

Appendix B.3

Final – Hydrology Baseline Report, Golder Associates



REPORT Fifteen Mile Stream Gold Project Hydrology Baseline

Submitted to:

Atlantic Mining NS Corp

409 Billybell Way, Mooseland Middle Musquodoboit, Nova Scotia B0N 1X0

Submitted by:

Golder Associates Ltd.

201 Brownlow Avenue, Suite 26, Dartmouth, Nova Scotia, B3B 1W2, Canada

+1 902 466 1668

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Executive Summary

Atlantic Mining NS Corp (AMNS), a wholly owned subsidiary of St. Barbara Ltd., is planning to develop the Fifteen Mile Stream Gold Project (the Project) located approximately 115 km east of Halifax, in Halifax County, in the province of Nova Scotia. The scope of this study and the hydrological data presented was intended to reflect the existing conditions of the watersheds that drain the Project site, and to support the Environmental Impact Statement (EIS) Process. The scope of work for the hydrological baseline study consisted of a review and summary of available related reports and data summarizing regional climatological data, collected hydrological data at the Project site, and supplementary data related to the regional watershed management (e.g., hydroelectric facilities).

Majority of the Project site footprint is in the northeastern portion of the Sheet Harbour watershed, which drains in a generally southern direction from headwaters north of the Project, to the Atlantic Ocean. A small portion of the Project site resides in the Moser River watershed, which drains to the southeast and eventually to the Atlantic Ocean via the Moser River. The surficial geology at the Project site is predominantly glacial till, with glaciofluvial outwash plains and alluvial floodplains.

The Halifax International Airport climate monitoring station was selected as most representative of the Project site. The climate of the Project site is characterized by a relatively moderate temperature regime, with a typical low of approximately -6 °C in January, and a high of 19 °C in July and August. Precipitation is greatest in the fall and winter months, and the proportion of snowfall in winter months is less than 50%.

The regional hydrological monitoring station of St. Mary's River at Stillwater was selected as the most representative of the Project site. Discharge records from this regional hydrological station indicate that the lowest flows occur during the summer months, when less precipitation and higher potential evaporation occur, and consistent flows through the winter months based on the presence of rainfall throughout the winter, rather than precipitation being stored in snowpack

In the vicinity of the Project site are the Seloam Reservoir (also called the Sloane Reservoir) and the Anti Dam Reservoir (also called the Anti Dam Flowage), which are located within the East River Sheet Harbour Hydro System. These reservoirs are operated according to specific guidelines that are intended to balance economic and social requirements.

The hydrological monitoring program for the Project site was initiated in early 2018. Currently, five locations are monitored, approximately monthly, for streamflow and water level changes. To date, the flow measurements collected from the monitoring locations are generally indicative of greater streamflow in spring and a relatively wet fall, separated by dry summer conditions. Ongoing hydrological monitoring will continue to refine the seasonal, annual (temporal), and catchment (spatial) variability in surface water quantity at the Project site.

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1.0 INTRODUCTION

Atlantic Mining NS Corp (AMNS), a wholly owned subsidiary of St. Barbara Ltd., is planning to develop an open pit gold mine at the Fifteen Mile Stream Gold Project (the Project) located approximately 115 km east of Halifax, in Halifax County, in the province of Nova Scotia (Figure 1).

This factual report is intended to present the results of the hydrology baseline study, with the objective of supporting the Environmental Impact Statement (EIS) process necessary to develop the Project.

1.1 Overview of the Fifteen Mile Stream Project

AMNS is planning to construct, operate, and eventually reclaim a new open pit gold mine at the Project site, which is defined by the red boundary noted on Figure 1. The proposed site infrastructure layout is also presented in Figure 1, which may be refined as a result of ongoing consultation and engineering studies. The major proposed Project components are expected to consist of:

- Open pit
- Tailings Management Facility
- Ore Stockpile
- Waste Rock Stockpile
- Till Stockpile
- Plant Site

These facilities will be supported by other infrastructure, as required, during the construction, operations, and closure of the Project.

2.0 SCOPE OF WORK

The scope of work for the hydrological baseline study consisted of the following tasks:

- 1) Review and summary of available related reports and data that summarize regional climatological data.
- 2) Review and summary of hydrological data collected on the Project site.
- 3) Summary of supplementary data related to regional watershed management (i.e., hydroelectric facilities).

The scope of this report and the hydrological data presented, was intended to reflect the existing conditions of the watersheds that drain the Project site, and to support further hydrological modelling and analyses required as a part of the EIS for the Project site.

3.0 STUDY AREA

The Project site is located in Halifax County, Nova Scotia, about 25 km north of Sheet Harbour, on the coast of the Atlantic Ocean (Figure 2). The Project is situated in the Atlantic Maritime ecozone of Canada; this ecozone is characterized by a generally temperate climate that is influenced by oceanic currents (Natural Resources Canada 2018). Regional mean annual runoff of approximately 1000 mm indicates that inputs from precipitation are normally well above the evaporation demand (National Atlas of Canada 1974).

Knight Piésold Limited (KP; 2018a) described the surficial geology at FMS as comprised of predominantly glacial till, with glaciofluvial outwash plains and alluvial floodplains. Wetlands are extensive throughout the Project site.

The Project site footprint is in the northeastern portion of the East River Sheet Harbour watershed, which drains in a generally southern direction from headwaters north of the Project, to the Atlantic Ocean (Figure 2). The East River Sheet Harbour is the primary drainage feature in this watershed, and the Fifteen Mile Stream is a tributary of the East River Sheet Harbour (Figure 3). Fifteen Mile Stream flows along the southwestern boundary of the Project site.

A small portion of the Project site resides in the Moser River watershed, which drains to the southeast and eventually to the Atlantic Ocean via the Moser River (Figure 2).

The Fifteen Mile Stream and East River Sheet Harbour form a component of the provincial hydroelectric system in Nova Scotia, specifically the East River Sheet Harbour Hydro System (Nova Scotia Power Incorporated [NSPI] 2009). There are seven water control features and/or hydroelectric generating stations along this watershed, and the water control structures in close proximity to the Project site are located on Seloam Reservoir (also termed Sloane Reservoir) and the Anti Dam Flowage (also termed Anti Dam Reservoir; Figure 3).

4.0 METHODS

4.1 Desktop Methods

Desktop review methods for this baseline study were focussed on extracting relevant information from previous studies completed for the Project site. These previous studies were supplemented with additional data, where available and applicable.

4.1.1 Climatological Data

KP (2018b) completed a Preliminary Engineering Hydrometeorology Report that summarized the regional climate of the Project site and recommended historical monitoring locations applicable to the Project site. The Environment and Climate Change Canada (ECCC) climate monitoring stations summarized in Table 1 were selected by KP as potentially representative, with a period of record of at least three years and a maximum distance of 50 km from the Project site. Data for these locations is available from the ECCC Historical Climate Database (ECCC 2018).

ECCC Climate Monitoring Station Name	ECCC ID	Active/Inactive	Years of Record	Latitude and Longitude	Elevation (masl)
Collegeville	6329	Inactive	101 (1916-2016)	45.5°N, 62.0°W	76.2
Malay Falls	6399	Inactive	51 (1950-2000)	45.0°N, 62.5°W	39.6
Malay Falls	30668	Active	20 (1999-2018)	45.0°N, 62.5°W	39.6
Stillwater	6481	Inactive	65 (1915-1979)	45.2°N, 62.0°W	17.1
Stillwater Sherbrooke	6482	Inactive	38 (1967-2004)	45.1°N, 62.0°W	14
Upper Stewiacke	6495	Inactive	91 (1915-2005)	45.2°N, 63.0°W	22.9
Upper Stewiacke RCS	6466	Inactive	13 (2005-2018)	44.9°N, 62.5°W	9.1
Halifax Stanfield International Airport	6358	Inactive	60 (1953-2012)	44.9⁰N, 63.5⁰W	145.4
Halifax International Airport	71395	Active	7 (2012-2018)	44.9⁰N, 63.5⁰W	145.4

Table 1: Potential Representative Regional Climate Monitoring Stations (KP 2018b)

4.1.2 Hydrological Data

As with the climatological stations, KP (2018) selected regional hydrological monitoring stations from ECCC that were potentially representative of the Project site, based on a period of record of at least 30 years and a maximum distance of 50 km from the Project site (Table 2). Archived regional hydrology data are available from the Water Survey of Canada (WSC 2018).

Table 2: Potential Representative Regional Hydrological Monitoring Stations (KP 2018b)

ECCC Hydrological Monitoring Station Name	ECCC ID	Active/Inactive	Watershed Area (km²)	Years of Record
St. Mary's River at Stillwater	01EO001	Active	1,350	104
Musquodoboit River at Crawford Falls	01EK001	Inactive	650	82
Liscomb River at Liscomb Mills	01EN002	Inactive	389	35

4.2 Field Methods – Streamflow

Field data collection for hydrology was undertaken by McCallum Environmental Ltd. (MEL) in 2018 and 2019. Five locations have been monitored for streamflow within the Project site footprint (Figure 3). At each of these monitoring locations, a datalogging water level sensor and manual staff gauge have been installed to record changes to water level. Discharge measurements have been recorded using the mid-section stream current method, where stream velocity is recorded along segments of a cross section of the stream. Discharge was then estimated by multiplying the recorded velocity by the stream cross section segment and summed to provide total

streamflow. During winter months, if safe to access, thin river ice is removed from the sampling location, prior to stream current measurements.

5.0 RESULTS

5.1 Regional Climate

KP (2018b) selected the Halifax International Airport climate monitoring station as most representative of the Project site. A monthly summary of climate from the KP (2018b) analysis is provided in Table 3.

Month	Temperature (ºC)	Total Precipitation (mm)	Percent Total Precipitation as Snow	Wind Speed (m/s)	Wind Direction	Potential Evapotranspiration ¹ (mm)
January	- 5.8	138	41%	4.9	NW	0
February	-5.6	118	46%	5.1	NW	0
March	-1.5	122	34%	5.1	N	0
April	3.9	113	17%	5.1	N	23
Мау	9.8	108	2%	4.6	S	64
June	14.9	97	0%	4.2	S	99
July	18.7	93	0%	3.9	S	126
August	18.6	99	0%	3.7	S	116
September	14.5	103	0%	4	S	78
October	8.9	134	1%	4.4	W	43
November	3.5	150	9%	4.9	NW	14
December	-2.4	164	29%	5.1	NW	0
Annual	6.5	1,440	17%	4.6	S	564

Table 3: Monthly Regional Climate – Fifteen Mile Stream

¹Potential Evaporation as calculated by KP using the Thornthwaite Heat Index method (Thornthwaite and Mather 1957)

The climate of the Project site is characterized by a relatively moderate temperature regime, which fluctuates between a typical low of approximately -6 °C in January, and a high of 19 °C in July and August. Precipitation is greatest in the fall and winter months, and the proportion of snowfall in winter months is less than 50%, further indicating moderate climate conditions at the Project site. Potential evapotranspiration is about 40% of the total precipitation received on an average annual basis.

5.1.1 Wet and Dry Year Precipitation

KP (2018b) applied a normal distribution curve to the average annual total precipitation from Halifax Airport data to develop return periods for wet and dry conditions at the Project site (Table 4).

Wet/Dry	Return Period	Annual Total Precipitation (mm)				
	1:100 year	1,912				
	1:50 year	1,856				
WET	1:20 year	1,773				
	1:10 year	1,700				
MEAN	1:2 year	1,440				
	1:10 year	1,180				
	1:20 year	1,107				
DRY	1:50 year	1,024				
	1:100 year	968				

Table 4: Wet and Dry Year Total Annual Precipitation

The total variation between these return periods is greater between the median (1:2 year return period) and the 1:10 year return period (260 mm difference), than between other analysed periods (e.g., between a 1:20 year and 1:50 year return). The total annual variation between a 100-year dry year and a 100-year wet year was estimated to be 944 mm.

5.1.2 Statistical Rainfall Events

Using the Halifax Airport rainfall data, KP (2018b) applied a Log- Pearson III frequency analysis and developed extreme 24-hour rainfall event statistics for the Project site (Table 5).

Return Period (years)	Total Rainfall, 24 hour duration (mm)
2	75
5	100
10	116
15	126
25	137
50	153
100	168

Table 5: Extreme Rainfall Statistics

5.2 Regional Hydrology

5.2.1 Literature Review

KP (2018b) selected the ECCC St. Mary's River at Stillwater hydrological monitoring station as the most representative regional station for hydrology at the Project site, based on proximity and record length (Table 6).

Description	Unit	Jan	Feb	Mar	Apr	Мау	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Recorded Discharge	m³/s	50.3	40.8	56.3	88.8	54	24.2	14.7	14.8	17.7	34.6	58	60	42.9
Unit Discharge	L/s/km ²	37.3	30.2	41.8	65.8	40.1	17.9	10.9	11	13.2	25.8	43.2	44.3	31.8
Runoff ¹	mm	100	73	112	170	107	46	29	29	34	69	111	119	1,002

Table 6: Average Monthly Discharge

¹Runoff calculated using watershed area of 1,350 km²

Records from this regional hydrological station indicate that the lowest flows occur during the summer months, which coincide with less precipitation and higher potential evapotranspiration (Section 5.1). The consistency of flows through the winter months is supported by the presence of rainfall, throughout the winter, that moves water through the watersheds, rather than storing precipitation in snowpack (Section 5.1). The average annual runoff estimated here (1,002 mm) is aligned with the regional estimate of 1,000 mm (Section 3.0).

5.2.2 Low Flow Statistics

Low flow statistics based on the St. Mary's at Stillwater monitoring location, were developed by KP (2018b) for a seven-day duration (Table 7). These low flow values are generally one or two orders of magnitude less than the monthly mean discharges (Section 5.2.1). Note that low flows are time independent (i.e., can occur at any time of the year over a seven-day duration).

Table 7: Seven-day Duration Low Flow Statistics

Duration	Unit	1:2 year	1: 5 year	1: 10 year	1 : 20 year	1: 50 year	1: 100 year
7 days	m³/s	2.01	0.98	0.65	0.46	0.30	0.23

5.2.3 Dam Operations and Water Management

Within the East River Sheet Harbour Hydro System and in the vicinity of the Project site are the Seloam Reservoir (also called the Sloane Reservoir) and the Anti Dam Reservoir (also called the Anti Dam Flowage; Figure 3). These reservoirs help to regulate the East River Sheet Harbour system, but do not have hydroelectric generating stations associated with them. Specific details of the reservoirs and the dam structures at the outlet of these reservoirs are shown in Table 8.

Dam Name	Dam Name Drainage Area (km²)		Spillway Elevation (masl)	Crest Elevation (masl)	Low Flow Feature
Seloam (Sloane) Reservoir	17.9	4.54 x 10 ⁶	128.4	129.6	Gated Sluiceway
Anti Dam Reservoir	160.6	7.43 x 10 ⁶	95.0	97.1	Gated Sluiceway

Table 8: Water Controlling Structures Near the Project Site

These reservoirs are operated according to specific guidelines that are intended to balance the Public and Employee Safety, Regulatory Requirements, Hydroelectric Power Generation and Recreational Use (NPSI 2009). As such, the reservoirs are actively monitored for water levels and flows, and adjustments are made to the outflow rate of these structure to maintain these objectives.

5.3 Local Watersheds

Local (site) watersheds were delineated based on the upstream areas contributing to each surface water monitoring location (Figure 3). A summary of local watersheds is shown in Table 9.

Table 9: Local Watersheds

Watershed ID	Area (km²)
SW2	18.8
SW5	9.5
SW6	48.7
SW14	97.4
SW15	2.8

5.3.1 Local Streamflow

Streamflow measurements at the Project site were initiated in early 2018 and supplemented with additional stations in summer 2018 (Table 10). These flow measurements are generally indicative of greater streamflow in spring (May) and a relatively wet fall (October and November), separated by dry summer conditions.

Date	SW2	SW5	SW6	SW14	SW15
4/2/2018	0.8	0.9	Not yet installed		
5/2/2018	1.7	2.4	Not yet installed		
6/18/2018	0.3	0.3	Not yet installed		
8/10/2018	0.5	0.3	5.3	0.7	<0.1
8/28/2018	0.4	0.2	1.0	0.5	<0.1
9/11/2018	0.2	0.2	0.4	0.3	<0.1
10/17/2018	<0.1	0.5	0.5	8.5	0.3
11/18/2018	1.4	1.0	n/a¹	6.1	0.1
12/14/2018	0.5	n/a¹	6.9	n/a¹	<0.1
01/15/2019	1.2	0.7	6.7	n/a ¹	<0.1
02/19/2019	0.6	0.4	n/a¹	n/a ¹	0.1
03/15/2019	0.6	0.4	4.6	n/a1	<0.1
04/11/2019	2.3	1.5	7.5	5.1	<0.1
05/25/2019	0.7	0.5	4.5	2.9	<0.1
06/07/2019	0.7	1.0	n/a ¹	n/a ¹	0.4

Table 10: On-Site Streamflow Measurements (m³/s)

¹Measurement not completed, due to safety concerns.

6.0 SUMMARY AND CONCLUSIONS

Located in the Atlantic Maritime ecozone of Canada, the Project site is characterized by a generally moderate climate, with an average of 25 °C between the coldest and warmest months of the year. This moderate climate produces precipitation in excess of 1,400 mm per year on average, and less than 50% of this precipitation falls as snow in any month. As a result, streamflow is generally maintained throughout the winter months and is lowest during the warmer summer months. Total annual runoff, as estimated from regional streamflow gauges, is approximately 1,000 mm per year.

Surface water discharge and water levels are currently being monitored at the Project site, and the collected information for 2018 and 2019 reflects the wet shoulder seasons and dry summer conditions. Ongoing hydrological monitoring will continue to refine the seasonal, annual (temporal), and catchment (spatial) variability in surface water quantity at the Project site.

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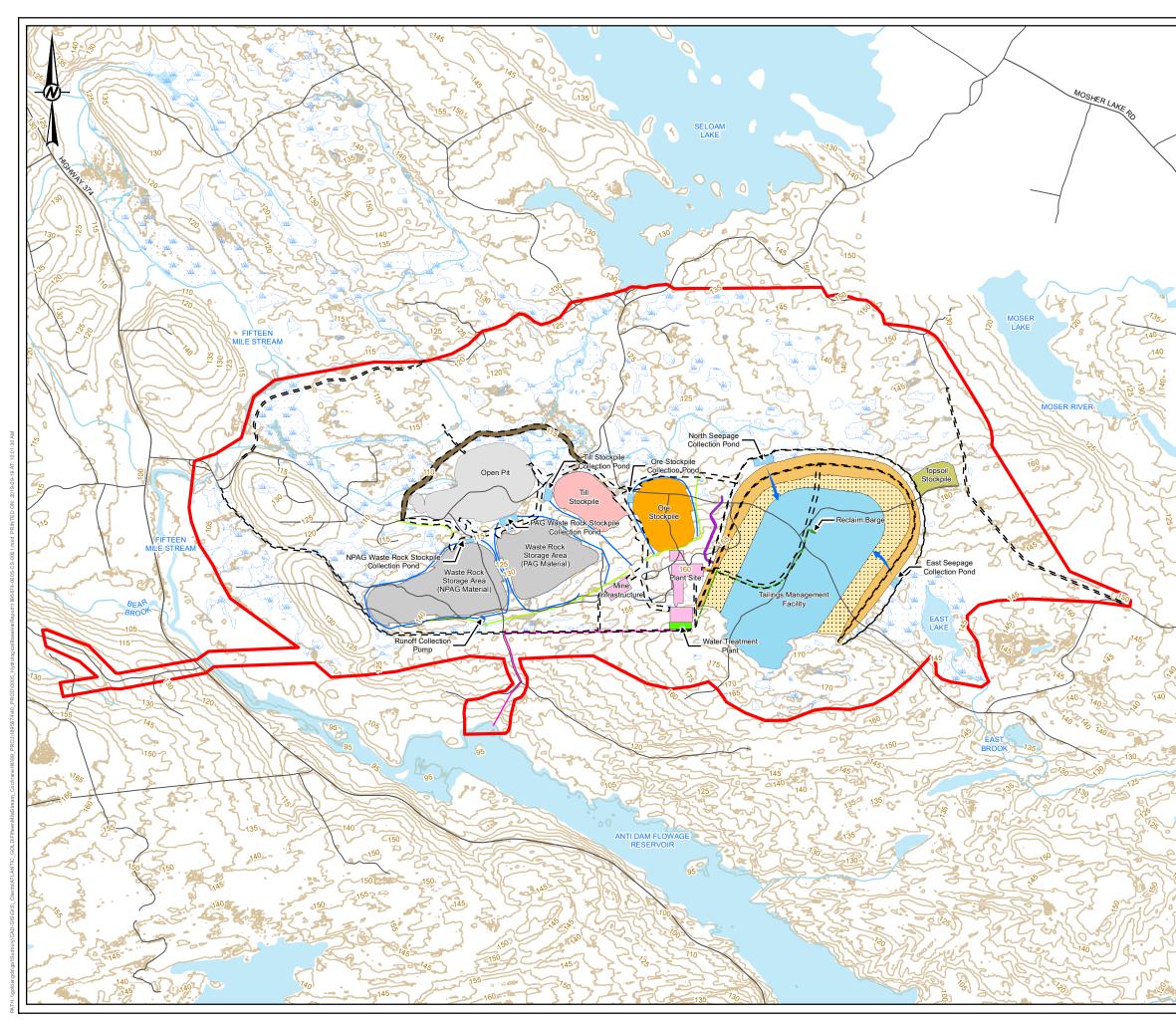
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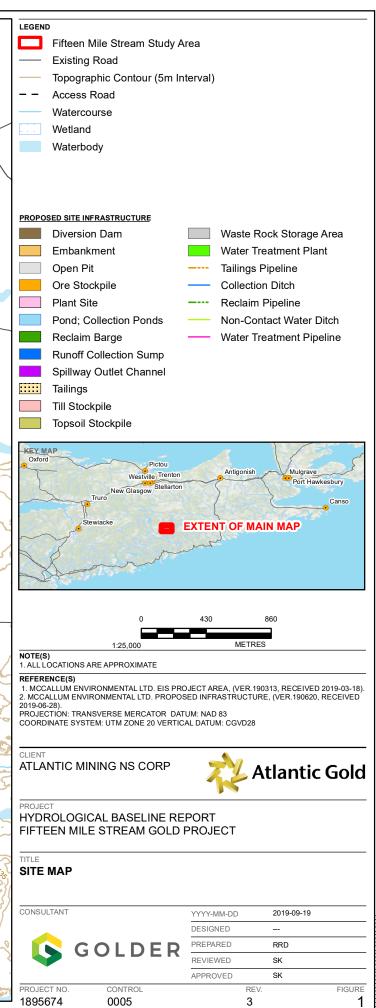
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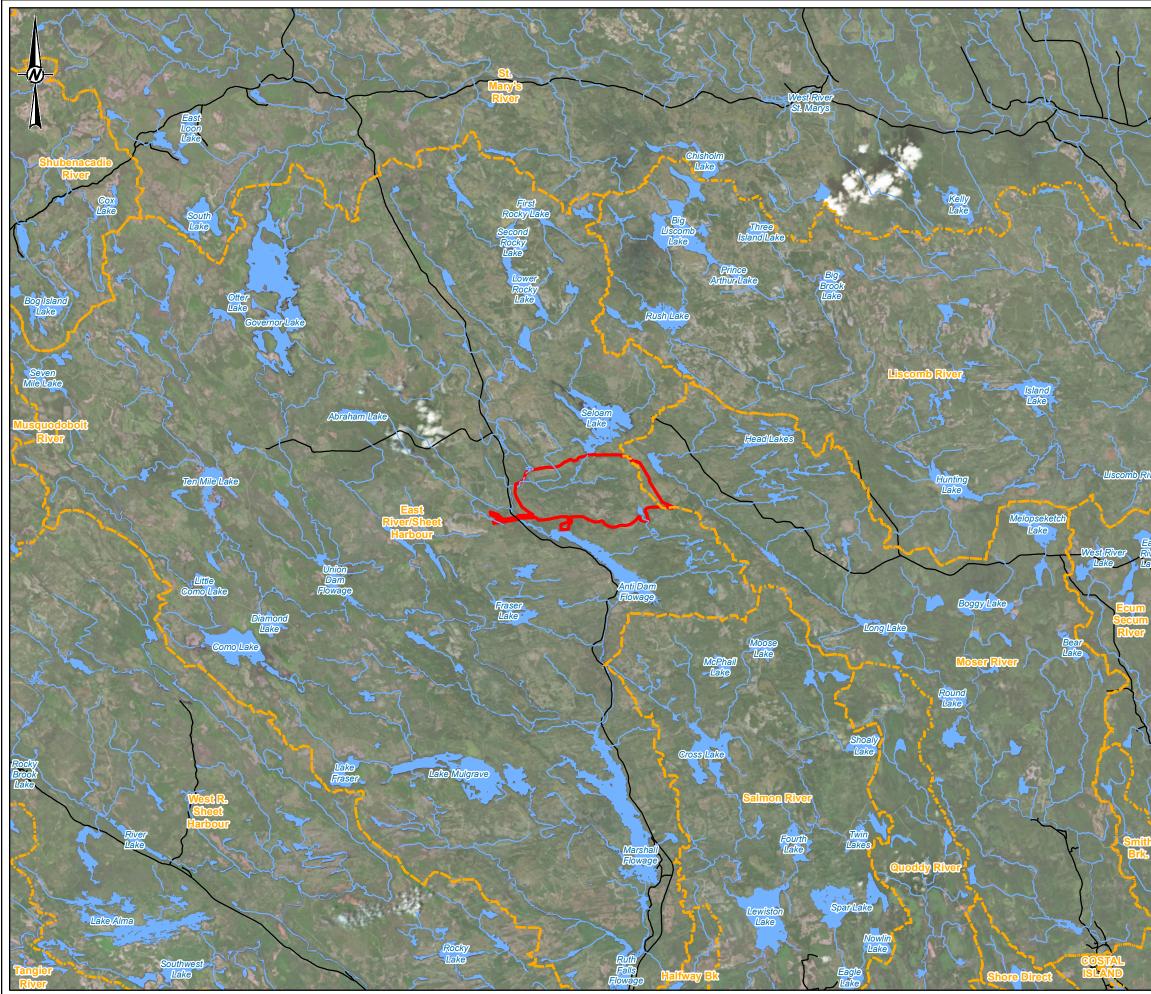
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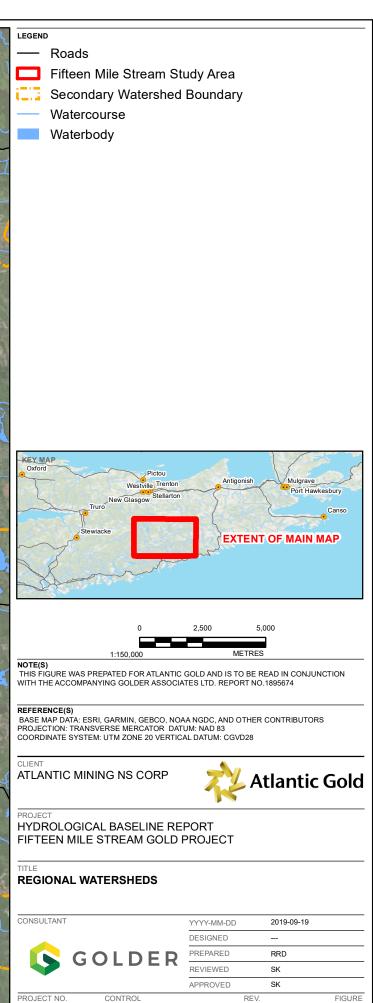
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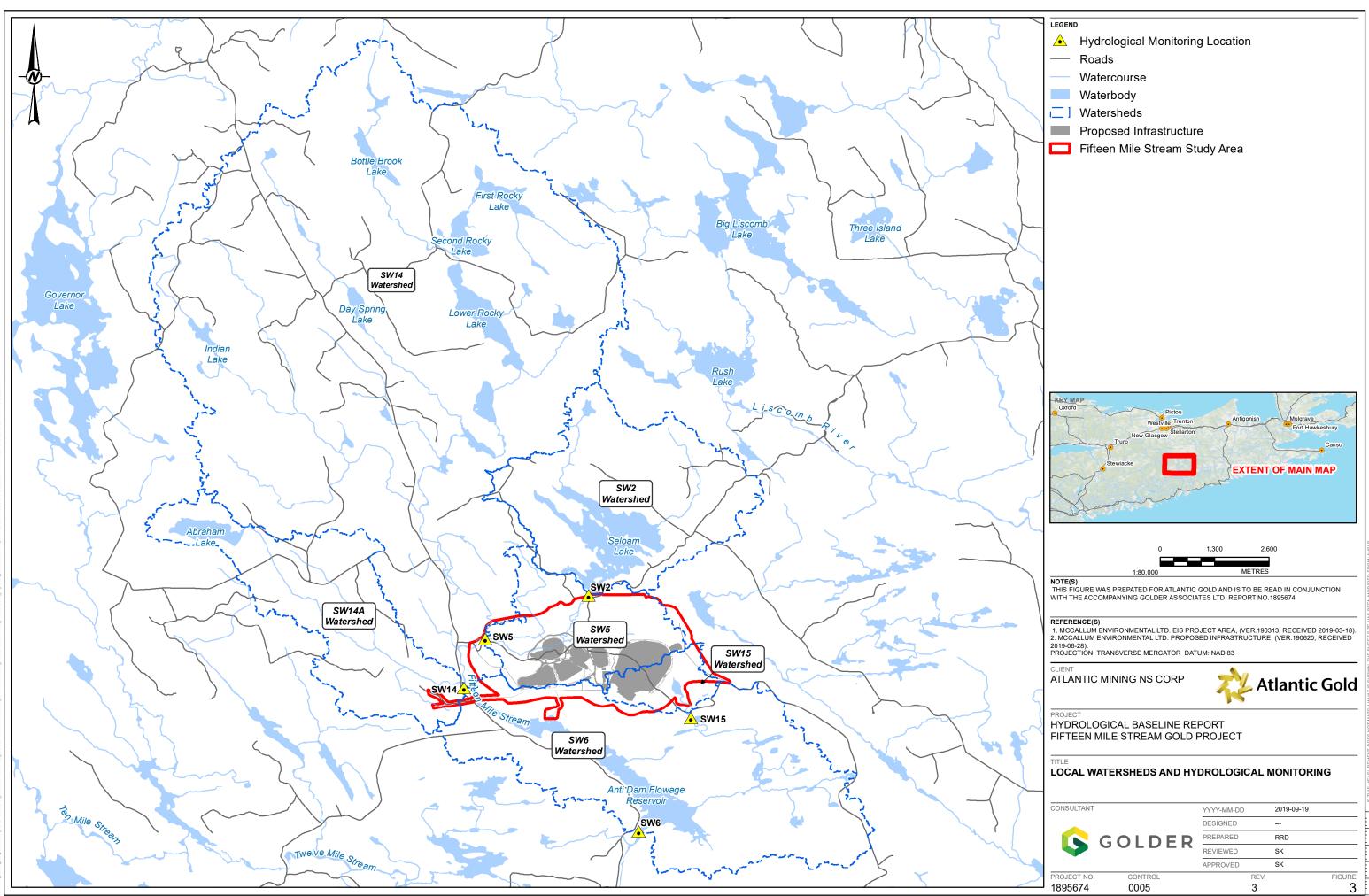




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