8.4 WATER RESOURCES

Water is essential for life on Earth. As a key resource for human and ecological life, changes in the availability of water, both in terms of the amount of water and the quality of the water, may affect the lives of people and other living things. Water Resources are defined herein as the groundwater and surface water resources that are available for human use. Water Resources has been identified as a valued environmental component (VEC) because of the importance of this resource in providing potable water to users in the area surrounding the Project. Water Resources are closely linked to other VECs, including the Aquatic Environment (as a resource for fish and aquatic life), Terrestrial Environment (as a resource for wildlife), Vegetated Environment (as a resource for plants), Wetland Environment (as habitat for plants, animals and communities, and for hydrological function), and Land and Resource Use (as a resource for humans), and the potential environmental effects of changes to water resources on these VECs are discussed in those sections of this EIA Report. For convenience, the use of water as a resource for human use, and by extension for all living things, is assessed in this VEC. Particular emphasis is on the use of water as a resource for human consumption.

The Project will interact with Water Resources in the following ways.

- Alterations to some watercourses during Construction, either through elimination of portions of those watercourses to construct the Project facilities, or through re-routing or diversion of water around Project facilities, will result in a local re-distribution of water resources.

- Dewatering of the open pit during Operation will result in localized lowering of the water table, possibly affecting surface water hydrology and nearby well users (if any are present).

- Sequestration of mine contact and process water within the tailings voids in the tailings storage facility (TSF) during Operation, filling of the open pit during Closure, and evaporation from the TSF pond and the eventual pit lake Post-Closure, will reduce the amount of surface water (and thus groundwater) available for possible human consumption.

- Discharges of surplus water (beyond Project needs), and seepage through or beneath the TSF embankments, may affect groundwater or surface water quality if not adequately contained or treated to acceptable standards prior entering the receiving environment.

As will be demonstrated in the assessment that follows, the environmental effects of the Project on Water Resources will not be significant because:

- the environmental effects of watercourse alterations on surface water hydrology will be mitigated and authorized under provincial and federal regulation;

- virtually all of the water requirements for the Project will be met by the reuse of water collected on-site, and recycled through the TSF;

- the collection of mine contact and process water in the TSF during Operation, and in the pit lake during Closure, will not adversely affect downstream surface water use or groundwater use;

- discharge of surplus water from the Project will be treated (as necessary) to acceptable discharge standards prior to release; and

- the design and management of the TSF will ensure that seepage through the TSF embankments will not affect downstream groundwater and surface water quality to an extent that it causes an exceedance of Health Canada's "Guidelines for Canadian Drinking Water Quality" (GCDWQ; Health Canada 2012a) that would adversely affect human health.

Portions of watercourses and watersheds within the Project Development Area (PDA) will be permanently eliminated to make way for the open pit, TSF, and associated Project facilities, particularly Bird and Sisson brooks and a small unnamed tributary (known as Tributary "A") to West Branch Napadogan Brook. Later during Operation, fingertip portions of McBean Brook near the open pit may also be affected, either directly or indirectly. The elimination of substantial portions of these watercourses and various Project-related diversions and consumptions will result in a re-distribution of water resources in these watersheds. The watercourse alterations will be conducted under an authorization under the *Fisheries Act* and a permit under the *Watercourse and Wetland Alteration Regulation*. The affected watercourses and watersheds are tributary to the larger Napadogan Brook and Nashwaak River watersheds. Though some mine contact water falling onto the PDA as precipitation and run-off will be sequestered in the TSF during Operation, and in the open pit during Closure, thereby resulting in a reduction of flows in these headwaters, minimal long-term reductions to flows within the downstream Napadogan Brook or the Nashwaak River watershed as a whole will result from these alterations and sequestration. No large surface water users for human consumption were identified on Napadogan Brook, and therefore, the reductions are not anticipated to affect surface water availability for potential users.

Groundwater seepage and precipitation into the open pit will be periodically removed from the pit using conventional (pit sump) dewatering approaches, and will result in the lowering of the water table and affect the availability of groundwater up to 2 km from the open pit. However, the closest known residential well users as identified by the New Brunswick Department of Environment and Local Government (NBDELG) are located more than 9 km from the open pit, in Napadogan. Other potential groundwater users, including recreational campsites, are located more than 1.5 km from the open pit, and are not expected to be affected by pit dewatering as these water supplies are likely local shallow groundwater beyond the zone of influence of the open pit drawdown. There are no known plans for surface water or groundwater use within the zone of influence of the open pit or the PDA itself, except for the mine fresh water supply. This fresh potable water supply will be sited and developed in consideration of the potential zone of influence of the Project, and other users are too far removed from the Project to be of concern from a human consumption perspective.

During Operation, the water from open pit dewatering will be directed to a water management pond to the north of the pit, and then to the TSF for use in the Project. Water surplus to Project needs will be drawn from the TSF, clarified and treated before release to the receiving environment in the lower Sisson Brook above its confluence with Napadogan Brook such that downstream water quality does not adversely affect existing users. During Post-Closure of the Project, similar treatment of the pit lake water will be undertaken before discharge for as long as necessary to ensure downstream water quality objectives are met.

The bulk of the water requirements for ore processing will be derived from reclaiming mine contact water collected in the TSF, and subsequently discharged back to the TSF following clarification and use in the process. This will minimize the demand for fresh water for the Project, allow for a predictable water budget over the life of the Project, and minimize the requirement for discharge and treatment of mine-contact water, at least until approximately Year 7 of Operation. Until that time, there will be no need for treatment and discharge of surplus water. Fresh water will be required for on-site potable water, sanitary facilities, fire suppression, watering of unpaved roads and exposed areas, and process make-up water. It will be supplied by on-site wells drilled for the Project, outside the zone of influence of the Project, and water requirements will be relatively modest in comparison to water available in the area.

As highlighted above and detailed in the sections that follow, the Project will not result in significant adverse residual environmental effects (including cumulative environmental effects) to Water Resources. Follow-up or monitoring programs will be established to verify the downstream flow reductions in Napadogan Brook during Operation of the Project, to verify the predictions of groundwater and surface water quality due to Project releases, and to inform adaptive Project water management to ensure the Project meets applicable legislation, regulations and guidelines.

8.4.1 Scope of Assessment

This section defines the scope of the environmental assessment of Water Resources in consideration of the nature of the regulatory setting, issues identified during public, stakeholder, and First Nations engagement activities, potential Project-VEC interactions, and existing knowledge.

8.4.1.1 Rationale for Selection of Valued Environmental Component, Regulatory Context, and Issues Raised During Engagement

Water resources are essential for life on Earth. As humans, we need water for drinking, bathing, sanitation, recreation, and for the production of food and goods. Fish, birds, animals and plants also rely on the availability of water to live and flourish. Changes in the availability of water, both in the amount of water and the quality of the water, may affect the lives of people and other living things.

Water Resources, as considered in this document, are the groundwater and surface water resources available for human use. Water Resources was selected as a VEC based on the importance of the resource, and as there is a high potential for these resources to be affected by the Project during the Construction, Operation, and Decommissioning, Reclamation and Closure phases. Water Resources are closely linked to other VECs, including Aquatic Environment, Terrestrial Environment, Vegetated Environment, Wetland Environment, and Land and Resource Use, and the analyses presented in this VEC are relied upon as appropriate in other VECs.

The Final Guidelines for the environmental impact assessment (EIA) of the Project (NBENV 2009) and the Terms of Reference (Stantec 2012a) developed to establish the scope of the EIA require that the environmental effects of the Project on Water Resources be assessed. Specifically, Section 4.2 of the Final Guidelines requires that potential environmental effects of the Construction, Operation, and Decommissioning phases of the Project on groundwater and surface water resources be assessed. An evaluation of water conservation measures through innovative technologies and a detailed water budget to evaluate water quality and quantity effects are required. A Water Supply Source Assessment is required if the volume of water to be used is greater than 50 m^3 per day, including water for domestic use and for fire protection. The potential for interference with domestic wells and surface water supplies, and potential Project-related changes to surface water and groundwater flow regimes, are also to be assessed. Section 4.4 of the Terms of Reference provided the methodology by which the requirements of the Final Guidelines would be met.

The following issues were raised during public and stakeholder engagement activities for the Project, which are relevant to Water Resources.

- How will groundwater be affected by the Project?
- Will waterways be re-routed?

Concerns about potential contamination of surface water and groundwater supplies from the operation of the mine as well as from potential accidental events were raised by several members of the public and First Nations in relation to potential environmental effects to aquatic organisms, and by extension those concerns are also applicable to Water Resources.

8.4.1.2 Selection of Environmental Effect and Measurable Parameters

The environmental assessment of Water Resources is focused on the following environmental effect:

- Change in Water Resources.

The human use of water resources can be affected in both the quantity of water that is available as a source, but also by the quality of the available water. The Project has the potential to change Water Resources due to possible reductions to groundwater recharge, increased groundwater withdrawals and drawdowns, collection and diversion of surface water flows and physical changes to the local surface hydrology, as well as the potential alteration of groundwater and surface water chemistry.

Several Crown-lease recreational campsites located near Napadogan Brook (approximately 1.5 km east of the open pit) are the closest potential users of water as a potable supply. In addition, individuals from First Nations may also consume surface water when within the LAA.

The measurable parameters used for the assessment of Water Resources and the rationale for their selection is provided in Table 8.4.1.

Table 8.4.1 Measurable Parameters for Water Resources

Environmental Effect	Measurable Parameter	Rationale for Selection of the Measurable Parameter
Change in Water Resources	Groundwater Drawdown (m)	• Pumping of groundwater for both fresh water supply and pit dewatering results in a drawdown of the water table which can extend some distance away from the source of the water taking (*i.e.,* a well or pit face). Drawdown at wells operated by current users could reduce the recoverable quantity of groundwater for these users.
	Surface Water Flow (m^3/s)	• Physical changes in the hydrology of the PDA as well as changes in groundwater recharge or baseflow could change the flow rates in Napadogan Brook and/or McBean Brook.
	Water Quality (various parameters)	• Degradation of the water quality of previously unaffected surface water or groundwater that would affect the availability of water resources for human uses. The parameters to be measured are those in Health Canada's Guidelines for Canadian Drinking Water Quality (GCDWQ).

8.4.1.3 Temporal Boundaries

The temporal boundaries for the environmental effects assessment of Water Resources include the three phases of Construction, Operation, and Decommissioning, Reclamation and Closure of the Project.

In addition to the time required for reclamation and decommissioning activities, Decommissioning, Reclamation and Closure includes post-Closure monitoring or active site management for as long as is required to ensure that an appropriate end land use has been established. Project-related environmental effects are generally considered to be temporary during Construction and Operation, while environmental effects after Decommissioning and Reclamation will persist until such time as a new equilibrium state is achieved.

8.4.1.4 Spatial Boundaries

The spatial boundaries for the environmental effects assessment of Water Resources include the Project Development Area (PDA) as well as the potential zone of influence surrounding the Project (defined as the Local Assessment Area or LAA). The spatial boundaries for Water Resources are illustrated in Figure 8.4.1 and are as follows.

Project Development Area (PDA): The PDA (Figure 8.4.1) is the most basic and immediate area of the Project, and consists of the area of physical disturbance associated with the Construction and Operation of the Project. Specifically, the PDA consists of an area of approximately 1,253 hectares that includes: the open pit; ore processing plant; storage areas; TSF; quarry; the relocated Fire Road and new Project site access road; and new and relocated power transmission lines. The PDA is the area represented by the physical Project footprint as detailed in Chapter 3.

Local Assessment Area (LAA): The LAA is the maximum anticipated area within which Project-related environmental effects are expected to be discernible. For Water Resources, the LAA includes the McBean and Napadogan Brook sub-watersheds (Figure 8.4.1). Spatial boundaries for surface water flows and hydrology will be considered for watercourses draining to and away from Project components and facilities, with a particular emphasis on those watercourses downstream of the Project to determine the potential for flow reductions as a result of the Project. The spatial distribution of these environmental effects will be analyzed as far as is required to assess consequent environmental effects for human use in this section. Aquatic environmental effects related to changes in hydrology are discussed in Section 8.5.

Regional Assessment Area (RAA): The 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. For Water Resources, the RAA includes the Nashwaak River watershed (Figure 8.4.1). This does not include the St. John River watershed as the proportion of affected drainage in the headwater tributaries of the Nashwaak River are so comparatively small that they would have no measurable environmental effect on the larger St. John River watershed. The extent to which cumulative environmental effects for Water Resources may occur depend on physical and biological conditions and the type and location of other past, present, or reasonably foreseeable future projects or activities that have been or will be carried out, as defined within the RAA.

8.4.1.5 Administrative and Technical Boundaries

The administrative boundaries for Water Resources include various legislative, regulatory and policy instruments at the provincial and federal level as well as guidelines issued pursuant to those instruments. Provincially, these include, but are not limited to, the *Water Well Regulation* under the *Clean Water Act* and the *Water Quality Regulation* under the *Clean Environment Act*. Potable water quality is generally based on Health Canada's "Guidelines for Canadian Drinking Water Quality" (GCDWQ; Health Canada 2012a), which has also been adopted by the Canadian Council of Ministers of the Environment (CCME). Federally, releases from mining operations are regulated by the *Metal Mining Effluent Regulations (MMER)* under the *Fisheries Act*.

A technical boundary for Water Resources is the limited time period for which observations of stream flow and climate data have been collected within the PDA. These data have been correlated to long-term observations, which improve their applicability, but these correlations will continue to be evaluated as more data are available so as to support Project design and follow-up.

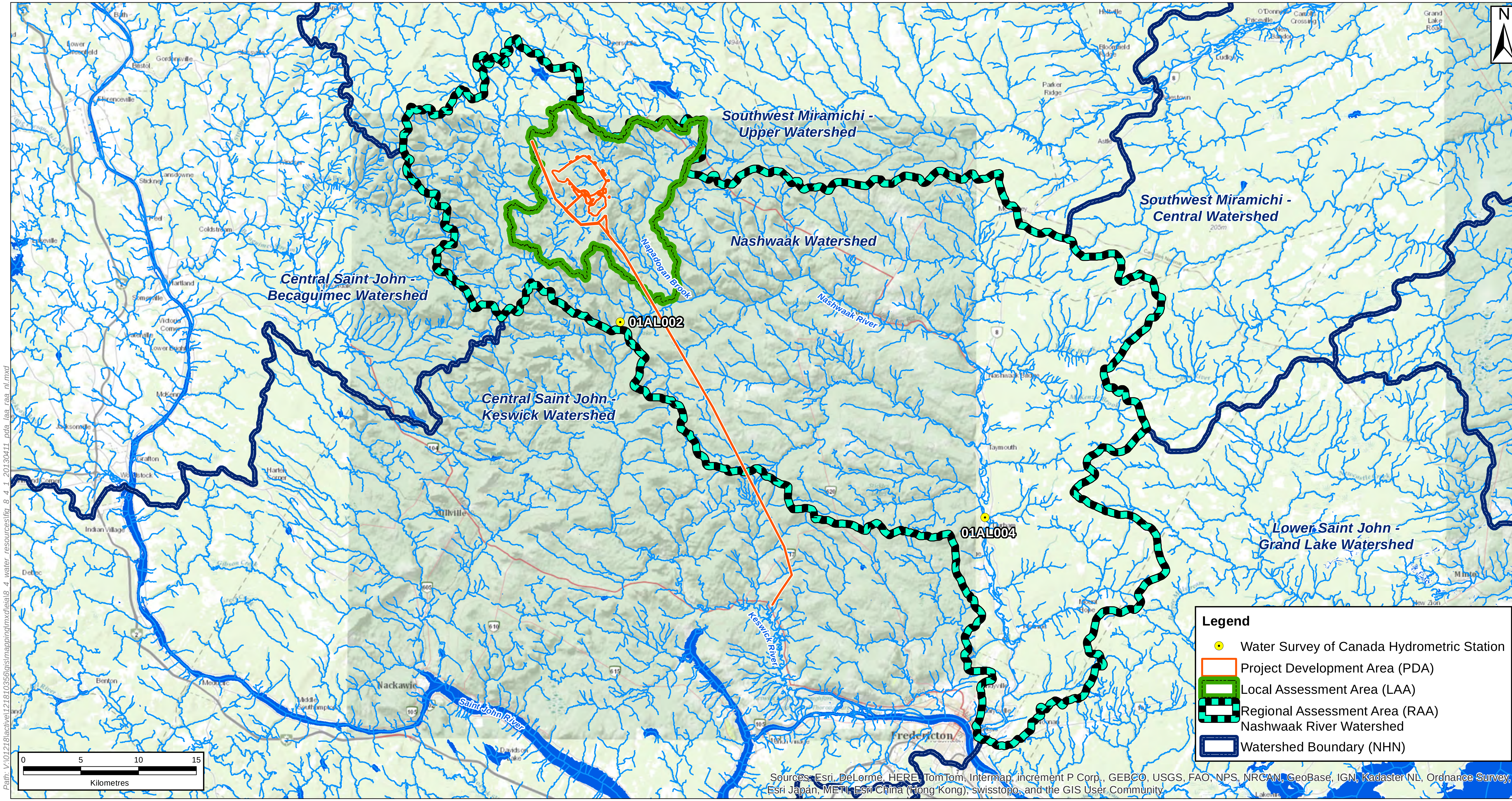
Another technical boundary for Water Resources is the simplifying assumptions upon which the environmental effects assessment is based. Groundwater drawdown predictions due to open pit dewatering are based on an assumption of uniform hydraulic conductivity over the entire depth of the open pit, as well as spatially as distance from the open pit increases. This is an inherent assumption built into the analytical solution used in the assessment of dewatering. However, the complexity of the geology in the LAA introduces some uncertainty around some of these assumptions. Follow-up and monitoring of actual mine dewatering will better inform the actual hydraulic characteristics around the open pit, and water management will be adapted to the results of this increasing information base.

Predictions of water quality described in Section 7.6 are based on metal leaching/acid rock drainage (ML/ARD) predictions from humidity cell and barrel tests as described in Section 7.5. Though these tests and predictive studies are best practice, there is an inherent uncertainty in the results that limits the reliability of the water quality predictions. Similarly, the source terms for the nitrogen species were based on assumed concentrations from blasting. Proposed water quality follow-up will verify these predictions and mitigation, and monitoring will inform adaptive water management and treatment.

8.4.1.6 Residual Environmental Effects Significance Criteria

For Water Resources, including groundwater and surface water, a significant adverse residual environmental effect is one that:

- degrades the quality of previously unaffected surface water or groundwater by exceeding the standards of one or more parameters as specified in the Guidelines for Canadian Drinking Water Quality for potable domestic water supplies for a period of more than 30 days; or
- reduces the quantity of groundwater recoverable from an aquifer on a sustainable basis such that it no longer meets present or future needs of current users or land owners; or



Path: V:\01218\active\121810356\gis\mapping\mxd\eia\8_4_water_resources\fig_8_4_1_20130411_pda_laa_raa_nl.mxd

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

Project Development Area (PDA), Local Assessment Area (LAA) and Regional Assessment Area (RAA) for Water Resources

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

Client: Sisson Mines Ltd.

Scale: 1:325,000

Project No.: 121810356

Data Sources:
NBDNR
NHN
NBADW

Fig. No.: 8.4.1

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

Fig. By: JAB

Appd. By: DLM

Coordinate System: NAD 1983 CSRS New Brunswick Stereographic

- reduces groundwater discharge and consequently adversely affects base flow to a stream, preventing current users from meeting present and future needs on a sustainable basis; or
- reduces the quantity of surface water available for surface water supplies, preventing current users from meeting present and future needs on a sustainable basis; or
- degrades the physical and chemical characteristics of an aquifer or stream to the extent that interaction with local surface water results in stream flow or chemistry changes that adversely affect sustainable surface water flow or aquatic life.

8.4.2 Existing Conditions

8.4.2.1 Climate and Water Resources

The existing climate conditions within the LAA are summarized here as they relate to Water Resources. Regional climate data for Central New Brunswick was previously provided in Section 6.3.2.1 for the Fredericton Airport weather station, given its long-term record of meteorological monitoring and representativeness to the region. The summary of climate conditions provided below was developed by Knight Piésold to present a climate dataset for the Sisson meteorological station as measured at the Project site. As described by Knight Piésold (2012d), the Sisson meteorological station is a short-term monitoring record (since 2007) that has been extrapolated to local conditions using a long-term climate record at the nearby Juniper weather station to supplement the regional data presented in Section 6.3.2.1. These data are complementary.

The existing climate conditions within the LAA are presented in the 2011 Hydrometeorology Report developed by Knight Piésold (Knight Piésold 2012d), and this report was used for the basis of the summary provided in this section. The report was based on results from the Sisson meteorological station which has been operated since 2007 and measures air temperature, relative humidity, atmospheric pressure, precipitation, snow depth, incoming solar radiation, and wind speed and direction. Data are recorded on an hourly basis.

The period of record for the Sisson meteorological station was too short to properly evaluate variability in the climate record that is required for hydrological analysis. Therefore, Knight Piésold (2012d) conducted an analysis of meteorological data within the LAA using data from the Sisson meteorological station supplemented with regional climate data and long-term (30-year) trends collected from the Juniper climate station operated by the Meteorological Service of Canada (Environment Canada 2012g). The results of this analysis provide a long-term climate record for the LAA, which is presented in Table 8.4.2 and summarized below.

Table 8.4.2 Long-term Average Monthly and Annual Climate Statistics within the LAA

Parameter	Mean Monthly Value for Parameter												Mean Annual or Total Annual Value for Parameter
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Temperature (°C)	-11.8	-10.3	-4.4	2.2	9.4	13.9	16.6	15.6	11.2	5.3	-0.3	-7.8	3.3
Rainfall (mm)	34	21	45	70	110	113	127	122	119	113	85	51	1,012
Snowfall (cm)	81	62	62	26	1	0	0	0	0	0	3	31	338

Table 8.4.2 Long-term Average Monthly and Annual Climate Statistics within the LAA

Parameter	Mean Monthly Value for Parameter												Mean Annual or Total Annual Value for Parameter
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Total Precipitation (mm)	115	83	107	96	111	113	127	122	119	117	116	123	1,350
Potential Evapotranspiration (calculated, mm)	0	0	0	15	68	100	119	104	65	29	0	0	500

Notes:
1 cm of snowfall is assumed to be equivalent to 1 mm of rainfall.

Source: Knight Piésold (2012d).

As shown in Table 8.4.2, the mean annual temperature for the LAA is 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 distribution of long-term mean monthly temperatures for the LAA is shown in Table 8.4.2.

The mean annual precipitation for the LAA is 1,350 mm, and the mean monthly distribution of precipitation is shown in Table 8.4.2. The precipitation within the LAA falls both as snow and rain, with 25% of the total annual precipitation contributed by snowfall. 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). Snowfall generally occurs between November and April.

The potential evapotranspiration (PET) was calculated for the LAA using the Thornthwaite (1948) equation, and is listed in Table 8.4.2. As shown in the table, the annual PET is 500 mm/a, with no PET in the cold months.

8.4.2.1.1 Precipitation Analysis

Knight Piésold developed a long-term precipitation record for the LAA using the data from the Sisson meteorological station supplemented by data from the Juniper climate station to evaluate the variability in precipitation in the LAA year over year (Knight Piésold 2012d). The analysis included an estimate of the total annual and monthly distribution of total precipitation for a wet year and a dry year. Both the wet and dry years were defined as occurring once every 10 years and were calculated using a normal distribution. The variability in the annual precipitation for an average year and for wet and dry years is presented in Table 8.4.3.

Table 8.4.3 Variability in Annual Precipitation for Wet and Dry Years within the LAA (mm)

Return Period	Annual Precipitation - Mean Monthly Value for Return Period (mm)												Annual Total for Return Period (mm)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
10 year (wet)	184	135	154	155	166	173	192	195	178	195	176	194	1,634
Average year	115	83	107	96	111	113	127	122	119	117	116	123	1,350
10 year (dry)	45	31	0	0	56	53	63	49	60	38	55	52	1,066

Source: Knight Piésold (2012d).

8.4.2.1.2 Extreme Precipitation

Knight Piésold estimated the total rainfall corresponding to a major storm lasting 24-hours from the long-term rainfall record using the data collected at the Sisson meteorological station supplemented by the Juniper climate station (Knight Piésold 2012d). This is an important component in the engineering design of water storage and conveyance features such as the TSF, water management ponds, culverts and pumps. The 24-hour rainfall was estimated for return periods of 2 to 1,000 years, as shown in Table 8.4.4.

Table 8.4.4 Estimated 24-Hour Extreme Rainfall Return Period Values for PDA

Return Period (years)	24-Hour Extreme Rainfall (mm)
2	69
5	85
10	95
15	100
20	104
25	108
50	117
100	126
200	136
500	148
1,000	158
Probable Maximum Precipitation (PMP)	352

Source: Knight Piésold (2012d)

The 24-hour extreme precipitation values for return periods of 10, 50, and 200 years are estimated to be 95 mm, 117 mm, and 136 mm, respectively. In addition to the statistical analysis of extreme rainfall, the 24-hour Probable Maximum Precipitation (PMP) was also calculated by Knight Piésold using the Herschfield (1961) equation. As shown in Table 8.4.4, the 24-hour PMP for the PDA is 352 mm (Knight Piésold 2012d).

8.4.2.1.3 Environmental Water Balance

Knight Piésold prepared a monthly environmental water balance for the LAA using a semi-distributed precipitation model in the RAA (Knight Piésold 2012b). The model accepts precipitation and upstream inflows of groundwater and surface water, and partitions the inputs into surface run-off, groundwater recharge, and evapotranspiration. Precipitation as snowfall was accumulated in storage until the air temperature was above freezing. Groundwater and surface water accumulation in storage, and discharge from storage, were simulated using a linear-reservoir model. The water balance results from the model under the long-term average climate conditions described in Section 8.4.2.1 are presented in Table 8.4.5.

Table 8.4.5 Water Balance Results under the Long-Term Average Climate Conditions

Parameter	Mean Monthly Value for Parameter												Annual Total for Parameter
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Total Precipitation (mm)	115	83	107	96	111	113	127	122	119	117	116	123	1,350
Actual Evapotranspiration (mm)	0	0	0	15	68	100	119	104	65	29	0	0	500
Run-off (mm)	44	30	64	209	128	53	36	27	26	54	81	72	824
Groundwater Recharge (mm)	5	5	15	20	10	5	5	5	10	10	15	10	110

Source: Safadi, C, Personal communication, March 24, 2013

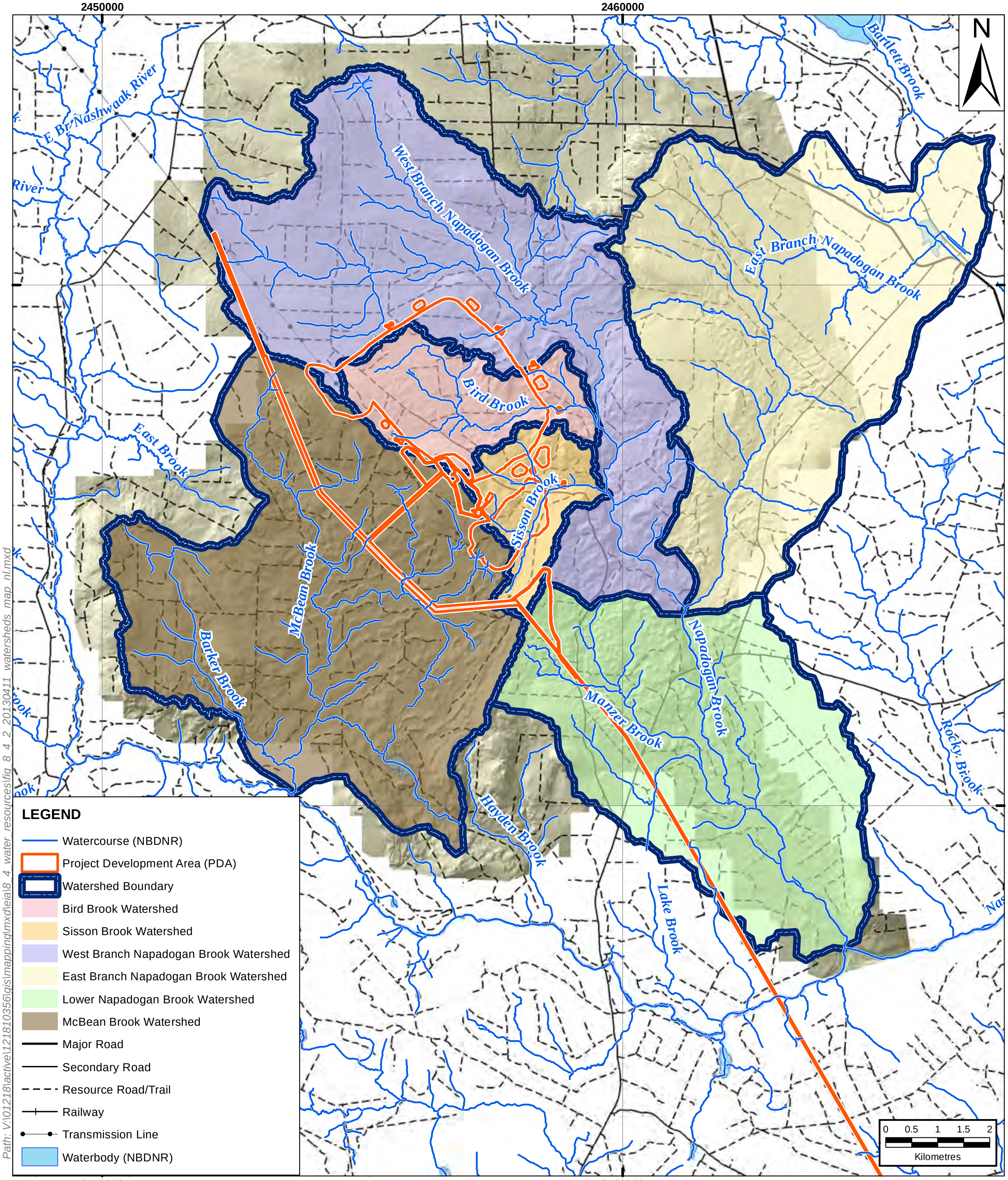
8.4.2.2 Hydrological Conditions

In 2011, Northcliff installed hydrometric stations to monitor the stage and flow at selected brooks that may interact with the Project. Five continuous monitoring stations were installed, as shown in Figure 8.4.3. Continuous stations are instrumented with a pressure transducer and data logger to collect the water levels at the stations. Periodic stream flow measurements were collected at the stations using the United States Geological Service's (USGS) Mid-Section Method beginning when the stations were installed in May 2011.

Investigations of the surface water hydrology and water quality were led by Knight Piésold, and are presented in the 2011 Hydrometeorology Report (Knight Piésold 2012d) and in the Baseline Water Quality Report (Knight Piésold 2012e). A summary of some key features of these reports is provided below.

8.4.2.2.1 Watershed Delineation

As shown in Figure 8.4.2, the PDA straddles two headwater sub-watersheds located in the Nashwaak River watershed: Napadogan Brook to the north (which includes the TSF and a portion of the open pit); and McBean Brook to the south (which includes a portion of the open pit). The Napadogan Brook watershed has a drainage area of 122 km^2, and includes several smaller brooks (Bird Brook, Sisson Brook, Manzer Brook, and Frenchman's Creek) and two lakes (Mud Lake and Napadogan Lake). The McBean Brook watershed, located adjacent to Napadogan Brook within the Nashwaak River watershed, has a drainage area of 43 km^2 and includes four lakes (Christmas Lake, Trouser Lake, Chainy Lakes, and Barker Lake) and several tributaries (the outlet tributary of Chainy Lakes and Barker Brook).



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

Watershed Map

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

Client: Sisson Mines Ltd.

Scale: 1:100,000

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.: 8.4.2

Stantec

Map: NAD83 CSRS NB Double Stereographic

Watershed and sub-watershed areas for reference watercourses and watercourses potentially affected by the Project are shown in Table 8.4.6. Also shown in Table 8.4.6 and in Figure 8.4.3 are hydrometric stations located within each watershed for which continuous monitoring records are available as collected for the Project and from the Water Survey of Canada (Environment Canada 2012j). Table 8.4.6 is arranged showing watersheds from upstream to downstream, with sub-watersheds indented within the parent watersheds (Figure 8.4.1 and Figure 8.4.2). For example, hydrometric station B-2 is located in the Bird Brook watershed, which is a sub-watershed of Napadogan Brook, which is a sub-watershed of Nashwaak River.

Table 8.4.6 Hydrometric Monitoring Stations within Watersheds

Hydrometric Station (Figures 8.4.1 and 8.4.3)	Drainage area (km^2)	Period of Record	Annual Flow Rates (m^3/s)			Unit Flow Rates ($m^3/s/km^2$)
			Mean	Minimum	Maximum	
Nashwaak River – Total drainage area = 1,708 km^2						
McBean Brook – Total drainage area = 43 km^2						
CL-1A[a]	4.4	2011-2012	0.09	0.03	0.14	0.021
MBB-2[a]	31.5	2011-2012	0.73	0.29	1.12	0.027
Narrows Mountain Brook						
01AL004[b]	3.9	1972-2012	0.09			0.023
Napadogan Brook – Total drainage area = 122 km^2						
Bird Brook – Total drainage area = 8.2 km^2						
B-2[a]	7.7	2011-2012	0.20	0.09	0.31	0.026
Sisson Brook – Total drainage area = 5.2 km^2						
SB-1[a]	5.0	2011-2012	0.13	0.06	0.19	0.025
NB-2B[a]	52.6	2011-2012	1.38	0.55	2.12	0.026
01AL002[b]	1450	1961-2012	36.6			0.025

Notes:
1) Stations are arranged from upstream to downstream, with sub-watersheds indented within the parent watersheds.
2) Watersheds and watercourses are identified Figure 8.4.1 and Figure 8.4.2.
3) Hydrometric station locations are shown in Figure 8.4.1 and 8.4.3.
[a] Stations installed for Project (Knight Piésold 2012d)
[b] Stations installed by the Water Survey of Canada (Environment Canada 2012j)

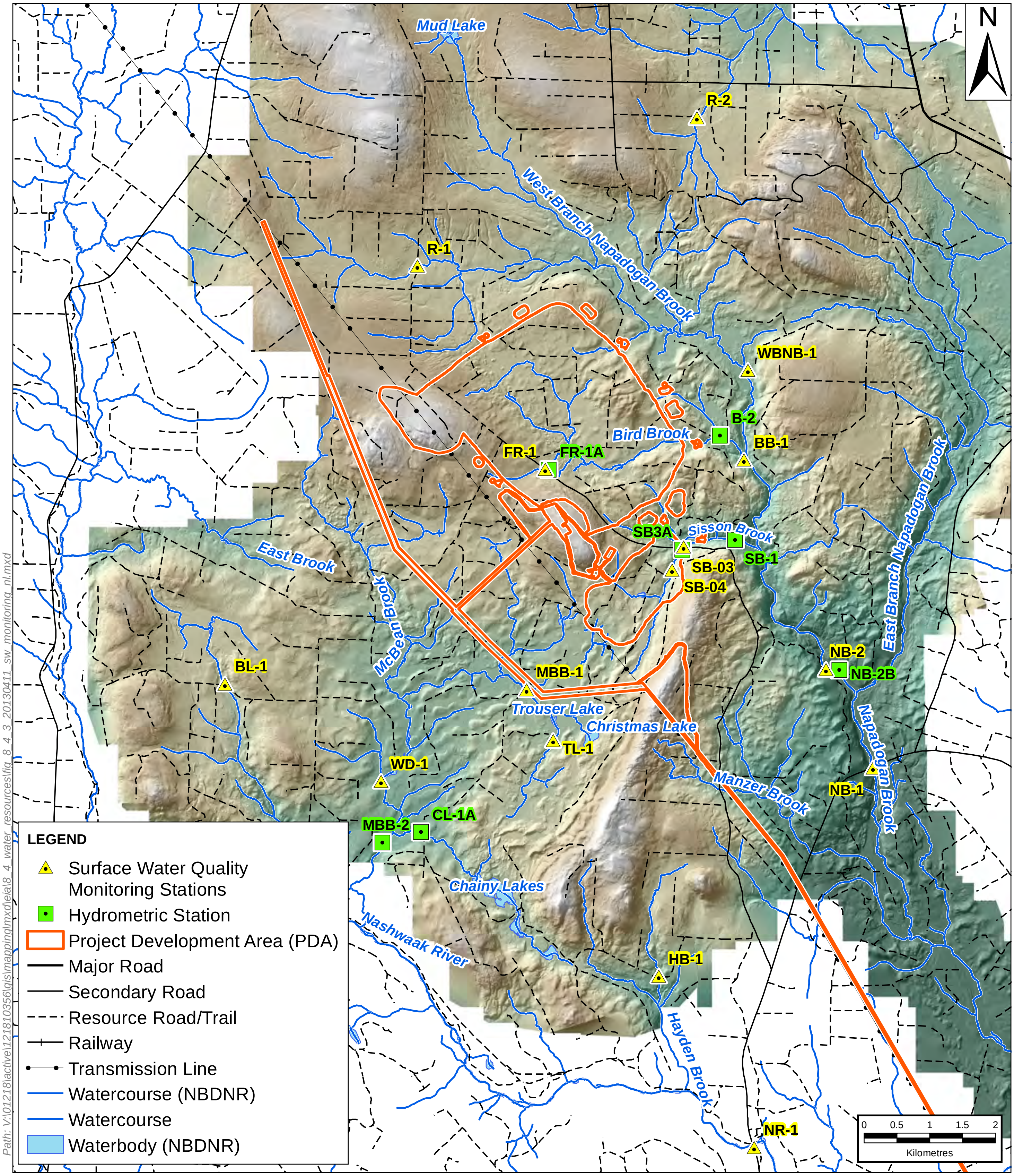
8.4.2.2.2 Stream Flow

As shown in Figure 8.4.3, hydrometric stations were installed for the Project on McBean Brook (MBB-2), Chainy Lakes near the confluence with McBean Brook (CL-1A), Napadogan Brook (NB-2B), Bird Brook near the confluence with Napadogan Brook (B-2), and Sisson Brook near the confluence with Napadogan Brook (SB-1). These stations are supplemented by data collected from hydrometric stations operated by the Water Survey of Canada (WSC) within the Napadogan Brook watershed. Of particular relevance to the Project are the Narrows Mountain Brook station (WSC ID 01AL004, located about 10 km south of the mine site), and the Nashwaak River at Penniac station (WSC ID 01AL002, located approximately 42 km southeast of the mine site), as shown in Figure 8.4.1.

Stream flow data at the stations installed for the Project were compared to the data from the WSC stations for the periods where the datasets overlap. Correlation equations were developed by Knight Piésold (2012d) in order to synthesize the long-term flow conditions at the Project stations from the WSC stations. The resulting long-term flow statistics are reported in Table 8.4.6 for the monitored streams.

The average monthly hydrograph presented in Figure 8.4.4 illustrates the seasonality of stream flow in terms of unit run-off, observed within the LAA. The hydrographs for all of the Project stations have similar shapes, although some minor differences are observed. Peak flows are encountered in the spring, typically in April, corresponding with the spring freshet. A smaller increase in flows are observed in the late fall, typically in November, due to increased precipitation in the fall. Periods of lower flows are typically encountered during the summer and winter months.

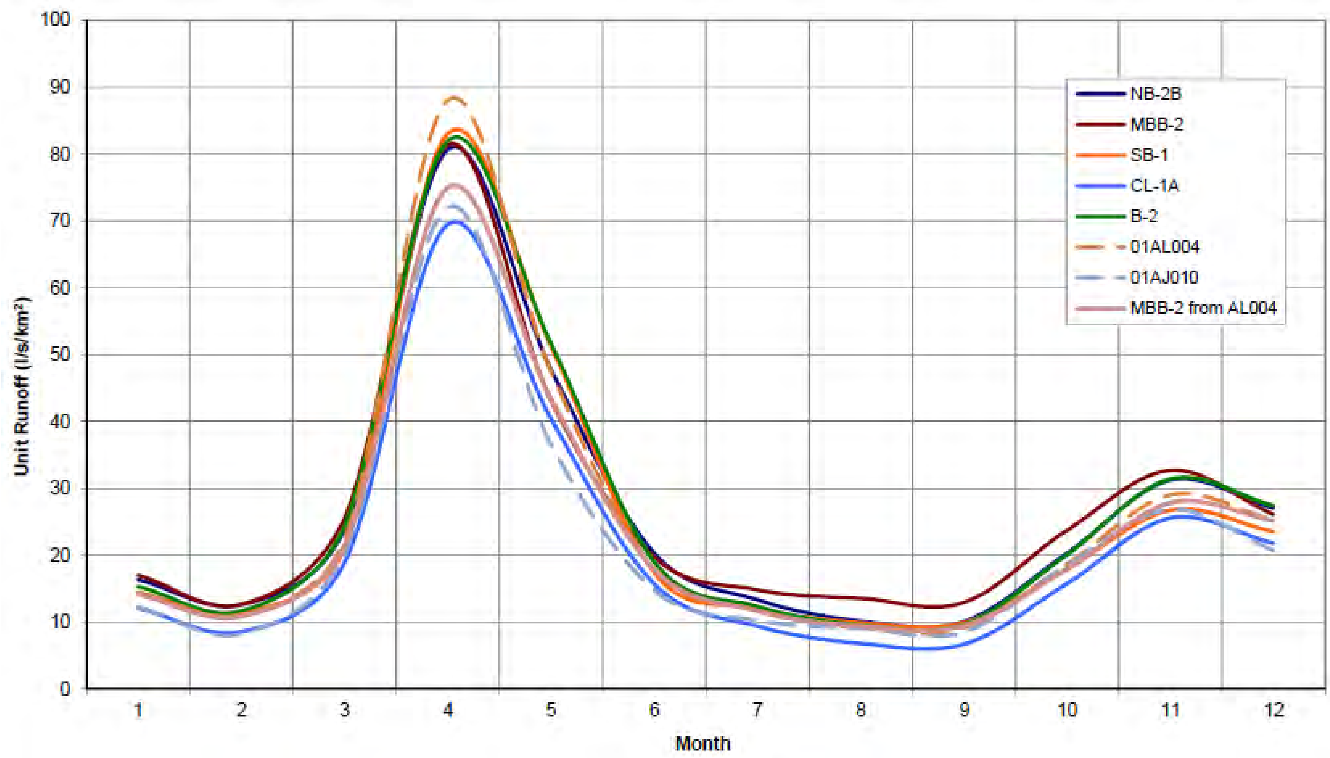
These differences in the unit run-off hydrographs can be caused by local climatic conditions and differences in basin parameters such as the shape, area, stream network, land cover and in-catchment storage. The unit run-off in the McBean Brook watershed tends to have lower unit run-off and a slower hydrologic response to storm events than Napadogan Brook. This is likely due to the presence of more lakes in the McBean Brook watershed which tend to attenuate the hydrologic response, and reduce the stream flow due to increased evaporation.



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

Location of Surface Water Monitoring Sisson Project: Environmental Impact Assessment (EIA) Report, Napadogan, N.B.	Scale: 1:80,000	Project No.: 121810356		Data Sources: NBDNR	Fig. No.: 8.4.3
	Date: (dd/mm/yyyy) 23/11/2014	Dwn. By: JAB	Appd. By: DLM		
Client: Sisson Mines Ltd.					

Map: NAD83 CSRS NB Double Stereographic



Source: Knight Piésold (2012d).

Figure 8.4.4 Mean Monthly Stream Flow Hydrograph as Unit Run-off for Hydrometric Stations in the RAA. Station locations are shown in Figures 8.4.1 and 8.4.3.

A low flow analysis was conducted by Knight Piésold (2012d) to provide an estimate of the water available for withdrawal throughout the PDA and LAA. The analysis estimated the annual, seven-day duration low flow with return periods of 2, 5, 10, 20, 50 and 100 years for five regional hydrometric stations operated by the WSC (01AL004, 01AJ010, 01AK006, 01AK007 and 01AL002). The 7-day low flows for the WSC stations were estimated using the LFA software from Environment Canada, which in turn were used to develop the statistics for the Project stations. The results are presented in Table 8.4.7.

Table 8.4.7 Annual Seven-Day Low Flows by Return Period (m^3/s)

Return Period (years)	Annual Seven-Day Low Flow for Return Period at Hydrometric Station (m^3/s)				
	B-2	SB-1	NB-2B	CL-1A	MBB-2
2	0.0146	0.0095	0.095	0.0025	0.0145
5	0.0074	0.0048	0.055	0.00045	0.0042
10	0.0047	0.00285	0.039	0.00017	0.0021
20	0.0029	0.0017	0.029	0.00005	0.00105
50	0.00145	0.0008	0.019	0.00001	0.00043
100	0.00021	0.00009	0.007	<0.00001	0.00035

Notes:
Refer to Figure 8.4.3 for the location of hydrometric stations.

Source: Knight Piésold (2012d)

Analysis of high flow was also conducted by Knight Piésold (2012d) to provide an estimate of potential flood flow in the LAA for different basis that may be caused by rainfall, snowmelt, or a combination of the two. A flood frequency analysis was conducted assuming a Generalized Extreme Value distribution and using long-term statistical values for WSC stations 01AL004 and 01AL003. Equations were developed to estimate the peak flows by drainage area for basins less than 10 km^2. Flood flows for return periods of 2, 5, 10, 20, 50, 100 and 200 years are provided for stations B-2 and SB-1 in Table 8.4.8.

Table 8.4.8 Flood Flows (m^3/s) by Return Period

Return Period (years)	Flood Flows for Return Period at Hydrometric Station (m^3/s)		
	B-2	SB-1	CL-1A
2	3.5	2.3	2.0
5	5.3	3.5	3.0
10	7.2	4.7	4.1
20	9.1	5.9	5.2
50	12.7	8.3	7.3
100	16.0	10.4	9.2
200	20.2	13.1	11.5

Notes:
Flood flows were calculated from equations presented by Knight Piésold (2012d), and are only applicable for hydrometric stations with a drainage less than 10 km^2.

Source: Knight Piésold (2012d).

8.4.2.2.3 Surface Water Quality

Several surface water quality monitoring stations have been monitored by Northcliff across the PDA and LAA, as well as both observation and reference stations included in the RAA. A list of monitoring stations arranged by watershed is provided in Table 8.4.9 (Knight Piésold 2012e). Surface water quality sampling began in June 2007, with *in situ* evaluation of physicochemical parameters and laboratory analysis of total and dissolved metals, nutrients and major anions. Surface water chemistry sampling continues; however, the results presented by Knight Piésold (2012e) only include samples collected up to and including April 2012, which are summarized in this EIA report.

Table 8.4.9 Surface Water Quality Monitoring Stations

Surface Water Quality Monitoring Station	Stream Order	Location	Number of Samples	Sampling Frequency	Period of Record for Analyses
Nashwaak River					
McBean Brook					
TL-1	2	LAA	16	Quarterly	July 2008 to April 2012
MBB-1	3	LAA	57	Monthly	August 2007 to April 2012
WD-1	4	LAA	16	Quarterly	July 2008 to April 2012
Chainy Lakes					
CL-1	2	LAA	11	Monthly	February 2008 to July 2008
Barker Creek					
BL-1	2	LAA	16	Quarterly	July 2008 to April 2012

Table 8.4.9 Surface Water Quality Monitoring Stations

Surface Water Quality Monitoring Station	Stream Order	Location	Number of Samples	Sampling Frequency	Period of Record for Analyses
Hayden Brook					
HB-1	2	RAA	57	Monthly	August 2007 to April 2012
NR-1	5	RAA	19	Quarterly	August 2007 to April 2012
Napadogan Brook					
R-1	2	LAA	57	Monthly	August 2007 to April 2012
WBNB-1	4	LAA	19	Quarterly	August 2007 to April 2012
Bird Brook					
FR-1	1	PDA	49	Monthly	April 2008 to April 2012
BB-1	3	LAA	44	Monthly	July 2008 to April 2012
Sisson Brook					
SB-04	2	PDA	11	Monthly	February 2008 to July 2008
SB-03	3	PDA	58	Monthly	June 2007 to April 2012
NB-2	4	LAA	58	Monthly	August 2007 to April 2012
NB-1	4	LAA	55	Quarterly	August 2007 to April 2012
NR-2	5	RAA	18	Quarterly	August 2007 to April 2012

Notes:
1) Refer to Figure 8.4.3 for the location of the stations.
2) Stations are arranged by watercourse from upstream to downstream, with indent levels of the stations representing respective tributaries. For example, the outlets of McBean Brook and Hayden Brook are both tributaries to the Nashwaak River upstream of NR-1. Similarly, the outlets of Chainy Lakes and Barker Creek are located downstream of station WD-1 on McBean Brook, but the samples collected at CL-1 and BL-1 do not represent the water quality in McBean Brook itself.

Source: Knight Piésold (2012e).

The surface water quality has been summarized on a sub-watershed basis, with the results for the McBean Brook watershed summarized in Table 8.4.10 and for the Napadogan Brook watershed in Table 8.4.11. Values in ***bold italics*** indicate a concentration in excess of the Health Canada Guidelines for Canadian Drinking Water Quality (GCDWQ; Health Canada 2012a).

Table 8.4.10 Surface Water Quality in McBean Brook Sub-Watershed

Parameter (Unit)	Concentration			Total Number of Samples	Guideline for Canadian Drinking Water Quality (GCDWQ)	No. of Samples Exceeding GCDWQ
	Minimum	Mean	Maximum			
***In Situ* Parameters**						
Conductivity (µS/cm)	3.4	22	50	103		
pH	***5.73***	6.94	***9.02***	111	6.5-8.5	36
Temperature (°C)	0	9	***23***	109	15	24
Physical Parameters						
Total Acidity (as $CaCO_3$) (mg/L)	<5	5.56	60	114		
Total Alkalinity (as $CaCO_3$) (mg/L)	2	8.53	19	114		
Colour (TCU)	***21***	***86***	***228***	114	15	114
Turbidity (NTU)	0.2	0.8	4.6	114		
Total Organic Carbon (TOC) (mg/L)	2.7	8.8	28	114		

Table 8.4.10 Surface Water Quality in McBean Brook Sub-Watershed

Parameter (Unit)	Concentration			Total Number of Samples	Guideline for Canadian Drinking Water Quality (GCDWQ)	No. of Samples Exceeding GCDWQ
	Minimum	Mean	Maximum			
Total Dissolved Solids (TDS) (mg/L)	<5	41	143	114	500	0
Total Suspended Solids (TSS) (mg/L)	<5	<5	15	114		
Hardness[a] (as $CaCO_3$) (mg/L)	3.3	11.6	21	114		
Dissolved Anions (mg/L)						
Bicarbonate[a] (as $CaCO_3$) (mg/L)	0	8.32	19	114		
Carbonate[a] (as $CaCO_3$) (mg/L)	0	0.008	0.0549	114		
Bromide (mg/L)	<0.01	<0.01	0.01	114		
Chloride (mg/L)	0.6	1.3	3.4	114	250	0
Fluoride (mg/L)	<0.05	0.15	0.37	114	1.5	0
Sulphate (mg/L)	<1	1.6	6	114	500	0
Nutrients (mg/L)						
Ammonia (as N) (mg/L)	<0.05	<0.05	<0.25	114		
Nitrate+Nitrite (as N) (mg/L)	<0.05	0.19	***12.7***	114	10	1
Nitrate (as N) (mg/L)	<0.05	0.19	***12.7***	114	10	1
Nitrite (as N) (mg/L)	<0.05	<0.05	<0.05	114	1	0
Total Kjeldahl Nitrogen (mg/L)	0.2	<0.25	0.7	114		
Orthophosphate (mg/L)	<0.01	0.01	0.3	114		
Dissolved Phosphorus (mg/L)	<0.02	<0.02	0.04	114		
Total Phosphorus (mg/L)	0.02	<0.02	0.03	114		
Calculated Parameters						
Anion Sum[a] (meq/L)	0.0256	0.24	0.985	114		
Cation Sum[a] (meq/L)	0.118	0.308	0.511	114		
Ion Balance[a] (%)	-73.8	20	64.3	114		
Saturation pH[a]	9.4	10	13.6	114		
Dissolved Metals (mg/L)						
Aluminum (mg/L)	0.032	0.108	0.343	114		
Antimony (mg/L)	<0.0001	<0.0001	0.0001	114	0.006	0
Arsenic (mg/L)	<0.001	<0.001	0.002	114	0.01	0
Barium (mg/L)	0.001	0.003	0.008	114	1	0
Beryllium (mg/L)	<0.0001	<0.0001	<0.0001	114		
Bismuth (mg/L)	<0.001	<0.001	<0.001	114		
Boron (mg/L)	0.001	0.002	0.004	114	5	0
Cadmium (mg/L)	0.00001	0.00003	0.00015	114	0.005	0
Calcium (mg/L)	1.01	3.75	7.06	114		
Chromium (mg/L)	<0.001	<0.001	<0.001	114	0.05	0
Cobalt (mg/L)	<0.0001	<0.0001	0.0001	114		
Copper (mg/L)	<0.001	<0.001	0.003	114	1.0	0
Iron (mg/L)	0.03	0.15	***0.67***	114	0.3	9
Lead (mg/L)	0.0001	0.0001	0.0004	114	0.01	0

Table 8.4.10 Surface Water Quality in McBean Brook Sub-Watershed

Parameter (Unit)	Concentration			Total Number of Samples	Guideline for Canadian Drinking Water Quality (GCDWQ)	No. of Samples Exceeding GCDWQ
	Minimum	Mean	Maximum			
Lithium (mg/L)	0.0002	0.0004	0.0007	114		
Magnesium (mg/L)	0.19	0.55	0.84	114		
Manganese (mg/L)	0.001	0.01	***0.052***	114	0.05	1
Mercury (mg/L)	<0.000025	<0.000025	0.00004	114	0.001	0
Molybdenum (mg/L)	<0.0001	0.0006	0.0033	114		
Nickel (mg/L)	<0.001	<0.001	0.001	114		
Phosphorus (mg/L)	<0.02	<0.02	0.03	105		
Potassium (mg/L)	0.18	0.35	0.58	114		
R-silica (as SiO_2) (mg/L)	<0.1	7.2	12.3	114		
Rubidium (mg/L)	0.0005	0.0009	0.0016	114		
Selenium (mg/L)	<0.001	<0.001	<0.001	114	0.01	0
Silver (mg/L)	<0.0001	<0.0001	<0.0001	114		
Sodium (mg/L)	0.6	1.32	1.85	114	200	0
Strontium (mg/L)	0.004	0.017	0.032	114		
Tellurium (mg/L)	<0.0001	<0.0001	<0.0001	114		
Thallium (mg/L)	<0.0001	<0.0001	<0.0001	114		
Tin (mg/L)	<0.0001	<0.0001	<0.0001	114		
Tungsten (mg/L)	<0.0001	0.0023	<0.005	114		
Uranium (mg/L)	<0.0001	<0.0001	0.0001	114	0.02	0
Vanadium (mg/L)	<0.001	<0.001	<0.001	114		
Zinc (mg/L)	0.002	0.004	0.012	114	5	0
Total Metals (mg/L)						
Aluminum (mg/L)	0.016	0.13	0.471	114		
Antimony (mg/L)	<0.0001	<0.0001	0.0005	114	0.006	0
Arsenic (mg/L)	<0.001	<0.001	0.002	114	0.01	0
Barium (mg/L)	<0.001	0.003	0.008	114	1	0
Beryllium (mg/L)	<0.0001	<0.0001	<0.0001	114		
Bismuth (mg/L)	<0.001	<0.001	0.001	114		
Boron (mg/L)	0.001	0.002	0.005	114	5	0
Cadmium (mg/L)	0.00001	0.000025	0.00012	114	0.005	0
Calcium (mg/L)	1.05	3.86	6.97	114		
Chromium (mg/L)	<0.001	<0.001	0.002	114	0.05	0
Cobalt (mg/L)	<0.0001	<0.0001	0.0002	114		
Copper (mg/L)	<0.001	<0.001	0.002	114	1.0	0
Iron (mg/L)	<0.02	0.18	***0.82***	114	0.3	14
Lead (mg/L)	0.0001	0.0002	0.0006	114	0.01	0
Lithium (mg/L)	<0.0001	0.0004	0.0008	114		
Magnesium (mg/L)	<0.01	0.55	0.87	114		
Manganese (mg/L)	<0.001	0.014	***0.058***	114	0.05	2
Mercury (mg/L)	<0.000025	<0.000025	0.00008	114	0.001	0
Molybdenum (mg/L)	<0.0001	0.0006	0.0035	114		
Nickel (mg/L)	<0.001	<0.001	0.001	114		
Phosphorus (mg/L)	<0.02	<0.02	0.03	105		

Table 8.4.10 Surface Water Quality in McBean Brook Sub-Watershed

Parameter (Unit)	Concentration			Total Number of Samples	Guideline for Canadian Drinking Water Quality (GCDWQ)	No. of Samples Exceeding GCDWQ
	Minimum	Mean	Maximum			
Potassium (mg/L)	<0.02	0.36	0.58	114		
Rubidium (mg/L)	<0.0001	0.001	0.0016	114		
Selenium (mg/L)	<0.001	<0.001	<0.001	114	0.01	0
Silver (mg/L)	<0.0001	<0.0001	0.0002	114		
Sodium (mg/L)	0.09	1.33	1.97	114	200	0
Strontium (mg/L)	<0.001	0.018	0.032	114		
Tellurium (mg/L)	<0.0001	<0.0001	<0.0001	114		
Thallium (mg/L)	<0.0001	<0.0001	<0.0001	114		
Tin (mg/L)	<0.0001	<0.0001	0.0016	114		
Tungsten (mg/L)	<0.0001	0.0024	0.008	114		
Uranium (mg/L)	<0.0001	<0.0001	0.0001	114	0.02	0
Vanadium (mg/L)	<0.001	<0.001	0.009	114		
Zinc (mg/L)	<0.001	0.002	0.01	114	5	0

Notes:
1) All parameter results are presented in mg/L unless otherwise indicated.
2) A value in ***bold italics*** indicates a concentration in excess of the Guidelines for Canadian Drinking Water Quality (GCDWQ; Health Canada 2012a).

[a] = Laboratory-calculated parameter.

Source: Knight Piésold (2012e).

Table 8.4.11 Surface Water Quality in Napadogan Brook Sub-Watershed

Parameter (Unit)	Concentration			Total Number of Samples	Guideline for Canadian Drinking Water Quality (GCDWQ)	No. of Samples Exceeding GCDWQ
	Minimum	Mean	Maximum			
***In Situ* Parameters**						
Conductivity (µS/cm)	0	17	69	287		
pH	***4.97***	6.99	***9.12***	304	6.5-8.5	77
Temperature (°C)	0	7.3	***19.6***	304	15	53
Physical Parameters						
Total Acidity (as $CaCO_3$) (mg/L)	<5	<5	15	312		
Total Alkalinity (as $CaCO_3$) (mg/L)	2	6.63	14	312		
Colour (TCU)	***19***	***74***	***289***	312	15	311
Turbidity (NTU)	0.2	1	121	312		
Total Organic Carbon (TOC) (mg/L)	2.4	7.5	27	312		
Total Dissolved Solids (TDS) (mg/L)	<5	37	332	312	500	0
Total Suspended Solids (TSS) (mg/L)	<5	<5	101	312		
Hardness[c] (as $CaCO_3$)	2.83	8.24	13.3	312		
Dissolved Anions (mg/L)						
Bicarbonate[a] (as $CaCO_3$) (mg/L)	0	6.58	14	312		
Carbonate[a] (as $CaCO_3$) (mg/L)	0	0.006	0.121	312		
Bromide (mg/L)	<0.01	<0.01	0.02	312		

Table 8.4.11 Surface Water Quality in Napadogan Brook Sub-Watershed

Parameter (Unit)	Concentration			Total Number of Samples	Guideline for Canadian Drinking Water Quality (GCDWQ)	No. of Samples Exceeding GCDWQ
	Minimum	Mean	Maximum			
Chloride (mg/L)	<0.5	1.1	2.4	312	250	0
Fluoride (mg/L)	<0.05	0.15	0.55	312	1.5	0
Sulphate (mg/L)	<1	1.3	6	312	500	0
Nutrients (mg/L)						
Ammonia (as N) (mg/L)	0	<0.05	0.77	312		
Nitrate+Nitrite (as N) (mg/L)	<0.05	0.098	0.8	312	10	0
Nitrate (as N) (mg/L)	<0.05	0.1	1.95	312	10	0
Nitrite (as N) (mg/L)	<0.05	<0.05	<0.05	312	1	0
Total Kjeldahl Nitrogen (mg/L)	0.2	0.28	6.9	312		
Orthophosphate (mg/L)	<0.01	0.01	0.19	312		
Dissolved Phosphorus (mg/L)	0.02	0.02	0.05	312		
Total Phosphorus (mg/L)	<0.02	0.02	0.2	312		
Calculated Parameters						
Anion Sum (meq/L)	0.023	0.189	0.357	312		
Cation Sum (meq/L)	0.107	0.253	0.374	312		
Ion Balance (%)	-11.9	20	71	312		
Saturation pH	9.8	10	13.6	312		
Dissolved Metals (mg/L)						
Aluminum (mg/L)	0.029	0.131	0.609	312		
Antimony (mg/L)	<0.0001	<0.0001	0.0003	312	0.006	0
Arsenic (mg/L)	<0.001	0.001	0.006	312	0.01	0
Barium (mg/L)	0.001	0.003	0.01	312	1	0
Beryllium (mg/L)	<0.0001	<0.0001	0.0001	312		
Bismuth (mg/L)	<0.001	<0.001	<0.001	312		
Boron (mg/L)	0.001	0.002	0.005	312	5	0
Cadmium (mg/L)	<0.00001	0.000026	0.00019	312	0.005	0
Calcium (mg/L)	0.77	2.52	4.37	312		
Chromium (mg/L)	<0.001	<0.001	<0.001	312	0.05	0
Cobalt (mg/L)	<0.0001	<0.0001	0.0004	312		
Copper (mg/L)	<0.001	<0.001	0.003	312	1.0	0
Iron (mg/L)	0.04	0.17	0.74	312	0.3	25
Lead (mg/L)	0.0001	0.0001	0.0006	312	0.01	0
Lithium (mg/L)	0.0003	0.0009	0.0031	312		
Magnesium (mg/L)	0.21	0.48	0.87	312		
Manganese (mg/L)	0.001	0.0079	***0.063***	312	0.05	3
Mercury (mg/L)	<0.000025	<0.000025	0.00005	312	0.001	0
Molybdenum (mg/L)	<0.0001	0.001	0.0102	312		
Nickel (mg/L)	<0.001	<0.001	0.002	312		
Phosphorus (mg/L)	<0.02	0.02	0.04	301		
Potassium (mg/L)	0.16	0.35	0.83	312		
R-silica (as SiO_2) (mg/L)	<0.1	8.6	14.5	312		
Rubidium (mg/L)	0.0006	0.001	0.0029	312		
Selenium (mg/L)	<0.001	<0.001	<0.001	312	0.01	0

Table 8.4.11 Surface Water Quality in Napadogan Brook Sub-Watershed

Parameter (Unit)	Concentration			Total Number of Samples	Guideline for Canadian Drinking Water Quality (GCDWQ)	No. of Samples Exceeding GCDWQ
	Minimum	Mean	Maximum			
Silver (mg/L)	<0.0001	<0.0001	<0.0001	312		
Sodium (mg/L)	0.59	1.57	2.49	312	200	0
Strontium (mg/L)	0.005	0.013	0.022	312		
Tellurium (mg/L)	<0.0001	<0.0001	<0.0001	312		
Thallium (mg/L)	<0.0001	<0.0001	<0.0001	312		
Tin (mg/L)	<0.0001	<0.0001	0.0001	312		
Tungsten (mg/L)	<0.0001	0.0023	<0.005	312		
Uranium (mg/L)	<0.0001	0.0001	0.0005	312	0.02	0
Vanadium (mg/L)	<0.001	<0.001	0.001	312		
Zinc (mg/L)	0.001	0.005	0.076	312	5	0
Total Metals (mg/L)						
Aluminum (mg/L)	<0.001	0.249	13.4	312		
Antimony (mg/L)	<0.0001	<0.0001	0.0003	312	0.006	0
Arsenic (mg/L)	<0.001	0.001	***0.012***	312	0.01	1
Barium (mg/L)	<0.001	0.003	0.044	312	1	0
Beryllium (mg/L)	<0.0001	<0.0001	0.0004	312		
Bismuth (mg/L)	<0.001	<0.001	0.001	312		
Boron (mg/L)	0.001	0.002	0.005	312	5	0
Cadmium (mg/L)	<0.00001	0.000022	0.00016	312	0.005	0
Calcium (mg/L)	<0.05	2.6	4.6	312		
Chromium (mg/L)	<0.001	<0.001	0.009	312	0.05	0
Cobalt (mg/L)	<0.0001	0.0001	0.0028	312		
Copper (mg/L)	<0.001	<0.001	0.022	312	1.0	0
Iron (mg/L)	<0.02	0.25	7.43	312	0.3	51
Lead (mg/L)	<0.0001	0.0002	0.0086	312	0.01	0
Lithium (mg/L)	0.0002	0.001	0.0084	312		
Magnesium (mg/L)	<0.01	0.5	1.69	312		
Manganese (mg/L)	<0.001	0.014	***0.27***	312	0.05	9
Mercury (mg/L)	<0.000025	<0.000025	0.00009	312	0.001	0
Molybdenum (mg/L)	<0.0001	0.001	0.0115	312		
Nickel (mg/L)	<0.001	<0.001	0.005	312		
Phosphorus (mg/L)	<0.02	<0.02	0.04	301		
Potassium (mg/L)	<0.02	0.37	3.18	312		
Rubidium (mg/L)	<0.0001	0.002	0.0249	312		
Selenium (mg/L)	<0.001	<0.001	<0.001	312	0.01	0
Silver (mg/L)	<0.0001	<0.0001	<0.0001	312		
Sodium (mg/L)	0.11	1.61	2.6	312	200	0
Strontium (mg/L)	<0.001	0.014	0.023	312		
Tellurium (mg/L)	<0.0001	<0.0001	<0.0001	312		
Thallium (mg/L)	<0.0001	<0.0001	0.0002	312		
Tin (mg/L)	<0.0001	0.0002	0.0183	312		
Tungsten (mg/L)	<0.0001	0.0023	0.01	312		
Uranium (mg/L)	0.0001	0.0001	0.0009	312	0.02	0

Table 8.4.11 Surface Water Quality in Napadogan Brook Sub-Watershed

Parameter (Unit)	Concentration			Total Number of Samples	Guideline for Canadian Drinking Water Quality (GCDWQ)	No. of Samples Exceeding GCDWQ
	Minimum	Mean	Maximum			
Vanadium (mg/L)	<0.001	<0.001	0.014	312		
Zinc (mg/L)	<0.001	0.002	0.019	312	5	0

Notes:
1) All parameter results are presented in mg/L unless otherwise indicated.
2) A value in ***bold italics*** indicates a concentration in excess of the Guidelines for Canadian Drinking Water Quality (GCDWQ; Health Canada 2012a).
[a] = Laboratory-calculated parameter.

Source: Knight Piésold (2012e).

The general water characteristics are very similar for both the McBean Brook and Napadogan Brook watersheds, that is, soft, coloured, naturally-acidic water with low total dissolved solids (TDS). Overall, the water quality in both watersheds is good, although some users may find it unpalatable due to the colour of the water, or that it is too warm in the summer months. The occasional exceedance of iron and manganese concentrations relative to the GCDWQ is common in New Brunswick, but can result to some undesirable taste for sensitive users.

The temperature in the McBean Brook watershed is warmer than in the Napadogan Brook watershed, which correlates with the presence of more lakes in the McBean Brook watershed, which tend to attenuate the flow and allow more warming of the water.

In general, the Total Suspended Solids (TSS) concentrations in the Napadogan Brook watershed are higher than those in the McBean Brook watershed. This leads to higher total metals concentrations in the Napadogan Brook watershed than in the McBean Brook watershed. Total metals concentrations were observed to exceed the GCDWQ in the Napadogan Brook watershed for iron (6% of samples) and manganese (3%). Similarly, the dissolved metals exceeding the GCDWQ were iron (8%) and manganese (10%).

Fewer parameters were observed to exceed the GCDWQ in the McBean Brook watershed, with only total iron (12% of samples) and total manganese (2%) and dissolved iron (8%) and dissolved manganese (1%) exceeding the GCDWQ. The lower TSS and total metals concentrations in the McBean Brook watershed are attributed to the relatively slower, more ponded nature of the flows in the watershed compared to the Napadogan Brook watershed.

8.4.2.2.4 Surface Water Users

Surface water users within the LAA are limited to several recreational campsites located near Napadogan Brook below Sisson Brook, approximately 1.5 m east of the open pit location. Surface water from small spring-fed tributaries to Napadogan Brook was observed to be used at recreational campsites. These tributaries have been observed to flow throughout the winter and summer (2011 and 2012) along the hillside. These springs originate on the southeastern side of Napadogan Ridge, which acts a watershed (and groundwater) divide between the Sisson Brook watershed and Lower Napadogan Brook.

The average daily water demand for the 39 recreational campsites combined would be 13.5 m^3/d or 0.16 L/s, based on daily demand per camp of 450 L/d (NBDOH 2012). If all of this demand were sourced just from Napadogan Brook, it would account for about 2% of the seven-day low stream flow that is predicted to occur only once in 100 years in the brook (as measured at station NB-2B, see Table 8.4.7).

8.4.2.3 Groundwater

An assessment of the groundwater resources was conducted by Knight Piésold, and the results are presented in several reports (Knight Piésold 2011, 2012a, 2012c, 2012e and 2013a). A summary of some of the key findings of these reports is provided in this section.

8.4.2.3.1 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 is illustrated in Figure 8.4.5 and was described in Section 3.1.3.2. Very few fractured contacts or faults were identified in the 2011 open pit geotechnical/hydrogeological site investigation program. Rubble zones and gouge filled structures identified in drillholes were localized in nature, and do not imply any large-scale continuous fractured features at the drillhole locations. Therefore, these features do not contribute significantly to groundwater resources.

8.4.2.3.2 Surficial Geology

The regional surficial geology within the LAA was characterized by Rampton (1984) as consisting of morainal till sediments of Late Wisconsinan age. As shown in Figure 8.4.6, the deposits underlying most of the McBean Brook watershed, the Bird Brook sub-watershed and the area underlying the confluence of the West and East Branches of Napadogan Brook are mainly boulder-till greater than 1.5 m thick. The overburden thicknesses vary from a 0.5 m to 3 m under the upper reaches of West Branch Napadogan Brook and in lower Napadogan Brook below Manzer Brook. Elsewhere within the LAA, the boulder-till thickness is characterized as a discontinuous veneer (less than about 0.5 m).

Investigations of the local surficial geology (Knight Piésold 2011) indicate that the surficial materials consist of basal till, and are slightly thicker than reported in the regional interpretations by Rampton (1984), ranging from 5 to 25 m thick with an average thickness of 12 m in the vicinity of the Project. Very little overburden was observed in the area of the open pit, which consisted of a thin veneer of topsoil covers about 0.3 to 4 m thick (Knight Piésold 2012a).

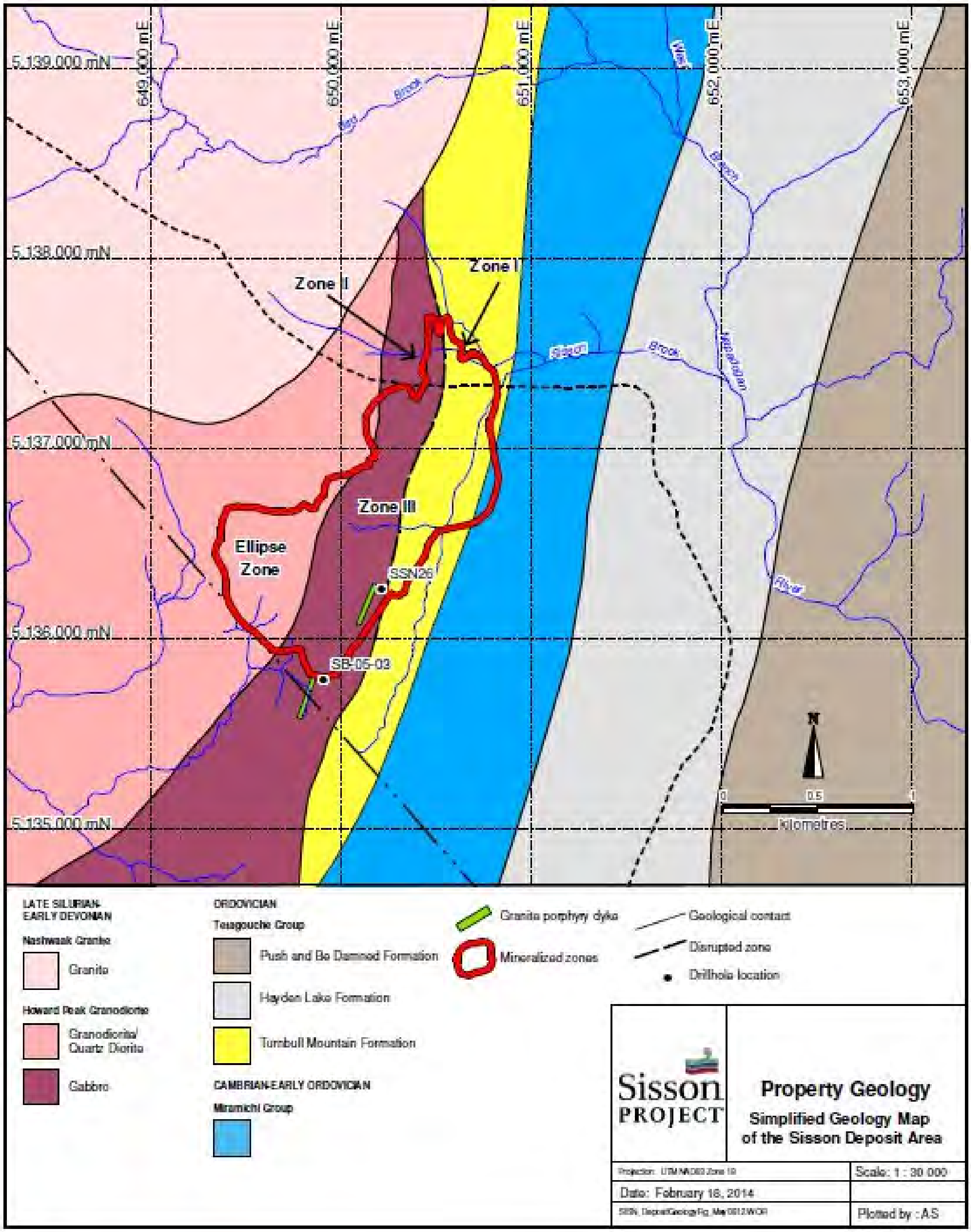


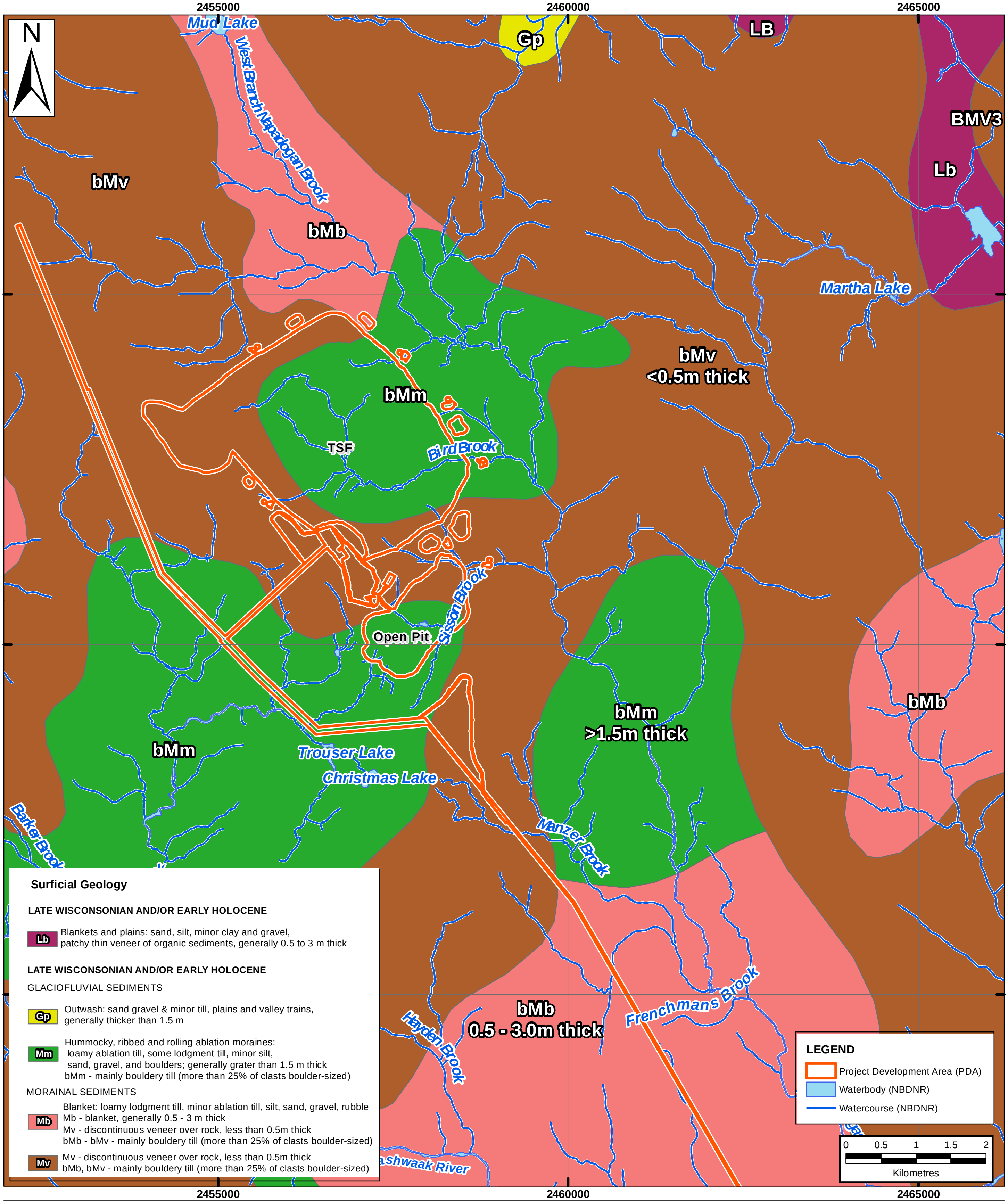
Figure 8.4.5 Simplified Geology Map of the Sisson Deposit Area

8.4.2.3.3 Hydrogeologic Setting

Regional hydrogeologic maps prepared for the Fredericton Region (NBENV 1980) indicate that the groundwater potential for the Nashwaak River watershed is limited almost entirely to the bedrock aquifer. The eastern half of the basin is underlain by relatively flat lying Pennsylvanian sandstone, shale and conglomerate, while the western portion of the basin is underlain by folded Ordovician to Silurian aged meta-sediments, and by intrusive Devonian granites. Within these units, groundwater movement is almost totally controlled by fracture flow (NBENV 1980).

Based on the regional maps, the LAA is mostly situated on a complex of Ordovician, Silurian and Devonian aged, fine-grained, sedimentary and meta-sedimentary rocks with minor volcanic rocks. Well yields for these hydrostratigraphic units are generally low (between 0.1 and 0.4 L/s), although well yields as high as 2 L/s have been reported (NBENV 1980). Higher than average yields are known to occur near contacts between metacrystalline bedrock and intrusives. Groundwater yields for the geologic units in the eastern portion of the LAA were reported to be even lower, with a substantial number of wells having yields less than 0.1 L/s (NBENV 1980).

Eleven 51 mm diameter monitoring wells at six locations were installed in 2011 to investigate the hydrogeology within the PDA (Knight Piésold 2011). These wells were installed in nested pairs, at five locations, with a single well installed at one of the locations. Six wells were installed with shallow screens (bottom of screen less than 10 m below ground surface) in the upper bedrock or the till-bedrock interface and five wells were installed in bedrock with deep screens (bottom of screen greater than 20 m below ground surface). The location of the wells is in Figure 8.4.7 and the construction detail is listed in Table 8.4.12. The wells were developed following construction to remove drilling debris and fines from the well screen and filter pack.

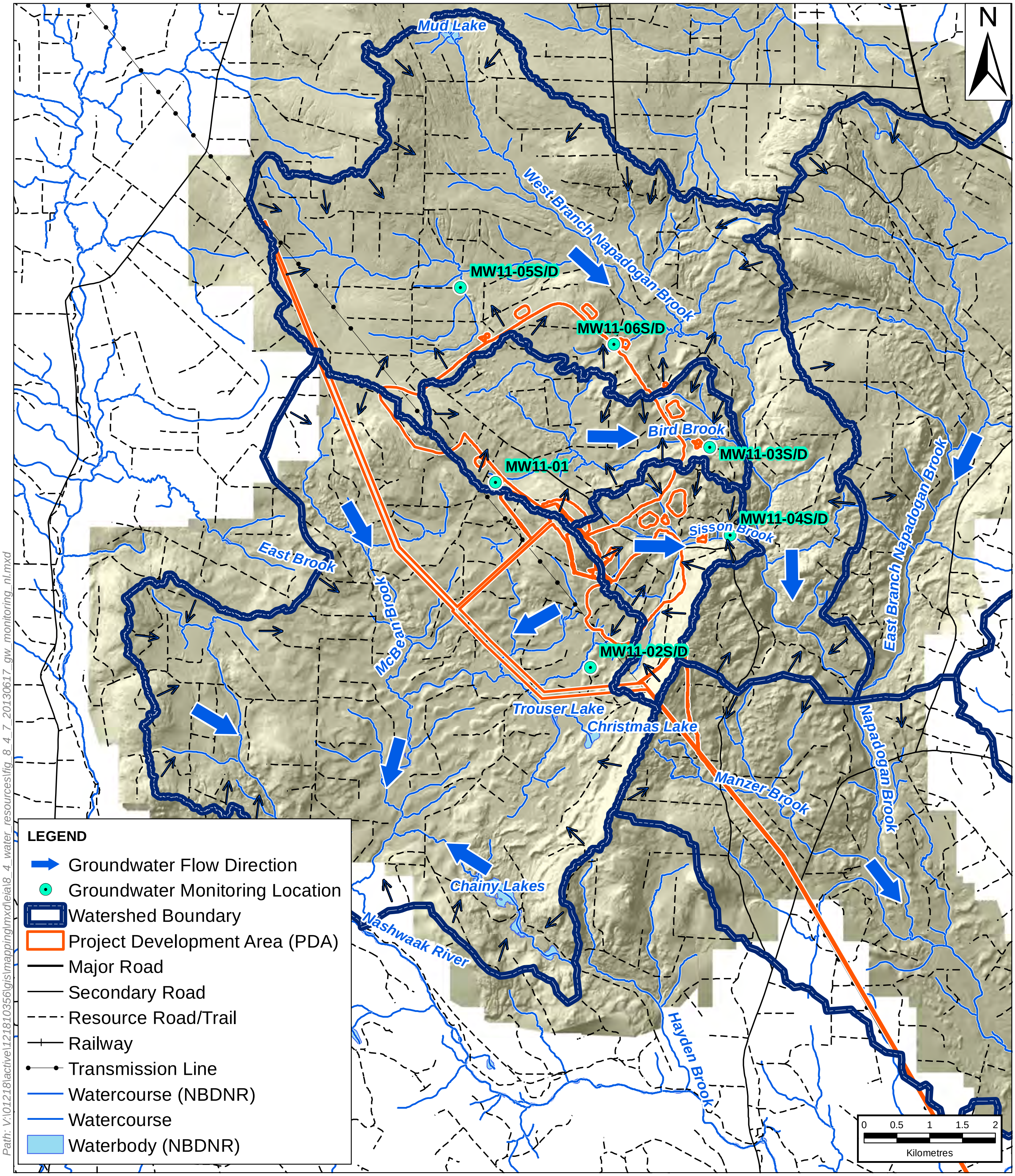


Path: V:\01218\active\121810356\gis\mapping\mxd\eia\8_4_water_resources\fig_8_4_6_20130412_surficial_geology_nl.mxd

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

Regional Surficial Geology Sisson Project: Environmental Impact Assessment (EIA) Report, Napadogan, N.B.	Scale: 1:75,000	Project No.: 121810356	Data Sources: NBDNR Rampton 1984	Fig. No.: 8.4.6	Stantec
	Date: (dd/mm/yyyy) 23/11/2014	Dwn. By: JAB	Appd. By: DLM		
Client: Sisson Mines Ltd.					

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.

Location of Groundwater Monitoring	Scale: 1:80,000	Project No.: 121810356	Data Sources: NBDNR	Fig. No.: 8.4.7	Stantec
Sisson Project: Environmental Impact Assessment (EIA) Report, Napadogan, N.B.	Date: (dd/mm/yyyy) 23/11/2014	Dwn. By: JAB	Appd. By: DLM		
Client: Sisson Mines Ltd.					

Map: NAD83 CSRS NB Double Stereographic

Table 8.4.12 Monitoring Well Construction Details and Hydraulic Conductivity Distribution

Location	Ground Surface Elevation (m) [a]	Screened Interval (m bgs)	Overburden Thickness (m)	Average Depth to Water (m bgs) [b]	Water level variation (m)	Hydraulic Conductivity (m/s)	Completion Details
MW11-01	345.55	20.5 - 23.6	21.4	1.39	1.0	4.0×10^{-6}	Bedrock/Silty Sand Interface
MW11-02S	293.20	5.3 - 6.8	6.4	2.25	1.88	3.0×10^{-5}	Bedrock/Cobble Interface
MW11-02D	293.35	25.3 - 28.3	n/a	2.43	1.49	5.0×10^{-7}	Bedrock (Howard Peak Granodiorite)
MW11-03S	287.62	6.8 - 9.1	6.2	2.21	2.54	5.0×10^{-5}	Bedrock (Miramichi Group)
MW11-03D	287.69	18.6 - 21.7	n/a	2.04	2.12	5.0×10^{-6}	Bedrock (Miramichi Group)
MW11-04S	270.29	5.2 - 8.3	1.6	-0.15	0.57	7.0×10^{-7}	Bedrock (Turnbull Mountain Formation)
MW11-04D	270.59	27.3 - 30.3	n/a	-3.79	1.46	-	Bedrock (Turnbull Mountain Formation)
MW11-05S	308.92	5.9 - 9.0	11	1.68	0.92	1.4×10^{-5}	Overburden (sand and silt)
MW11-05D	309.00	30.4 - 33.5	12.2	1.97	0.52	2.0×10^{-5}	Bedrock (Nashwaak Granite)
MW11-06S	306.35	6.7 - 8.5	6.6	2.75	1.60	3.0×10^{-5}	Bedrock/sand interface
MW11-06D	306.15	20.6 - 23.8	n/a	1.75	1.58	4.5×10^{-6}	Bedrock (Nashwaak Granite)
Geometric mean			7.4			7.2×10^{-6}	

Notes:
[a] Ground surface elevation interpolated from LiDAR-based digital terrain model.
[b] bgs = below ground surface.

Source: Knight Piésold (2013a).

Rising and falling head tests were conducted at these wells following development in order to estimate the hydraulic conductivity of the bedrock near the wells. Table 8.4.12 provides the results of this testing. The hydraulic conductivity varied from 5.0×10^{-7} to 5.0×10^{-5} m/s, with a geometric mean of 7.2×10^{-6} m/s. The hydraulic conductivity of the shallow wells was generally higher than that observed in the deep well, consistent with a decreasing degree of fracturing and bulk hydraulic conductivity with depth. These results are higher than hydraulic conductivity estimates from packer testing conducted by TerrAtlantic (2010) within the PDA that reported hydraulic conductivity ranging from 1.1×10^{-9} to 7.9×10^{-6} m/s, with a geometric mean of 3.4×10^{-7} m/s. A potable well installed to a depth of about 40 m in a formation of hydraulic conductivity of 7×10^{-6} m/s is estimated to have a well yield up to about 2 L/s.

Several boreholes were drilled in the footprint of the open pit as part of the ore exploration program in 2011. Packer testing was conducted at these boreholes by Knight Piésold (2012a) and the reported hydraulic conductivity from these tests ranged from $<1.0\times10^{-8}$ to 1.3×10^{-4} m/s with a geometric mean of 2.0×10^{-7} m/s. In general, the hydraulic conductivity decreased with increasing depth. The packer testing is more representative of the deep bedrock and the slug testing is more representative of the upper 20 m of bedrock.

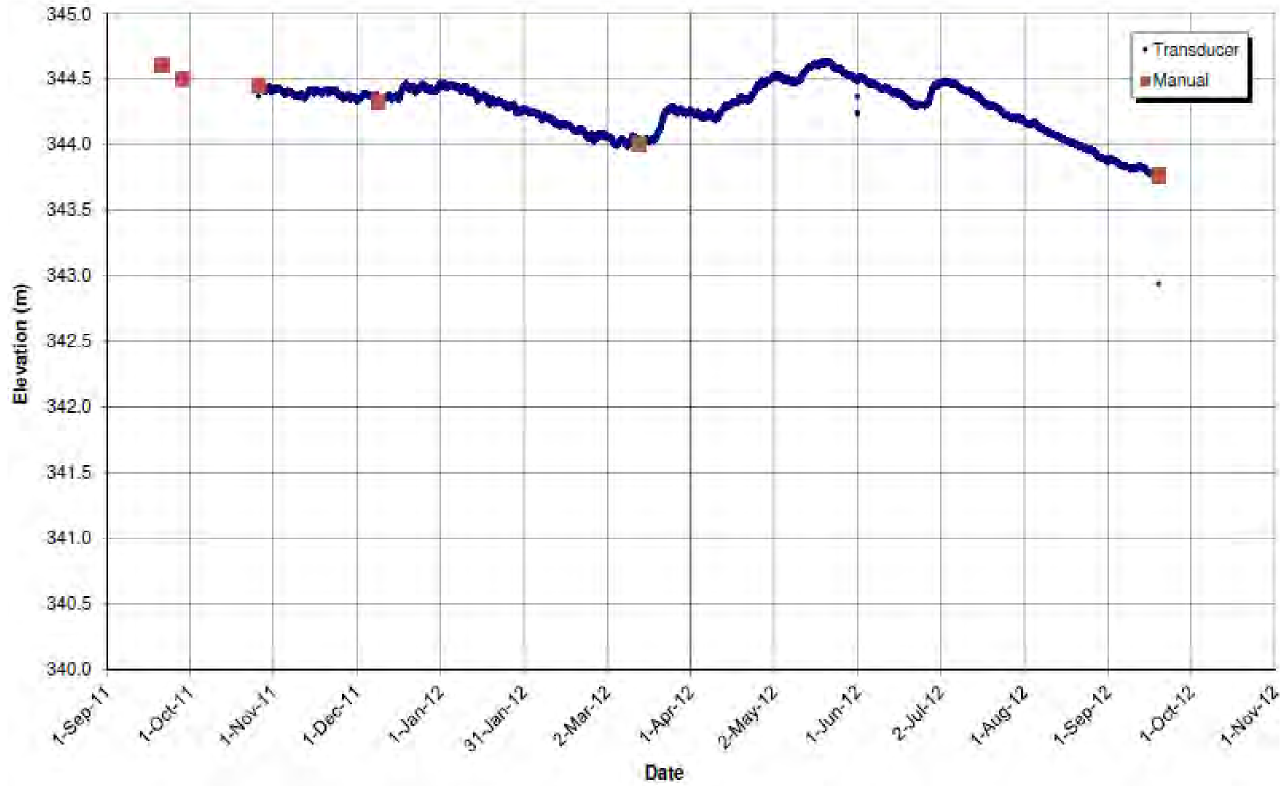
Water level monitoring in the wells listed in Table 8.4.12 began in October 2011. Water level was measured using a combination of automated, continuous measurements with pressure transducers, and periodic manual measurements with an electronic water level tape. Hydrographs for all of the wells, grouped by well nest, are shown in Figure 8.4.8. The water levels across the LAA varied from artesian conditions at MW11-04 (*i.e.*, above ground surface), to about 2.75 m below ground surface at MW11-06S (Knight Piésold 2013a). Based on the year of record presented in Figure 8.4.8, the seasonal fluctuation in water levels observed across the PDA during the reporting period ranged from 0.52 to 2.54 m with a mean of 1.38 m (Knight Piésold 2013a), suggesting minimal change in groundwater storage. This is consistent with the low primary porosity of the parent rock material.

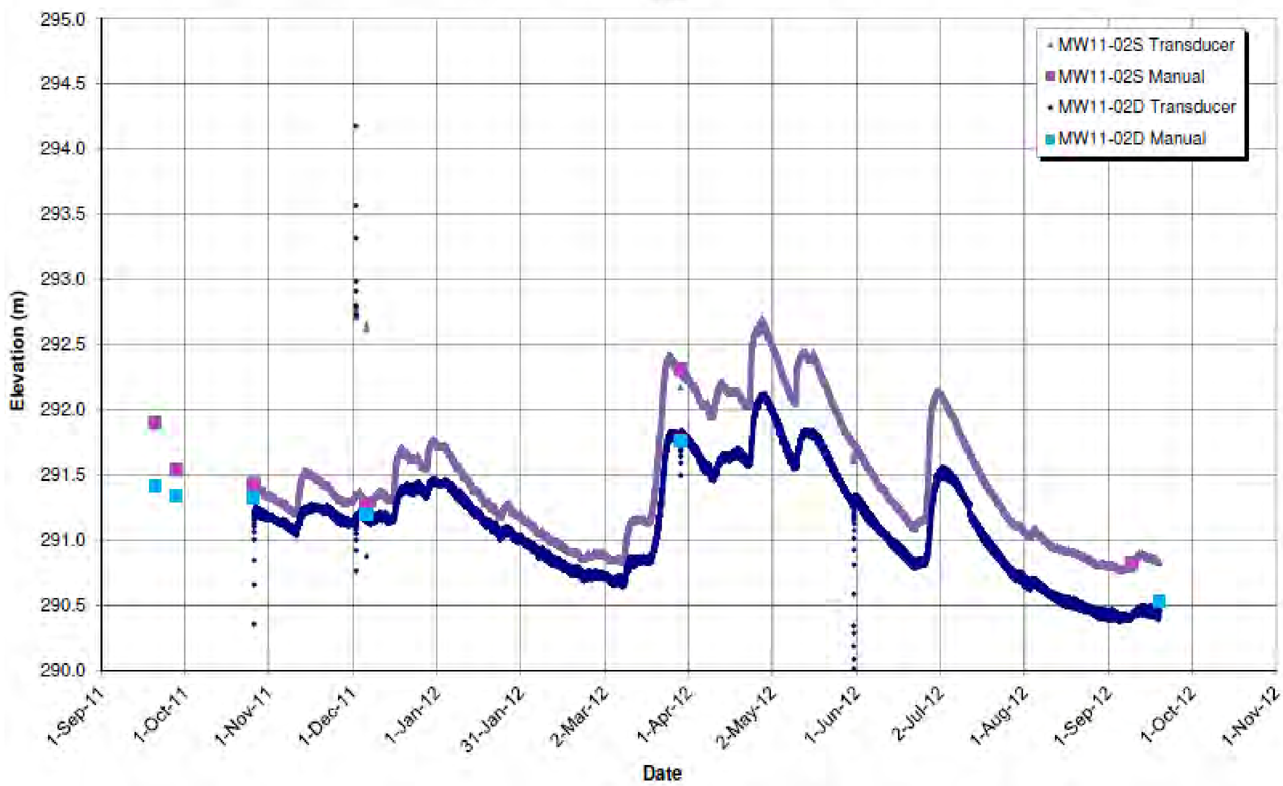
The shapes of the groundwater hydrographs are similar to the mean monthly surface water hydrographs shown on Figure 8.4.4. A large rise occurs in response to the spring freshet, followed by a decline over the summer, a rise in the fall, and a decline in the winter. This can also be seen when comparing the above to the unit flow hydrographs shown on Figure 8.4.4.

Vertical hydraulic gradients between shallow bedrock and/or overburden and deep bedrock at the well nest locations can be observed by comparing the groundwater elevations between the well nests shown on Figure 8.4.8. Downward vertical gradients were noted at MW11-02 and MW11-05, and strong upward gradients were observed at MW11-04 and MW11-06. The vertical groundwater gradient at MW11-03 was downward in the fall of 2011, but was observed to reverse during the spring freshet in March 2012.

In general, regional groundwater flow patterns tend to follow topography and groundwater flow divides will coincide with surface water divides (Freeze and Cherry 1979). Groundwater will be recharged from infiltration in topographically high areas, as demonstrated by downward vertical gradients in these areas. Groundwater from these areas will flow to low areas within the watersheds, and discharge to surface water features as base flow, as indicated by the upward vertical gradients observed in topographically low areas. The inferred groundwater flow directions within the PDA are shown on Figure 8.4.7. Monitoring level data generally indicates a correlation between the observed water levels and groundwater flow direction. However, further monitoring well information is required to comprehensively map groundwater flow directions throughout the LAA.

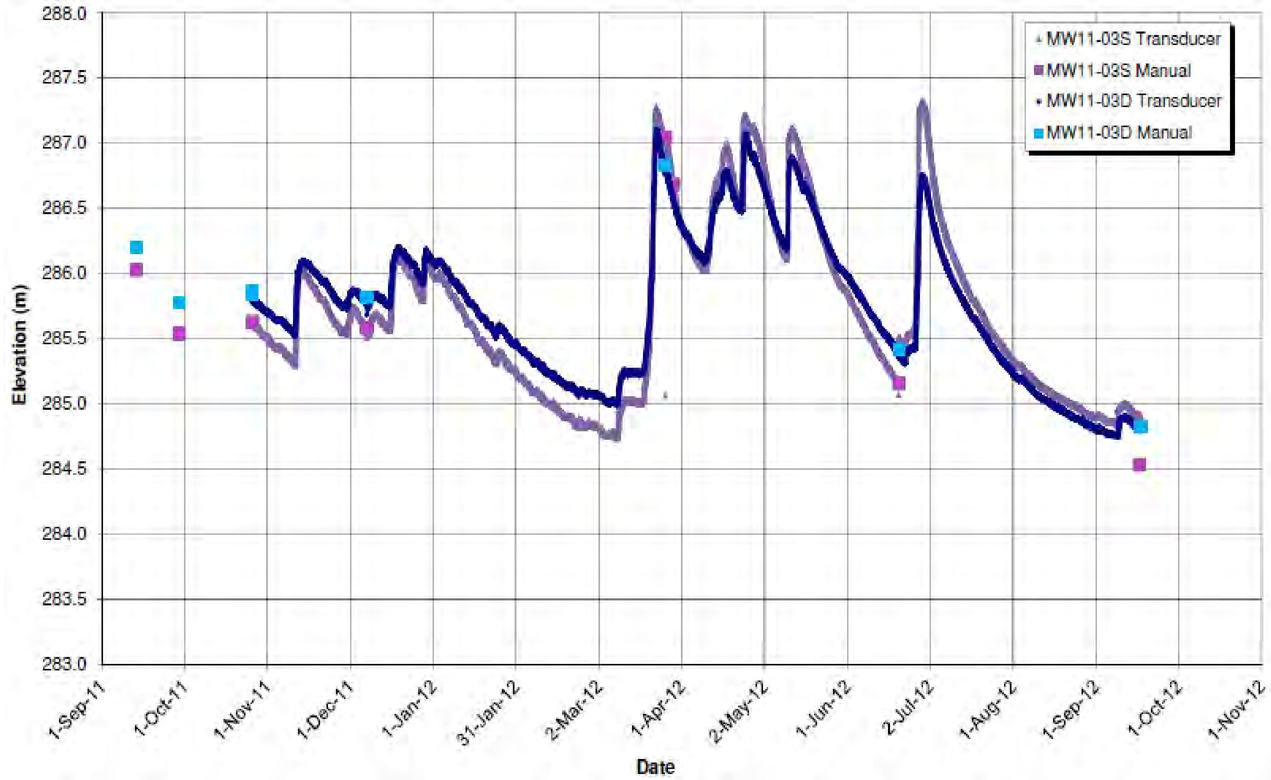
Groundwater recharge rates within the LAA were estimated to be 8% of total the precipitation within the watershed, or 109 mm/yr. The average annual groundwater (base flow) component of stream flow is estimated to be in the order of 10.8L/s/km^2 (Knight Piésold 2013c). These values are considered to be reasonable for fractured crystalline bedrock aquifers with thin to discontinuous overburden cover.

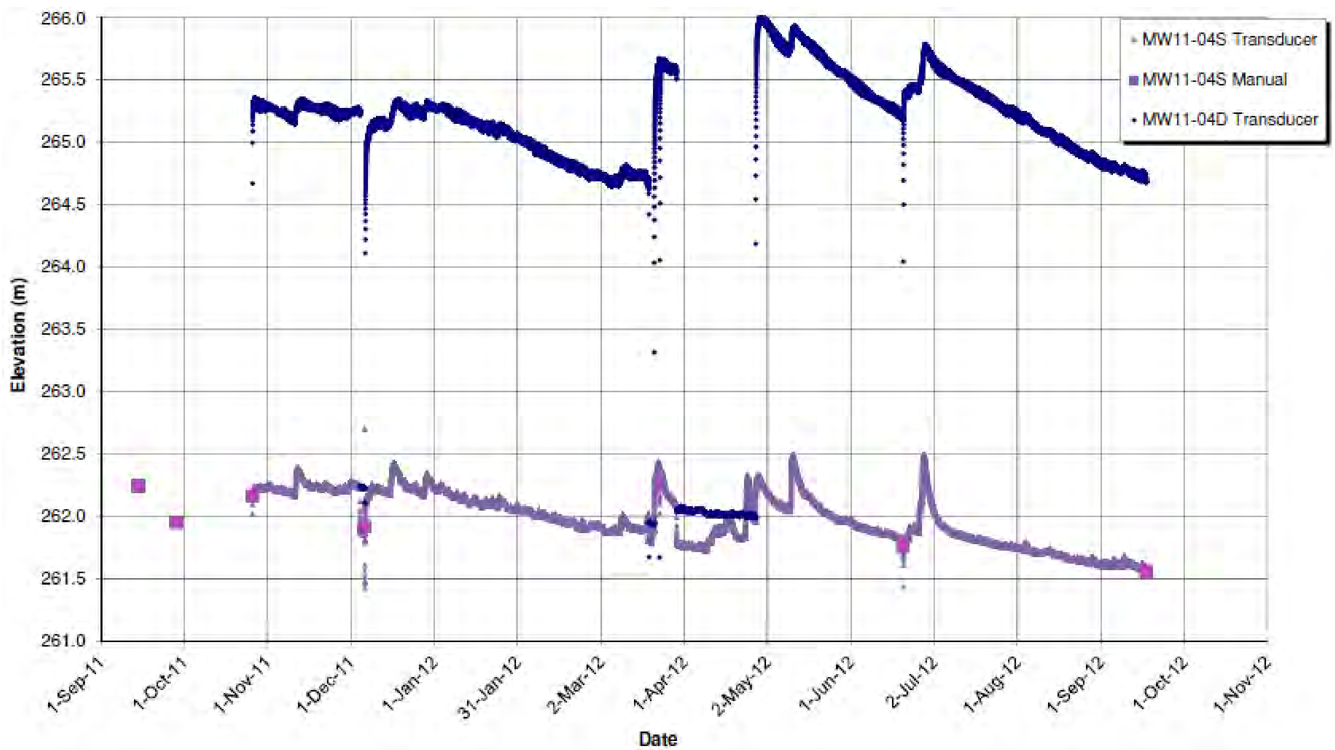




Source: Knight Piésold (2013a).

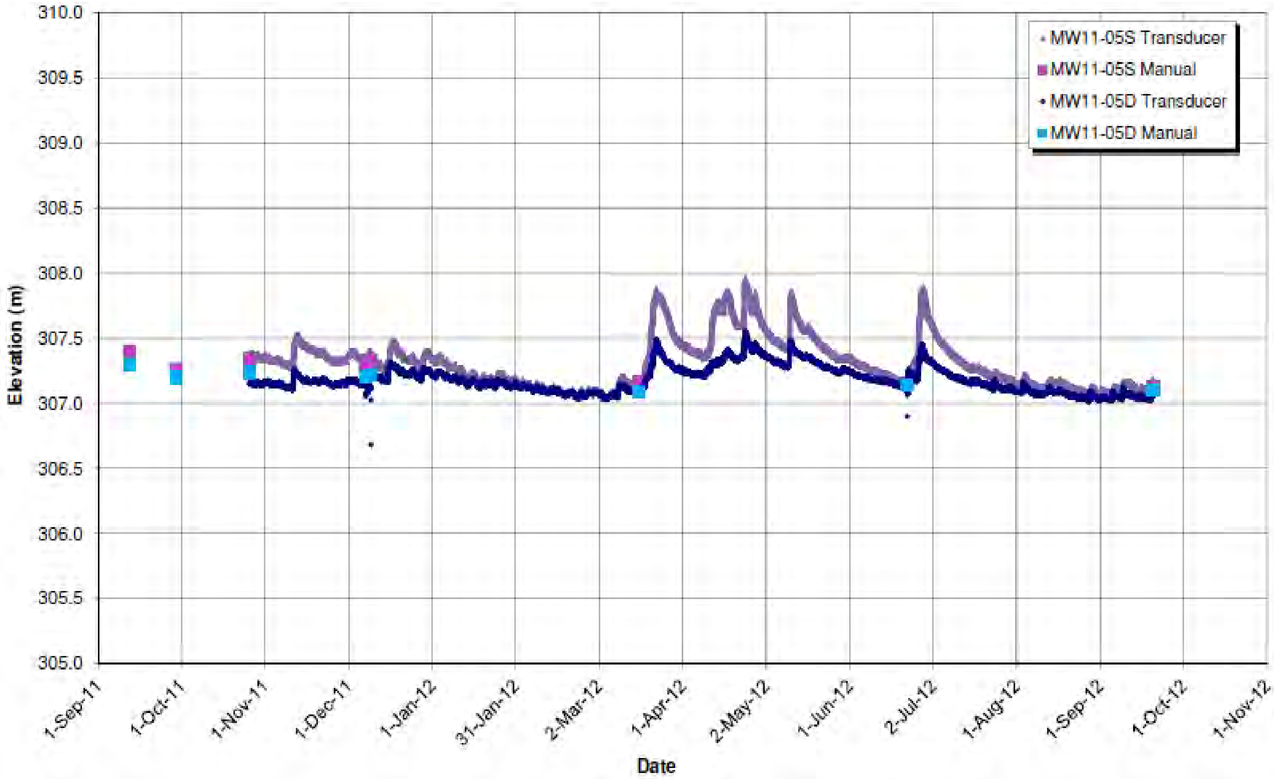
Figure 8.4.8 Continuous Water Level Record at Monitoring Wells

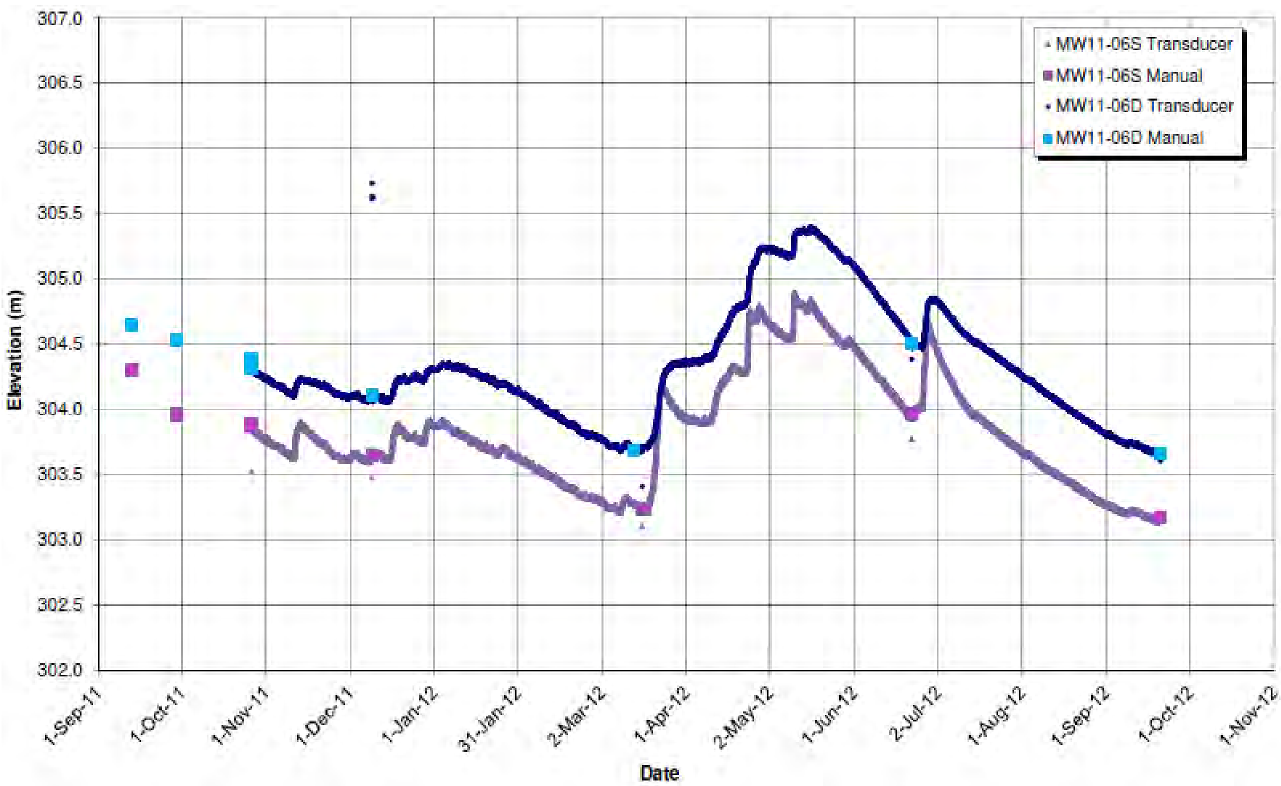




Source: Knight Piésold (2013a).

Figure 8.4.8 (continued) Continuous Water Level Record at Monitoring Wells





Source: Knight Piésold (2013a).

Figure 8.4.8 (continued) Continuous Water Level Record at Monitoring Wells

8.4.2.3.4 Groundwater Quality

Groundwater quality in the Napadogan Brook watershed was reported by Knight Piésold (2012e). Groundwater sampling occurs on a quarterly basis, and began in November 2011. A summary of the groundwater quality collected from the two sampling events, up to and including April 2012, are in Table 8.4.13. Values in ***bold italics*** indicate a concentration in excess of the GCDWQ (Health Canada 2012a).

Table 8.4.13 Groundwater Water Chemistry in Napadogan Brook Sub-Watershed

Parameter (Units)	Concentration			Total Number of Samples	Guideline for Canadian Drinking Water Quality (GCDWQ)	Percent of Samples Exceeding GCDWQ (%)
	Minimum	Mean	Maximum			
***In Situ* Parameters**						
Conductivity (µS/cm)	15	96	189	22		
Dissolved Oxygen (mg/L)	0	2.4	7.86	22		
pH	***5.54***	7.2	***9.5***	22	6.5-8.5	45
Oxidation-reduction potential (ORP) (mV)	-215	11.3	240	22		
Temperature (°C)	2.81	5.16	8.13	22	15	0
Turbidity (NTU)	0.27	10.8	48.8	22		
Physical Parameters						
Total Alkalinity (as $CaCO_3$) (mg/L)	<2	37	75	22		
Lab Turbidity (NTU)	0.9	7.5	33.4	22		
Total Organic Carbon (TOC) (mg/L)	<0.5	0.71	2.3	22		
Total Dissolved Solids (TDS) (mg/L)	12	67	103	22	500	0
Total Suspended Solids (TSS) (mg/L)	<5	8.2	56	22		
Hardness[a] (as $CaCO_3$) (mg/L)	4.2	42.1	88.9	22		
Dissolved Anions (mg/L)						
Bicarbonate[a] (as $CaCO_3$) (mg/L)	0	36.9	74.4	22		
Carbonate[a] (as $CaCO_3$) (mg/L)	0	0.45	2.5	22		
Chloride (mg/L)	<0.5	1.6	6.4	22	250	0
Cyanide (mg/L)	<0.01	<0.01	<0.01	22	0.2	0
Fluoride (mg/L)	<0.05	0.25	1.42	22	1.5	0
Sulphate (mg/L)	1	10	24	22	500	0
Nutrients (mg/L)						
Ammonia (as N) (mg/L)	<0.05	0.06	0.75	22		
Nitrate+Nitrite (as N) (mg/L)	<0.05	0.06	0.14	22	10	0
Nitrate (as N) (mg/L)	<0.05	0.06	0.14	22	10	0
Nitrite (as N) (mg/L)	<0.05	<0.05	<0.05	22	1	0
Total Kjeldahl Nitrogen (mg/L)	<0.25	<0.25	<0.25	22		
Orthophosphate (mg/L)	<0.01	0.02	0.16	22		
Dissolved Phosphorus (mg/L)	<0.002	0.012	0.078	22		
Total Phosphorus (mg/L)	0.002	0.027	0.086	22		

Table 8.4.13 Groundwater Water Chemistry in Napadogan Brook Sub-Watershed

Parameter (Units)	Concentration			Total Number of Samples	Guideline for Canadian Drinking Water Quality (GCDWQ)	Percent of Samples Exceeding GCDWQ (%)
	Minimum	Mean	Maximum			
Calculated Parameters						
Anion Sum (meq/L)	0.071	1.01	1.84	22		
Cation Sum (meq/L)	0.124	1.05	1.89	22		
Ion Balance (%)	-3.4	3.4	27.2	22		
Saturation pH	8.3	9.0	10.2	22		
Dissolved Metals (mg/L)						
Aluminum (mg/L)	<0.001	0.015	0.076	22		
Antimony (mg/L)	<0.0001	0.0001	0.0003	22	0.006	0
Arsenic (mg/L)	<0.001	***0.02***	***0.05***	22	0.01	55
Barium (mg/L)	<0.001	0.009	0.023	22	1	0
Beryllium (mg/L)	<0.0001	<0.0001	0.0003	22		
Bismuth (mg/L)	<0.001	<0.001	<0.001	22		
Boron (mg/L)	0.002	0.004	0.006	22	5	0
Cadmium (mg/L)	<0.00001	0.00002	0.0001	22	0.005	0
Calcium (mg/L)	1.17	13.8	27.2	22		
Chromium (mg/L)	<0.001	<0.001	<0.001	22	0.05	0
Cobalt (mg/L)	0.0001	0.0002	0.001	22		
Copper (mg/L)	<0.001	<0.001	0.002	22	1.0	0
Iron (mg/L)	0.02	***0.33***	***2.74***	22	0.3	23
Lead (mg/L)	<0.0001	<0.0001	0.0002	22	0.01	0
Lithium (mg/L)	0.0002	0.0023	0.0052	22		
Magnesium (mg/L)	0.3	1.8	5.4	22		
Manganese (mg/L)	0.008	***0.143***	***0.465***	22	0.05	13
Mercury (mg/L)	<0.000025	<0.000025	<0.000025	22	0.001	0
Molybdenum (mg/L)	<0.0001	0.002	0.0128	22		
Nickel (mg/L)	<0.001	<0.001	0.003	22		
Potassium (mg/L)	0.37	1.71	7.62	22		
R-silica (as SiO_2) (mg/L)	5.8	12.8	22.5	22		
Rubidium (mg/L)	0.0011	0.0044	0.0194	22		
Selenium (mg/L)	<0.001	<0.001	<0.001	22	0.01	0
Silver (mg/L)	<0.0001	<0.0001	<0.0001	22		
Sodium (mg/L)	0.66	3.3	7.23	22	200	0
Strontium (mg/L)	0.01	0.085	0.197	22		
Tellurium (mg/L)	<0.0001	<0.0001	<0.0001	22		
Thallium (mg/L)	<0.0001	<0.0001	<0.0001	22		
Tin (mg/L)	<0.0001	<0.0001	0.0001	22		
Tungsten (mg/L)	<0.0001	0.0501	0.62	22		
Uranium (mg/L)	<0.0001	0.0004	0.003	22	0.02	0
Vanadium (mg/L)	<0.001	<0.001	<0.001	22		
Zinc (mg/L)	<0.001	0.002	0.009	22	5.0	0
Total Metals (mg/L)						
Aluminum (mg/L)	0.004	0.478	4.49	22		
Antimony (mg/L)	<0.0001	<0.0001	0.0001	22	0.006	0

Table 8.4.13 Groundwater Water Chemistry in Napadogan Brook Sub-Watershed

Parameter (Units)	Concentration			Total Number of Samples	Guideline for Canadian Drinking Water Quality (GCDWQ)	Percent of Samples Exceeding GCDWQ (%)
	Minimum	Mean	Maximum			
Arsenic (mg/L)	0.001	***0.012***	***0.035***	22	0.01	55
Barium (mg/L)	0.001	0.012	0.026	22	1	0
Beryllium (mg/L)	<0.0001	<0.0001	0.0002	22		
Bismuth (mg/L)	<0.001	<0.001	<0.001	22		
Boron (mg/L)	0.002	0.004	0.006	22	5	0
Cadmium (mg/L)	0.00001	0.00004	0.00025	22	0.005	0
Calcium (mg/L)	1.25	14.9	29.5	22		
Chromium (mg/L)	<0.001	<0.001	0.005	22	0.05	0
Cobalt (mg/L)	<0.0001	0.0003	0.0012	22		
Copper (mg/L)	<0.001	0.001	0.005	22	1.0	0
Iron (mg/L)	0.21	***1.17***	***2.81***	22	0.3	20
Lead (mg/L)	<0.0001	0.0009	***0.0125***	22	0.01	1
Lithium (mg/L)	0.0002	0.003	0.007	22		
Magnesium (mg/L)	0.32	2.03	5.68	22		
Manganese (mg/L)	0.009	***0.163***	***0.618***	22	0.05	16
Mercury (mg/L)	<0.000025	<0.000025	<0.000025	22	0.001	0
Molybdenum (mg/L)	<0.0001	0.0023	0.0151	22		
Nickel (mg/L)	<0.001	0.001	0.003	22		
Potassium (mg/L)	0.41	1.94	9.48	22		
Rubidium (mg/L)	0.0014	0.0055	0.0254	22		
Selenium (mg/L)	<0.001	<0.001	<0.001	22	0.01	0
Silver (mg/L)	<0.0001	<0.0001	0.0003	22		
Sodium (mg/L)	0.79	3.59	7.73	22	200	0
Strontium (mg/L)	0.011	0.093	0.228	22		
Tellurium (mg/L)	<0.0001	<0.0001	<0.0001	22		
Thallium (mg/L)	<0.0001	<0.0001	<0.0001	22		
Tin (mg/L)	<0.0001	0.0001	0.0009	22		
Tungsten (mg/L)	<0.0001	0.05	0.64	22		
Uranium (mg/L)	<0.0001	0.0005	0.0033	22	0.02	0
Vanadium (mg/L)	<0.001	<0.001	0.005	22		
Zinc (mg/L)	0.001	0.003	0.019	22	5.0	0

Notes:

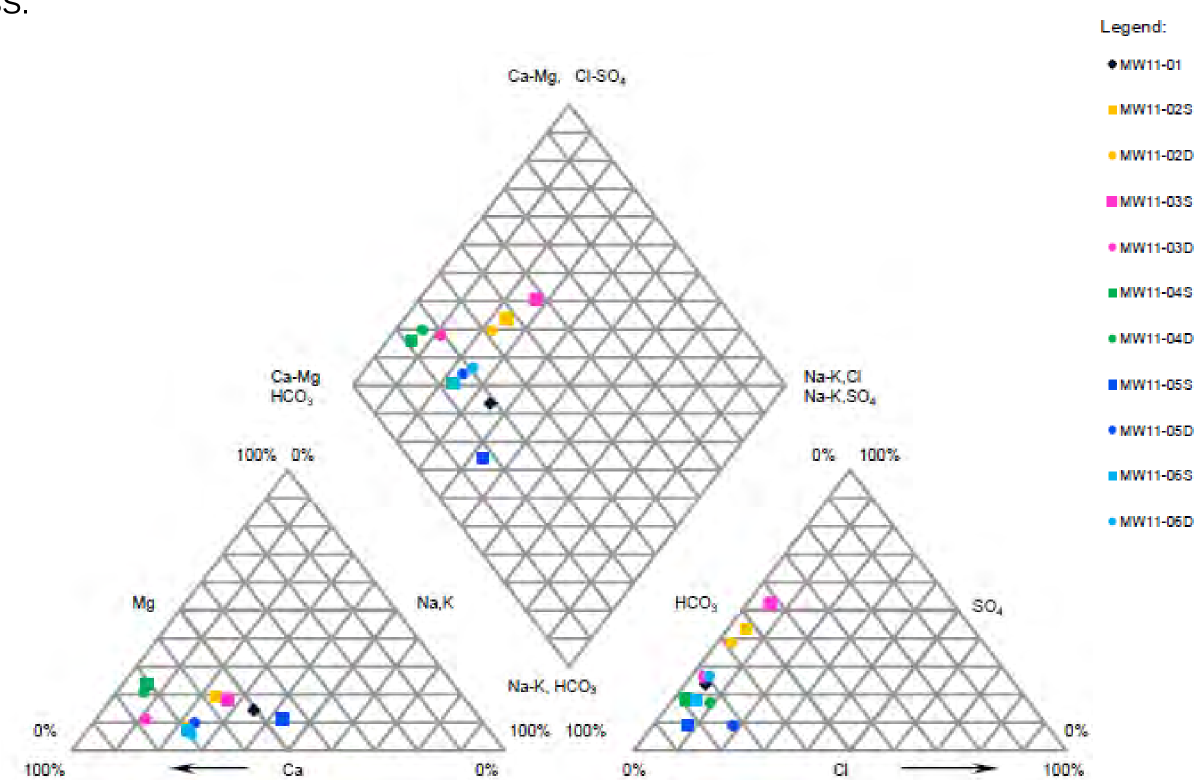
1) All parameter results are presented in mg/L unless otherwise indicated.
2) A value in ***bold italics*** indicates a concentration in excess of the Guidelines for Canadian Drinking Water Quality (GCDWQ; Health Canada 2012a).

[a] = Laboratory-calculated parameter.

Source: Knight Piésold (2012e).

In general, the groundwater quality within the LAA is good, with only a few parameters exceeding the GCDWQ. The groundwater is characterized as soft with low total dissolved solids. Parameters that occasionally exceeded the GCDWQ include pH, arsenic, iron, lead and manganese, as shown in Table 8.4.13. Concentrations of these parameters above the GCDWQ are relatively common in New Brunswick, and have been observed in other wells sampled within the RAA, as shown in the New Brunswick Groundwater Chemistry Atlas (NBENV 2008). The concentrations of the parameters are still relatively low, and if this were used as a source of drinking water, it could easily be treated using a domestic treatment system.

The major ion chemistry of the groundwater is plotted on a Piper Tri-linear plot on Figure 8.4.9. As shown on the figure, the water chemistry from all wells plot relatively close together, and represents a dominantly calcium bicarbonate, with an increasing sulphate trend in wells MW11-02S, MW11-02D and MW11-03S.



Source: Knight Piésold (2012e).

Figure 8.4.9 Piper Tri-linear Plot of Average Groundwater Chemistry by Monitoring Well within the LAA

Long-term monitoring of groundwater temperature using transducers in wells shows a variability range of 1.4C°. Groundwater temperatures from deep wells exhibited very little variability, while temperature ranges up to 4.6C° were observed in shallow wells which are more likely to be influenced by surface effects and shallow interflow. This decrease in variability with depth is commonly observed in groundwater (Heath 1983), and indicates that shallow groundwater interacts more readily with infiltrated precipitation.

8.4.2.3.5 Groundwater Users

There are no known groundwater users within the LAA, although it is possible that some recreational campsites near Napadogan Brook may use groundwater as a potable supply. The nearest known groundwater users within the RAA are located in Napadogan, based on the presence of residences and the absence of a municipal water supply in Napadogan. In addition, the NBDELG Online Well Log System was queried to identify the closest well logs in the vicinity of the PDA. The closest wells identified are located in Napadogan, approximately 9 km northeast of the PDA (NBDELG 2012d).

8.4.3 Potential Project-VEC Interactions

Table 8.4.14 below lists each Project activity and physical work for the Project, and ranks each interaction as 0, 1, or 2 based on the level of interaction each activity or physical work will have with Water Resources.

Table 8.4.14 Potential Project Environmental Effects to Water Resources

Project Activities and Physical Works	Potential Environmental Effects
	Change in Water Resources
Construction	
Site Preparation of Open Pit, TSF, and Buildings and Ancillary Facilities	1
Physical Construction and Installation of Project Facilities	2
Physical Construction of Transmission Lines and Associated Infrastructure	1
Physical Construction of Realigned Fire Road, New Site Access Road, and Internal Site Roads	1
Implementation of Fish Habitat Offsetting/Compensation Plan	1
Emissions and Wastes	1
Transportation	0
Employment and Expenditure	0
Operation	
Mining	1
Ore Processing	0
Mine Waste and Water Management	2
Linear Facilities Presence, Operation, and Maintenance	1
Emissions and Wastes	1
Transportation	0
Employment and Expenditure	0
Decommissioning, Reclamation and Closure	
Decommissioning	0
Reclamation	1
Closure	2
Post-Closure	1
Emissions and Wastes	1
Transportation	0
Employment and Expenditure	0

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.

The following activities will have no interaction with Water Resources, and have been ranked as 0 in Table 8.4.14: Transportation (all phases); Employment and Expenditure (all phases); Ore Processing; and Decommissioning. These activities are discussed here by Project phase.

During the Construction phase, no interaction is expected from the Transportation or Employment and Expenditure activities. Transportation of equipment, supplies, material and personnel will occur along defined corridors, and will not interact in a substantive way with the surface or groundwater resources. Similarly, the purchase of equipment, supplies, materials and paying of employee salaries will not interact with water resources.

During the Operation phase, no substantive interaction is expected from the Ore Processing, Transportation and Employment and Expenditures activities. The actual processing of ore will require water and will result in mine wastes. However, these processes are discussed under the Mine Waste and Water Management activity, and therefore, the ore processing activity as defined will not interact directly with the Water Resources.

During the Decommissioning, Reclamation and Closure phase, no interaction is expected from the Decommissioning, Transportation, or Employment and Expenditure activities. The act of decommissioning buildings and equipment, transporting materials to and from the Project site, or employment or expenditure will not interact in any substantive way with Water Resources.

All of the Project activities ranked as 0 in Table 8.4.14 will not interact in a substantive way with Water Resources, and there will be no significant adverse environmental effects from these activities. They are not considered further in this EIA Report.

8.4.3.1 Construction

The following activities during Construction will interact with Water Resources, and have been ranked as 1 in Table 8.4.14:

- Site Preparation of Open Pit, TSF, and Buildings and Ancillary Facilities;
- Physical Construction of Transmission Lines and Associated Infrastructure;
- Physical Construction of Realigned Fire Road, New Site Access Road, and Internal Site Roads;
- Implementation of Fish Habitat Offsetting/Compensation Plan; and
- Emissions and Wastes.

These activities are discussed further below.

Site Preparation of Open Pit, TSF, and Buildings and Ancillary Facilities activities such as clearing, grubbing, removal and stockpiling of overburden may introduce sediment to streams without mitigation. Standard mitigation measures such as the use of silt fences, sediment traps and sedimentation ponds will be used to manage the potential release of sediment to streams. These measures will be implemented through the Environmental Protection Plan (EPP).

Physical Construction of Transmission Lines and Associated Infrastructure may interact with Water Resources from the movement of equipment and materials, foundation preparation, structure erection, and the stringing of conductors for the new 138 kV transmission line and the relocation of the 345 kV transmission line. These activities may introduce sediment to nearby watercourses, but can be easily mitigated by best management practices outlined in the EPP, including locating structures more than 30 m from watercourses, use of silt fencing, and maintaining vegetated buffers, where possible.

Physical Construction of Realigned Fire Road, New Site Access Road, and Internal Site Roads will interrupt overland flow drainage patterns and watercourse crossings, and will be mitigated with properly-sized culverts and standard sediment control mitigation measures. Roadside ditches will route overland flow to local watercourses with appropriate sediment control measures emplaced. Such measures will be incorporated into design and described in the EPP.

Implementation of Fish Habitat Offsetting/Compensation Plan will affect local surface water flows (and groundwater, to a certain extent) for a limited period while the Nashwaak Lake culvert is being demolished and replaced with a new woods road bridge, particularly as a result of the use of a coffer dam to carry out construction activities in the dry. This will only occur for a short period while the culvert replacement is taking place, and normal flow patterns will resume once construction is complete. Erosion and sedimentation control measures will be used to minimize environmental effects to local surface water from these activities.

Emissions and Wastes (including surface run-off) during Construction will be managed through appropriate measures outlined in the EPP, including erosion control measures, dust suppression on roads, and avoidance of work activities in extreme weather.

All of these activities during Construction ranked as 1 in Table 8.4.14 will be mitigated with best management practices outlined in the EPP and through compliance with applicable permits and conditions of approval. The potential environmental effects (including cumulative environmental effects) of these activities on Water Resources during Construction, even without mitigation, will not be significant. They are not discussed further.

8.4.3.2 Operation

The following activities during Operation will interact with Water Resources, and have been ranked as 1 in Table 8.4.14:

- Mining;
- Linear Facilities Presence, Operation and Maintenance; and
- Emissions and Wastes**.**

These activities are discussed further below.

Mining activities will result in the direct seepage of groundwater into the open pit and the consequent lowering of the water table surrounding the open pit. The management of groundwater seepage is assessed under the Mine Waste and Water Management activity, which was ranked as 2. No adverse environmental effects on groundwater users are anticipated (since a distance of 9 km separates the Project and the nearest residences with on-site water supplies).

The Linear Facilities Presence, Operation and Maintenance activity can result in stormwater run-off from aggregate surfaced roads that can contain high TSS concentrations, especially under intense rainfall conditions, and can be compounded during periods of high snowmelt. All access roads will incorporate roadside ditches and suitably sized culverts. Water management for the road network is not expected to require water collection for sedimentation treatment, but instead, roadside ditches are expected to provide sedimentation control by reducing erosion; as required, best management practices will be employed in the design and maintenance of the road to control erosion in steep areas and during extreme events.

The Emissions and Wastes activity of water collected and used by the various Project activities may result in a change in water quality. This water will be collected in the TSF and will be used (recirculated) as process water. For approximately the first 7 years of Operation, there will be no need to release water from the TSF as all stored water will be required as a water supply for processing ore. However, starting at about Year 8 of Operation, it is projected that water in the TSF will be in surplus, and surplus water will need to be treated and released to the receiving environment. Prior to any release to the environment, this water will be treated at an on-site treatment plant to meet the applicable standards (including those of the *Metal Mining Effluent Regulations* and as may be contained in provincial Certificates of Approval), and released in a controlled manner with appropriate monitoring and within permitted limits.

All of these activities during Operation ranked as 1 in Table 8.4.14 will be mitigated with best management practices, through design and operational controls aimed at meeting applicable permits and conditions of approval. The potential environmental effects (including cumulative environmental effects) of these activities on Water Resources during Operation, even without mitigation, will not be significant. They are not discussed further.

8.4.3.3 Decommissioning, Reclamation and Closure

The following activities during Decommissioning, Reclamation and Closure will interact with Water Resources, and have been ranked as 1 in Table 8.4.14:

- Reclamation;
- Post-Closure; and
- Emissions and Wastes.

These activities are discussed further below.

The earthworks activities associated with Reclamation activities have the potential to introduce sediment to surface water run-off. Standard mitigation measures such as silt fencing, sediment traps and the maintenance and operation of sedimentation facilities will be used to manage the potential discharge of sediments to streams until most facility decommissioning is complete.

Water chemistry in the future pit lake, which will include the inflow of surplus water from the TSF, is predicted to initially require treatment to meet the GCDWQ, but is predicted to be of sufficient quality to meet the GCDWQ at some point during the Post-Closure period, as described in Section 7.6. However, proposed monitoring of the open pit lake water quality (and associated release of surplus water to the receiving environment) will verify these predictions, and active management with water treatment will be provided as necessary. Monitoring to confirm the water quality of discharge from the Project during Operation will be undertaken in relation to Mine Waste and Water Management, with water treatment as necessary, and is discussed further in Section 8.4.5.

All of these activities during Decommissioning, Reclamation and Closure ranked as 1 in Table 8.4.14 will be mitigated with best management practices, and monitoring (and adaptive management as necessary) will be implemented to verify that both open pit and TSF water releases comply with applicable release standards, with plans to implement treatment if required. The potential environmental effects (including cumulative environmental effects) of these activities on Water Resources during Decommissioning, Reclamation and Closure will not be significant. They are not considered further.

Thus, in consideration of the nature of the interactions and the planned implementation of known and proven mitigation, monitoring to verify mitigation effectiveness and predictions, and adaptive management measures as required, the potential environmental effects of all Project activities and physical works that were ranked as 0 or 1 in Table 8.4.14, including cumulative environmental effects, on Water Resources during any phase of the Project are rated not significant and are not considered further in this EIA Report.

8.4.4 Assessment of Project-Related Environmental Effects

A summary of the environmental effects assessment and prediction of residual environmental effects resulting from interactions ranked as 2 on Water Resources is provided in Table 8.4.15.

Table 8.4.15 Summary of Residual Project-Related Environmental Effects on Water Resources

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 Water Resources • Change in surface water availability. • Change in surface water quality. • Change in groundwater availability. • Change in groundwater quality.	Construction • Physical Construction and Installation of Project Facilities.	• Document the pre-construction status and condition of water supplies at recreational campsites. • Maintain existing drainage patterns to the extent possible. • Comply with the Watercourse and Wetland Alteration (WAWA) permit. • Implement erosion and sedimentation control during Construction and document measures taken as prescribed in the EPP. • Site fresh water wells for the Project outside the zone of influence of the TSF to ensure Project water quantity and quality requirements are met.	A	L	L	P/O	I	U	N	H	--	Y	• Monitor TSS in discharge from construction areas to verify predictions and confirm compliance and identify need for further mitigation. • Monitor water quality of discharge from starter pit dewatering to evaluate treatment requirements, if any. • Monitor the Project's potable water supply to ensure it meets GCDWQ.
	Operation • Mine Waste and Water Management.	• Implement erosion and sedimentation control during progressive construction of the TSF and other earth moving activities. • Design water management structures to reduce erosion and assure adequate water conveyance in extreme events. • Recycle water from the TSF for use in the ore processing to	A	M	L	LT/ C	I	D	N	M	--	N	• Monitor to verify the seepage from the TSF is not adversely affecting downstream groundwater and surface water quality, and to identify the need for mitigation. • Monitor WTP effluent for compliance with conditions of Approval

Table 8.4.15 Summary of Residual Project-Related Environmental Effects on Water Resources

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					
		minimize Project demands on the environment for water, and to reduce the production of contact water. • Collect and treat (as required) surplus mine contact water before discharge to the environment. • Construct engineered surface water drainage and diversion channels to collect TSF embankment run-off and seepage and associated collection in lined WMPs which are pumped back to the TSF. • Install and operate groundwater pump-back wells below the northwestern TSF embankment to collect some groundwater seepage for return to the TSF. • Implement an adaptive management plan to install groundwater monitoring wells below the TSF WMPs to monitor the groundwater quality, which can be converted to groundwater pump-back wells should downstream water quality monitoring indicate that seepage is jeopardizing downstream water quality objectives.											to Operate. • Monitor the Project's fresh water supply to assess need for treatment to meet GCDWQ. • Follow-up to confirm open pit dewatering is not interfering adversely with nearby recreational campsite water supplies.

Table 8.4.15 Summary of Residual Project-Related Environmental Effects on Water Resources

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					
		• Construct engineered drainage and diversion channels to divert non-contact water around the Project facilities wherever possible.											
	Decommissioning, Reclamation and Closure • Closure.	• Flood the open pit during Closure to minimize the potential for metal leaching and acid rock drainage (ML/ARD) from remaining pit walls. • Maintain ponded water over PAG tailings and waste rock within the TSF to effectively mitigate the potential for ML/ARD. • As required, treat water released from Project following Closure, for as long as necessary to meet discharge water quality requirements. • Post-Closure, maintain pit lake level to ensure it is a groundwater sink until water quality meets discharge conditions of the Approval to Operate.	A	L	L	P/O	R	D	N	M	--	Y	• Monitor discharge from the TSF, and water in the open pit, to evaluate need for treatment before discharge to Sisson Brook.
	Residual Environmental Effects for all Phases								N	M	--	Y	

Table 8.4.15 Summary of Residual Project-Related Environmental Effects on Water Resources

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: Environmental effect occurs that is detectable but is within the normal variability of existing conditions.
- M Medium: Environmental effect occurs that is larger than the normal variability of existing conditions but is within regulatory objectives or limits and restricted to the LAA.
- H High: Environmental effect occurs that would singly or as a substantial contribution in combination with other sources may cause exceedance of objectives or regulatory limits within the LAA or RAA.

Geographic Extent
- S Site-specific: Within the PDA.
- L Local: Within the LAA.
- R Regional: Within the RAA.

Duration
- ST Short-term: Occurs and lasts for short periods (*e.g.,* days/weeks).
- MT Medium-term: Occurs and lasts for extended periods of time (*e.g.,* years).
- LT Long-term: Occurs during Construction and/or Operation and lasts for the life of Project.
- P Permanent: Occurs during Construction and Operation and beyond.

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, 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, 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 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 projects or activities in RAA.

8.4.4.1 Potential Project Environmental Effects Mechanisms

Activities identified in Table 8.4.15 with a ranking of 2 are considered to have the potential to affect local or regional groundwater or surface water resources either temporarily or permanently, and will thus be considered in more detail in the sub-sections that follow:

- Physical Construction and Installation of Project Facilities;
- Mine Waste and Water Management; and
- Closure.

The nature of these potential interactions and environmental effects mechanisms with Water Resources is described further below.

8.4.4.1.1 Construction: Physical Construction and Installation of Project Facilities

The Physical Construction and Installation of Project Facilities will result in the permanent alteration or loss of surface water resources in the PDA and LAA, affecting drainage patterns in Bird Brook, Sisson Brook, an unnamed tributary (Tributary “A”) to West Branch Napadogan Brook, and fingertip portions of small unnamed tributaries to McBean Brook, and the associated permanent loss of these portions of watercourses to the construction of Project facilities. These alterations will result from the construction of starter dams for the TSF along the main branch of Bird and Sisson brooks, from engineered water collection channels and water management ponds for mine contact water at low points around the perimeter of the TSF, and from associated diversion of non-contact water throughout the life of the Project. Similarly, the construction of a diversion channel east of the open pit to redirect a portion of the residual stream flow from Sisson Brook headwaters into McBean Brook, and the construction of other diversion channels around the perimeter of the open pit, will alter drainage patterns in Sisson Brook.

The alterations of drainage patterns arising from Physical Construction and Installation of Project Facilities will have some minor interactions with groundwater, mostly related to diverting groundwater recharging streams to other locations within the same watersheds, or in the case of the open pit, both the same and adjacent watersheds. The clearing and grubbing associated with Construction will result in some changes to potential groundwater recharge areas and rates of recharge and run-off, and evapotranspiration, but will not result in a substantive change in the availability of groundwater, nor in groundwater quality. The development of the starter pits during Construction will result in reductions to downstream surface and groundwater flows, and may affect groundwater availability within the PDA and possibly the LAA.

In addition, a small fresh water supply for the Project will be constructed as part of Physical Construction and Installation of Project Facilities. The fresh water supply will be sourced from groundwater wells, the location of which will be determined through detailed Project design outside the zone of influence of the TSF. The water will be treated as necessary for various Project uses. This groundwater removal will result in interaction with the groundwater within the PDA and possibly the LAA.

8.4.4.1.2 Operation: Mine Waste and Water Management

The activities associated with Mine Waste and Water Management during Operation will result in several interactions with Water Resources, as follows.

- Dewatering of the open pit will result in lowering of the water table within the PDA/LAA within the zone of influence of the open pit, thereby possibly affecting baseflow contributions of groundwater to nearby surface watercourses and water bodies, and with potential consequent environmental effects to local water users in the LAA including those at nearby recreational campsites.

- The sequestration of water, including precipitation and run-off falling within the PDA upstream of water management ponds, within the TSF tailings voids, plus evaporation from the TSF pond, will reduce the amount of surface water (and thus groundwater) available for possible human consumption in the future, both downgradient and downstream. These reductions will be the greatest during Years 1 to 7 of Operation, after which the Project will discharge treated surplus water about Year 8.

- The progressive construction of TSF embankments to accommodate storage of additional tailings throughout Operation may also slightly alter the drainage patterns at the toe of the embankments. The environmental effect of this is expected to be minimal, as any area within the perimeter engineering drainage collection channels surrounding the TSF will have been altered during Construction, and any surface water within this perimeter will be captured in these collection channels, contained in water management ponds, and pumped to the TSF.

- The storage of tailings and waste rock within the TSF will create a potential source of metals enrichment that may result in seepage of metal enriched water through the embankments towards local streams and into the groundwater under the TSF and downgradient, thence following groundwater pathways to local streams. Perimeter engineered drainage collection channels at the toe of the TSF embankments, and lined water management ponds, will collect most of this seepage. However, some seepage will escape to the receiving environment, potentially affecting downgradient/downstream water quality. Groundwater pump-back wells will be installed below the northwestern TSF embankment to collect some groundwater seepage, with pumping back to the TSF to reduce water quality effects in Napadogan Brook. Groundwater quality monitoring wells will also be established below the water management ponds, and can be converted to pump-back wells if required to ensure downstream water quality objectives are met.

- Blasting activities within the open pit will result in residual nitrogen species constituents in the water pumped from the pit during mining. Also, there is the potential for ML/ARD effects in the pit water from precipitation on the exposed pit walls. Dewatering of the open pit and subsequent release to the receiving environment can move the water with concentrations of nitrates and metals to surface water features, including Napadogan Brook, unless properly managed.

8.4.4.1.3 Decommissioning, Reclamation and Closure: Closure

The activities associated with Closure following the operation of the mine may have several interactions with Water Resources, as follows.

- Exposed PAG rock on the open pit walls potentially leading to ML/ARD reactions resulting in changes to water quality in the pit lake.
- As during Operation, seepage of metal enriched water through the TSF embankments towards local streams, and into the groundwater under the TSF and downgradient, then following groundwater pathways to local streams.
- Flooding of the open pit with surplus water from the TSF, and all precipitation and groundwater seepage into the open pit, will result in a reduction of flows in Napadogan Brook similar to reductions during Years 1 to 7 of Operation, possibly affecting the water availability downstream during the flooding period.

During Closure, there will be no release of water to the receiving environment from either the open pit or the TSF, as surplus water from the TSF will be directed to the open pit until such time as the open pit is full. At that point, the Post-Closure period will begin and surplus pit lake water will be discharged to Sisson Brook, treated as necessary to meet permit conditions. Thus, there will be minimal environmental effects to receiving water quality during Closure as there will be no direct release of water to the receiving environment except for seepage. Similarly, since there will be no water discharge from the Project during the Closure period, the effects on downgradient/downstream surface and groundwater availability will be about the same as during the first seven years of Operation.

8.4.4.2 Mitigation of Project Environmental Effects

The following mitigation measures, through careful design and planning, will be employed to avoid or reduce the environmental effects of the Project on Water Resources potentially resulting from the environmental effects mechanisms described above:

- document the pre-Construction status and condition of water supplies at recreational campsites;
- maintain existing drainage patterns to the extent possible;
- comply with the Watercourse and Wetland Alteration (WAWA) permit;
- implement erosion and sedimentation control during Construction and document measures taken as prescribed in the EPP;
- site fresh water wells for the Project outside the zone of influence of the TSF to ensure Project water quantity and quality requirements are met;
- implement erosion and sedimentation control during progressive construction of the TSF and other earth moving activities;

- design water management structures to reduce erosion and assure adequate water conveyance in extreme events;
- recycle water from the TSF for use in ore processing to minimize Project demands on the environment for water, and to reduce the production of contact water;
- collect and treat (as required) surplus mine contact water before discharge to the environment;
- construct engineered drainage collection channels to collect TSF embankment run-off and seepage, and associated collection in lined water management ponds (WMPs) which are pumped back to the TSF;
- install and operate groundwater pump-back wells at the northern extent of the TSF to collect some groundwater seepage that bypasses the collection system for pump back to the WMP and TSF;
- implement an adaptive management plan to install groundwater monitoring wells below the WMPs to monitor the groundwater quality; these can be converted to groundwater interception wells, and augmented with other interception wells, should downstream water quality monitoring indicate that seepage is jeopardizing downstream water quality objectives;
- construct engineered surface water diversion channels to divert non-contact water around Project facilities wherever possible;
- flood the open pit during Closure to minimize the potential for metal leaching and acid rock drainage (ML/ARD) from the remaining pit walls;
- maintain ponded water over PAG tailings and waste rock within the TSF to effectively mitigate the potential for ML/ARD;
- Post-Closure, maintain pit lake level to ensure it is a groundwater sink until water quality meets discharge requirements described in the Approval to Operate; and
- as required, treat water released from the Project following Closure for as long as necessary to meet discharge water quality requirements.

In the unlikely event that a residential or on-site water supply well is adversely affected by Construction or Operation activities such that water quantity or quality is not suitable for human consumption, it will be inspected, assessed, and if warranted, remediated to the satisfaction of the owner. Options that could be implemented in such cases could include:

- provision of bottled water (temporary);
- provision of appropriate water treatment;
- well deepening in the event of water level lowering leading to loss of well yield; or

- well replacement in the event of a well collapse or unacceptable loss of well yield or change in quality.

8.4.4.3 Characterization of Residual Project Environmental Effects

8.4.4.3.1 Construction

The Physical Construction and Installation of Project Facilities will result in the permanent alteration of drainage patterns in Bird Brook, Sisson Brook, an unnamed tributary (Tributary “A”) to West Branch Napadogan Brook, and fingertip portions of small tributaries to McBean Brook. This will occur as the result of the progressive construction of the open pit, the quarry, the TSF and the related engineered drainage collection and diversion channels which begin during Construction and continue through into Operation. An assessment of the environmental effects of the construction of these facilities is presented here, although the progressive construction of these facilities may continue into Operation.

Engineered drainage collection and diversion channels will be built during Construction, for the future management of mine site water, as shown on Figure 8.4.11. Some channels will divert natural surface water outside the PDA to prevent contact with Project facilities/activities, while others will collect water that has come in contact with Project facilities/activities for use by the Project.

Open Pit

The excavation of the open pit will begin with the excavation of a starter pit at the location shown on Figure 8.4.10. This may require some shallow pit dewatering using conventional sump-pit pumping. Surplus water from the pit will be pumped to a WMP installed within the current channel of Sisson Brook as shown on Figure 8.4.10, and then to the TSF. The construction of a starter pit will result in some groundwater infiltration and lowering of the water table in proximity to the pit, but given the relatively limited depth and extent of the starter pit, this is not expected to be substantive and environmental effects on groundwater resources from the presence of the starter pit are expected to be of little consequence.

As discussed in Section 7.4, the construction of the starter pit (and eventually the open pit throughout Operation), and the installation of a water management pond in the main channel of Sisson Brook will result in the permanent loss of about 58% of the catchment area of Sisson Brook and small fingertip portions of unnamed tributaries to McBean Brook, as shown on Figure 8.4.11. As shown on Figure 8.4.10, a portion of the Sisson Brook drainage will be diverted toward the McBean Brook watershed. The total drainage area of Sisson Brook to be diverted to the McBean Brook watershed is 0.93 km^2 which is 19% of the total Sisson drainage area above its confluence with Napadogan Brook, thereby partially restoring some lost flow in the McBean Brook watershed as a result of the lost fingertip portions of the small tributaries to McBean Brook. Except for this small amount of diversion, Sisson Brook is conservatively assumed to be permanently lost in its entirety as a result of the presence of the open pit. The diversion of stream flow is expected to have little interaction with groundwater availability during Construction. No current human users of Sisson Brook for potable water have been identified; therefore the alteration of drainage patterns in the Sisson Brook watershed will not alter the availability of surface water as a water source as there are no existing users.

TSF

The construction of the TSF will begin with the construction of starter dams at the locations shown on Figure 8.4.10 following the site clearing and grubbing of the TSF embankment foundation areas. The creation of these starter dams will allow for the ponding of precipitation and collected surface run-off from within the PDA for use to start up ore processing; it is estimated that collection of the volumes of water from two spring freshets are required. The starter dams will be constructed of non-potentially acid generating (NPAG) local borrow material or rock quarried from the northwestern corner of TSF (Figure 8.4.10). As discussed in Section 7.5, rock quarried from this location is classified as NPAG, and would not be a source of water quality concerns related to ML/ARD.

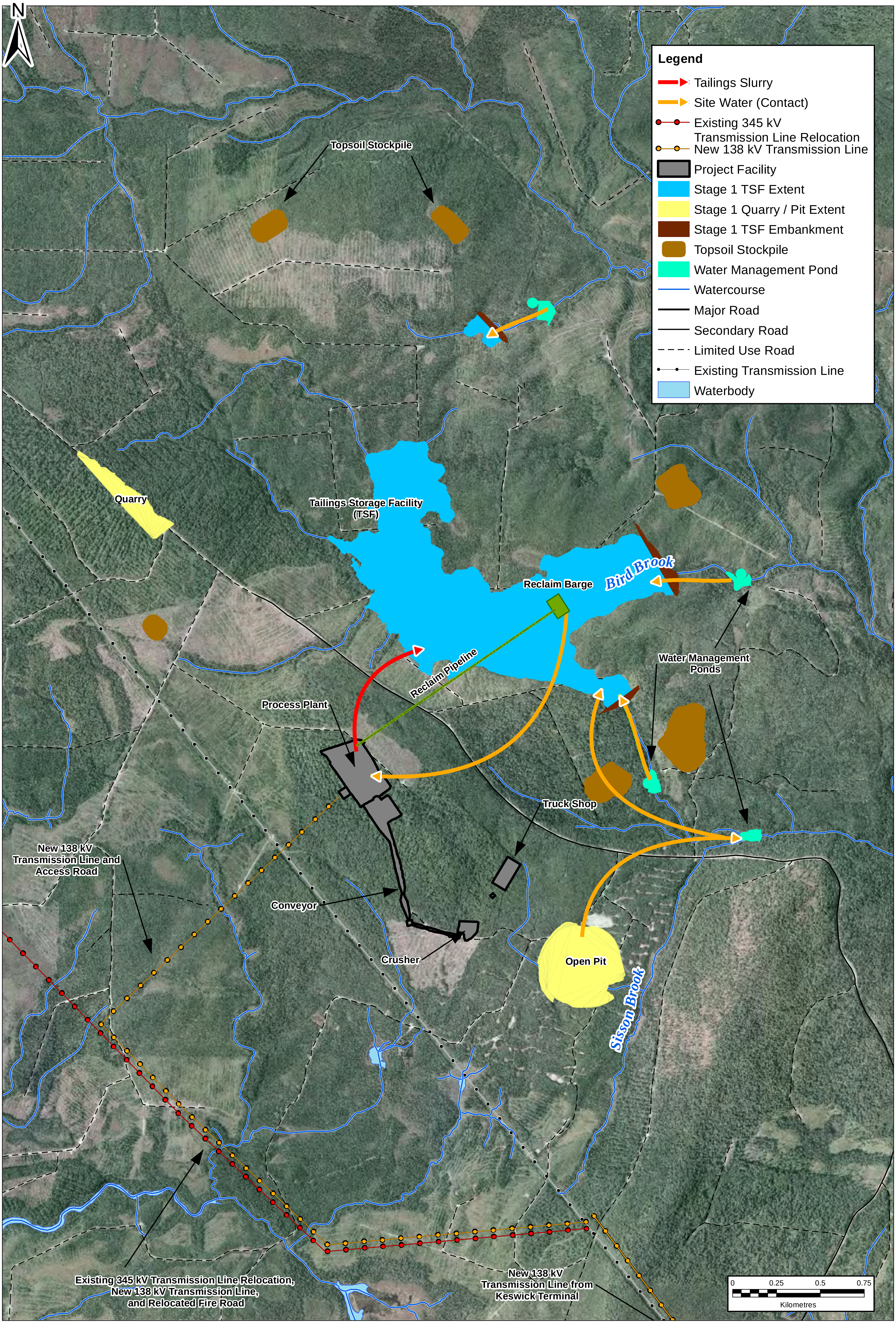
In general, the engineered diversion channels collect water within one sub-watershed, and divert this water around the Project facilities to another location within the same watershed. The construction of the TSF will result in the permanent loss of approximately 84% of Bird Brook (including its unnamed tributaries) and approximately 61% of Tributary “A” to West Branch Napadogan Brook, as shown on Figure 8.4.11. As discussed in the Aquatic Environment VEC (Section 8.5), an authorization under the *Fisheries Act* and a WAWA permit will be required to complete this work. However, no current human users of these watercourses for potable water have been identified; therefore the alteration of drainage patterns in the watershed will not alter the availability of surface water as a water source as there are no existing users.

The ponding of water within the TSF may alter the groundwater recharge patterns locally within the Bird Brook watershed, with some mounding of the water table beneath the ponded water. However, this is not expected to affect the availability or the quality of groundwater resources within or beyond the footprint of the TSF.

Other Project Facilities

The quarry used to construct the TSF embankments may require shallow dewatering to excavate the rock, which will be performed using conventional sump-pit pumping. Any water collected from dewatering activities at the quarry will be collected with accumulated precipitation within the footprint of the TSF. The dewatering activities from the quarry are expected to intercept shallow groundwater interflow resulting from precipitation, but the volume of pumping is anticipated to be relatively small and of little consequence to surface hydrology of the surrounding watercourses.

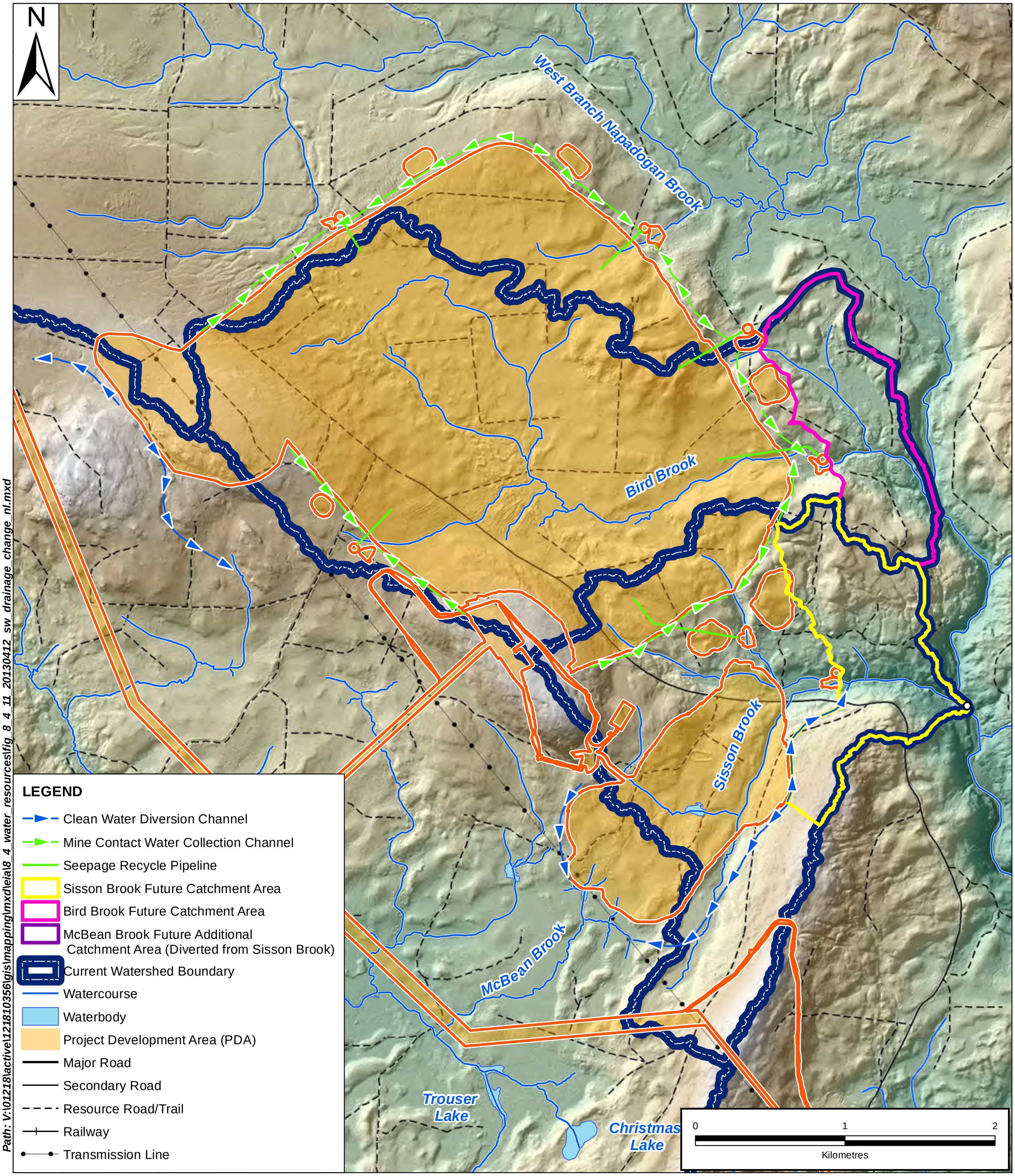
Other features of the Project include buildings and structures associated with the Project, such as the processing plant, the electrical substation, the primary crusher, the ore conveyor, the maintenance shop, and explosives storage. The construction of these facilities will interact with Water Resources in a minimal way due to the relatively small footprint of the facilities. These activities may introduce sediment to nearby watercourses, but can be easily mitigated by best management practices outlined in the EPP, including locating structures more than 30 m from watercourses, and use of silt fencing. No interactions with groundwater are expected with these facilities.



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

Location of Project Facilities at End of Construction Sisson Project: Environmental Impact Assessment (EIA) Report, Napadogan, N.B.	Scale: 1:20,000	Project No.: 121810356	Data Sources: NBDNR	Fig. No.: 8.4.10	Stantec
	Date: (dd/mm/yyyy) 23/11/2014	Dwn. By: JAB	Appd. By: DLM		
Client: Sisson Mines Ltd.					

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.

Changes in Surface Water Drainage Areas Sisson Project: Environmental Impact Assessment (EIA) Report, Napadogan, N.B.	Scale: 1:35,000	Project No.: 121810356	Data Sources: NBDNR Leading Edge Geomatics Ltd.	Fig. No.: 8.4.11
Client: Sisson Mines Ltd.	Date: (dd/mm/yyyy) 12/04/2013	Dwn. By: JAB / Appd. By: GPY		

Stantec

Map: NAD83 CSRS NB Double Stereographic

Fresh Water Supply

A supply of fresh water for will be required for Operation of the Project, which will be installed during the Construction phase. Fresh water will be required for potable and sanitary purposes by mine workers, for dust suppression, fire suppression, and as make-up water for the ore processing operation. The total fresh water demand for the Project is estimated to be 21 m^3/h (or 504 m^3/d) on average (Samuel Engineering 2013). Several wells will need to be installed to satisfy this demand based on the estimated well yields presented in Section 8.4.2.3.3. Since the yield of this fresh water supply is predicted to exceed 50 m^3/d, groundwater development will require a Water Supply Source Assessment (WSSA) under the *Clean Water Act*. The withdrawal of this quantity of groundwater would be expected to be of no consequence to the closest water resource users at nearby recreational campsites (approximately 1.5 km away) or at nearest residences (approximately 9 km away).

The siting of the water supply wells to meet the fresh water requirements will be important, due to the possible constraints imposed by the presence of the TSF. The wells will need to be sited to avoid areas where the migration of potential contaminants from the TSF could be drawn toward the wells, and also avoid the zone of increased drawdown resulting from the dewatering of the open pit.

Environmental Effects on Stream Flow through the Life of Project

The Construction activities will result in alterations to stream flows as illustrated on Figure 8.4.12. The alterations to stream flow throughout the life of the Project are illustrated in Figure 8.4.12 as a percentage of the baseline mean annual flow (MAF). Key phases of the Project are also presented on the figure, including:

- Construction, from Year -2 to -1;
- Operation, from Year 1 to Year 27;
- Closure, from Year 28 to about Year 39; and
- Post-Closure, from about Year 40 onward.

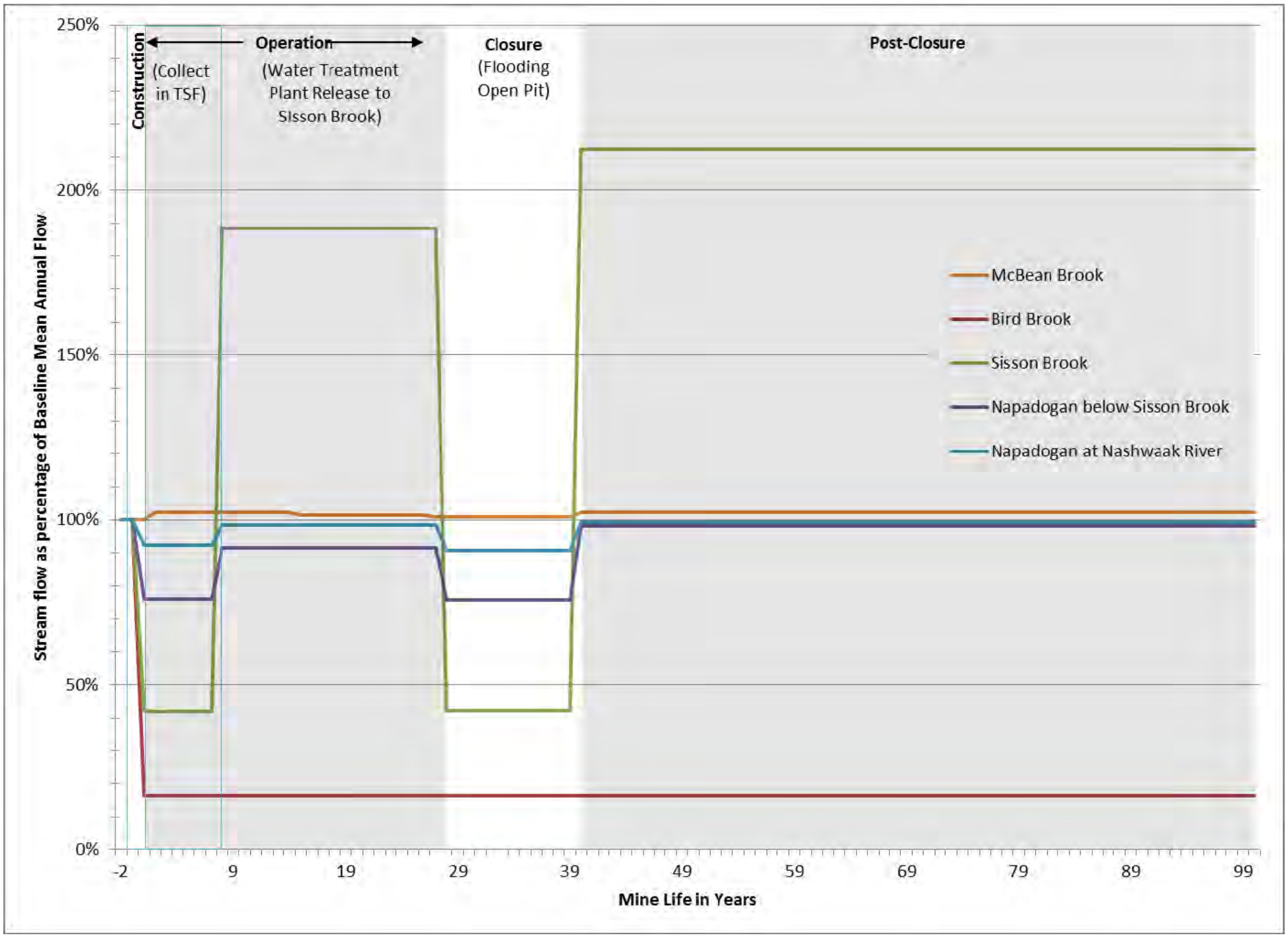


Figure 8.4.12 Stream Flow Alteration Throughout the Project Life as Percentage of Baseline Mean Annual Flow

Operation is further divided into two periods that relate to the management of the TSF. From the start of the Operation phase and until about Year 7, all mine contact water within the PDA, including water discharged from the open pit, is collected in the TSF for use in the ore processing operation, with no surplus to be treated or released. Starting about Year 8, a surplus of water is available within the TSF, and there is thus a need to treat and release the surplus water to the former Sisson Brook channel from this point forward until the end of the Operation phase. This water will be treated at an on-site water treatment plant prior to release to the former Sisson Brook channel.

The environmental effects of water management operations for the Project for each of the phases and periods are provided for each of five key hydrologic locations: the mouth of McBean Brook, the mouth of Bird Brook, the mouth of Sisson Brook, Napadogan Brook below the confluence with Sisson Brook, and the mouth of Napadogan Brook at the Nashwaak River.

The Construction activities (Years -2 and -1) will result in retention of Bird Brook water within the PDA which will permanently reduce the stream flows to 16% of MAF. The diversion of a portion of flow of Sisson Brook to McBean Brook, and the installation of a starter dam and WMP, will reduce the flow in Sisson Brook to 42% of MAF, while increasing the flow in McBean Brook to 102% of MAF. The combined effect of stream flow reductions from Bird and Sisson brooks will reduce the flow in Napadogan Brook to 76% of MAF below the confluence with Sisson Brook, and to 91% of MAF at the confluence of Napadogan Brook with the Nashwaak River.

The Operation activities during Years 1 to 7 include the retention of all mine contact water within the PDA, including the dewatering of the open pit. The water collected from the open pit is collected at a WMP on Sisson Brook, and pumped to the TSF. As shown on Figure 8.4.12, these activities do not change the stream flows compared to the MAF at the end of Construction.

The Operation activities during Years 8 to 27 will include the continued dewatering of the open pit, and the treatment and release of surplus water that is collected in the TSF to the residual segment of the former Sisson Brook channel. As shown on Figure 8.4.12, these activities do not change the stream flows in Bird or McBean brooks compared to the MAF at the end of Year 7. However, stream flows in Sisson Brook increase from 42% of MAF at the end of Year 7 to 188% of MAF from the end of Year 8 until the end of Year 27. Similarly, the stream flows in Napadogan Brook below the confluence of Sisson Brook increase from 76% of MAF at the end of Year 7 to 92% of MAF from the end of Year 8 until the end of Year 27. The stream flows in Napadogan Brook at its confluence with the Nashwaak River increase from 91% of MAF at the end of Year 7 to 98% of MAF from the end of Year 8 until the end of Year 27.

The Closure activities from Year 28 to about Year 39 include the ceasing of pit dewatering, and the flooding of the open pit by directing water from the quarry and TSF to the open pit. As shown on Figure 8.4.12, these activities do not change the stream flows in Bird or McBean brooks compared to the MAF at the end of Year 27, but do result in the lowest predicted flows in the other streams presented, at the same rates as for Years 1 to 7 of Operation. Stream flows in Sisson Brook decrease to 42% of MAF during this period. Similarly, the stream flows in Napadogan Brook below the confluence of Sisson Brook decrease to 76% of MAF, and the stream flows in Napadogan Brook at the confluence with the Nashwaak River decrease to 91% of MAF.

Following the flooding of the open pit, new equilibrium stream flows will be established in the watercourses. Post-Closure stream flows in Bird and McBean brooks will continue at the rates established at the end of Construction at 16% of MAF and 102% of MAF, respectively. Stream flows in Sisson Brook will rise to 213% of MAF, and in Napadogan Brook, the stream flows will return to near baseline levels of 98% MAF and 99% MAF at the confluence of Sisson Brook and Nashwaak River, respectively.

Overall, the Project will alter the stream flows in Bird Brook, Sisson Brook, Napadogan Brook, and McBean Brook. The stream flow in Bird Brook will be decreased permanently to 16% of the baseline MAF. The largest flow reductions Sisson and Napadogan brooks will be during Years 1 to 7 when water is being collected in the TSF, and during flooding of the open pit from Years 28 to about Year 39. Outside of these periods, the stream flows in the residual Sisson Brook segment will be supplemented by the release of water from the Project which will restore the flows in Napadogan Brook to near baseline levels. Stream flows in McBean Brook will only be altered slightly through the Project life, but are not expected to result in indirect loss of fish habitat.

In the case of Bird and Sisson brooks, as discussed in Section 7.4, the stream flow reductions are assumed to result in the permanent loss of fish habitat in the residual watercourse segments, which will require an authorization under the *Fisheries Act* and a WAWA permit. Temporary reductions in stream flows in Napadogan Brook will result in temporary indirect losses of fish habitat, which will also require an authorization under the *Fisheries Act.* The loss of fish habitat and the proposed Offsetting Plan for the loss are discussed in Section 7.4. No permanent surface water users have been identified for any of the above streams; therefore, no adverse environmental effects to Water Resources are predicted to result from these flow alterations.

8.4.4.3.2 Operation

Mine Waste and Water Management during Operation includes several activities that will interact with Water Resources, including the dewatering of the open pit, the storage of tailings and PAG waste rock in the TSF and the collection, management, treatment, release and monitoring of site contact water. The ongoing use of the potable water supply discussed in Section 8.4.4.3.1 above will also continue throughout Operation.

Open Pit

The development of the open pit will occur progressively over the estimated 27-year life of the mine, to an ultimate footprint of the open pit of 145 ha and a total pit depth at end of mine life of between 300 and 370 m. Development of the open pit will result in groundwater seepage through the pit walls, and precipitation and surface run-off into the open pit. Collection and management of this water will be required to allow for mining operations to occur, using sump-pit type pumping of collected water at the base of the open pit, into a water management pond, and then into the TSF. The excavation and dewatering of the open pit will result in the gradual lowering (drawdown) of the water table in an area surrounding the open pit over the Operation period. As described in Section 7.6, the rate of groundwater inflow into the open pit is estimated to be 0 L/s at the beginning of mining, increasing to an estimated 40 L/s at the end of the 27-year mine life (Knight Piésold 2013b).

The seepage of groundwater into the open pit will result in a circular to oval cone-shaped depression of the water table, with the walls of the cone intersecting the walls of the open pit, and the top of the cone intersecting the water table at some distance from the centre of the open pit. Knight Piésold estimates the extent of the top of the cone of depression could extend as far as 2 km from the centre of the open pit near the end of Operation (Knight Piésold 2012c), as shown on Figure 8.4.13. Groundwater and surface water users within this cone of depression may experience some decrease in water level. The potentially affected area includes several recreational campsites approximately 1.5 km to the east of the edge of the open pit, as shown in Figure 8.4.13. The nearest permanently occupied residence to the Project is located in the community of Napadogan, approximately 9 km northeast of the PDA, and the Project is not expected to affect water quality or quantity at these locations as it is sufficiently distant from them to avoid adverse environmental effects.

Several of the recreational campsites were observed to collect surface water originating from springs. These springs are likely present as the result of localized, shallow interflow from precipitation infiltrating at the top of nearby Nashwaak Ridge which surface as springs at a lower elevation on the ridge. The environmental effects of open pit dewatering on these springs within the potential limits of groundwater drawdown discussed above are not clear, as the location of the springs have not been identified. However, given the local topography, the springs are unlikely to be affected by dewatering the open pit as they are located on the opposite side of the groundwater divide created by Nashwaak Ridge. If complaints are received about groundwater drawdown at these locations during Operation, Northcliff will investigate further to determine the extent and magnitude of drawdown during Operation including any effects on recreational campsites, and mitigation will be implemented. Prior to beginning Operation, the condition of the water supplies for the recreational campsites will be confirmed with the owners, and the owner's permission to document pre-Construction status will be obtained.

As spring-fed tributaries are unaffected, and no other local users of surface water are known, then there is no significant environmental effect on the availability of surface water as result of the dewatering of the open pit.

As discussed in Section 7.5, the rock within the open pit walls has been characterized as PAG, with the timing for ARD onset to be greater than 100 years following the start of Operation. Mining activities, exposing PAG rock on the open pit walls, are limited to 27 years, and as such, groundwater seepage collected from the pit walls during Operation is predicted to be similar to groundwater samples collected within the PDA. All water collected during dewatering of the open pit will be collected in a WMP prior to being pumped to the TSF. As the open pit will be dewatered, pulling fresh groundwater toward it, no significant adverse environmental effects to groundwater quality would be expected.

TSF

As discussed for Construction, all precipitation that falls on the Project site will be collected, stored in the TSF, and reclaimed for use as process water in ore processing activities, including water collected from dewatering the open pit. Once used in the ore processing operation, the water will return to the TSF as tailings slurry. The TSF will contain tailings from two ore processing streams. Tungsten tailings, about 95% to the total tailings, will be NPAG and will form the exposed tailings beaches around the interior perimeter of the TSF. Molybdenum tailings will be PAG, and will be deposited sub-aqueously in the TSF along with all waste rock from the open pit.

The TSF supernatant pond serves to submerge the PAG tailings and waste rock in order to effectively mitigate the potential formation of ML/ARD. Collection of all contact water within the TSF will continue until approximately Year 7 of Operation, after which a surplus of water will be available within the TSF that will be treated to meet permit conditions and then discharged to the natural environment. The discharge of surplus water beginning in about Year 8 will result in increased stream flows in the residual segment of Sisson Brook at almost double the baseline flow rates, and return stream flows in Napadogan Brook to 98% of the pre-development stream flow rates, as shown on Figure 8.4.12.

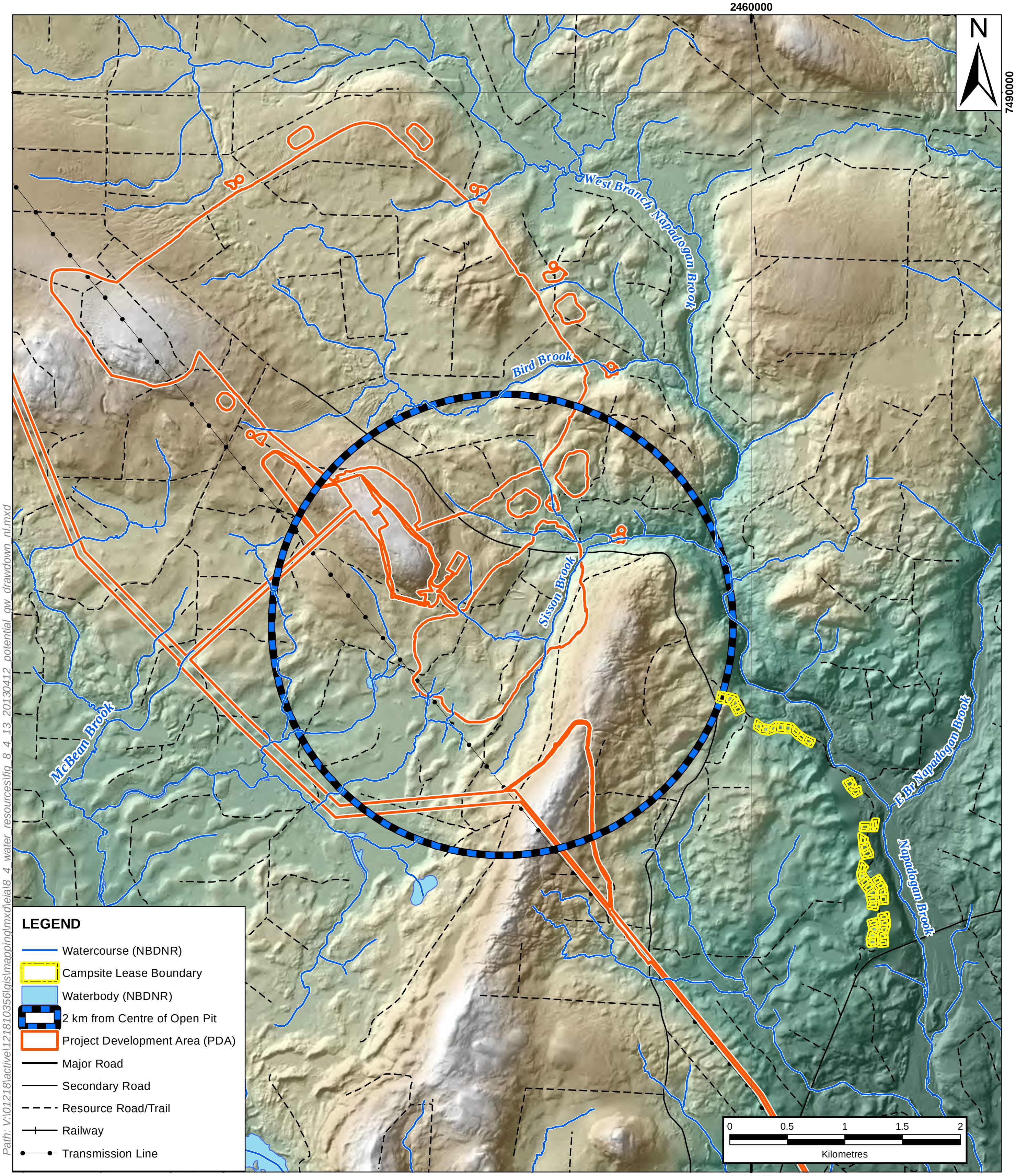
Some of the water collected in the TSF will seep through the tailings and embankments of the TSF. The seepage source is water in the supernatant pond and precipitation infiltrating through the TSF beaches. The TSF embankments are designed with interior filter zones and a seepage collection system at their base to collect and route seepage to the WMPs. Collection channels around the exterior perimeter of the embankments will also collect seepage, as well as embankment run-off, and direct it to the WMPs to be pumped back into the TSF. Nonetheless, some seepage will bypass this collection system to the groundwater which is expected to flow downgradient and radially away from the TSF, toward streams in the LAA that are natural groundwater discharge zones. Groundwater seepage from the southeast TSF embankment is expected to flow toward the open pit as this area is located within the anticipated groundwater drawdown zone of the open pit (Figure 8.4.13).

Groundwater monitoring wells below the WMPs will be used to determine if downstream water quality might be jeopardized by seepage that enters groundwater. If necessary, the monitoring wells can be converted to groundwater pump-back wells to return problematic groundwater to the WMPs and TSF. Additional groundwater pump-back wells can be installed as needed around the TSF perimeter if operational monitoring indicates the need for them. The base case Project design includes such pump-back wells for the northwestern TSF embankment. The water quality modeling for the Project, described in Section 7.6, explicitly includes TSF seepage in the model predictions.

Knight Piésold has prepared predictions of the surface water quality in Napadogan and McBean brooks that will result from the operation of the TSF. As described in Section 7.6, the predicted concentrations of all parameters in McBean Brook are predicted to be below the GCDWQ. However, the concentrations of three parameters in Napadogan Brook (aluminum, manganese, and sodium, discussed below) are predicted to exceed the GCDWQ at some time during Operation in the portions of the West Branch Napadogan Brook upstream of its confluence with East Branch Napadogan Brook. No exceedances of the GCDWQ were identified in the water quality predictions downstream of the confluence of West and East Branch Napadogan Brook.

The average annual concentrations of aluminum are predicted to not exceed the GCDWQ operational guidance of an average of 0.2 mg/L over 12 months, although the maximum concentration will exceed the guidance value. During Operation in the upper reaches of West Branch Napadogan Brook, the average annual concentration is predicted to reach a maximum of 0.159 mg/L. The average annual concentration of naturally-occurring aluminum in Napadogan Brook is also not observed to exceed the guidance value. Though it will not be exceeded, the GCDWQ operational guidance value is not a health-based criterion, but rather guidance that applies to water treatment plants for potable water. Therefore, there is no significant adverse environmental effect associated with an exceedance of the GCDWQ for aluminum in Napadogan Brook.

The concentrations of manganese are predicted to exceed the GCDWG aesthetic objective of 0.05 mg/L, with a predicted maximum concentration of 0.055 mg/L at the confluence of Sisson Brook with West Branch Napadogan Brook during Operation. The concentrations are predicted to exceed the guidelines for a period of up to 30 days, typically during the month of August. Naturally occurring concentrations of manganese in Napadogan Brook are not observed to exceed the guidelines.



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

Title	Scale:	Project No.:	Data Sources:	Fig. No.:
Limits of Potential Groundwater Drawdown from Open Pit Dewatering Sisson Project: Environmental Impact Assessment (EIA) Report, Napadogan, N.B.	1:45,000	121810356	NBDNR Leading Edge Geomatics Ltd. Knight Piésold 2012c	8.4.13
Client: Sisson Mines Ltd.	Date: (dd/mm/yyyy) 23/11/2014	Dwn. By: JAB	Appd. By: DLM	

Map: NAD83 CSRS NB Double Stereographic

The concentrations of sodium are predicted to exceed the GCDWG aesthetic objective of 200 mg/L, with a predicted maximum concentration of 293 mg/L at the confluence of Sisson Brook with West Branch Napadogan Brook during Operation. The concentrations are predicted to exceed the guidelines for a period of more than 30 consecutive days in a given year, typically between October and April. Naturally occurring concentrations of sodium in Napadogan Brook are not observed to exceed the guidelines.

The maximum concentrations of both manganese and sodium are close to the aesthetic limits presented by Health Canada, which are based on the aesthetic quality of the water and not health concerns. Manganese oxides can begin to form on fixtures at when manganese levels exceed 0.05 mg/L, and water can begin to taste salty when sodium levels exceed 200 mg/L. Consumption of the water with these sodium and manganese levels would not cause adverse health effects in humans, but rather, some water users may object to the taste. As no current or long-term human users of the water in Napadogan Brook have been identified, there is no significant adverse environmental effect from these temporary potential exceedances.

As discussed above, the water quality in the reaches of West Branch Napadogan Brook above the confluence of Sisson Brook is predicted to temporarily exceed the GCDWQ for manganese. As groundwater seepage is the only Project-related input to these segments of Napadogan Brook, the quality of this groundwater seepage is also expected to be in excess of the GCDWQ for manganese. As there are no known groundwater users within the PDA, any exceedances of the GCDWQ in groundwater around the Project site are not significant. Monitoring of the quality of groundwater seeping past the TSF and WMPs is recommended to verify the groundwater quality predictions, and to inform adaptive Project water management measures should groundwater quality pose a significant risk to water quality in the downstream watercourses. These measures may include groundwater interceptor wells with flow-back pumping to the WMPs. Monitoring of water quality in the receiving environment will confirm water quality predictions and whether additional control is required. This is an adaptive management approach that will be applied throughout the Project life.

Fresh Water Supply

Without mitigation and the proper siting of groundwater well(s) outside the zone of influence of the Project, the supply and quality of the fresh water supply could be affected by both the presence of the TSF and the open pit. Additional site investigation during Basic and Detailed Engineering will inform the siting of the water supply well(s) and confirm the well location(s) prior to Construction. Monitoring of the water quality and water levels will be necessary to confirm the continued safe use of this water supply during Operation.

8.4.4.3.3 Decommissioning, Reclamation and Closure

Upon the completion of mining, the focus of the activities will shift to Decommissioning, Reclamation and Closure. This includes the management of ML/ARD issues associated with the rock on the walls of the open pit, and the tailings stored within the TSF by means of underwater storage.

Open Pit

During Closure, pit dewatering will cease and the open pit will be flooded as a reclamation measure and to minimize the potential for sulphide-bearing rock exposed on the walls of the open pit to generate acid and leached metals. The pit will be filled with water from groundwater inflows, direct precipitation and run-off from land adjacent to the pit, and water diverted from the TSF. As indicated in Section 7.6, the flooding of the open pit is estimated to require about twelve years to complete. The pit lake will be maintained at a level to ensure it is a ground water sink by pumping to a WTP for treatment as needed, to meet requirements set out in the Approval to Operate. It will then be discharged to the residual Sisson Brook. Treatment will be required until the reclaimed TSF and the exposed pit walls above the lake no longer generate contaminants in quantities that make the pit lake water unsuitable for direct discharge. When the pit lake water quality is such that it no longer needs treatment before discharge, the pumping and treatment will cease, and the lake will be allowed to fill and overflow into Sisson Brook through an engineered channel.

The filling of the pit will gradually allow the surrounding groundwater table to rise and thus and reduce the potential interactions with the availability of groundwater resources away from the open pit. The rate at which the groundwater table recovery will take place is not currently known.

At the end of about Year 39, the open pit is predicted to be full, and will effectively be a new lake located on the present Sisson Brook. The water quality in this new lake could potentially interact with the groundwater downstream of the lake; however, this will be mitigated by maintaining the lake level at an elevation that ensures that it is a groundwater sink, and there are thus no potential environmental effects on groundwater quality around the pit. Therefore, the pit lake will not interact in a substantive way with Water Resources, as the closest groundwater users are located far outside this zone.

The filling of the open pit by storing all water from the open pit and TSF during Years 28 to about Year 39 will result in predicted reductions to stream flow in Napadogan Brook like those during Years 1 to 7 of Operation. As shown in Figure 8.4.12, a 24% reduction is predicted just below the confluence with Sisson Brook. The magnitude of the reduction decreases to 9% just above the confluence with the Nashwaak River. Stream flows along the Nashwaak River under this water withholding case are predicted to be reduced by 3% just below the confluence with Napadogan Brook, and by less than 2% at Stanley (Rees, A, Personal communication, December 18, 2012). The reduction is insufficient to adversely affect potential surface water users in the RAA.

All surplus water from the TSF will continue to be directed to the open pit following the initial flooding period. The water quality in the pit lake will be monitored, and the water will be treated before discharge until such time that treatment is no longer required to meet the provincial Approval to Operate. At that time, the water level in the open pit lake will be allowed to rise, such that natural drainage along the residual segment of Sisson Brook will occur. This will re-establish the stream flows in Napadogan Brook to near baseline levels. Specifically, the stream flow in Napadogan Brook below the confluence with Sisson Brook will rise to 98% of MAF, and to 99% of MAF at the mouth of Napadogan Brook at the Nashwaak River.

Knight Piésold has prepared predictions of the surface water quality in Napadogan and McBean brooks that will result from Closure and Post-Closure activities. As shown in Section 7.6, the predicted concentrations of all parameters in McBean and Napadogan brooks are predicted to be below the

GCDWQ, following treatment, with the exception of aluminum in Napadogan Brook which as previously discussed will not exceed the significance criteria.

As noted above, water treatment and will continue until such time as the water quality in the pit lake is of sufficient quality to no longer require treatment. Water quality monitoring will continue post-Closure until such time that the water quality is of acceptable quality to meet discharge requirements established by the provincial Approval to Operate.

TSF

The issues identified for Operation (Section 8.4.4.3.2) will continue into the Decommissioning, Reclamation and Closure phase, and do not require further discussion.

The groundwater seepage from beneath the TSF into receiving waters will continue in perpetuity. Water quality monitoring will continue post-closure until such time that the water quality is acceptable and the termination of monitoring, and the operation of any pump-back wells, can be justified and approved by the appropriate regulatory agencies.

The operation of the water management ponds for embankment run-off and seepage collection and pump-back to the TSF, and the associated water quality monitoring, will continue until such time as the collected water is of a quality that discharge to the natural environment can be justified and approved by government.

8.4.5 Assessment of Cumulative Environmental Effects

In addition to the Project environmental effects discussed above, an assessment of the potential cumulative environmental effects was conducted for other projects or activities that have potential to cause environmental effects that overlap with those of the Project, as identified in Table 8.4.15. Table 8.4.16 presents the potential cumulative environmental effects to Water Resources, and ranks each interaction with other projects or activities as 0, 1, or 2 with respect to the nature and degree to which important Project-related environmental effects overlap with those of other projects or activities.

Table 8.4.16 Potential Cumulative Environmental Effects to Water Resources

Other Projects or Activities With Potential for Cumulative Environmental Effects	Potential Cumulative Environmental Effects
	Change in Water Resources
Past or Present Projects or Activities That Have Been Carried Out	
Industrial Land Use (Past or Present)	0
Forestry and Agricultural Land Use (Past or Present)	1
Current Use of Land and Resources for Traditional Purposes by Aboriginal Persons (Past or Present)	0
Recreational Land Use (Past or Present)	0
Residential Land Use (Past or Present)	0
Potential Future Projects or Activities That Will Be Carried Out	
Industrial Land Use (Future)	0
Forestry and Agricultural Land Use (Future)	1
Current Use of Land and Resources for Traditional Purposes by Aboriginal Persons (Future)	0

Table 8.4.16 Potential Cumulative Environmental Effects to Water Resources

Other Projects or Activities With Potential for Cumulative Environmental Effects	Potential Cumulative Environmental Effects Change in Water Resources
Recreational Land Use (Future)	0
Planned Residential Development (Future)	0

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 will not measurably change the state of 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 may measurably change the state of the VEC.

The following activities will have no interaction with Water Resources, and have been ranked 0 in Table 8.4.16. No past, present or potential future Industrial Land Use that may interact with Water Resources has been identified within the RAA. Similarly, no past, present or future Recreational Land Use, Residential Land Use, or Current Use of Land and Resources for Traditional Purposes by Aboriginal Persons have been identified within the RAA that may interact with Water Resources in any substantive way. Even if these activities did occur in the future, the quantities of water used for these activities would be expected to be small in comparison to the amount of water available, and the environmental effects on Water Resources would not be expected to overlap spatially with those of the Project in any substantive way.

Only past, present, or future Forestry and Agricultural Land Use is anticipated to have environmental effects to Water Resources that overlap with those of the Project, but these interactions can be managed through standard operating procedures and best management practices and have therefore been ranked as 1 in Table 8.4.16. Forestry land use has the potential to alter the local water balance, and result in increased run-off and sedimentation to surface water resources. However, best management practices, and regulations restricting logging within buffer areas around streams will continue to mitigate these interactions. Limited agricultural land uses have been identified within the RAA and they would not be expected to have environmental effects to Water Resources that overlap spatially with those of the Project. No large-scale residential or industrial developments have been identified in the future that would be expected to have environmental effects to Water Resources that overlap spatially with those of the Project in any substantive way.

8.4.6 Determination of Significance

8.4.6.1 Residual Project Environmental Effects

Though alterations to the availability and quality of surface and groundwater resources will result from the Construction and Operation of the Project, the extent of the loss will not adversely affect users of the water resources in the LAA to the extent that such environmental effects would be significant. Watercourse alterations that may affect surface water hydrology will be authorized. The sequestration of mine contact water in the TSF will not adversely affect downstream surface water use or nearby groundwater use. Discharge of surplus water from the Project will be treated (as necessary) to acceptable discharge standards prior to release. Most of the water requirements for the Project will be met by the reuse of collected water reclaimed from (and discharged back into) the TSF.

The prediction of water quality along West Branch Napadogan Brook between Sisson Brook and East Branch Napadogan Brook indicates that concentrations of sodium will exceed the GCDWQ for a period of more than 30 consecutive days, which exceeds the significance criteria set out in Section 8.4.1.6. However, this exceedance will not result in a significant adverse environmental effect as the GCDWQ for sodium is an aesthetic objective and not a health-based guideline. No residences are situated near West Branch Napadogan Brook, no potable water supplies derived from surface water downstream, and the only potential use is occasional and intermittent by people who may be in the area for recreational activities or traditional First Nations land uses in the region. Therefore, the predicted water quality will not have a significant adverse environmental effect on local water users.

In light of the above and in consideration of proposed mitigation and environmental protection measures, the potential environmental effects of a Change in Water Resources during all phases of the Project are rated not significant. This conclusion has been determined with a moderate level of confidence. Follow-up will be conducted to increase the level of confidence by monitoring surface water levels in receiving watercourses and by monitoring groundwater and surface water quality.

8.4.6.2 Residual Cumulative Environmental Effects

The cumulative environmental effect of a Change in Water Resources from the Project in combination with other projects or activities that have been or will be carried out will be limited in spatial extent, and are not expected to adversely affect users of the water resources in the RAA in such a way that environmental effects would be significant. The cumulative environmental effects of the Project in combination with other projects or activities that have been or will be carried out on a Change in Water Resources are rated not significant. This determination has been made with a high level of confidence, given the limited temporal and spatial nature of the potential residual cumulative environmental effects, the professional knowledge and experience of the Study Team, as well as the associated mitigation.

8.4.7 Follow-up or Monitoring

Follow-up or monitoring programs will be implemented for Water Resources as presented in Table 8.4.15 and as listed below. Additional details on the follow-up and monitoring programs are presented in Chapter 9.

Follow-up to verify the environmental effects predictions or the effectiveness of mitigation is proposed as follows.

- Sample the water quality released from the starter pit to determine the requirement for water treatment during Construction. This will include the collection of water samples from the outlet of the sedimentation pond, which will be submitted for laboratory analysis of general chemistry and metals.

- Measure the stream flow at the existing hydrometric stations (B-2, SB-1, and NB-2B, TL-2 and MBB-2) to confirm the predicted changes in flow. Compare the measured flows to the equivalent pre-Project stream flow rates calculated from the Narrows Mountain Brook (NMB) station operated by Environment Canada. Knight Piésold (2012d) has demonstrated a strong correlation of pre-Project flows at the Project hydrometric stations to the NMB station.

- Sample the surface water quality in McBean and Napadogan brooks to confirm the predicted water quality in the receiving environments, with comparison to GCDWQ.

- Install and instrument monitoring wells to record groundwater seepage quality from beneath the TSF, and below the WMPs, to the Napadogan Brook watershed, and conduct quarterly groundwater quality sampling to detect trends in key water quality parameters relative to the GCDWQ, and trends that may jeopardize downstream water quality. A reference groundwater monitoring location in the East Branch Napadogan Brook watershed is also proposed to identify possible regional trends in groundwater quality.

Monitoring will be conducted to ensure the Project meets applicable legislation, regulations and guidelines, as follows.

- Monitor TSS in run-off from construction areas.

- Water quality monitoring from TSF WMPs and groundwater monitoring wells around the perimeter of the TSF will begin during Operation, and continue post-Closure until such time that the water quality is of acceptable quality that can justify the termination of monitoring.

- Routine monitoring of water quality from the Project water supply wells or potable water treatment system (if required) to ensure that potable water required for the Project meets the GCDWQ.