Baffinland Iron Mines Corporation
Mary River Expansion Project

Borrow Source Investigation Factual Data Report

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2019-04-26	0	Approved for Use	M. Yang	W. Hoyle	F. van Biljon	F. Pittman
Date	**Rev.**	**Status**	**Prepared By**	**Checked By**	**Approved By**	**Approved By**
HATCH						**Client**

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To: [Hatch Ltd.] [***confirm entity***] (together with its affiliates, the "Consultant")

Re: Draft Report for [***insert description of report***] (and together with any subsequent revisions thereof, the "**Report**") dated [***insert date***] prepared by the Consultant for [***insert name of client***] (the "**Client**"), in respect of the [***insert description of project***].

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Dated: [***insert current date***]

[INSERT NAME OF REPORT RECIPIENT]

By:____

Name:

Title:

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1. Introduction

Baffinland Iron Mines Corporation (BIM) currently operates the Mary River iron ore mine in Nunavut, Canada. BIM plans to increase the production to 12 Mtpa, shipping the output through Milne Port. This will be achieved by upgrading the mine fleet, constructing an approximately 110 km long rail line from the mine site to the port, building a new crushing and screening facility at the port, constructing larger ore stockpiles and building a second ore dock for ship loading.

Hatch Ltd. (Hatch) was retained by BIM to design a railway alignment spanning from Milne Port to the Mary River Mine Site. As part of this project, a borrow source assessment program was carried out to determine the suitability of identified potential quarry locations as sources of rockfill and ballast for the Rail alignment. The sampling of potential quarry locations was divided into two phases (Phase 1 included sampling locations near the Tote Road, while Phase 2 comprised of potential quarry borrow sources along the rail Deviation area.

This report presents results from both Phase 1 and 2 of the borrow source assessment program. The visual observations, laboratory testing and physical property testing results are detailed in the following sections.

1.1 Local Topology and Geology

The approximately 110 km Tote Road runs parallel to the proposed rail line. The Tote Road begins at Milne Port and passes through approximately 20 km of Precambrian bedrock terrain, glacial fluvial sand and gravel terraces. For the next 60 km the Tote Road spans across relatively flat lying ground comprised of fine grained glacial till veneer overlying Paleozoic rocks, mainly dolomitic limestone units. The final stretch of the Tote Road, as it approaches the Milne Site, traverses glaciolacustrine and glaciofluvial plains, terraces, eskers and bedrock outcrops ranging from granitic gneiss to sedimentary rocks.

2. Quarry Sampling Program

2.1 General

The sampling of potential quarry locations was carried out by Hatch field staff. This sampling program was divided into two phases. Phase 1 was executed in October 2018, during which quarry samples were collected from locations along the Tote Road, while Phase 2 was completed in May 2019 with a focus on collecting samples from locations identified in the Deviation area.

A total of 16 of 29 potential quarry locations were sampled as part of Phase 1 of the sample collection process. Phase 2 comprised 5 potential quarry locations in the Deviation area, of which 2 were sampled. An additional 4 samples were able to be collected from the potential quarry locations originally identified in Phase 1. The other potential locations could not be sampled for reasons outlined later in this report. The rock samples from these quarry locations were tested to provide information on the mineralogical, chemical, physical and strength properties of the rock.

The focus of this report is to detail the results of the tests performed on the quarry samples and to summarize the findings.

2.2 Quarry Sampling Locations

A summary of potential quarries and the sampling locations are shown in Table 2-1. All coordinates are located within Zone 17 of the Transverse Mercator (UTM) Grid. The coordinates were recorded using a hand-held GPS unit. The horizontal datum for this project is the North American Datum 1983 (NAD 83). Further details on the potential quarry and sampling locations are shown in the Borrow Source Assessment Location Plan in Appendix A.

Table 2-1: Potential Quarry Sampling Locations 1

Quarry Number	Easting (m)	Northing (m)	Elevation (m)
Q1	504087	7975305	28.7
Q5	505934	7972277	83.2
Q4	507467	7970570	293.6
Q6	507838	7969986	31.4
Q10	510645	7967479	99.3
Q11	513663	7966247	91
Q13	542481	7923789	217
PQ2B	517445	7962002	113.8
PQ2A	N/A	N/A	N/A
Q16	521793	7952516	48.5
Q19	523043	7945110	149.5
PQ4A	523600	7942909	185
PQ4B	523505	7941976	184.4
PQ5A	525289	7938702	199.8
PQ5B	525723	7937982	202
Q24	527045	7934268	148.39
PQ6A	528576	7929593	169
PQ6B	528798	7929044	185
PQ12A	539277	7921138	173
PQ12B	539912	7921427	157
PQ13	542481	7923782	195.5
PQ14A	550889	7917740	101.9
PQ14B	551082	7917411	156.2
PQ15B	555185	7915620	226.2
PQ15A	555849	7915556	218
QMR2	560022	7914204	178.4
Q42	561573	7912671	162.5
Q27	527226	7923273	122.3
PQ9A	527238	7920330	260.8
PQ9B	527706	7920404	198.3
PQ10A	531544	7917602	203.7
PQ10B	527226	7923273	206.2

2.3 Sampling Methodology

Potential quarry locations were sampled using hand held tools including; a 15-pound sledge hammer, a shovel, a pickaxe and five-gallon plastic buckets. The process of obtaining the samples involved removing surface snow with the shovel, breaking up the rock and soil with either the 15-pound sledge hammer or the pick-axe and transferring the rock into the five-gallon bucket. Figure 2-1 shows the process used to break the frozen rock.

Figure 2-1: Potential Quarry Sampling Method

Other major equipment used in this sampling investigation included snowmobiles and a Prinoth track vehicle for transportation. Figure 2-2 shows the samples after being stored in the five gallon buckets. Figure 2-3 shows the snowmobile and Prinoth used to collect and transport samples that were collected from the potential quarries locations.

Figure 2-2: Samples Packaged for Transportation

Figure 2-3: Off-Road Transport

2.4 Sampling Constraints

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Difficulties were encountered during the sampling process that prevented the collection of samples from some potential quarry locations. Eleven of the potential locations could not be sampled due to the hardness of the ground preventing sample collection using the equipment available. One potential location was not sampled due to accessibility issues, as the distance prevented foot travel, and the lack of adequate snow depth prevented the use of snowmobiles. Currently, preliminary plans are being made to sample from the potential borrow source location (PQ2A) that was skipped due accessibility issues in a future program expected in the summer of 2020 when foot travel is possible. The sampling status of all identified potential quarry locations are shown in Table 2-2. It should be noted while certain quarry sampling locations contained granular material, there is potential for bedrock underneath the surficial granular material. However it was not possible to determine if there was shallow-covered bedrock present in these locations using the available sampling tools. During the borrow source development program, the aforementioned quarry sampling locations containing/with surficial granular materials may be further investigated using equipment capable of exposing the subsurface conditions (excavator). If bedrock is found during the abovementioned borrow source development program, laboratory testing to determine its suitability as a borrow source should follow the criteria outlined in this report. Photographs of select quarry sampling locations are provided in Appendix I.

Table 2-2: Quarry Sampling Status

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Quarry ID	Quarry Sample Status (m)	Phase
Q1	Sampled (rock)	1
Q5	Sampled (rock)	
Q4	Sampled - granular material	
Q6	Not sampled - hard ground, granular material	
Q10	Sampled - granular material	
Q11	Sampled - granular material	
Q13	Not sampled – hard ground, granular material	
Q16	Not sampled - hard ground, granular material	
Q19	Not sampled - hard ground, granular material	
PQ4B	Sampled (rock)	
PQ5B	Sampled (rock)	
Q24	Sampled (rock)	
PQ6A	Not sampled - hard ground, granular material	
PQ6B	Sampled (rock)	
PQ12A	Sampled (rock)	
PQ12B	Not sampled - hard ground, granular material	
PQ13	Sampled (rock)	
PQ14A	Not sampled - hard ground, granular material	
PQ14B	Not sampled - hard ground, granular material	
PQ15B	Sampled (rock)	
PQ15A	Sampled (rock)	
QMR2	Sampled (rock)	
Q42	Not sampled - hard ground, granular material	
PQ2B	Sampled - granular material	2
PQ2A	Not sampled - accessibility issues	
PQ4A	Sampled (rock)	
PQ5A	Sampled (rock)	
Q27	Sampled - granular material	
PQ9A	Sampled (rock)	

Quarry ID	Quarry Sample Status (m)	Phase
PQ9B	Sampled (rock)	
PQ10A	Not sampled - hard ground, granular material	
PQ10B	Not sampled - hard ground, granular material	

2.5 Safety Management Plan

Safety management was a key consideration during the planning process of the geotechnical investigations. A Job Hazard Analysis (JHA) was developed by Hatch and BIM and reviewed by Marlon Coakley (Hatch site manager), Bruno Lavallee (labourer) and Darren Gardiner (Hatch health and safety representative). This JHA was reviewed periodically and updated according to the work activities. A copy of both the final JHA and the notification procedure is presented in Appendix D.

2.6 Laboratory Testing

2.6.1 Rock Testing

The quarry samples were shipped to the Hatch geotechnical laboratory in Niagara Falls for sample processing and point load testing. SGS was contracted by Hatch to crush and perform the following analyses on the rock samples:

- Mineral identification by X-Ray Diffraction (Rietveld method)
- Four-Acid Digestion/Total Metals by ICP-MS
- Acid Base Accounting
- Leachable Metals by Shake Flask Extraction (SFE).

Rock samples from quarry locations Q1 and QMR2 were sent to Wood Environment and Infrastructure Solutions (Wood) to test the physical properties of these samples. Laboratory testing was conducted only on the rock samples for evaluation purposes; testing of granular materials is outside the scope of this report. A summary of the analyses performed on the samples is shown in Table 2-3. Laboratory Certificates of Analysis are presented in Appendix E.

Table 2-3: Sample Testing Summary

Sample ID	Tests Performed									
	Point Load	Mineral identification by X-Ray Diffraction (Rietveld method)	Acid Base Accounting	Four-Acid Digestion/Total Metals by ICP-MS	Leachable Metals by Shake Flask Extraction (SFE)	Sieve Analysis of Fine and Coarse Aggregates	Soundness of Aggregates by use of Magnesium Sulphate	Bulk Density and Voids in Aggregate	Relative Density and Absorption of Coarse Aggregates	Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
Q1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Q5	✓	✓	✓	✓	✓					
PQ4A	✓	✓	✓	✓	✓					
PQ4B	✓	✓	✓	✓	✓					
PQ5A	✓	✓	✓	✓	✓					
PQ5B	✓	✓	✓	✓	✓					
Q24	✓	✓	✓	✓	✓					
PQ6B	✓	✓	✓	✓	✓					
PQ12A	✓	✓	✓	✓	✓					
PQ13	✓	✓	✓	✓	✓					
PQ15B	✓	✓	✓	✓	✓					
PQ15A	✓	✓	✓	✓	✓					
QMR2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PQ9A	✓	✓	✓	✓	✓					
PQ9B	✓	✓	✓	✓	✓					

3. Quarry Sampling Program Test Results

This section provides a brief summary of potential quarry sample test results for Phase 1 and Phase 2 of the geotechnical investigation. Detailed sample testing results can be found in Appendix B. 1

3.1 X-Ray Diffraction (Rietveld Method)

SGS was contracted to perform mineral identification of the quarry samples using the Rietveld Method of mineral Identification. The mineral identification was done by matching the diffraction patterns of unknown material to the patterns of single-phase reference material. The reference diffraction patterns used in the test were compiled by the Joint Committee on Powder Diffraction Standards – International Center for Diffraction Data. The analysis was performed to determine the amount of sulphide minerals in the rock, as sulphides are acid rock drainage producers. The amount of carbonate minerals was also considered, as they are an acid neutralizer. The mineralogy of the quarry samples based on the x-ray diffraction test are shown in Table 3-1.

Table 3-1: X-Ray Diffraction Results

Mineral/Compound	Quarry ID														
	Q1	Q5	Q24	QMR2	PQ4A	PQ4B	PQ5A	PQ5B	PQ6B	PQ12A	PQ13	PQ15A	PQ15B	PQ9A	PQ9B
Quartz (wt %)	29.7	30.7	1.1	65.8	0.9	1.1	1.2	0.5	0.8	1.7	41.4	26.1	34.8	2.6	2.0
Albite (wt %)	40.6	32.7	-	12.3	-	-	-	-	-	-	11.4	28.7	18.9	-	-
Muscovite (wt %)	3.1	4.9	-	6.7	0.6	0	1.0	-	-	-	5.5	8.4	10.4	0.6	0.8
Biotite (wt %)	1.3	2.5	-	3.7	-	-	-	-	-	-	0.7	8.9	4.6	-	-
Chlorite (wt %)	1.5	2.7	-	1.2	-	-	-	-	-	-	2.4	0.2	0	-	-
Magnetite (wt %)	0.6	0.3	-	0.3	-	-	-	0.4	0.4	-	0.8	1.1	0.6	-	-
Microcline (wt %)	23.2	23.3	-	9.9	-	-	-	-	-	-	36.9	24.1	29.8	-	-
Hematite (wt %)	-	0.9	-	0.1	-	-	-	0.1	0.2	0.8	-	-	-	-	-
Diopside (wt %)	-	1.3	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepidocrocite (wt %)	-	0.6	-	-	-	-	-	-	-	-	-	0.8	-	-	-
Calcite (wt %)	-	-	90.6	-	98.5	98.7	96.9	86.6	80.6	0.1	0.6	1.1	0.4	83.0	89.5
Ankerite (wt %)	-	-	5.2	-	-	-	0.3	12.3	5.1	-	0.1	0.6	0.3	1.6	3.0
Dolomite (wt %)	-	-	3.1	-	-	0.2	0.6	-	12.9	91.5	0.2	0.1	0.2	12.4	4.7
Sanidine (wt %)	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-

3.2 Acid Base Accounting

SGS was contracted to perform Acid Base Accounting tests to determine the acid generating potential of the quarry rock samples. The tested parameters and corresponding test method codes are shown in Table 3-2.

Table 3-2: Acid Base Accounting Parameters Tested

Parameter Tested	Reference Method Code
Acid Potential	MEND PROJECT 1.16.1B
Carbon/Sulphur	ASTM E1915-07A
Neutralization Potential	MEND PROJECT 1.16.1B
Paste pH	ARD Prediction Manual, 2009

The Acid Base Accounting analysis included measurements of sulphur species, carbon, carbonate, paste pH, Acid Generation Potential (AP), Neutralization Potential (NP), Neutralization Potential Ratio (NPR = NP/AP),the Net Neutralization Potential (NNP = NP-AP) and Fizz rate. A summary of the acid base accounting results for each quarry sample is presented in Table 3-3. 1

Table 3-3: Acid Base Accounting Results

Quarry ID	AP	NP	Paste pH	Fizz Rate	Neutralization Potential Ratio	Net Neutralization Potential (tonnes/ $CaCO^3$ 1000 tonnes)	Total Sulphur (%)	Sulphide Sulphur (%)
Q1	0.62	12	9.74	1	18.5	10.9	< 0.005	< 0.02
Q5	0.62	12	9.25	1	18.9	11.1	0.006	< 0.02
Q24	0.62	975	8.19	4	1561	975	0.02	0.02
QMR2	0.62	4.3	9.53	1	6.94	3.68	0.005	< 0.02
PQ4A	0.62	942	8.15	4	1520	942	0.023	< 0.02
PQ4B	0.62	958	8.19	4	1546	958	< 0.005	< 0.02
PQ5A	0.62	920	8.19	4	1484	919	0.011	< 0.02
PQ5B	0.62	1185	8.27	4	1911	1184	0.006	< 0.02
PQ6B	0.62	1135	8.18	4	1831	1134	< 0.005	< 0.02
PQ12A	1.25	870	8.81	4	696	868	0.032	0.04
PQ13	0.62	5.4	9.14	1	8.71	4.78	< 0.005	< 0.02
PQ15A	0.62	4.8	9.28	1	7.74	4.18	< 0.005	< 0.02
PQ15B	0.62	5.6	9.13	1	9.03	4.98	< 0.005	< 0.02
PQ9A	0.62	960	8.00	4	1549	960	0.012	< 0.02
PQ9B	0.62	945	7.95	4	1525	945	0.010	< 0.02

A guideline for interpreting Acid Rock Drainage results developed by BC Ministry of Energy of Mines (Price 1997), was used as a screening criteria for the Neutralization Potential Ratio (NPR) and a reference for how NPR values affect the likelihood of Acid Rock Drainage (ARD). The criteria used to interpret the results for the quarry samples are shown in Table 3-4. 1

Table 3-4: Neutralization Potential Ratio (NPR) Reference Criteria

Potential for ARD	Initial Screening Criteria	Comments
Likely	NPR < 1	Likely ARD-generating unless sulphide minerals are non-reactive.
Possible	1 < NPR < 2	Possibly ARD-generating if NP is insufficiently reactive or is depleted at a faster rate than sulphides.
Low	2 < NPR < 4	Not potentially ARD-generating unless there is significant preferential exposure of sulphides along fracture planes or extremely reactive sulphides in combination with an insufficiently reactive NP.
None	NPR > 4	

3.3 Four-Acid Digestion/Total Metals by ICP-MS

SGS was contracted by Hatch Ltd. to test the concentration of metals in the quarry rock samples. The tested parameter and corresponding method code is shown in Table 3-5.

Table 3-5: Four-Acid Digestion/Total Metals by ICP-MS Parameters Tested

Parameter Tested	Reference Method Code
Metals – Microwave ICP-MS	EPA 3052/200.8

Total metal results were compared to the average continental crustal abundances of each element (Price 1997). Element concentrations were considered enriched if the concentration was greater than ten times the average crustal abundance (Price 1997).

Table 3-6 shows a summary of the results from the four acid total metals test. The average continental crustal abundance of the tested elements can be found in Appendix G.

Table 3-6: Four-Acid Digestion/Total Metals by ICP-MS Results

Parameter				Quarry Sample ID										
	Q1	Q5	Q24	QMR2	PQ4A	PQ4B	PQ5A	PQ5B	PQ6B	PQ12A	PQ13	PQ15A	PQ15B	PQ9A	PQ9B
Silver (µg/g)	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Aluminum (µg/g)	76000	76000	3000	39000	2600	3700	3500	2900	3000	9000	57000	86000	69000	4000	3500
Arsenic (µg/g)	1.1	0.6	< 0.5	0.6	2.6	0.6	0.80	< 0.5	< 0.5	2	1.9	0.9	0.9	1.5	0.84
Barium (µg/g)	750	650	13	150	9.3	14	16	12	12	51	270	1200	1900	18	12
Beryllium (µg/g)	1.8	2.3	0.11	1.6	0.074	0.11	0.11	0.11	0.11	0.25	2	1.9	1.2	0.11	0.10
Bismuth (µg/g)	< 0.09	< 0.09	< 0.09	< 0.09	0.12	< 0.09	< 0.09	< 0.09	< 0.09	0.09	0.33	< 0.09	0.09	< 0.09	< 0.09
Calcium (µg/g)	9200	7000	360000	3700	350000	380000	360000	370000	340000	200000	1800	8500	4300	320000	360000
Cadmium (µg/g)	0.03	0.03	< 0.02	0.03	0.087	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.03	0.05	0.07	0.036	0.023
Cobalt (µg/g)	2.4	4.1	0.57	2	0.7	0.66	0.69	0.5	0.52	2.7	1.7	7	3.2	0.83	0.67
Chromium (µg/g)	92	80	4.8	99	2.2	3.3	2.5	2.1	2.3	4.6	98	83	75	3.0	2.6
Copper (µg/g)	2.7	6.4	0.9	4.2	7.3	1.2	1.6	1.1	1.2	6.2	3.4	3.2	3.5	2.7	2.6
Iron (µg/g)	11000	16000	2100	10000	2400	2600	3000	2000	2300	5300	14000	28000	17000	2800	2300
Potassium (µg/g)	33000	34000	1800	20000	1600	2300	2000	1700	1900	9900	53000	41000	47000	3100	2000
Lithium (µg/g)	28	31	5	10	4.1	6	5.4	5	5	27	28	28	19	6.6	8.1
Magnesium (µg/g)	3700	7200	14000	4800	4600	5000	5200	17000	25000	120000	5500	9800	6400	18000	13000
Manganese (µg/g)	230	230	72	190	91	110	140	70	68	150	130	520	240	69	130
Molybdenum (µg/g)	6.2	6.7	0.5	11	< 0.1	0.2	< 0.1	0.1	0.2	0.8	8.3	6.4	7.8	0.18	0.12
Sodium (µg/g)	33000	28000	220	9500	140	210	140	220	220	390	10000	30000	16000	150	150
Nickel (µg/g)	25	9.6	3.8	8.5	3.1	4	4.1	3.3	3	4.6	5.1	17	5.9	3.9	3.7
Phosphorus (µg/g)	110	280	64	85	34	110	48	40	38	130	58	400	240	76	25
Lead (µg/g)	52	24	0.91	8.8	10	1.4	2.1	0.95	0.75	4.8	22	20	28	3.1	3.4
Antimony (µg/g)	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8
Selenium (µg/g)	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7
Tin (µg/g)	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6
Strontium (µg/g)	250	170	310	27	270	290	280	390	350	67	28	160	98	210	270
Titanium (µg/g)	700	1300	170	660	170	210	220	160	160	330	660	1800	1400	230	190
Thallium (µg/g)	0.65	0.48	0.06	0.28	0.042	0.03	0.032	0.03	< 0.02	0.18	0.92	0.72	0.5	0.043	0.064
Uranium (µg/g)	3.1	2.4	0.42	2.7	0.40	0.47	0.47	0.37	0.42	1	5.2	1.9	2.2	0.52	0.49
Vanadium (µg/g)	8	21	4	11	3.9	5	4.8	5	4	12	5	27	15	4.9	4.2
Yttrium (µg/g)	5.4	5.5	1.9	7.9	2.0	2.6	2.1	1.4	1.5	3.3	11	7.1	6.4	1.6	1.5
Zinc (µg/g)	26	35	2.8	21	37	3.2	6.6	3.5	2.7	3.8	17	59	39	14	11

3.4 Shake Flask Extraction (SFE)

Shake flask extraction tests were performed on the quarry rock samples to determine the presence of potentially leachable metals. Shake flask extraction tests provide a screening assessment of the potential for metal leaching and are not intended to simulate site-specific conditions. The tested parameters and corresponding method codes that were part of the Shake Flask Extraction test are shown in Table 3-7.

Table 3-7: Shake Flask Extraction (SFE) Parameters Tested

Parameter Tested	Reference Method Code
Alkalinity	SM 2320
Anions by discrete analyzer	US EPA 325.2
Anions by discrete analyzer	US EPA 375.4
Conductivity	SM 2510
Mercury by CVAAS	EPA 7471A/SM 3112B
Metals in aqueous samples – ICP-MS	SM 3030/EPA 200.8
pH	SM 4500

The results of the shake flask extraction test were compared to the Canadian Water Quality Guidelines for the Protection of Aquatic Life (Canadian Council of Ministers of the Environment 2018), specifically the guidelines for long term freshwater, and the Metal and Diamond Mining Effluent Regulations for the Maximum Authorized Concentration in a Composite Sample (MMER 2019). The guidelines will be used as a screening tool to identify parameters of interest when assessing final discharge to receiving water bodies, and can be found in Appendix H. The results of the shake flask extraction test are summarized in Table 3-8.

Table 3-8: Shake Flask Extraction Results

Parameter	Analysis														
	Q1	Q5	Q24	QMR2	PQ4A	PQ4B	PQ5A	PQ5B	PQ6B	PQ12A	PQ13	PQ15A	PQ15B	PQ9A	PQ9B
Sample weight (g)	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
Volume D.I. Water (mL)	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750
Final pH	9.40	8.92	8.80	9.06	9.15	8.79	9.22	9.34	9.21	8.34	8.17	8.61	8.35	9.1	9.23
pH	9.16	8.01	8.47	9.03	8.43	8.44	8.35	8.34	8.51	9.32	7.97	7.78	7.51	8.5	8.68
Alkalinity (mg/L as CaCO3)	28	32	28	37	25	26	26	26	29	88	39	22	46	32	29
Conductivity (uS/cm)	68	79	106	126	77	81	75	81	100	272	90	50	109	118	86
Chloride (mg/L)	3	4	11	4	6	8	6	7	9	35	2	1	2	15	7
Sulphate (mg/L)	2	< 2	6	< 2	2	< 2	< 2	< 2	< 2	3	< 2	< 2	< 2	2	2
Mercury (mg/L)	0.00001	0.00001	0.00001	0.00018	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00002	< 0.00001	< 0.00001
Silver (mg/L)	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Aluminum (mg/L)	0.771	0.420	0.196	0.445	0.266	0.235	0.254	0.149	0.128	0.026	0.448	1.06	0.389	0.184	0.122
Arsenic (mg/L)	0.0011	0.0003	< 0.0002	0.0013	< 0.0002	< 0.0002	0.0002	< 0.0002	0.0004	0.0010	0.0016	0.0010	0.0005	0.0002	< 0.0002
Barium (mg/L)	0.00454	0.00277	0.00151	0.00193	0.00202	0.00075	0.00211	0.00074	0.00080	0.00269	0.00194	0.00801	0.00920	0.00192	0.00265
Boron (mg/L)	0.009	0.022	0.085	0.026	0.053	0.047	0.044	0.059	0.078	0.071	0.033	0.041	0.035	0.156	0.303
Beryllium (mg/L)	0.000008	0.000017	< 0.000007	0.000012	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	0.000034	0.000020	0.000015	< 0.000007	< 0.000007
Bismuth (mg/L)	< 0.000007	0.000010	< 0.000007	< 0.000007	< 0.000007	0.000032	< 0.000007	0.000020	0.000051	< 0.000007	0.000027	< 0.000007	0.000012	< 0.000007	< 0.000007
Calcium (mg/L)	3.33	4.37	11.2	3.84	9.13	10.5	9.70	7.92	8.69	9.20	4.98	0.21	7.25	11.3	8.47
Cadmium (mg/L)	0.000003	0.000003	0.000009	0.000009	< 0.000003	0.000003	< 0.000003	0.000003	0.000021	0.000004	0.000007	0.000007	0.000003	< 0.000003	< 0.000003
Cobalt (mg/L)	0.000044	0.000034	< 0.000004	0.000069	0.000021	0.000007	0.000016	0.000109	0.000015	0.000052	0.000055	0.000099	0.000202	0.000059	0.000009
Chromium (mg/L)	0.00017	0.00015	0.00022	0.00007	0.00038	0.00035	0.00037	0.00023	0.00110	0.00011	0.00004	0.00023	0.00006	0.00017	0.00021
Copper (mg/L)	0.00038	0.00637	0.00876	0.00048	0.0003	0.00091	0.0003	0.00041	0.00097	0.00110	0.00198	0.00299	0.01076	0.0003	< 0.0002

Parameter	Analysis														
	Q1	Q5	Q24	QMR2	PQ4A	PQ4B	PQ5A	PQ5B	PQ6B	PQ12A	PQ13	PQ15A	PQ15B	PQ9A	PQ9B
Iron (mg/L)	0.105	0.079	0.008	0.061	< 0.007	< 0.007	< 0.007	< 0.007	0.016	0.007	0.190	0.353	0.139	< 0.007	< 0.007
Potassium (mg/L)	7.36	6.41	1.96	15.4	1.75	2.14	1.80	1.35	1.49	6.58	13.4	10.3	16.9	2.40	1.55
Lithium (mg/L)	0.0126	0.0047	0.0042	0.0061	0.0031	0.0038	0.0030	0.0024	0.0030	0.0239	0.0035	0.0019	0.0013	0.0055	0.0059
Magnesium (mg/L)	0.496	1.29	4.08	1.14	1.41	1.62	1.54	3.33	4.36	22.1	1.84	0.236	1.16	5.07	3.14
Manganese (mg/L)	0.00320	0.00137	0.00002	0.00147	0.00007	0.00002	0.00003	< 0.00001	0.00005	0.00007	0.00192	0.00610	0.00740	0.00011	0.00015
Molybdenum (mg/L)	0.00039	0.00174	0.00111	0.00345	0.00033	0.00156	0.00034	0.00052	0.00230	0.00301	0.00068	0.00095	0.00198	0.00056	0.00036
Sodium (mg/L)	5.96	6.07	1.24	8.84	0.88	0.96	0.89	0.84	1.15	6.10	2.68	4.41	2.57	1.58	1.21
Nickel (mg/L)	0.0001	0.0001	0.0001	0.0001	< 0.0001	0.0001	< 0.0001	0.0001	0.0001	0.0004	0.0001	0.0002	0.0001	0.0004	< 0.0001
Lead (mg/L)	0.00079	0.00010	0.00006	0.00022	0.00001	0.00002	0.00001	< 0.00001	< 0.00001	0.00002	0.00018	0.00019	0.00039	0.00001	0.00001
Antimony (mg/L)	0.0004	0.0004	0.0003	0.0004	< 0.0009	0.0003	< 0.0009	0.0003	0.0002	0.0003	0.0005	0.0005	0.0005	< 0.0009	< 0.0009
Selenium (mg/L)	< 0.00004	0.00011	0.00006	0.00049	0.00008	< 0.00004	0.00008	< 0.00004	< 0.00004	0.00009	0.00007	0.00006	0.00010	0.00014	0.00005
Tin (mg/L)	0.00022	0.00015	0.00022	0.00022	< 0.00006	0.00012	< 0.00006	0.00009	0.00051	0.00008	0.00008	0.00040	0.00033	0.00008	< 0.00006
Strontium (mg/L)	0.0153	0.00593	0.129	0.00681	0.110	0.111	0.111	0.111	0.108	0.0498	0.00497	0.00093	0.00928	0.104	0.0905
Titanium (mg/L)	0.00719	0.00332	0.00074	0.00449	< 0.00005	0.00005	0.00014	< 0.00005	0.00048	0.00006	0.00346	0.0189	0.00650	< 0.00005	< 0.00005
Thallium (mg/L)	0.000009	< 0.000005	0.000006	0.000008	< 0.000005	< 0.000005	< 0.000005	0.000005	< 0.000005	0.000171	0.000013	0.000011	< 0.000005	0.000007	0.000023
Uranium (mg/L)	0.00963	0.00121	0.000046	0.00818	0.000042	0.000048	0.000048	0.000022	0.000035	0.000127	0.00250	0.000184	0.00161	0.000071	0.000026
Vanadium (mg/L)	0.00314	0.00370	0.00047	0.00618	0.00084	0.00065	0.00058	0.00049	0.00052	0.00198	0.00045	0.00398	0.00119	0.00054	0.00044
Tungsten (mg/L)	0.00017	0.00024	0.00004	0.00045	0.00006	0.00022	0.00008	0.00022	0.00017	0.00020	0.00074	0.00013	0.00026	0.00011	0.00005
Yttrium (mg/L)	0.000079	0.000110	0.000005	0.000163	< 0.000002	0.000003	0.000003	< 0.000002	0.000005	0.000019	0.000639	0.000139	0.000229	< 0.000002	0.000003
Zinc (mg/L)	0.002	0.002	0.002	0.002	< 0.002	0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002

3.5 Point Load Testing

Point load testing of the quarry samples was completed by Hatch Niagara's geotechnical laboratory to determine the strength properties of the rock samples. The average pressure at break and Uniaxial Compressive Strength values for each quarry sample is show in Table 3-9. See Appendix F for established rock strength criteria used to assign strength terms to quarry samples.

Table 3-9: Point Load Test Results

Quarry Sample ID	Average Pressure at Break (kPa)	Average Uniaxial Compressive Strength (MPa)
PQ6B	14713.3	36.40
PQ15A	14479.4	82.65
Q24	23687.5	32.87
PQ12A	30467	91.43
PQ4A	5688	19.08
PQ4B	13800	45.81
PQ5A	7911	24.65
PQ5B	15467	65.00
QMR2	29427	88.27
Q5	16800	61.49
Q15B	27417	58.43
PQ13	47500	105.26
Q1	31400	81.30
PQ9A	6894	21.71
PQ9B	11885	33.78

3.6 Physical Property Testing of Ballast Aggregate

Wood was contracted by Hatch to perform physical property testing on quarry rock samples Q1 and QMR2 to determine the suitability of these quarries as a source for ballast aggregate. The tests and standards used to determine the physical properties of quarry samples Q1 and QMR2 are shown in Table 3-10.

Table 3-10: Ballast Aggregate Parameters Tested

Parameter Tested	Reference Method Code
Sieve Analysis of Fine and Coarse Aggregates	ASTM C136
Soundness of Aggregates by use of Magnesium Sulphate	ASTM C88
Bulk Density and Voids in Aggregate	ASTM C29
Relative Density and Absorption of Coarse Aggregates	ASTM C127
Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine	ASTM C535

The results of all tests, aside from the sieve analysis, are summarized in Table 3-11, Table 3-12, Table 3-13 and Table 3-14. The results of the composite sieve analysis can be found in Appendix B.

Table 3-11: Weighted Percent Loss of Aggregate after Five Cycles (ASTM C88)

Sample Identification	Sieve Fraction (mm)	Initial Sample Mass (g)	Percent Passing After Test (%)	Weighted Percentage of Mass Loss (%)	
				Per Fraction	Total
QMR2	-37.5+19	1539.6	4.5	2	3
	+37.5*	2019.9	1.6	0.8	
Q1	-37.5+19	1507.5	1.1	0.5	1
	+37.5*	2035.4	0.4	0.2	

*37.5 mm fraction tested only

Table 3-12: Determination of Bulk Density

Sample Identification	Loose Density (kg/m^3)	Jigging Density (kg/m^3)	Voids in Loose Aggregate (%)	Voids in Rodded Aggregate (%)
QMR2	1351	1516	50	44
Q1	1307	1533	50	42

Table 3-13: Determination of Relative Density and Absorption

Sample Identification	Relative Density (Oven-Dry)	Relative Density (Saturated-Surface-Dry)	Absorption (%)
QMR2	2.728	2.740	0.42
Q1	2.630	2.636	0.21

Table 3-14: Determination of Resistance to Degradation using the Los Angeles Testing Machine

Sample Identification	Maximum Aggregate Size (mm)	Grading Designation	Sample Loss (%)
QMR2	37.5	2	21.2
Q1	37.5	2	23.2

4. Summary of Findings

4.1 Acid Generation

The results of the acid base accounting tests were compared with the reference established by the BC Ministry of Energy of Mines (Price 1997). Based on this established reference criteria, all quarry samples had an NPR value of 4 or greater, classifying them as having no potential for acid rock drainage. A summary of the interpretation of findings generated from the acid base accounting test results is shown in Table 4-1.

Table 4-1: Interpretation of Acid Base Accounting Results

Sample ID	Potential for Acid Rock Drainage
Q1	Low to None (NPR > 4)
Q5	Low to None (NPR > 4)
Q24	None (NPR > 4)
QMR2	Low to None (NPR > 4)
PQ4A	None (NPR > 4)
PQ4B	None (NPR > 4)

Sample ID	Potential for Acid Rock Drainage
PQ5A	None (NPR > 4)
PQ5B	None (NPR > 4)
PQ6B	None (NPR > 4)
PQ12A	None (NPR > 4)
PQ13	Low to None (NPR > 4)
PQ15A	Low to None (NPR > 4)
PQ15B	Low to None (NPR > 4)
PQ9A	None (NPR > 4)
PQ9B	None (NPR > 4)

4.2 Four-Acid Digestion/Total Metals by ICP-MS

The results of the four-acid digestion/total metals by ICP-MS test were compared with the average continental crustal abundances of each element (Price 1997). Element concentrations were considered enriched if the concentrations were greater than ten times the average crustal abundance (Price 1997). The concentration of bismuth from sample PQ13 was identified as being significantly higher than the screening value. Table 4-2 shows a summary of total metal concentrations that exceeded the guidelines. Limitations in the accuracy of concentration measurements prevented proper comparison between silver, bismuth (except PQ13) and selenium, as the smallest concentration that could be measured for those elements was similar in value to the screening criteria. A summary of the total metals test results and the average continental crustal abundance of each element can be found in Appendix G.

Table 4-2: Total Metal Results that Exceed Guidelines

Sample ID	Parameter Exceeded	Sample Concentration (µg/g)	10x Average Crustal Abundance Concentration (µg/g)
PQ13	Bismuth	0.33	0.085

4.3 Shake Flask Extraction (SFE)

The results from the shake flask extraction test were compared with the Canadian Water Quality Guidelines for Aquatic Life (Canadian Council of Ministers of the Environment 2018) and the Metal and Diamond Mining Effluent Regulations for the Maximum Authorized Concentration in a Composite Sample (MMER 2019). When the results of the shake flask extraction test were compared with the Metal and Diamond Mining Effluent Regulations for the Maximum Authorized Concentration in a Composite Sample, no samples exceeded the regulatory limits. When the shake flask extraction results were compared with the Canadian Water Quality Guidelines it was found that the concentrations of copper, mercury and aluminium significantly exceeded the guidelines for some rock samples. A summary of each sample that exceeded the guidelines can be found in Table 4-3. A summary of the results from the shake flask extraction test and the referenced guidelines can be found in Appendix H.

Table 4-3: Shake Flask Extraction Results that Exceed Guidelines

Sample ID	Parameter Exceeded	Sample Concentration (mg/L)	Canadian Water Quality Guidelines for Aquatic Life (mg/L)
QMR2	Mercury	0.00018	0.000026
Q1	Aluminum	0.771	0.100
Q5		0.420	
Q24		0.196	
QMR2		0.445	
PQ4A		0.266	
PQ4B		0.235	
PQ5A		0.254	
PQ5B		0.149	
PQ6B		0.128	
PQ13		0.448	
PQ15A		1.06	
PQ15B		0.389	
PQ9A		0.184	
PQ9B		0.122	
Q5	Copper	0.00637	0.002
Q24		0.00876	
PQ15A		0.00299	
PQ15B		0.01076	

4.4 Mineralogy

Using the results from the X-ray diffraction analysis the mineralogy showed no presence of sulphides, the primary acid producer, in any of the samples. The mineralogy of the quarry samples shows carbonate minerals in significant amounts, for samples Q24, PQ4A, PQ4B, PQ5A, PQ5B, PQ6B, PQ9A, PQ9B, and PQ12A. The presence of carbonate minerals provides a natural buffer to acid generation.

Table 4-4 summarizes the presence of acid generating and acid neutralizing minerals, primary mineral identified by XRD analysis, and the bedrock geology in the vicinity of the quarry samples. The bedrock geology interpretation map can be found in Appendix J.

Table 4-4: Summary of Findings from Minerology Results

Sample ID	Minerology			
	Acid Generation Minerals (iron sulfide/sulfides)	Natural Buffer Minerals (Carbonate Minerals)	Primary Minerals Identified by XRD	Bedrock Geology Interpretation
Q1	None Identified	None Identified	Albite, Quartz, Microcline	Undifferentiated Gneiss and Granitic Rocks
Q5	None Identified	None Identified	Albite, Quartz, Microcline	Undifferentiated Gneiss and Granitic Rocks
Q24	None Identified	Significant Amount of Calcite	Calcite	Sedimentary Rock
QMR2	None Identified	None Identified	Quartz, Albite	Veneered Rock; Undulated Rock Covered by a Discontinuous Glacial Fluvial Sand and Gravel
PQ4A	None Identified	Significant Amount of Calcite	Calcite	Sedimentary Rock

Sample ID	Minerology		Primary Minerals Identified by XRD	Bedrock Geology Interpretation
	Acid Generation Minerals (iron sulfide/sulfides)	Natural Buffer Minerals (Carbonate Minerals)		
PQ4B	None Identified	Significant Amount of Calcite	Calcite	Till Veneer; 0.5 – 2 m thick; Discontinuous
PQ5A	None Identified	Significant Amount of Calcite	Calcite	Sedimentary Rock
PQ5B	None Identified	Significant Amount of Calcite	Calcite, Dolomite	Sedimentary Rock
PQ6B	None Identified	Significant Amount of Calcite	Calcite, Dolomite	Sedimentary Rock
PQ12A	None Identified	Significant Amount of Dolomite	Calcite	Sedimentary Rock
PQ13	None Identified	None Identified	Quartz, Microcline	Till Veneer; 0.5 – 2 m thick; Discontinuous
PQ15A	None Identified	None Identified	Albite, Quartz, Microcline	Veneered Rock; Undulated Rock Covered by a Discontinuous Glacial Fluvial Sand and Gravel
PQ15B	None Identified	None Identified	Quartz, Albite, Muscovite	Veneered Rock; Undulated Rock Covered by a Discontinuous Glacial Fluvial Sand and Gravel
PQ9A	None Identified	Significant Amount of Calcite	Calcite, Dolomite	Sedimentary Rock
PQ9B	None Identified	Significant Amount of Calcite	Calcite	Sedimentary Rock

4.5 Strength Parameters

The results of the point load testing and subsequent uniaxial compressive strength calculation for the quarry sample were compared with the established rock strength criteria to classify the quarry samples by uniaxial compressive strength. See Appendix C for established rock strength criteria used to assign strength terms to quarry samples. The classification results of the quarry samples using the uniaxial compressive strength and available reference are shown in Table 4-5.

Table 4-5: Summary of Point Load Test Results

Sample ID	Average Pressure at Break (kPa)	Average Uniaxial Compressive Strength (MPa)	Strength Classification
PQ6B	14923.08	44.99	Medium Strong Rock
PQ15A	27363.64	91.32	Strong Rock
Q24	24416.67	32.13	Medium Strong Rock
PQ12A	28250.00	107.47	Very Strong Rock
PQ4A	5687.50	19.08	Weak Rock
PQ4B	13230.77	56.06	Strong Rock
PQ5A	7911.11	24.65	Weak Rock
PQ5B	15363.64	59.07	Strong Rock
QMR2	31230.77	108.91	Very Strong Rock
Q5	16666.67	73.34	Strong Rock
Q15B	25300.00	69.23	Strong Rock
PQ13	42000.00	122.80	Very Strong Rock
Q1	31250.00	103.92	Very Strong Rock
PQ9A	6894.12	21.71	Weak Rock
PQ9B	11885.00	33.78	Medium Strong Rock

4.6 Railway Ballast Aggregate

The physical property testing results of the rock samples from quarries Q1 and QMR2 were compared with the recommended values for ballast material (American Railway Engineering and Maintenance-of-Way Association, 2013). The recommended limiting values of testing for ballast material can be found in Appendix F. Based on the results of the x-ray diffraction tests shown in, recommended limiting values for granite material were adopted. Table 4-6 shows the test values for quarry samples Q1 and QMR2 relative to the recommended ballast values for granite material. It should be noted the recommended aggregate test values for bulk specific gravity are the minimum values while the rest of the values are the maximum.

Table 4-6: Comparison of Quarry Sample with Recommended Aggregate Ballast Test Values

Tested Properties	ASTM Test	QMR2	Q1	Recommended Ballast Aggregate Test Values for Granite
Percent Passing No.200 Sieve (%)	C 117	0	0	<1
Bulk Specific Gravity	C 127	2.728	2.63	>2.6
Absorption (%)	C 127	0.42	0.21	<1
Sample Loss (%)	C 535	21.2	23.2	<35
Weighted Percentage of Mass Loss for 5 Cycles (%) (Magnesium Sulphate)	C 88	3	1	<5

When the physical property test values for both quarry samples were compared with the recommended ballast aggregate values for granite it was found that both quarry sample Q1 and QMR2 were in accordance with the recommended test values required for ballast aggregate.

5. Current Borrow Source Development Plan and Testing

1

Following the completion of stage 1 of the waste rock analysis currently being undertaken by the Mining Operations, scheduled for completion on 31 December 2019 . The outcomes and recommendations from that analysis will be reviewed against the tests that have been completed for the proposed rail borrow sources and rock quarries. Currently stage 1 testing along the rail corridor has been completed and results have been made available in this report.

The completed current testing as presented in this report on the proposed rail borrow sources and quarries have shown that the sulphur content is at 0.02% or below 0.02%. The project is therefore confident that the rail quarries will likely be able to meet the outcomes from the stage 1 waste rock analysis planned for 31 December 2019 (BIM to confirm this date). However, it is premature to modify the screening criteria for the Railway borrow and rock quarry sources prior to the completion of all of the geochemical tests. The proposed rail quarries will be evaluated against the outcomes and recommendations made from the stage 1 waste rock analysis being undertaken by the Mining Operations. The results from this stage 1 waste rock analysis will be incorporated into the stage 2 project and should a quarry be found to be exceeding the limits from the stage 1 waste rock analysis the quarry would be removed from the proposed rail quarry list. The project quarry management plans would be updated accordingly and the required environmental management plans for dealing with PAG and potential acid leachable rock material would be followed at all times. The quarry management plans and environmental management plans requires the project to review each quarry location and to develop a drainage plan including water diversions and cut-off drains and also requires the project to follow the approved project protocols for addressing PAG material when these materials are found.

6. References

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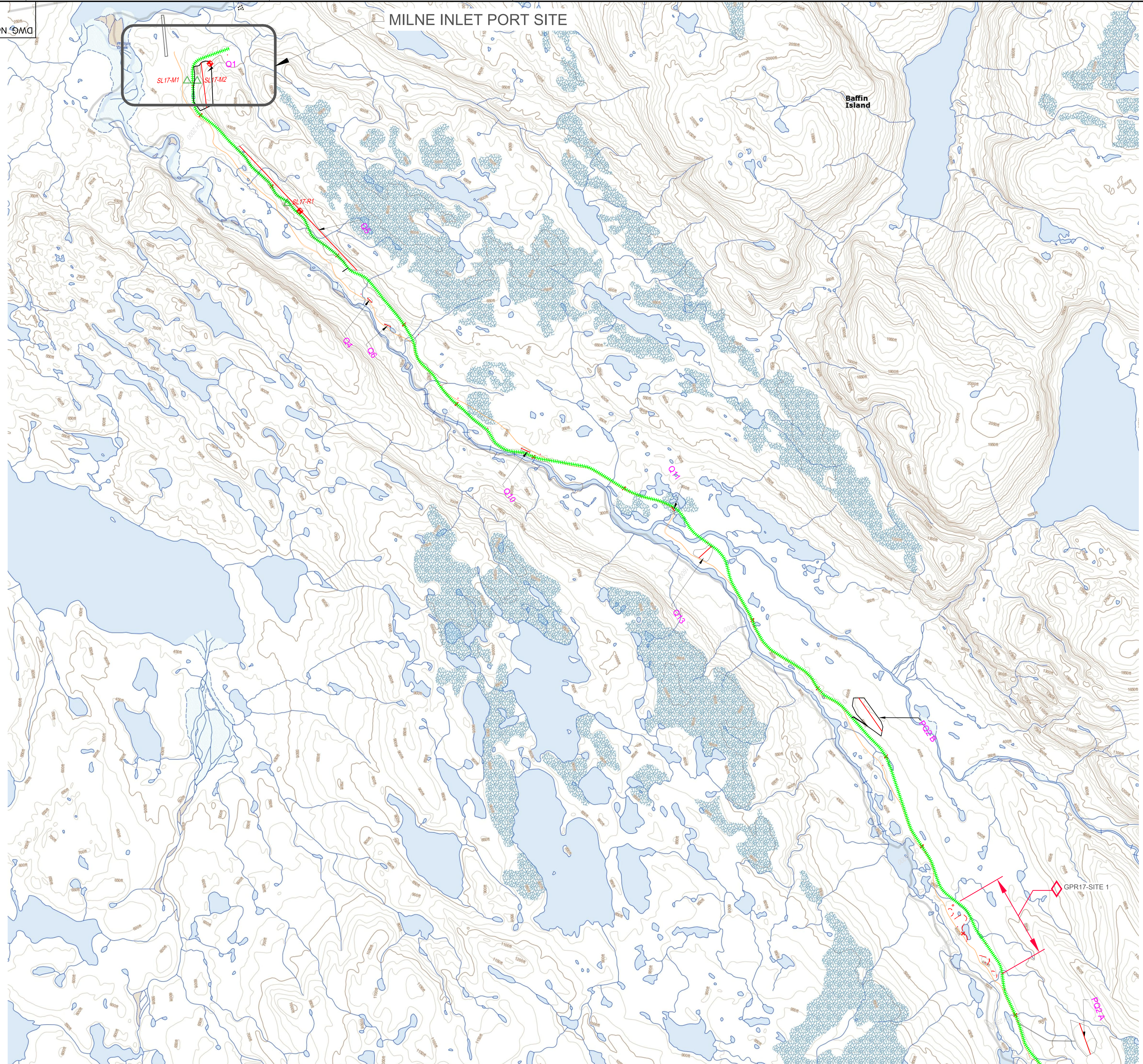
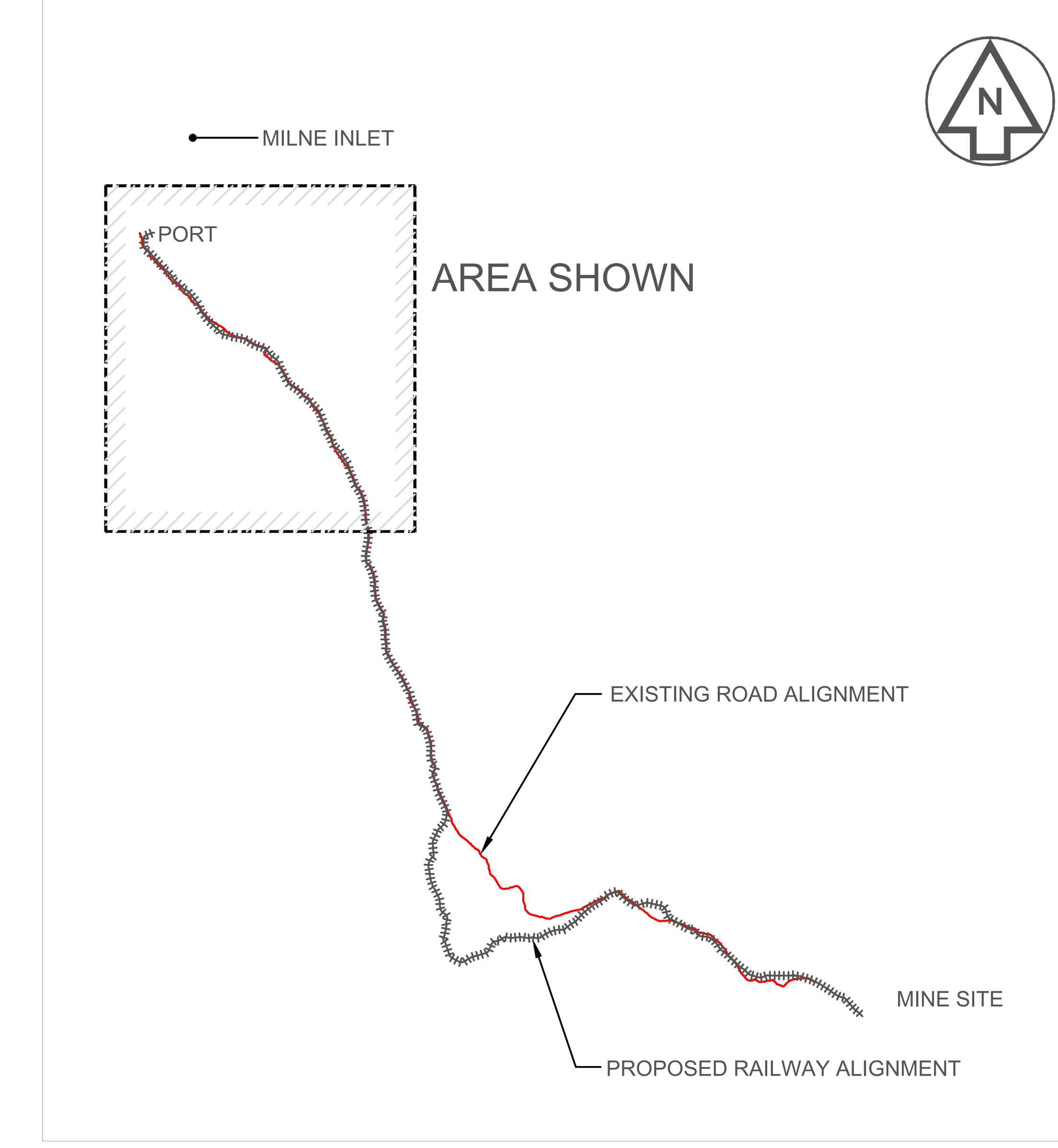
Appendix A

Borrow Source Assessment Location Plan



KEY PLAN



LEGEND

- SAMPLED LOCATIONS
- CHAINAGE POINT ALONG RAIL ALIGNMENT
- SEISMIC LINE LOCATION
- GROUND PENETRATING RADAR SURVEY (GPR) AREA
- PROPOSED RAILWAY (March 2018)
- EXISTING TOTE ROAD
- POTENTIAL QUARRY LOCATIONS

REFERENCES:

FOR SEISMIC AND GROUND PENETRATING RADAR DETAILS SEE GEOPHYSICS GPR INTERNATIONAL INC REPORT

0 1 2 3 4 5 KILOMETRES

SCALE 1:50 000 (B1 SHEET)

HATCH

Baffinland

No.	DESCRIPTION	BY	CHK'D	DATE
	ISSUED WITH GEOTECHNICAL REPORT			25/06/2019

REVISIONS

DRAWING No.	DRAWING TITLE

REFERENCE DRAWINGS

REG. PROFESSIONAL

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	M YANG	NR	25/06/2019
DESIGNER	M YANG	NR	25/06/2019
CHECKER	W HOYLE		25/06/2019
DESIGN COORD.	M YANG		25/06/2019
RESP. ENG.	H GHIABI		25/06/2019
LEAD DISC. ENG.	W HOYLE		25/06/2019
ENG. MANAGER	F VAN BILJON		25/06/2019
PROJ. MANAGER	S PERRY		25/06/2019

DRAWING APPROVAL STATUS: Record Document

BAFFINLAND IRON ORE MINES LP
MARY RIVER EXPANSION PROJECT

BORROW SOURCE ASSESSMENT LOCATION PLAN SHEET 1 OF 4

SCALE 1:50,000 OR AS NOTED

DWG. No. N/A

REV

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DWG. No.

$USERNAME$ $DATE$ $FILE$ $TIME$

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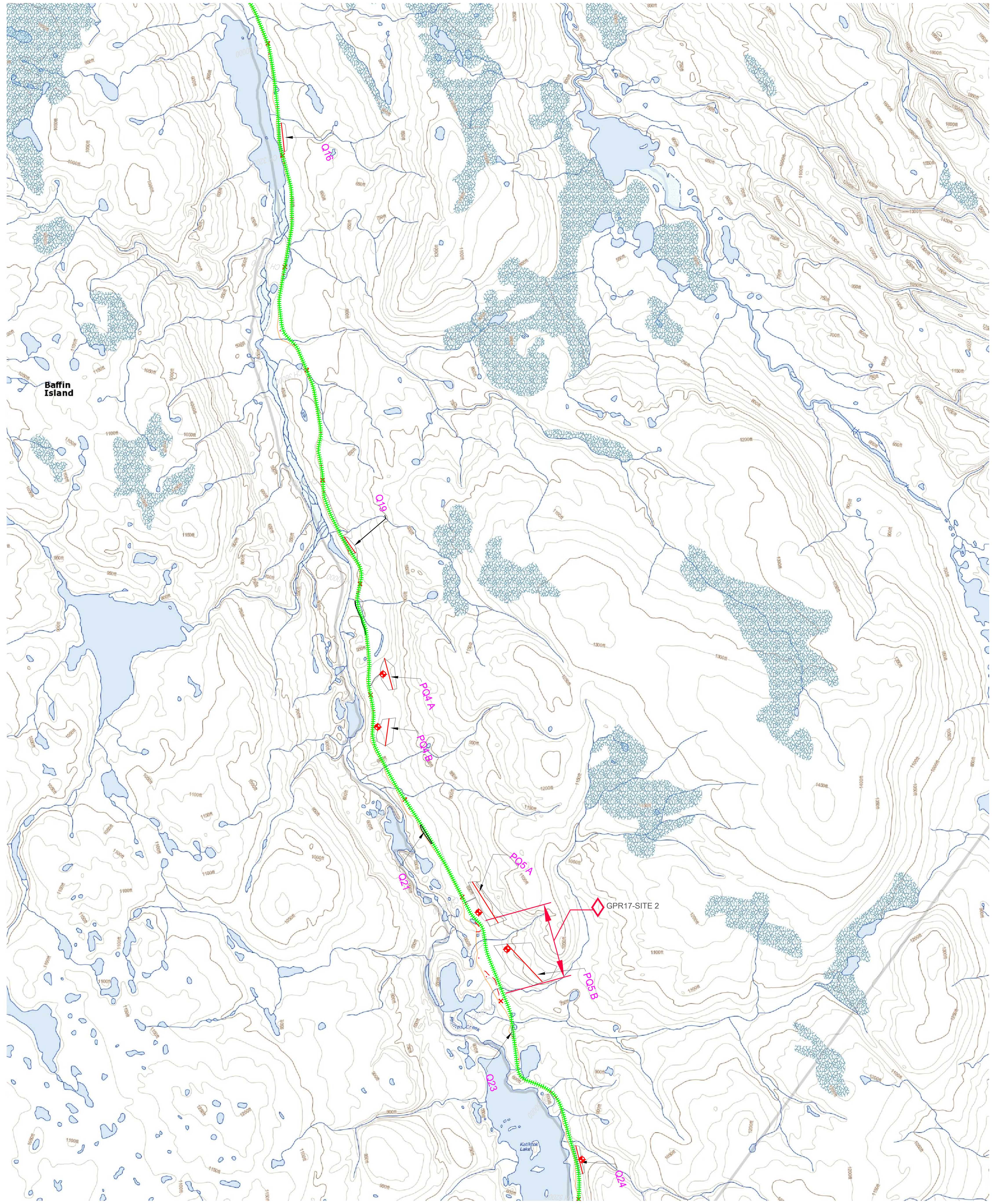

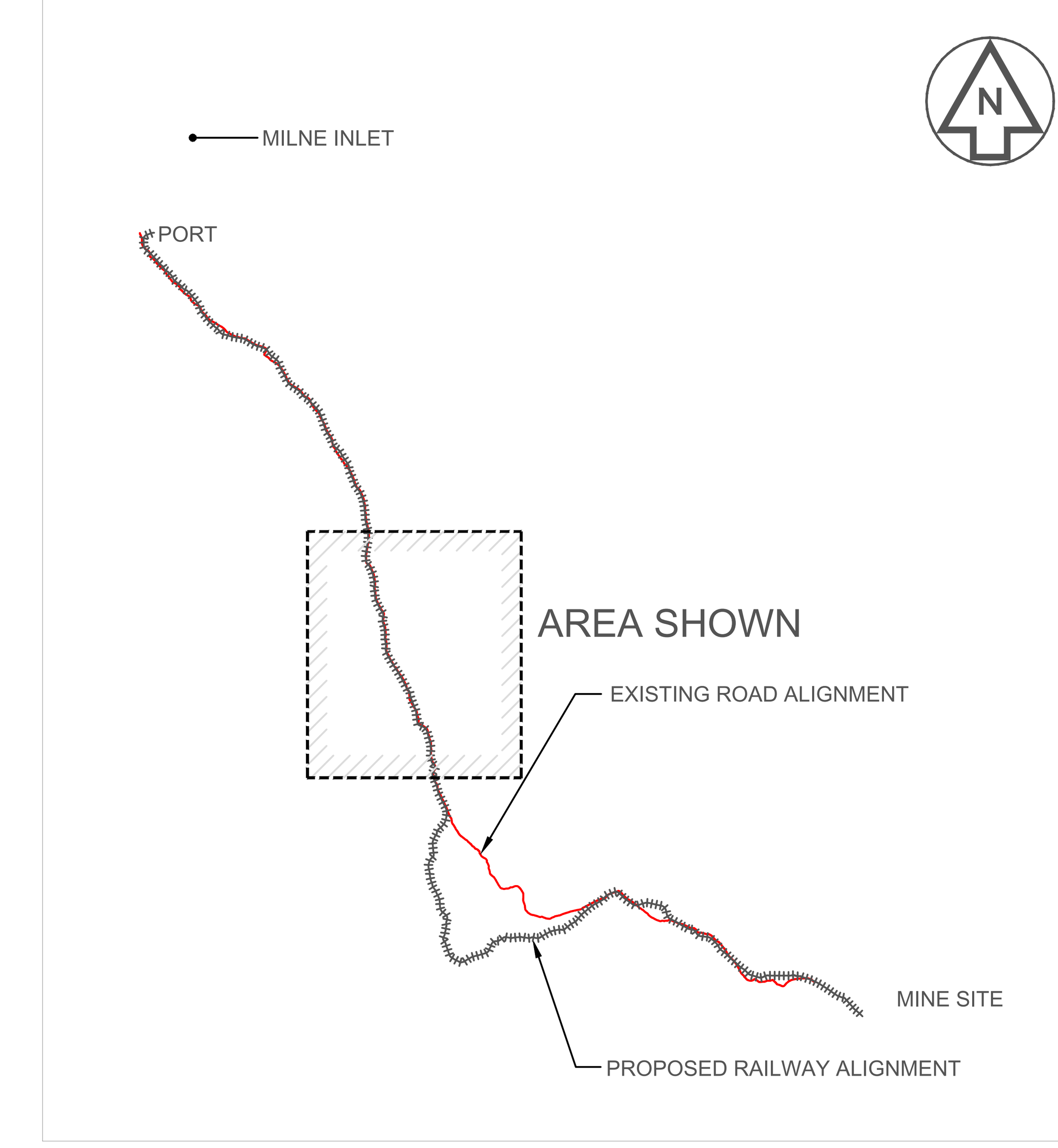

KEY PLAN

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SCALE 1:500 000

LEGEND

- SAMPLED LOCATIONS
- CHAINAGE POINT ALONG RAIL ALIGNMENT
- SEISMIC LINE LOCATION
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0 1 2 3 4 5 KILOMETRES

SCALE 1:50 000 (B1 SHEET)

HATCH

Baffinland

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REFERENCE DRAWINGS	

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DRAWING APPROVAL STATUS: Record Document

BAFFINLAND IRON ORE MINES LP
MARY RIVER EXPANSION PROJECT

BORROW SOURCE ASSESSMENT
LOCATION PLAN
SHEET 2 OF 4

SCALE 1:50,000 OR AS NOTED | DWG. No. N/A | REV

SHEET SIZE: D

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