)	0.040	1.4E-08	0.040
Molybdenum (Mo)	0.41	3.2E-06	0.41
Nickel (Ni)	0.34	4.3E-07	0.34
Thallium (Tl)	0.21	1.3E-06	0.21
Tungsten (W)	---	---	---
Uranium (U)	0.64	1.0E-06	0.64
Vanadium (V)	**1.2**	1.5E-06	**1.2**
Zinc (Zn)	0.30	8.0E-07	0.30

Notes:
"---" indicates not available or applicable.
There are insufficient data to define a benchmark for aluminum and tungsten; therefore, RQs are not calculated.
Bold indicates that value exceeds the RQ target (1.0).



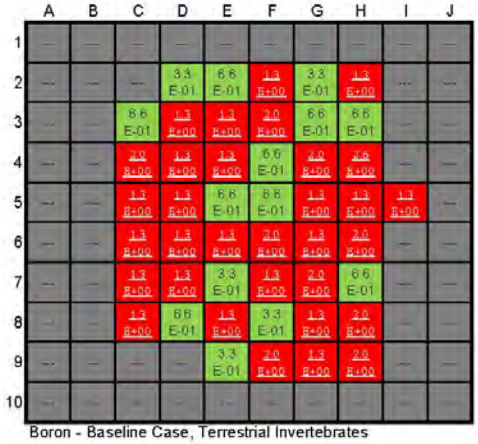
	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	8.3 E-03	6.6 E-02	1.6 E-02	8.3 E-02	1.3 E-01	---	---
3	---	---	1.6 E-02	3.3 E-02	3.3 E-02	1.1 E-01	2.5 E-01	4.3 E-01	---	---
4	---	---	3.3 E-02	3.3 E-02	3.3 E-02	1.6 E-02	1.0 E-01	2.0 E-01	---	---
5	---	---	5.0 E-02	6.6 E-02	1.0 E-01	6.3 E-01	1.5 E-01	1.0 E-01	1.0 E-01	---
6	---	---	3.3 E-02	5.0 E-02	1.6 E-01	5.0 E-02	4.1 E-01	6.6 E-02	---	---
7	---	---	3.3 E-02	5.0 E-02	3.3 E-02	6.3 E-01	8.3 E-01	8.3 E-02	---	---
8	---	---	6.6 E-02	1.0 E-01	5.0 E-02	1.7 E+00	1.6 E-01	3.3 E-02	---	---
9	---	---	---	---	5.0 E-02	1.6 E-01	3.1 E-01	1.5 E-01	---	---
10	---	---	---	---	---	---	---	---	---	---

Arsenic - Baseline Case, Terrestrial Invertebrates



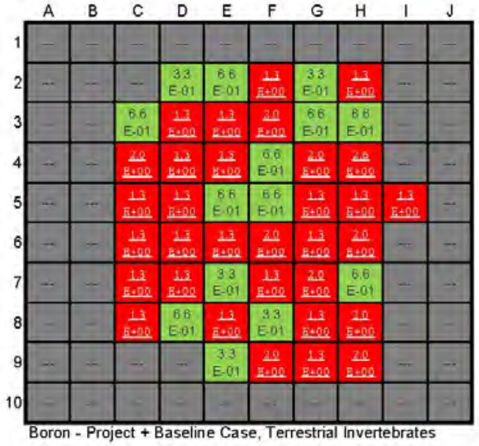
	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	8.3 E-03	6.6 E-02	1.6 E-02	8.3 E-02	1.3 E-01	---	---
3	---	---	1.6 E-02	3.3 E-02	3.3 E-02	1.1 E-01	2.5 E-01	4.3 E-01	---	---
4	---	---	3.3 E-02	3.3 E-02	3.3 E-02	1.6 E-02	1.0 E-01	2.0 E-01	---	---
5	---	---	5.0 E-02	6.6 E-02	1.0 E-01	6.3 E-01	1.5 E-01	1.0 E-01	1.0 E-01	---
6	---	---	3.3 E-02	5.0 E-02	1.6 E-01	5.0 E-02	4.1 E-01	6.6 E-02	---	---
7	---	---	3.3 E-02	5.0 E-02	3.3 E-02	6.3 E-01	8.3 E-01	8.3 E-02	---	---
8	---	---	6.6 E-02	1.0 E-01	5.0 E-02	1.7 E+00	1.6 E-01	3.3 E-02	---	---
9	---	---	---	---	5.0 E-02	1.6 E-01	3.1 E-01	1.5 E-01	---	---
10	---	---	---	---	---	---	---	---	---	---

Arsenic - Project + Baseline Case, Terrestrial Invertebrates



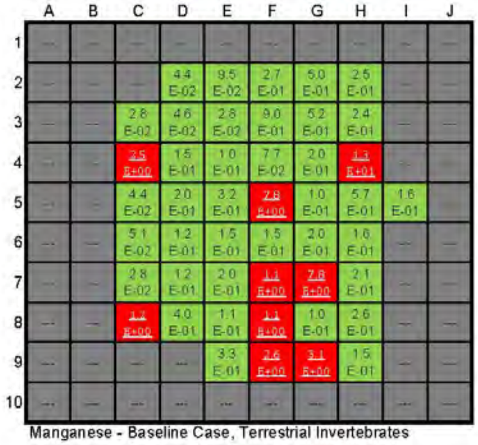
	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	3.3 E-01	6.6 E-01	1.3 E+00	3.3 E-01	1.3 E+00	---	---
3	---	---	6.6 E-01	1.3 E+00	1.3 E+00	2.0 E+00	6.6 E-01	6.6 E-01	---	---
4	---	---	2.0 E+00	1.3 E+00	1.3 E+00	6.6 E-01	2.0 E+00	2.6 E+00	---	---
5	---	---	1.3 E+00	1.3 E+00	6.6 E-01	6.6 E-01	1.3 E+00	1.3 E+00	1.3 E+00	---
6	---	---	1.3 E+00	1.3 E+00	1.3 E+00	2.0 E+00	1.3 E+00	2.0 E+00	---	---
7	---	---	1.3 E+00	1.3 E+00	3.3 E-01	1.3 E+00	2.0 E+00	6.6 E-01	---	---
8	---	---	1.3 E+00	6.6 E-01	1.3 E+00	3.3 E-01	1.3 E+00	2.0 E+00	---	---
9	---	---	---	---	3.3 E-01	2.0 E+00	1.3 E+00	2.0 E+00	---	---
10	---	---	---	---	---	---	---	---	---	---

Boron - Baseline Case, Terrestrial Invertebrates



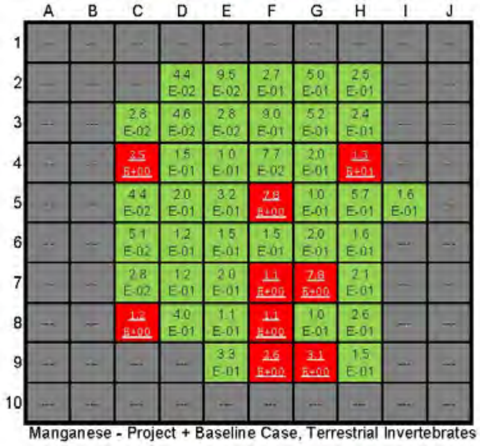
	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	3.3 E-01	6.6 E-01	1.3 E+00	3.3 E-01	1.3 E+00	---	---
3	---	---	6.6 E-01	1.3 E+00	1.3 E+00	2.0 E+00	6.6 E-01	6.6 E-01	---	---
4	---	---	2.0 E+00	1.3 E+00	1.3 E+00	6.6 E-01	2.0 E+00	2.6 E+00	---	---
5	---	---	1.3 E+00	1.3 E+00	6.6 E-01	6.6 E-01	1.3 E+00	1.3 E+00	1.3 E+00	---
6	---	---	1.3 E+00	1.3 E+00	1.3 E+00	2.0 E+00	1.3 E+00	2.0 E+00	---	---
7	---	---	1.3 E+00	1.3 E+00	3.3 E-01	1.3 E+00	2.0 E+00	6.6 E-01	---	---
8	---	---	1.3 E+00	6.6 E-01	1.3 E+00	3.3 E-01	1.3 E+00	2.0 E+00	---	---
9	---	---	---	---	3.3 E-01	2.0 E+00	1.3 E+00	2.0 E+00	---	---
10	---	---	---	---	---	---	---	---	---	---

Boron - Project + Baseline Case, Terrestrial Invertebrates



	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	4.4 E-02	9.5 E-02	2.7 E-01	5.0 E-01	2.5 E-01	---	---
3	---	---	2.8 E-02	4.6 E-02	2.8 E-02	9.0 E-01	5.2 E-01	2.4 E-01	---	---
4	---	---	2.5 E+00	1.5 E-01	1.0 E-01	7.7 E-02	2.0 E-01	1.3 E+01	---	---
5	---	---	4.4 E-02	2.0 E-01	3.2 E-01	7.8 E+00	1.0 E-01	5.7 E-01	1.6 E-01	---
6	---	---	5.1 E-02	1.2 E-01	1.5 E-01	1.5 E-01	2.0 E-01	1.6 E-01	---	---
7	---	---	2.8 E-02	1.2 E-01	2.0 E-01	1.1 E+00	7.8 E+00	2.1 E-01	---	---
8	---	---	1.2 E+00	4.0 E-01	1.1 E-01	1.1 E+00	1.0 E-01	2.6 E-01	---	---
9	---	---	---	---	3.3 E-01	2.6 E+00	3.1 E+00	1.5 E-01	---	---
10	---	---	---	---	---	---	---	---	---	---

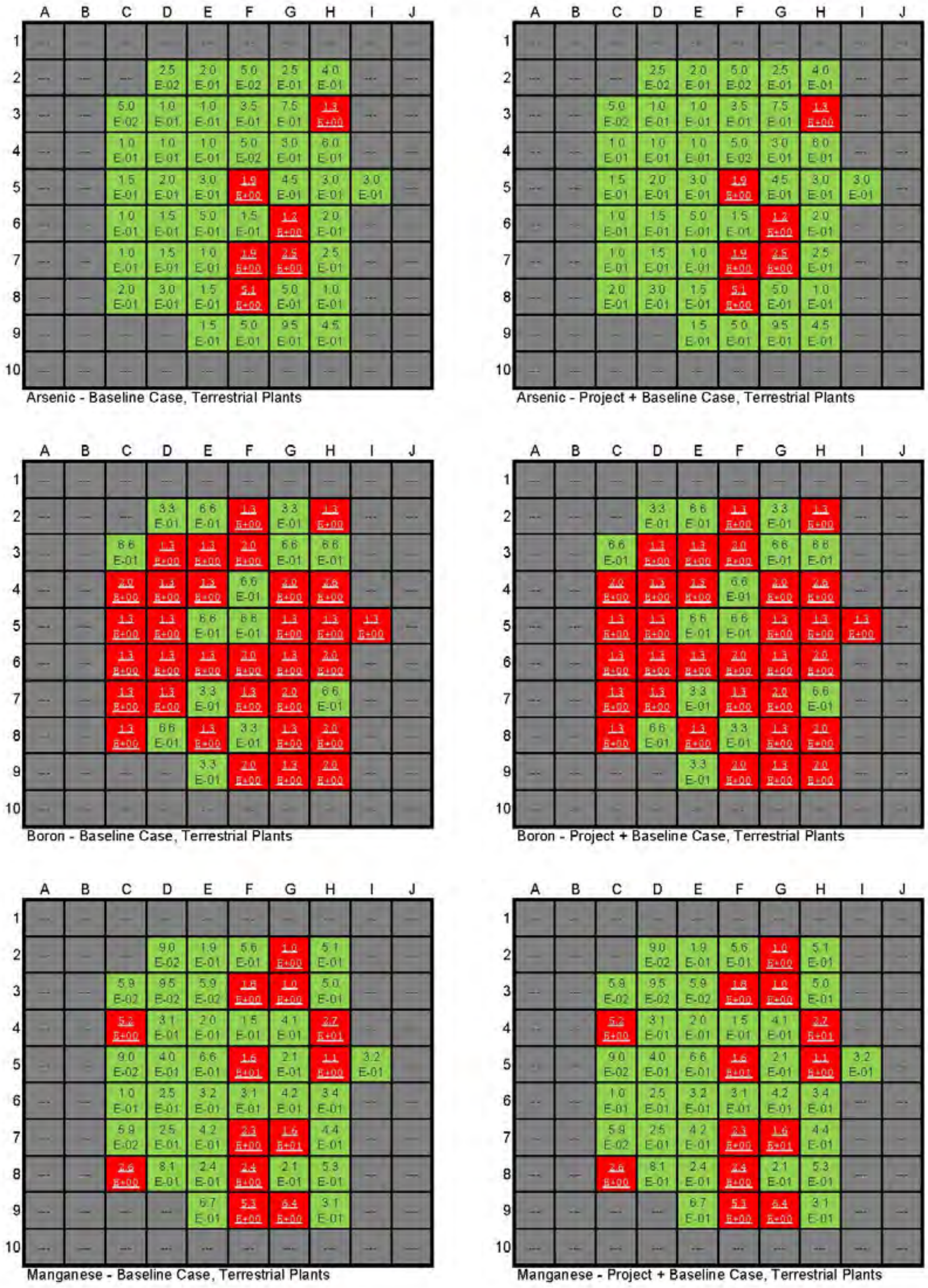
Manganese - Baseline Case, Terrestrial Invertebrates



	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	4.4 E-02	9.5 E-02	2.7 E-01	5.0 E-01	2.5 E-01	---	---
3	---	---	2.8 E-02	4.6 E-02	2.8 E-02	9.0 E-01	5.2 E-01	2.4 E-01	---	---
4	---	---	2.5 E+00	1.5 E-01	1.0 E-01	7.7 E-02	2.0 E-01	1.3 E+01	---	---
5	---	---	4.4 E-02	2.0 E-01	3.2 E-01	7.8 E+00	1.0 E-01	5.7 E-01	1.6 E-01	---
6	---	---	5.1 E-02	1.2 E-01	1.5 E-01	1.5 E-01	2.0 E-01	1.6 E-01	---	---
7	---	---	2.8 E-02	1.2 E-01	2.0 E-01	1.1 E+00	7.8 E+00	2.1 E-01	---	---
8	---	---	1.2 E+00	4.0 E-01	1.1 E-01	1.1 E+00	1.0 E-01	2.6 E-01	---	---
9	---	---	---	---	3.3 E-01	2.6 E+00	3.1 E+00	1.5 E-01	---	---
10	---	---	---	---	---	---	---	---	---	---

Manganese - Project + Baseline Case, Terrestrial Invertebrates

Figure 7.7.11 **Distribution of Risk Quotients within the HHERA Study Area for Soil Invertebrates**



	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	2.5 E-02	2.0 E-01	5.0 E-02	2.5 E-01	4.0 E-01	---	---
3	---	---	5.0 E-02	1.0 E-01	1.0 E-01	3.5 E-01	7.5 E-01	1.3 E+00	---	---
4	---	---	1.0 E-01	1.0 E-01	1.0 E-01	5.0 E-02	3.0 E-01	6.0 E-01	---	---
5	---	---	1.5 E-01	2.0 E-01	3.0 E-01	1.9 E+00	4.5 E-01	3.0 E-01	3.0 E-01	---
6	---	---	1.0 E-01	1.5 E-01	5.0 E-01	1.5 E-01	1.2 E+00	2.0 E-01	---	---
7	---	---	1.0 E-01	1.5 E-01	1.0 E-01	1.9 E+00	2.5 E+00	2.5 E-01	---	---
8	---	---	2.0 E-01	3.0 E-01	1.5 E-01	5.1 E+00	5.0 E-01	1.0 E-01	---	---
9	---	---	---	---	1.5 E-01	5.0 E-01	9.5 E-01	4.5 E-01	---	---
10	---	---	---	---	---	---	---	---	---	---

Arsenic - Baseline Case, Terrestrial Plants

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	2.5 E-02	2.0 E-01	5.0 E-02	2.5 E-01	4.0 E-01	---	---
3	---	---	5.0 E-02	1.0 E-01	1.0 E-01	3.5 E-01	7.5 E-01	1.3 E+00	---	---
4	---	---	1.0 E-01	1.0 E-01	1.0 E-01	5.0 E-02	3.0 E-01	6.0 E-01	---	---
5	---	---	1.5 E-01	2.0 E-01	3.0 E-01	1.9 E+00	4.5 E-01	3.0 E-01	3.0 E-01	---
6	---	---	1.0 E-01	1.5 E-01	5.0 E-01	1.5 E-01	1.2 E+00	2.0 E-01	---	---
7	---	---	1.0 E-01	1.5 E-01	1.0 E-01	1.9 E+00	2.5 E+00	2.5 E-01	---	---
8	---	---	2.0 E-01	3.0 E-01	1.5 E-01	5.1 E+00	5.0 E-01	1.0 E-01	---	---
9	---	---	---	---	1.5 E-01	5.0 E-01	9.5 E-01	4.5 E-01	---	---
10	---	---	---	---	---	---	---	---	---	---

Arsenic - Project + Baseline Case, Terrestrial Plants

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	3.3 E-01	6.6 E-01	1.3 E+00	3.3 E-01	1.3 E+00	---	---
3	---	---	6.6 E-01	1.3 E+00	1.3 E+00	2.0 E+00	6.6 E-01	6.6 E-01	---	---
4	---	---	2.0 E+00	1.3 E+00	1.3 E+00	6.6 E-01	2.0 E+00	2.6 E+00	---	---
5	---	---	1.3 E+00	1.3 E+00	6.6 E-01	6.6 E-01	1.3 E+00	1.3 E+00	1.3 E+00	---
6	---	---	1.3 E+00	1.3 E+00	1.3 E+00	2.0 E+00	1.3 E+00	2.0 E+00	---	---
7	---	---	1.3 E+00	1.3 E+00	3.3 E-01	1.3 E+00	2.0 E+00	6.6 E-01	---	---
8	---	---	1.3 E+00	6.6 E-01	1.3 E+00	3.3 E-01	1.3 E+00	2.0 E+00	---	---
9	---	---	---	---	3.3 E-01	2.0 E+00	1.3 E+00	2.0 E+00	---	---
10	---	---	---	---	---	---	---	---	---	---

Boron - Baseline Case, Terrestrial Plants

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	3.3 E-01	6.6 E-01	1.3 E+00	3.3 E-01	1.3 E+00	---	---
3	---	---	6.6 E-01	1.3 E+00	1.3 E+00	2.0 E+00	6.6 E-01	6.6 E-01	---	---
4	---	---	2.0 E+00	1.3 E+00	1.3 E+00	6.6 E-01	2.0 E+00	2.6 E+00	---	---
5	---	---	1.3 E+00	1.3 E+00	6.6 E-01	6.6 E-01	1.3 E+00	1.3 E+00	1.3 E+00	---
6	---	---	1.3 E+00	1.3 E+00	1.3 E+00	2.0 E+00	1.3 E+00	2.0 E+00	---	---
7	---	---	1.3 E+00	1.3 E+00	3.3 E-01	1.3 E+00	2.0 E+00	6.6 E-01	---	---
8	---	---	1.3 E+00	6.6 E-01	1.3 E+00	3.3 E-01	1.3 E+00	2.0 E+00	---	---
9	---	---	---	---	3.3 E-01	2.0 E+00	1.3 E+00	2.0 E+00	---	---
10	---	---	---	---	---	---	---	---	---	---

Boron - Project + Baseline Case, Terrestrial Plants

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	9.0 E-02	1.9 E-01	5.6 E-01	1.0 E+00	5.1 E-01	---	---
3	---	---	5.9 E-02	9.5 E-02	5.9 E-02	1.8 E+00	1.0 E+00	5.0 E-01	---	---
4	---	---	5.2 E+00	3.1 E-01	2.0 E-01	1.5 E-01	4.1 E-01	2.7 E+01	---	---
5	---	---	9.0 E-02	4.0 E-01	6.6 E-01	1.6 E+01	2.1 E-01	1.1 E+00	3.2 E-01	---
6	---	---	1.0 E-01	2.5 E-01	3.2 E-01	3.1 E-01	4.2 E-01	3.4 E-01	---	---
7	---	---	5.9 E-02	2.5 E-01	4.2 E-01	2.3 E+00	1.6 E+01	4.4 E-01	---	---
8	---	---	2.6 E+00	8.1 E-01	2.4 E-01	2.4 E+00	2.1 E-01	5.3 E-01	---	---
9	---	---	---	---	6.7 E-01	5.3 E+00	6.4 E+00	3.1 E-01	---	---
10	---	---	---	---	---	---	---	---	---	---

Manganese - Baseline Case, Terrestrial Plants

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	9.0 E-02	1.9 E-01	5.6 E-01	1.0 E+00	5.1 E-01	---	---
3	---	---	5.9 E-02	9.5 E-02	5.9 E-02	1.8 E+00	1.0 E+00	5.0 E-01	---	---
4	---	---	5.2 E+00	3.1 E-01	2.0 E-01	1.5 E-01	4.1 E-01	2.7 E+01	---	---
5	---	---	9.0 E-02	4.0 E-01	6.6 E-01	1.6 E+01	2.1 E-01	1.1 E+00	3.2 E-01	---
6	---	---	1.0 E-01	2.5 E-01	3.2 E-01	3.1 E-01	4.2 E-01	3.4 E-01	---	---
7	---	---	5.9 E-02	2.5 E-01	4.2 E-01	2.3 E+00	1.6 E+01	4.4 E-01	---	---
8	---	---	2.6 E+00	8.1 E-01	2.4 E-01	2.4 E+00	2.1 E-01	5.3 E-01	---	---
9	---	---	---	---	6.7 E-01	5.3 E+00	6.4 E+00	3.1 E-01	---	---
10	---	---	---	---	---	---	---	---	---	---

Manganese - Project + Baseline Case, Terrestrial Plants

Figure 7.7.12 **Distribution of Risk Quotients within the HHERA Study Area for Terrestrial Plants**

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	5.0 E-02	7.0 E-02	5.0 E-02	1.2 E-01	3.9 E-01	---	---
3	---	---	2.0 E-02	6.0 E-02	8.0 E-02	2.4 E-01	5.2 E-01	3.7 E-01	---	---
4	---	---	6.0 E-02	9.0 E-02	7.0 E-02	1.3 E-01	1.3 E-01	5.9 E-01	---	---
5	---	---	1.7 E-01	2.1 E-01	1.6 E-01	2.9 E-01	4.6 E-01	1.1 E+00	3.1 E-01	---
6	---	---	1.7 E-01	2.3 E-01	2.7 E-01	3.9 E-01	4.8 E-01	2.3 E-01	---	---
7	---	---	2.0 E-01	3.0 E-01	1.2 E-01	4.4 E-01	6.5 E-01	6.4 E-01	---	---
8	---	---	2.5 E-01	4.6 E-01	4.4 E-01	4.4 E-01	3.2 E-01	1.0 E-01	---	---
9	---	---	---	---	3.3 E-01	3.5 E-01	4.6 E-01	4.5 E-01	---	---
10	---	---	---	---	---	---	---	---	---	---

Vanadium - Baseline Case, Terrestrial Plants

	A	B	C	D	E	F	G	H	I	J
1	---	---	---	---	---	---	---	---	---	---
2	---	---	---	5.0 E-02	7.0 E-02	5.0 E-02	1.2 E-01	3.9 E-01	---	---
3	---	---	2.0 E-02	6.0 E-02	8.0 E-02	2.4 E-01	5.2 E-01	3.7 E-01	---	---
4	---	---	6.0 E-02	9.0 E-02	7.0 E-02	1.3 E-01	1.3 E-01	5.9 E-01	---	---
5	---	---	1.7 E-01	2.1 E-01	1.6 E-01	2.9 E-01	4.6 E-01	1.1 E+00	3.1 E-01	---
6	---	---	1.7 E-01	2.3 E-01	2.7 E-01	3.9 E-01	4.8 E-01	2.3 E-01	---	---
7	---	---	2.0 E-01	3.0 E-01	1.2 E-01	4.4 E-01	6.5 E-01	6.4 E-01	---	---
8	---	---	2.5 E-01	4.6 E-01	4.4 E-01	4.4 E-01	3.2 E-01	1.0 E-01	---	---
9	---	---	---	---	3.3 E-01	3.5 E-01	4.6 E-01	4.5 E-01	---	---
10	---	---	---	---	---	---	---	---	---	---

Vanadium - Project + Baseline Case, Terrestrial Plants

Figure 7.7.12 (continued) Distribution of Risk Quotients within the HHERA Study Area for Terrestrial Plants

7.7.4.7.5 Risk Characterization for the Sediment Community

Comparison of sediment concentrations for the Baseline Case, Project Alone Case and Project + Baseline Case to Canadian Sediment Quality Guidelines for the Protection of Aquatic Life probable effect levels are presented in Table 7.7.52. Maximum sediment concentrations were less than the available guidelines for the HHERA Study Area, with the exception of arsenic for Baseline Case, Project Alone Case and Project + Baseline Case. The Project + Baseline Case arsenic sediment concentrations are mainly related to pre-existing Baseline Case arsenic concentrations in the environment, and the Project-related contribution to these environmental effects is less than 33%. Canadian Sediment Quality Guidelines for the Protection of Aquatic Life are meant to be protective for a range of species and as such, sediment concentrations less than these guidelines are indicative of a negligible probability of adverse environmental effects. Where concentrations are greater than these guidelines, there is a possibility (but not a certainty) of adverse environmental effects to ecological receptors. Such cases require a careful review of predicted exposure levels, and more focused investigations may be required to reduce conservatism in the assessment. Follow-up may be used to confirm the predicted changes in sediment arsenic concentrations in view of the modelling uncertainties and conservatism.

Table 7.7.52 **Comparison Sediment Concentrations to Canadian Sediment Quality Guidelines**

COPC	CCME SQG Guidelines [a] (mg/kg dry weight)	Maximum Sediment Concentration (mg/kg dry weight)		
		Baseline Case	Project Alone Case	Project + Baseline Case
Aluminum (Al)	---	1.29E+04	2.42E+04	3.21E+04
Arsenic (As)	17	**3.83E+01**	1.24E+01	**4.49E+01**
Boron (B)	---	2.00E+00	3.05E+01	3.25E+01
Chromium (total) (Cr)	90	1.36E+01	2.32E+00	1.36E+01
Cobalt (Co)	---	3.40E+01	2.13E+01	3.40E+01
Copper (Cu)	197	5.23E+01	1.83E+01	5.25E+01
Lead (Pb)	91.3	4.55E+01	1.21E+01	4.57E+01
Manganese (Mn)	---	1.82E+03	3.19E+02	2.14E+03

Table 7.7.52 Comparison Sediment Concentrations to Canadian Sediment Quality Guidelines

COPC	CCME SQG Guidelines [a] (mg/kg dry weight)	Maximum Sediment Concentration (mg/kg dry weight)		
		Baseline Case	Project Alone Case	Project + Baseline Case
Mercury (Hg)	0.486	1.71E-01	6.22E-05	1.71E-01
Molybdenum (Mo)	---	1.23E+01	1.38E+01	1.85E+01
Nickel (Ni)	---	1.64E+01	1.13E+01	2.77E+01
Thallium (Tl)	---	6.17E-01	3.58E+00	3.89E+00
Tungsten (W)	---	2.50E+00	3.07E+01	3.32E+01
Uranium (U)	---	5.11E+00	8.47E+00	1.36E+01
Vanadium (V)	---	2.17E+01	3.20E+01	5.24E+01
Zinc (Zn)	315	1.39E+02	5.50E+00	1.39E+02

Notes:
"---" indicates not available or applicable.
[a] Canadian Sediment Quality Guidelines (SQG) for the Protection of Aquatic Life probable effect levels.
Bold indicates that value exceeds the CCME guidelines.

7.7.4.8 Ecological Risk Uncertainty Assessment

As a result of the scientific investigations, literature reviews, and risk assessment guidance that has been undertaken or followed in the preparation of this ERA, it is believed that the risk assessment results present a reasonable yet conservative evaluation of the risk to ecological receptors present in the HHERA Study Area. Where uncertainty or lack of knowledge were encountered in the development of the risk estimates, reasonable yet conservative assumptions were made, or data were selected, in order to ensure that risks were not underestimated.

Some limitations and assumptions applied in this ERA were previously discussed as part of the HHRA (Section 7.7.3.5), including uncertainties related to exposure assessment and uncertainties related to risk characterization. Limitations and assumptions specific to the ERA are identified and described in the following subsections.

7.7.4.8.1 Habitat Survey and Receptor Selection

This risk assessment invested significant effort into an examination of existing habitats and the species that may exist within them through a site visit by an experienced biologist, review of previous investigations carried out at the site and through a review of available site information. Terrestrial habitats were examined in detail to identify relevant species, and to support the selection of appropriate receptors. Therefore, the receptors that were selected are known to be present, or can reasonably be expected to be present in or near the PDA. These receptors are also known to be reasonably or conservatively representative of other species that may be present in or near the PDA and exposed to COPCs. Use of site-specific receptors decreases the uncertainty, since local species are considered.

7.7.4.8.2 Utilization of Receptors as Sentinels to Represent Other Organisms

The use of receptors as sentinels is intended to limit the number of ecological receptors evaluated. The receptors selected are considered to be sensitive, and consistently present at or near the PDA, and to be highly exposed to the COPCs present at the site via relevant exposure pathways. Therefore, it is reasonable to assume that conclusions that are reached in respect of the modelled receptor organisms can be generalized to other biota that might use the Project site.

7.7.4.8.3 Receptor-Specific Toxicity Data

For most COPCs and receptors, toxicity data are available in some form. However, it is important to note that toxicity data are not necessarily available for the particular receptor species under consideration (*e.g.*, black bears). Toxicity values are not necessarily specific to the receptor species, or to a reproductive or population-level endpoint. As a result, there is uncertainty associated with the extrapolations that may be used to translate toxicity data for one species into a TRV for a second species. The toxicity data represent an organism or organisms that are expected to be sensitive to the COPC. The conversion factors that are used are scientifically-based, and are applied in a manner that is believed to be reasonable. The use of the probable effects level (PEL) as a method to estimate the TRV is intended to provide an integration of multiple species toxicity data, as well as providing a weight-of-evidence evaluation of the toxicity data in support of the TRV.

7.7.4.8.4 Food Chain Interactions

Very limited "real world" data exist that allow quantification of the true relationship between a contaminant in an environmental medium and contaminant transfer through the food chain. Only a few classes of contaminants (excluding metals) appear to be magnified through the food chain. The extent of food chain magnification is another uncertainty that is generally treated in a conservative manner. Baseline (existing) concentrations of trace metals in a wide variety of environmental media and food items were measured, including surface water, sediment, soil, fish, forage, browse, berries, soil invertebrates, and small mammals. Future concentrations of trace metals in these environmental media and food items were predicted using methods and models that are considered to be realistic or conservative.

7.7.4.8.5 Wildlife Exposure Factors

Virtually every factor incorporated into dose calculations for wildlife species possesses a site-specific component. Validity of each exposure factor is dependent on consideration of the site-specific nature of these factors. In the absence of site-specific validation, exposure factors are incorporated based on validations performed elsewhere for other cases and sometimes for other species. Considerations such as food ingestion rates, water ingestion rates, incidental soil ingestion rates, dietary composition, home range, and time spent at the Project site were collected from the scientific literature based on other sites and locations.

7.7.4.8.6 Measurement Endpoints from the Toxicity Data

The paucity of toxicity data for many contaminants limited the measurement endpoints that were available. The risk of a toxic effect is evaluated using a lowest observed adverse effect level (LOAEL) based toxicity benchmark. Given the overall tendency to introduce conservatism (through the use of data or assumptions that are likely to overstate, rather than understate risk) into risk assessments, it is likely that no adverse environmental effect will exist below the RQ target value of less than 1.0. This approach is conservative, and if observed RQ values are lower than the target RQ values, it is assumed that there is little potential for observable environmental effects at the population or individual level, respectively. However, an RQ value greater than 1 is not by itself an indication that harm to receptor organisms is certain to occur. The conservatisms inherent in the model development mitigate this conclusion, and the movements of wildlife receptors and consequent risk-averaging tend to reduce their actual exposure level in comparison with the exposure level predicted at point locations.

7.7.4.8.7 Modelling Assumptions

Generally, uncertainties are addressed by incorporating conservative assumptions (*i.e.,* assumptions that are likely to overstate risk) in the analysis. Where several conservative assumptions are involved in the same calculation, a high level of conservatism can result from the combination of the assumptions. As a result, risk assessments tend to overstate the actual risk with the result that conclusions are very robust. Although many factors are considered in preparation of a risk assessment, the results are generally most sensitive to a few key assumptions. The uncertainty analysis is included to demonstrate that assumptions used are conservative, or that the result of the analysis is not sensitive to the key assumptions.

7.7.5 Summary

A Human Health and Ecological Risk Assessment (HHERA) was completed to quantify the potential risks to human and ecological health that could result from the Construction, Operation, and Decommissioning, Reclamation and Closure of the Project. The potential human and ecological health risks were assessed for both the existing (Baseline Case) and future (Project + Baseline Case) conditions, and followed published regulatory guidance for completion of HHERAs.

With respect to human health, as determined by the Human Health Risk Assessment (HHRA) the Project activities are not expected to result in short-term exposures above the health-based ambient air quality guidelines established by regulatory agencies at the recreational campsites, nearest residences in Napadogan, or the HHERA receptor locations. As well, the Project is not expected to affect the human health risks for long-term inhalation exposures, exposure to soil, or ingestion of water. Project-related activities have the potential to affect the human health risks for consumption of food.

The human health risks associated with consumption of food for the existing (Baseline Case) concentrations of a number of metals (*i.e.,* arsenic, chromium, cobalt, lead, manganese, methyl mercury (fish only), and thallium) found in the environment near the Project were determined through the HHRA to be high in relation to accepted benchmarks (even in the absence of the Project), thus potentially contributing to health risks to Aboriginal receptors that may currently be obtaining 100% of their game, 20% of their fish, and 10% of their total vegetation from the Study Area. Predicted human health risks associated with Project-related activities were generally similar to baseline human health risks, with the exception of predicted human health risks associated with predicted concentrations of arsenic, boron, cobalt and thallium in fish tissues. However, further examination of these data determined that concentrations of these metals in fish tissues or surface water are similar to published concentrations from other areas of Canada and North America obtained from reference locations or natural areas or meet fish tissue guidelines (where available).

With respect to ecological health, as determined by the Ecological Risk Assessment (ERA), predicted ecological health risks were identified for certain receptors in relation to arsenic, copper, manganese, thallium, vanadium and zinc exposure. However, differences in predicted ecological health risks between the Baseline Case and Project + Baseline Case scenarios were generally negligible for terrestrial mammalian and avian wildlife. Identified predicted ecological health risks to the terrestrial wildlife (which in some cases are localized) are generally related to pre-existing baseline metal concentrations in the environment, and the Project-related contribution to these environmental effects is negligible.

For semi-aquatic wildlife (*i.e.,* American mink, American black duck, and belted kingfisher), predicted ecological health risks were identified for certain receptors in relation to thallium and vanadium exposure. Ecological health risks in relation to thallium were identified for the Project + Baseline Case for the American black duck. Ecological health risks in relation to vanadium were identified for both the Baseline Case and the Project + Baseline Case for the American black duck and the belted kingfisher. Both can be related to an increase in predicted surface water concentrations due primarily to modelled seepage from the TSF toward small tributaries of West Branch Napadogan Brook. However, these ecological health risks are expected to be localized and as such are not expected to result in population-level environmental effects.

For the terrestrial community (*i.e.*, soil invertebrates and terrestrial plants), potential ecological health risks were identified for both soil invertebrates and terrestrial plants exposed to arsenic, boron, and manganese in soil for both the Baseline Case and the Project + Baseline Case; ecological health risks were also identified for terrestrial plants exposed to vanadium in soil for both the Baseline Case and Project + Baseline Case. Comparison of the Baseline Case soil concentrations to the predicted Project + Baseline Case soil concentrations revealed less than 0.001% increase arising from the Project. Therefore, ore dust deposition is expected to negligibly affect soil quality, or COPC concentrations, in terrestrial plants or soil invertebrates in areas that are not directly disturbed by mining activity.

For the sediment community (*i.e.*, benthic invertebrates), comparison of sediment concentrations to Canadian Sediment Quality Guidelines for the Protection of Aquatic Life probable effect levels revealed exceedances of the arsenic guideline. Predicted Project + Baseline Case sediment concentrations are mainly related to pre-existing Baseline Case metal concentrations. Canadian Sediment Quality Guidelines for the Protection of Aquatic Life are meant to be protective for a range of species and, as such, sediment concentrations less than these guidelines are indicative of a negligible probability of adverse environmental effects. Where concentrations are greater than these guidelines, there is a possibility (but not a certainty) of adverse environmental effects to ecological receptors. Such cases require a careful review of predicted exposure levels, and more focused investigations may be required to reduce conservatism in the assessment. Follow-up may be used to confirm the predicted changes in sediment arsenic concentrations in view of the modelling uncertainties and conservatism.