Attachment 9.4

2019 Geochemical Evaluation

(118 Pages)

Baffinland Iron Mines Corporation
Mary River Expansion Project

Borrow Source Investigation Factual Data Report

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By:____

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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 includes sampling locations near the Tote Road, while Phase 2 will sample borrow sources along the rail deviation area.

The current version of this report presents results from Phase 1 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. The sampling program was divided into two phases. Phase 1 was executed in October 2018, during which quarry samples were taken form locations along the Tote road. Only results from Phase 1 of the investigation will be discussed in this report.

A total of 29 potential quarry locations were identified, as part of Phase 1 of the sample collection process. Of the 29 potential quarry locations 16 locations were sampled, 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 any findings made.

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

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	N/A	N/A	N/A
PQ2A	N/A	N/A	N/A
Q16	521793	7952516	48.5
Q19	523043	7945110	149.5
PQ4A	N/A	N/A	N/A
PQ4B	523505	7941976	184.4
PQ5A	N/A	N/A	N/A
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

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: Quarry Sampling Method

Other major equipment used in this sampling investigation included snowmobiles for transportation and a towable sled. Figure 2-2 shows the samples after being stored in the five gallon buckets. Figure 2-3 shows the snowmobile and sled used to collect and transport quarry samples.

Figure 2-2: Samples Packaged for Transportation

Figure 2-3: Off-Road Transport

2.4 Sampling Constraints

Difficulties were encountered during the sampling process that prevented the collection of samples from some potential quarry locations. Nine of the potential locations could not be sampled due to the hardness of the ground preventing sample collection using the equipment available. Four potential locations were not sampled due to accessibility issues, as the distance prevented foot travel, and the lack of adequate snow depth prevented the use of snowmobiles. 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. Photographs of select quarry sampling locations are provided in Appendix I.

Table 2-2: Table 2-6: Quarry Sampling Status

Quarry ID	Quarry Sample Status (m)
Q1	Sampled (rock)
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
PQ2B	Not sampled - accessibility issues
PQ2A	Not sampled - accessibility issues
Q16	Not sampled - hard ground, granular material
Q19	Not sampled - hard ground, granular material
PQ4A	Not sampled - accessibility issues
PQ4B	Sampled (rock)
PQ5A	Not sampled - accessibility issues

Quarry ID	Quarry Sample Status (m)
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

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	✓	✓	✓	✓	✓					
PQ4B	✓	✓	✓	✓	✓					
PQ5B	✓	✓	✓	✓	✓					
Q24	✓	✓	✓	✓	✓					
PQ6B	✓	✓	✓	✓	✓					
PQ12A	✓	✓	✓	✓	✓					
PQ13	✓	✓	✓	✓	✓					
PQ15B	✓	✓	✓	✓	✓					
PQ15A	✓	✓	✓	✓	✓					
QMR2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

3. Quarry Sampling Program Test Results

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

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	PQ4B	PQ5B	PQ6B	PQ12A	PQ13	PQ15A	PQ15B
Quartz (wt %)	29.7	30.7	1.1	65.8	1.1	0.5	0.8	1.7	41.4	26.1	34.8
Albite (wt %)	40.6	32.7	-	12.3	-	-	-	-	11.4	28.7	18.9
Muscovite (wt %)	3.1	4.9	-	6.7	0	-	-	-	5.5	8.4	10.4
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	-	98.7	86.6	80.6	0.1	0.6	1.1	0.4
Ankerite (wt %)	-	-	5.2	-	-	12.3	5.1	-	0.1	0.6	0.3
Dolomite (wt %)	-	-	3.1	-	0.2	-	12.9	91.5	0.2	0.1	0.2
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
Neuralization 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 Neutralisation 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.

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
PQ4B	0.62	958	8.19	4	1546	958	< 0.005	< 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

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 quarry samples are shown in Table 3-4.

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	PQ4B	PQ5B	PQ6B	PQ12A	PQ13	PQ15A	PQ15B
Silver (µg/g)	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Aluminum (µg/g)	76000	76000	3000	39000	3700	2900	3000	9000	57000	86000	69000
Arsenic (µg/g)	1.1	0.6	< 0.5	0.6	0.6	< 0.5	< 0.5	2	1.9	0.9	0.9
Barium (µg/g)	750	650	13	150	14	12	12	51	270	1200	1900
Beryllium (µg/g)	1.8	2.3	0.11	1.6	0.11	0.11	0.11	0.25	2	1.9	1.2
Bismuth (µg/g)	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	0.09	0.33	< 0.09	0.09
Calcium (µg/g)	9200	7000	360000	3700	380000	370000	340000	200000	1800	8500	4300
Cadmium (µg/g)	0.03	0.03	< 0.02	0.03	< 0.02	< 0.02	< 0.02	< 0.02	0.03	0.05	0.07
Cobalt (µg/g)	2.4	4.1	0.57	2	0.66	0.5	0.52	2.7	1.7	7	3.2
Chromium (µg/g)	92	80	4.8	99	3.3	2.1	2.3	4.6	98	83	75
Copper (µg/g)	2.7	6.4	0.9	4.2	1.2	1.1	1.2	6.2	3.4	3.2	3.5
Iron (µg/g)	11000	16000	2100	10000	2600	2000	2300	5300	14000	28000	17000
Potassium (µg/g)	33000	34000	1800	20000	2300	1700	1900	9900	53000	41000	47000
Lithium (µg/g)	28	31	5	10	6	5	5	27	28	28	19
Magnesium (µg/g)	3700	7200	14000	4800	5000	17000	25000	120000	5500	9800	6400
Manganese (µg/g)	230	230	72	190	110	70	68	150	130	520	240
Molybdenum (µg/g)	6.2	6.7	0.5	11	0.2	0.1	0.2	0.8	8.3	6.4	7.8
Sodium (µg/g)	33000	28000	220	9500	210	220	220	390	10000	30000	16000
Nickel (µg/g)	25	9.6	3.8	8.5	4	3.3	3	4.6	5.1	17	5.9
Phosphorus (µg/g)	110	280	64	85	110	40	38	130	58	400	240
Lead (µg/g)	52	24	0.91	8.8	1.4	0.95	0.75	4.8	22	20	28
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
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
Tin (µg/g)	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6

Parameter	Quarry Sample ID										
	Q1	Q5	Q24	QMR2	PQ4B	PQ5B	PQ6B	PQ12A	PQ13	PQ15A	PQ15B
Strontium (µg/g)	250	170	310	27	290	390	350	67	28	160	98
Titanium (µg/g)	700	1300	170	660	210	160	160	330	660	1800	1400
Thallium (µg/g)	0.65	0.48	0.06	0.28	0.03	0.03	< 0.02	0.18	0.92	0.72	0.5
Uranium (µg/g)	3.1	2.4	0.42	2.7	0.47	0.37	0.42	1	5.2	1.9	2.2
Vanadium (µg/g)	8	21	4	11	5	5	4	12	5	27	15
Yttrium (µg/g)	5.4	5.5	1.9	7.9	2.6	1.4	1.5	3.3	11	7.1	6.4
Zinc (µg/g)	26	35	2.8	21	3.2	3.5	2.7	3.8	17	59	39

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	PQ4B	PQ5B	PQ6B	PQ12A	PQ13	PQ15A	PQ15B
Sample weight (g)	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
Final pH	9.40	8.92	8.80	9.06	8.79	9.34	9.21	8.34	8.17	8.61	8.35
pH	9.16	8.01	8.47	9.03	8.44	8.34	8.51	9.32	7.97	7.78	7.51
Alkalinity (mg/L as CaCO3)	28	32	28	37	26	26	29	88	39	22	46
Conductivity (uS/cm)	68	79	106	126	81	81	100	272	90	50	109
Chloride (mg/L)	3	4	11	4	8	7	9	35	2	1	2
Sulphate (mg/L)	2	< 2	6	< 2	< 2	< 2	< 2	3	< 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	0.00002
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
Aluminum (mg/L)	0.771	0.420	0.196	0.445	0.235	0.149	0.128	0.026	0.448	1.06	0.389
Arsenic (mg/L)	0.0011	0.0003	< 0.0002	0.0013	< 0.0002	< 0.0002	0.0004	0.0010	0.0016	0.0010	0.0005
Barium (mg/L)	0.00454	0.00277	0.00151	0.00193	0.00075	0.00074	0.00080	0.00269	0.00194	0.00801	0.00920
Boron (mg/L)	0.009	0.022	0.085	0.026	0.047	0.059	0.078	0.071	0.033	0.041	0.035
Beryllium (mg/L)	0.000008	0.000017	< 0.000007	0.000012	< 0.000007	< 0.000007	< 0.000007	< 0.000007	0.000034	0.000020	0.000015
Bismuth (mg/L)	< 0.000007	0.000010	< 0.000007	< 0.000007	0.000032	0.000020	0.000051	< 0.000007	0.000027	< 0.000007	0.000012
Calcium (mg/L)	3.33	4.37	11.2	3.84	10.5	7.92	8.69	9.20	4.98	0.21	7.25
Cadmium (mg/L)	0.000003	0.000003	0.000009	0.000009	0.000003	0.000003	0.000021	0.000004	0.000007	0.000007	0.000003
Cobalt (mg/L)	0.000044	0.000034	< 0.000004	0.000069	0.000007	0.000109	0.000015	0.000052	0.000055	0.000099	0.000202
Chromium (mg/L)	0.00017	0.00015	0.00022	0.00007	0.00035	0.00023	0.00110	0.00011	0.00004	0.00023	0.00006
Copper (mg/L)	0.00038	0.00637	0.00876	0.00048	0.00091	0.00041	0.00097	0.00110	0.00198	0.00299	0.01076
Iron (mg/L)	0.105	0.079	0.008	0.061	< 0.007	< 0.007	0.016	0.007	0.190	0.353	0.139
Potassium (mg/L)	7.36	6.41	1.96	15.4	2.14	1.35	1.49	6.58	13.4	10.3	16.9
Lithium (mg/L)	0.0126	0.0047	0.0042	0.0061	0.0038	0.0024	0.0030	0.0239	0.0035	0.0019	0.0013
Magnesium (mg/L)	0.496	1.29	4.08	1.14	1.62	3.33	4.36	22.1	1.84	0.236	1.16
Manganese (mg/L)	0.00320	0.00137	0.00002	0.00147	0.00002	< 0.00001	0.00005	0.00007	0.00192	0.00610	0.00740
Molybdenum (mg/L)	0.00039	0.00174	0.00111	0.00345	0.00156	0.00052	0.00230	0.00301	0.00068	0.00095	0.00198
Sodium (mg/L)	5.96	6.07	1.24	8.84	0.96	0.84	1.15	6.10	2.68	4.41	2.57
Nickel (mg/L)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0004	0.0001	0.0002	0.0001
Lead (mg/L)	0.00079	0.00010	0.00006	0.00022	0.00002	< 0.00001	< 0.00001	0.00002	0.00018	0.00019	0.00039
Antimony (mg/L)	0.0004	0.0004	0.0003	0.0004	0.0003	0.0003	0.0002	0.0003	0.0005	0.0005	0.0005
Selenium (mg/L)	< 0.00004	0.00011	0.00006	0.00049	< 0.00004	< 0.00004	< 0.00004	0.00009	0.00007	0.00006	0.00010
Tin (mg/L)	0.00022	0.00015	0.00022	0.00022	0.00012	0.00009	0.00051	0.00008	0.00008	0.00040	0.00033
Strontium (mg/L)	0.0153	0.00593	0.129	0.00681	0.111	0.111	0.108	0.0498	0.00497	0.00093	0.00928
Titanium (mg/L)	0.00719	0.00332	0.00074	0.00449	0.00005	< 0.00005	0.00048	0.00006	0.00346	0.0189	0.00650
Thallium (mg/L)	0.000009	< 0.000005	0.000006	0.000008	< 0.000005	0.000005	< 0.000005	0.000171	0.000013	0.000011	< 0.000005

Parameter	Analysis										
	Q1	Q5	Q24	QMR2	PQ4B	PQ5B	PQ6B	PQ12A	PQ13	PQ15A	PQ15B
Uranium (mg/L)	0.00963	0.00121	0.000046	0.00818	0.000048	0.000022	0.000035	0.000127	0.00250	0.000184	0.00161
Vanadium (mg/L)	0.00314	0.00370	0.00047	0.00618	0.00065	0.00049	0.00052	0.00198	0.00045	0.00398	0.00119
Tungsten (mg/L)	0.00017	0.00024	0.00004	0.00045	0.00022	0.00022	0.00017	0.00020	0.00074	0.00013	0.00026
Yttrium (mg/L)	0.000079	0.000110	0.000005	0.000163	0.000003	< 0.000002	0.000005	0.000019	0.000639	0.000139	0.000229
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

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
PQ4B	13800	45.81
PQ5B	15467	65.00
QMR2	29427	88.27
Q5	16800	61.49
Q15B	27417	58.43
PQ13	47500	105.26
Q1	31400	81.30

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)

<table>
<tr><th rowspan="2">Sample Identification</th><th rowspan="2">Initial Sample Mass (g)</th><th rowspan="2">Percent Passing After Test (%)</th><th colspan="2">Weighted Percentage of Mass Loss (%)</th></tr>
<tr><th>Per Fraction</th><th>Total</th></tr>
<tr><td>S346-18</td><td>1539.6</td><td>4.5</td><td>2</td><td rowspan="2">3</td></tr>
<tr><td>QMR2</td><td>2019.9</td><td>1.6</td><td>0.8</td></tr>
<tr><td>S348-18</td><td>1507.5</td><td>1.1</td><td>0.5</td><td rowspan="2">1</td></tr>
<tr><td>Q1</td><td>2035.4</td><td>0.4</td><td>0.2</td></tr>
</table>

Table 3-12: Determination of Bulk Density

Sample Identification	Jigging Density (kg/m^3)	Jigging Density (kg/m^3)	Voids in Loose Aggregate (%)	Voids in Rodded Aggregate (%)
S346-18				
QMR2	1351	1516	4.5	44
S348-18				
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 (%)
S346-18			
QMR2	2.728	2.740	0.42
S348-18			
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 (%)
S346-18			
QMR2	37.5	2	21.2
S348-18			
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)
PQ4B	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)

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 quarry 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
PQ15B	Aluminum	1.06	0.005
Q5	Copper	0.00637	0.002
Q24	Copper	0.00876	0.002
PQ15A	Copper	0.00299	0.002
PQ15B	Copper	0.01076	0.002

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, PQ4B, PQ5B, PQ6B and PQ12A. The presence of carbonate minerals act as natural buffer to acid generation.

Table 4-4 summarizes the presence of acid generating and acid neutralizing minerals in the quarry samples.

Table 4-4: Summary of Findings from Minerology Results

Sample ID	Minerology	
	Acid Generation Minerals (iron sulfide/sulfides)	Natural Buffer Minerals (Carbonate Minerals)
Q1	None Identified	None Identified
Q5	None Identified	None Identified
Q24	None Identified	Significant Amount of Calcite
QMR2	None Identified	None Identified
PQ4B	None Identified	Significant Amount of Calcite
PQ5B	None Identified	Significant Amount of Calcite
PQ6B	None Identified	Significant Amount of Calcite
PQ12A	None Identified	Significant Amount of Dolomite
PQ13	None Identified	None Identified
PQ15A	None Identified	None Identified
PQ15B	None Identified	None Identified

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
PQ4B	13230.77	56.06	Strong 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

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 Table 3-1, 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. References

Price, W.A. 1997. Draft Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Mine sites in British Columbia. British Columbia Ministry of Employment and Investment.

MMER. 2019. Metal and Diamond Mining Effluent Regulations SOR/2002-222.

Canadian Council of Ministers of the Environment. 2018, Canadian Water Quality Guidelines for the Protection of Aquatic Life.

Association, American Railway Engineering and Maintenance-of-Way. "Manual for Railway Engineering." 2013.

Nunavut, Department of Environment Government of. Environmental Guideline for the Management of Contaminated Sites. Government Guideline. Iqaluit: Department of Environment, 2014.

Nunavut, Department of Environment Government of. Environmental Guideline for the Management of Contaminated Sites. Government Guideline. Iqaluit: Department of Environment, 2014.

Association, American Railway Engineering and Maintenance-of-Way. "Manual for Railway Engineering." 2013.

Nunavut, Department of Environemnt Government of. Environmental Guidline for the Managment of Contaminated Sites. Government Guidline. Iqaluit: Department of Environemnt, 2014.

Nunavut, Department of Environment Government of. Environmental Guideline for the Management of Contaminated Sites. Government Guideline. Iqaluit: Department of Environment, 2014.

Appendix A

Borrow Source Assessment Location Plan

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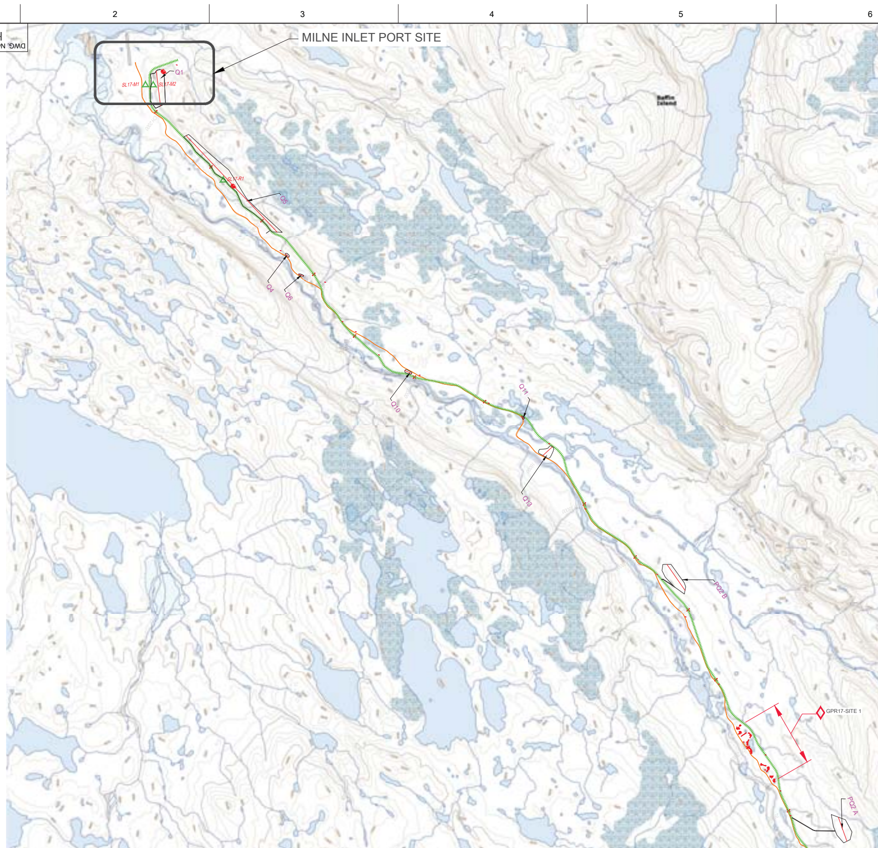

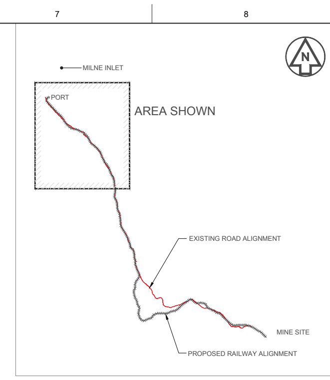

KEY PLAN

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

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BAFFINLAND IRON ORE MINES LP
MARY RIVER EXPANSION PROJECT

BORROW SOURCE ASSESSMENT
LOCATION PLAN
SHEET 1 OF 4

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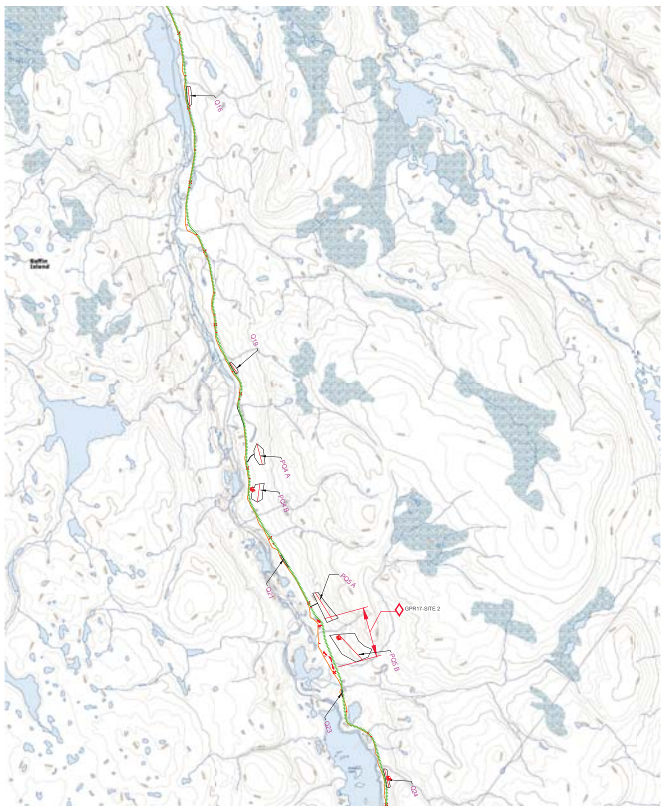

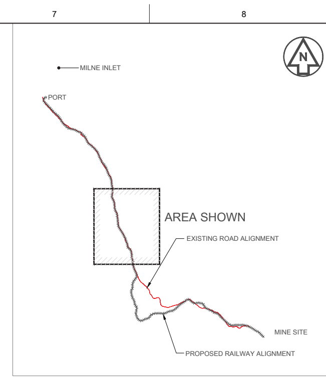

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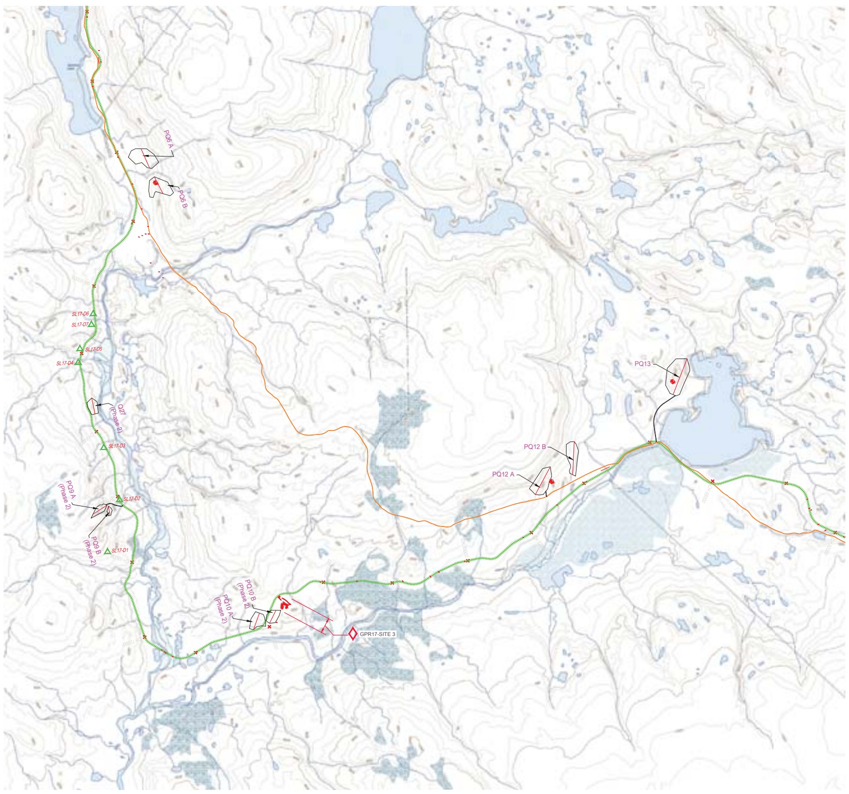

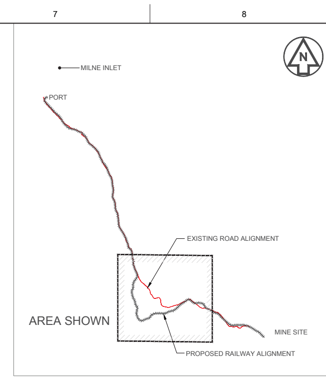

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BAFFINLAND IRON ORE MINES LP
MARY RIVER EXPANSION PROJECT

BORROW SOURCE ASSESSMENT
LOCATION PLAN
SHEET 3 OF 4

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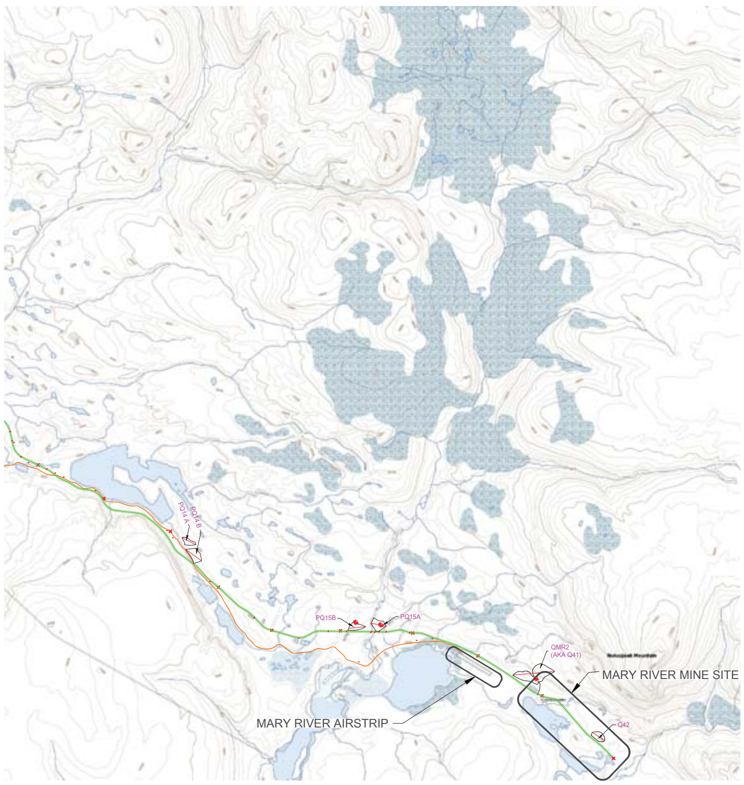

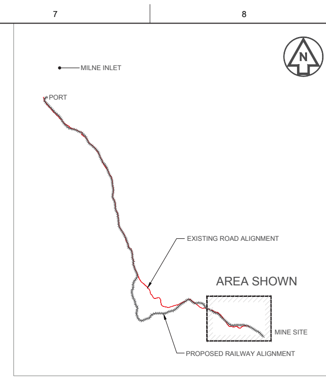

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ENG. MANAGER	F VAN BILJON		13/03/2019
PROJ. MANAGER	S PERRY		13/03/2019

DRAWING APPROVAL STATUS: Record Document

BAFFINLAND IRON ORE MINES LP
MARY RIVER EXPANSION PROJECT

BORROW SOURCE ASSESSMENT
LOCATION PLAN
SHEET 4 OF 4

SCALE	DWG. No.	REV
1:50,000 OR AS NOTED	H353004-30000-229-230-0002	A

SHEET SIZE: D

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

Appendix B

Laboratory Test Results

PHYSICAL PROPERTY TESTING OF BALLAST AGGREGATE

QMR2, Diabase, Q1 Materials

Project # TB152049

Prepared for:
Hatch Ltd.
4342 Queen St. Suite 500, Niagara Falls, Ontario, L2E 7J7

Attention: Ralph Serluca

Prepared by:
Wood Environment & Infrastructure Solutions
3450 Harvester Road
Suite 100
Burlington, Ontario, L7N 3W5
Canada
T: 905-335-2353

14 February 2019

1.0 Introduction

Wood Environment & Infrastructure Solutions, a Division of Wood Canada Limited (Wood) is pleased to present the results of laboratory testing conducted on a Ballast Stone received in our Wood Burlington, Ontario laboratory on 04 October 2018. It is understood that a representative Hatch Ltd. sampled the material in October 2018.

2.0 Methodology

Testing of the ballast stone included the following:

- ASTM C136 Sieve Analysis of Fine and Coarse Aggregates
- ASTM C88 Soundness of Aggregates by use of Magnesium Sulphate
- ASTM C29 Bulk Density ("Unit Weight") and Voids in Aggregate
- ASTM C127 Relative Density (Specific Gravity) and Absorption of Coarse Aggregates
- ASTM C535 Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine

3.0 Results

Results of the composite sieve analysis are presented in Enclosures 1 to 3. Each sample was crushed with the use of a sledge hammer in order to meet the grading requirements, provided by the client, referencing 2.2.12, Table 25 Fill-Rail Ballast.

Parameters and results for the remaining tests on the ballast aggregate are provided in Tables 1 through 4.

Table 1: Determination of weighted percent loss of aggregate after five cycles

ASTM C88 Soundness of Aggregates by Use of Magnesium Sulphate[1]

Sample Identification	Sieve Fraction (mm)	Initial Sample Mass (g)	Percent Passing After Test (%)	Weighted Percentage of Mass Loss (%)	
				Per Fraction	Total[4]
S346-18 QMR2	- 37.5 + 19[2]	1539.6	4.5	2.0	**3**
	+ 37.5[3,2]	2019.9	1.6	0.8	
S347-18 Diabase	- 37.5 + 19[2]	1533.9	1.0	0.4	**1**
	+ 37.5[3,2]	2060.5	0.9	0.4	
S348-18 Q1	- 37.5 + 19[2]	1507.5	1.1	0.5	**1**
	+ 37.5[3,2]	2035.4	0.4	0.2	

[1] Previously used Magnesium Sulphate solution
[2] Section 12.1.5 was not recorded, no distress in any particles was visible
[3] 37.5mm fraction tested only
[4] Final number rounded to the nearest whole number

Table 2: Determination of the bulk density

ASTM C29 Bulk Density ("Unit Weight") and Voids in Aggregate

Sample Identification	Loose Density (kg/m^3)	Jigging Density (kg/m^3)	Voids in Loose Aggregate (%)	Voids in Rodded Aggregate (%)
S346-18 QMR2	1351	1516	50	44
S347-18 Diabase	1417	1639	52	44
S348-18 Q1	1307	1533	50	42

Table 3: Determination of the relative density and absorption

ASTM C127 Relative Density (Specific Gravity) and Absorption of Coarse Aggregate

Sample Identification	Relative Density (OD)	Relative Density (SSD)	Absorption (%)
S346-18 QMR2	2.728	2.740	**0.42**
S347-18 Diabase	2.930	2.950	**0.68**
S348-18 Q1	2.630	2.636	**0.21**

Table 4: Determination of resistance to degradation using the Los Angeles testing machine.

ASTM C535 Resistance to Degradation of large-size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine

Sample Identification	Maximum Aggregate Size used (mm)	Grading Designation	Sample Loss (%)
S346-18 QMR2	37.5	2	**21.2**
S347-18 Diabase	37.5	2	**17.8**
S348-18 Q1	37.5	2	**23.2**

4.0 Copyright and non-disclosure notice

5.0 Third-party disclaimer

Any disclosure of this report to a third party is subject to this disclaimer. The report was prepared by Wood at the instruction of, and for use by, our client named on the front of the report. It does not in any way constitute advice to any third party who is able to access it by any means. Wood excludes to the fullest extent lawfully permitted all liability whatsoever for any loss or damage howsoever arising from reliance on the contents of this report. We do not however exclude our liability (if any) for personal injury or death resulting from our negligence, for fraud or any other matter in relation to which we cannot legally exclude liability.

If you have any questions with regards to the results of the testing conducted, please do not hesitate to contact the undersigned at your convenience.

Yours truly,

Wood Environment & Infrastructure Solutions,

a Division of Wood Canada Limited

Kristen Hand
Soils & Aggregate Laboratory Supervisor

Reviewed by,

Ognjenko Lazic
Asphalt & Concrete Laboratory Supervisor

kh:OL
Enclosure (3)

wood.

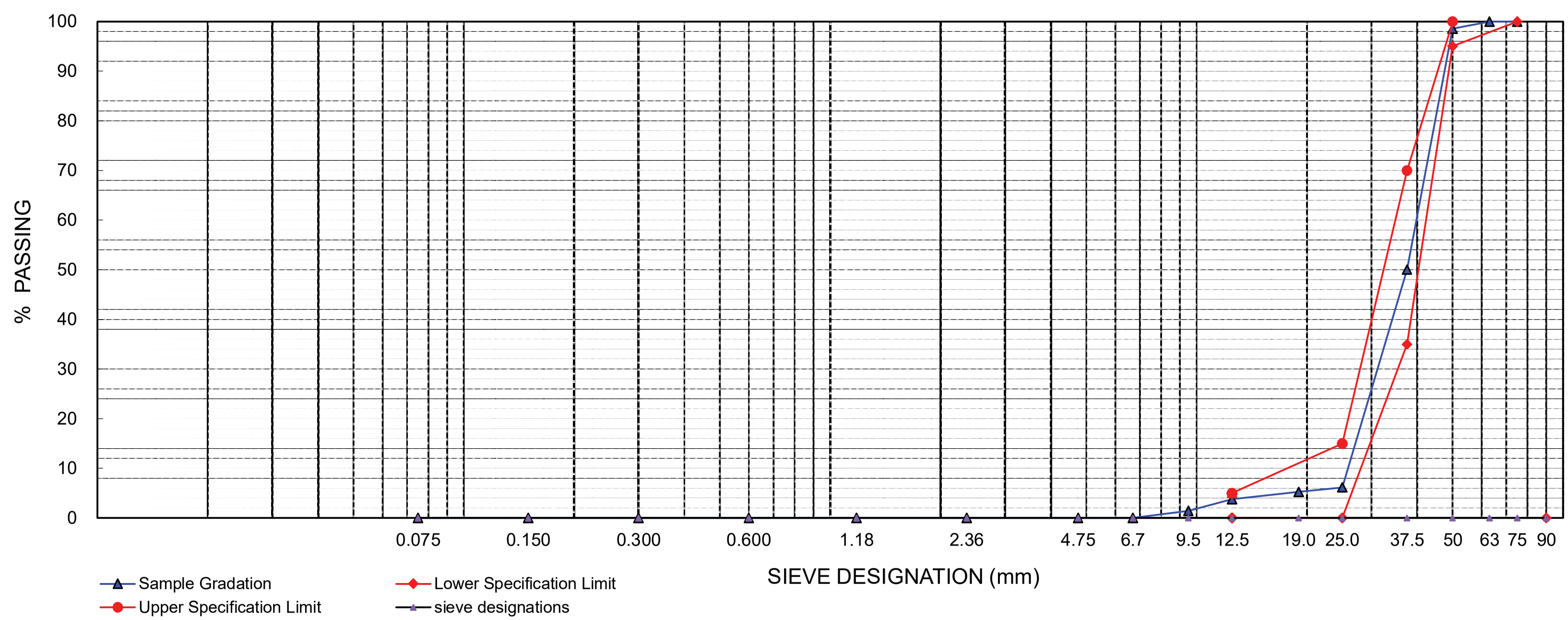
SIEVE ANALYSIS OF FINE AND COARSE AGGREGATE
ASTM C136

Enclosure: 1
Report Date: 26 October 2018
Project No.: TB152049

Client: Hatch Ltd.
Sample Source: QMR 2 - 1&2
Date Sampled: September 2018
Sampled by: Client
Sample Type: Rail Ballast Aggregate, Type 25 Fill
Specification: Section 2.2.12

Lab No: S346-18
Date Received: 04 October 2018
Date Tested: 19 October 2018
Lab Technician: J. Wood

SIEVE SIZES (mm)	100	90.0	75.0	63	50	37.5	25.0	19	12.5	9.5	4.75	2.36	1.18	0.600	0.300	0.150	0.075
SPECIFICATIONS	100.0	100.0	100.0	100.0	95-100	35-70	0-15	-	0-5	-	-	-	-	-	-	-	-
% PASSING	100.0	100.0	100.0	100.0	98.5	50.0	6.2	5.2	3.8	1.5	0.0	-	-	-	-	-	-



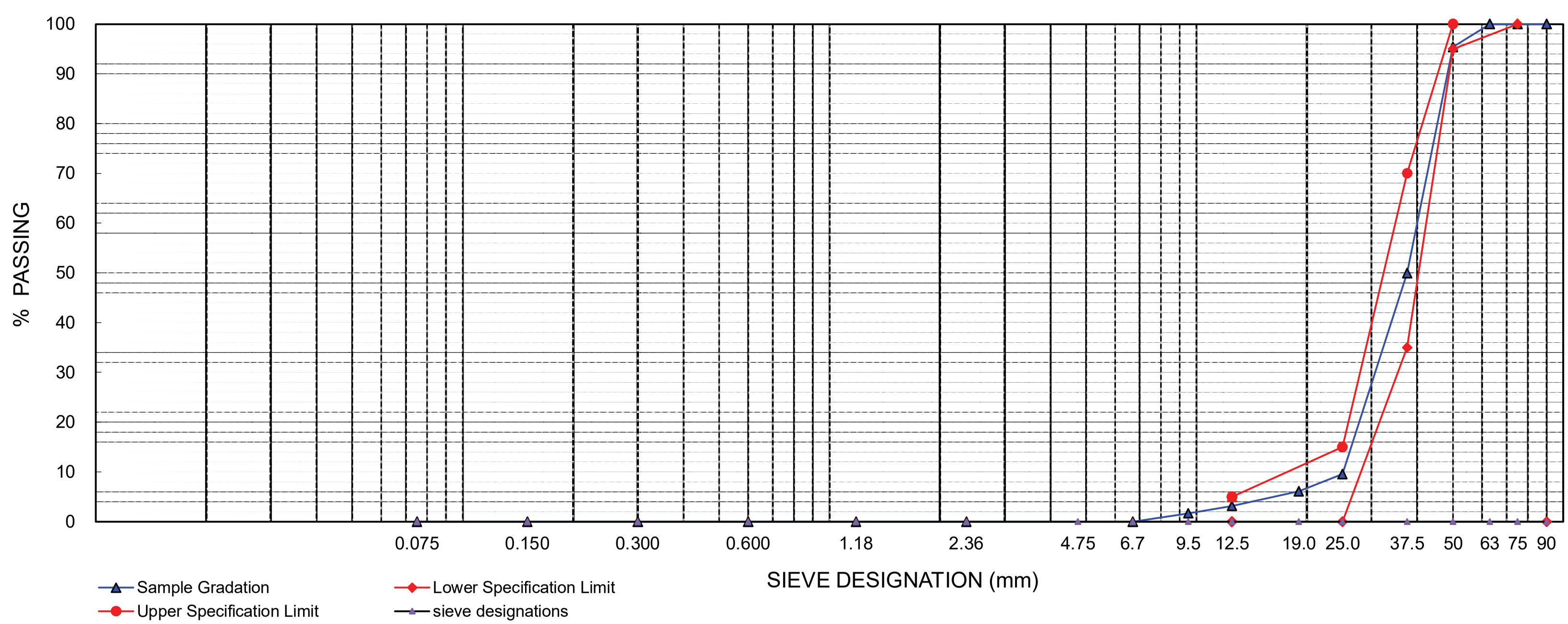
SIEVE ANALYSIS OF FINE AND COARSE AGGREGATE
ASTM C136

Enclosure: 2
Report Date: 26 October 2018
Project No.: TB152049

Client: Hatch Ltd.
Sample Source: Diabase 1 & 2
Date Sampled: September 2018
Sampled by: Client
Sample Type: Rail Ballast Aggregate, Type 25 Fill
Specification: Section 2.2.12

Lab No: S347-18
Date Received: 04 October 2018
Date Tested: 19 October 2018
Lab Technician: KH

SIEVE SIZES (mm)	100	90.0	75.0	63	50	37.5	25.0	19	12.5	9.5	4.75	2.36	1.18	0.600	0.300	0.150	0.075
SPECIFICATIONS	100.0	100.0	100.0	100.0	95-100	35-70	0-15	-	0-5	-	-	-	-	-	-	-	-
% PASSING	100.0	100.0	100.0	100.0	95.4	49.9	9.5	6.1	3.1	1.7	0.0	-	-	-	-	-	-



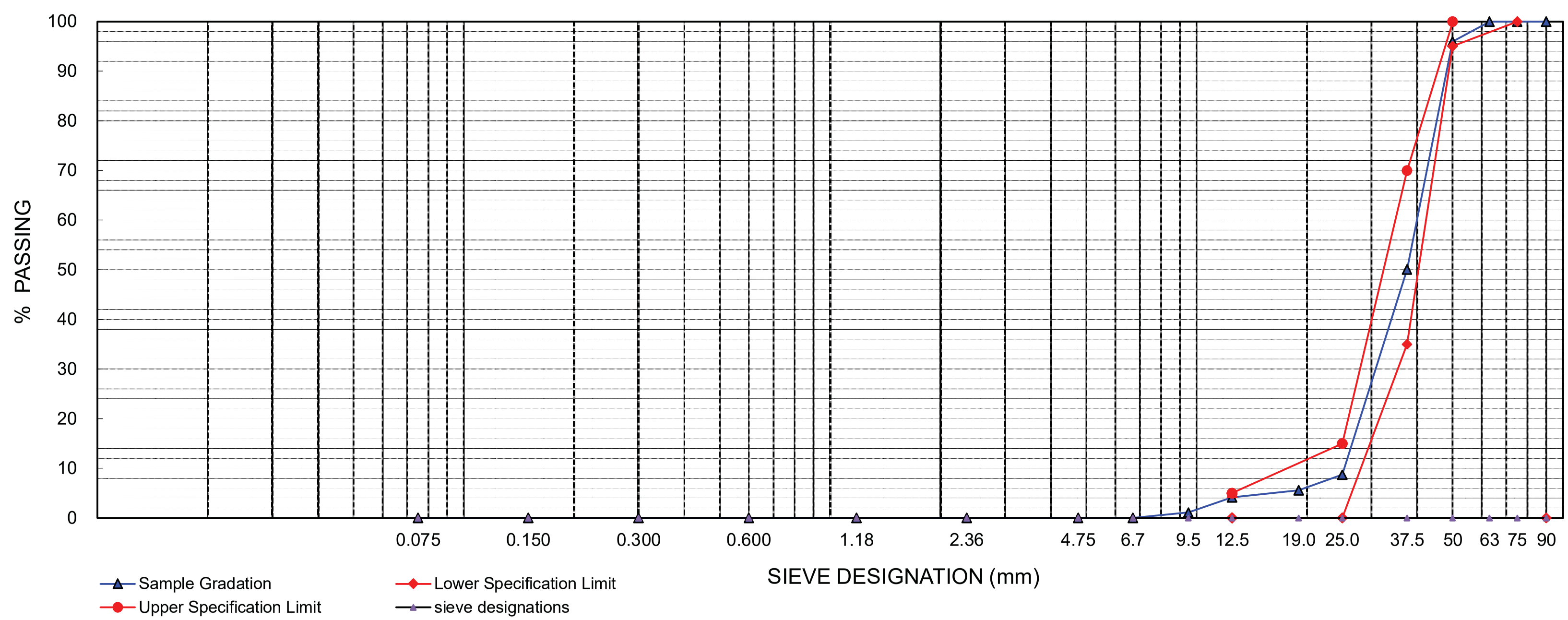
SIEVE ANALYSIS OF FINE AND COARSE AGGREGATE
ASTM C136

Enclosure: 3
Report Date: 26 October 2018
Project No.: TB152049

Client: Hatch Ltd.
Sample Source: Q1 1 & 2
Date Sampled: September 2018
Sampled by: Client
Sample Type: Rail Ballast Aggregate, Type 25 Fill
Specification: Section 2.2.12

Lab No: S348-18
Date Received: 04 October 2018
Date Tested: 19 October 2018
Lab Technician: KH

SIEVE SIZES (mm)	100	90.0	75.0	63	50	37.5	25.0	19	12.5	9.5	4.75	2.36	1.18	0.600	0.300	0.150	0.075
SPECIFICATIONS	100.0	100.0	100.0	100.0	95-100	35-70	0-15	-	0-5	-	-	-	-	-	-	-	-
% PASSING	100.0	100.0	100.0	100.0	96.0	50.1	8.7	5.6	4.1	1.1	0.0	-	-	-	-	-	-



HA-TEM-MAT-1000C-01

SGS

Quantitative X-Ray Diffraction by Rietveld Refinement

Report Prepared for:	*Environmental -Analytical*
Project Number/ LIMS No.	*Custom XRD/MI4500-JAN19*
Sample Receipt:	*January 2, 2019*
Sample Analysis:	*January 9, 2019*
Reporting Date:	*January 15, 2019*

Instrument:	BRUKER AXS D8 Advance Diffractometer
Test Conditions:	Co radiation, 40 kV, 35 mA Regular Scanning: Step: 0.02°, Step time: 1s, 2θ range: 3-80°
Interpretations :	PDF2/PDF4 powder diffraction databases issued by the International Center for Diffraction Data (ICDD). DiffracPlus Eva and Topas software.
Detection Limit :	0.5-2%. Strongly dependent on crystallinity.

Contents:

1) Method Summary
2) Quantitative XRD Results
3) XRD Pattern(s)

Kim Gibbs, H.B.Sc., P.Geo.
Senior Mineralogist

Huyun Zhou, Ph.D., P.Geo.
Senior Mineralogist

Method Summary

The Rietveld Method of Mineral Identification by XRD (ME-LR-MIN-MET-MN-D05) method used by SGS Minerals Services is accredited to the requirements of ISO/IEC 17025.

Mineral Identification and Interpretation:

Mineral identification and interpretation involves matching the diffraction pattern of an unknown material to patterns of single-phase reference materials. The reference patterns are compiled by the Joint Committee on Powder Diffraction Standards - International Center for Diffraction Data (JCPDS-ICDD) database and released on software as Powder Diffraction Files (PDF).

Interpretations do not reflect the presence of non-crystalline and/or amorphous compounds, except when internal standards have been added by request. Mineral proportions may be strongly influenced by crystallinity, crystal structure and preferred orientations. Mineral or compound identification and quantitative analysis results should be accompanied by supporting chemical assay data or other additional tests.

Quantitative Rietveld Analysis:

Quantitative Rietveld Analysis is performed by using Topas 4.2 (Bruker AXS), a graphics based profile analysis program built around a non-linear least squares fitting system, to determine the amount of different phases present in a multicomponent sample. Whole pattern analyses are predicated by the fact that the X-ray diffraction pattern is a total sum of both instrumental and specimen factors. Unlike other peak intensity-based methods, the Rietveld method uses a least squares approach to refine a theoretical line profile until it matches the obtained experimental patterns.

Rietveld refinement is completed with a set of minerals specifically identified for the sample. Zero values indicate that the mineral was included in the refinement calculations, but the calculated concentration was less than 0.05wt%. Minerals not identified by the analyst are not included in refinement calculations for specific samples and are indicated with a dash.

SGS Minerals
a division of SGS Canada Inc.
P.O. Box 4300, 185 Concession Street, Lakefield, Ontario, Canada K0L 2H0
Tel: (705) 652-2000 Fax: (705) 652-6365 www.sgs.com www.sgs.com/met
Member of the SGS Group (SGS SA)

SGS

Summary of Rietveld Quantitative Analysis X-Ray Diffraction Results

Mineral/Compound	Q1 JAN4500-01 (wt %)	Q5 JAN4500-02 (wt %)	Q24 JAN4500-03 (wt %)	QMR2 JAN4500-04 (wt %)	PQ4B JAN4500-05 (wt %)	PQ5B JAN4500-06 (wt %)	PQ6B JAN4500-07 (wt %)	PQ12A JAN4500-08 (wt %)	PQ13 JAN4500-09 (wt %)	PQ15A JAN4500-10 (wt %)	PQ15B JAN4500-11 (wt %)
Quartz	29.7	30.7	1.1	65.8	1.1	0.5	0.8	1.7	41.4	26.1	34.8
Albite	40.6	32.7	-	12.3	-	-	-	-	11.4	28.7	18.9
Muscovite	3.1	4.9	-	6.7	0.0	-	-	-	5.5	8.4	10.4
Biotite	1.3	2.5	-	3.7	-	-	-	-	0.7	8.9	4.6
Chlorite	1.5	2.7	-	1.2	-	-	-	-	2.4	0.2	0.0
Magnetite	0.6	0.3	-	0.3	-	0.4	0.4	-	0.8	1.1	0.6
Microcline	23.2	23.3	-	9.9	-	-	-	-	36.9	24.1	29.8
Hematite	-	0.9	-	0.1	-	0.1	0.2	0.8	-	-	-
Diopside	-	1.3	-	-	-	-	-	-	-	-	-
Lepidocrocite	-	0.6	-	-	-	-	-	-	-	0.8	-
Calcite	-	-	90.6	-	98.7	86.6	80.6	0.1	0.6	1.1	0.4
Ankerite	-	-	5.2	-	-	12.3	5.1	-	0.1	0.6	0.3
Dolomite	-	-	3.1	-	0.2	-	12.9	91.5	0.2	0.1	0.2
Sanidine	-	-	-	-	-	-	-	6.0	-	-	-
TOTAL	100	100	100	100	100	100	100	100	100	100	100

Zero values indicate that the mineral was included in the refinement, but the calculated concentration is below a measurable value.

Dashes indicate that the mineral was not identifed by the analyst and not included in the refinement calculation for the sample.

The weight percent quantities indicated have been normalized to a sum of 100%. The quantity of amorphous material has not been determined.

Mineral/Compound	Formula
Quartz	SiO_2
Albite	$NaAlSi_3O_8$
Muscovite	$KAl_2(AlSi_3O_{10})(OH)_2$
Biotite	$K(Mg,Fe)_3(AlSi_3O_{10})(OH)_2$
Chlorite	$(Fe,(Mg,Mn)_5,Al)(Si_3Al)O_{10}(OH)_8$
Magnetite	Fe_3O_4
Microcline	$KAlSi_3O_8$
Hematite	Fe_2O_3
Diopside	$CaMgSi_2O_6$
Lepidocrocite	FeOOH
Calcite	$CaCO_3$
Ankerite	$CaFe(CO_3)_2$
Dolomite	$CaMg(CO_3)_2$
Sanidine	$KAlSi_3O_8$

Environmental -Analytical
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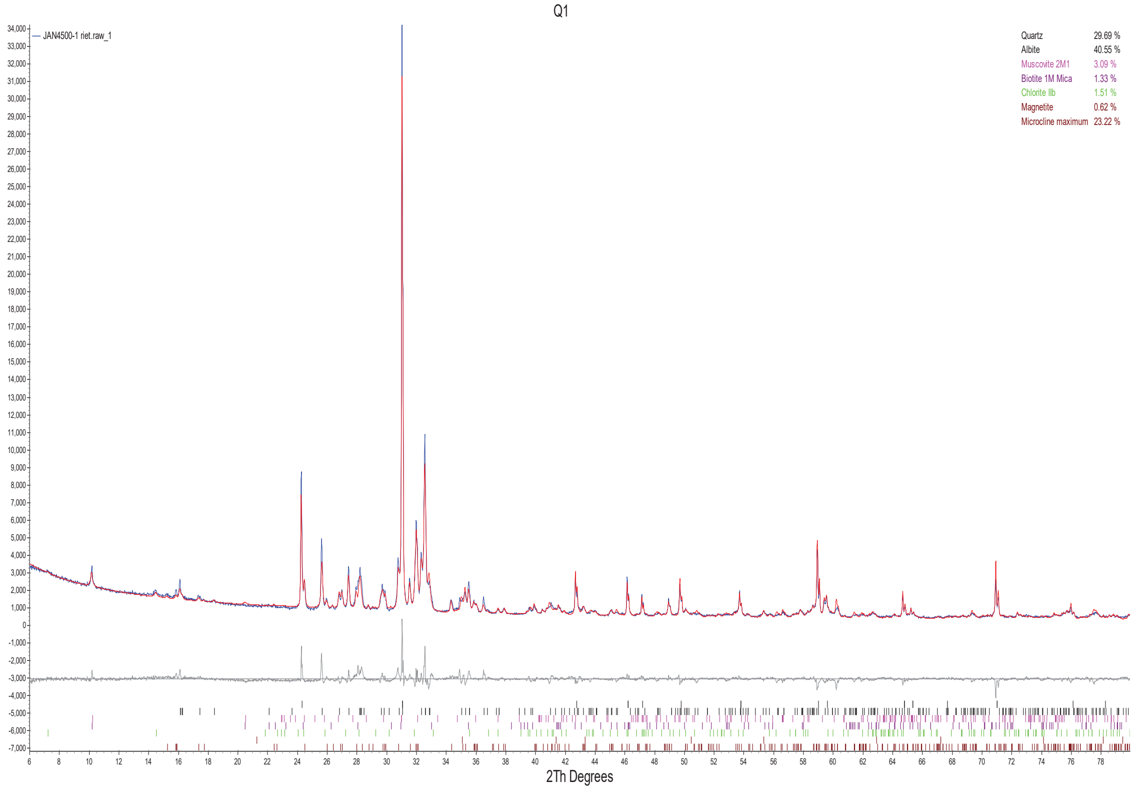
15-Jan-19

Q1



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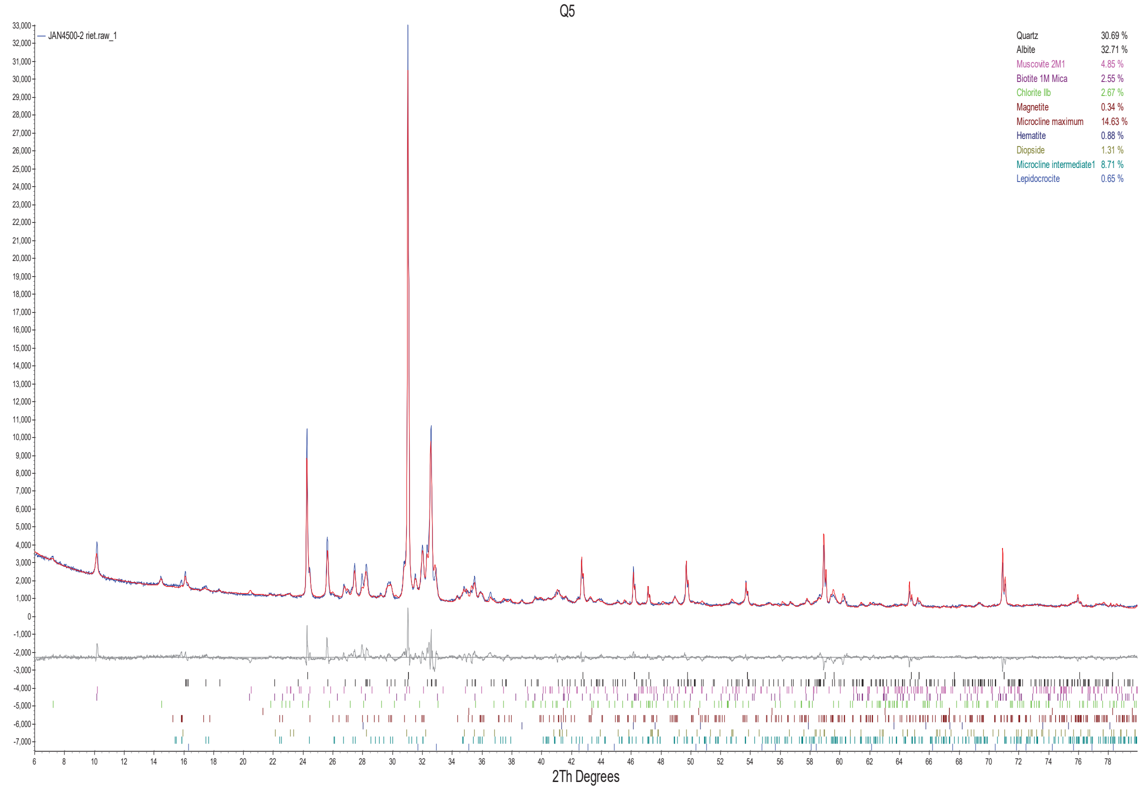
Custom XRD/MI4500-JAN19
15-Jan-19

Q5



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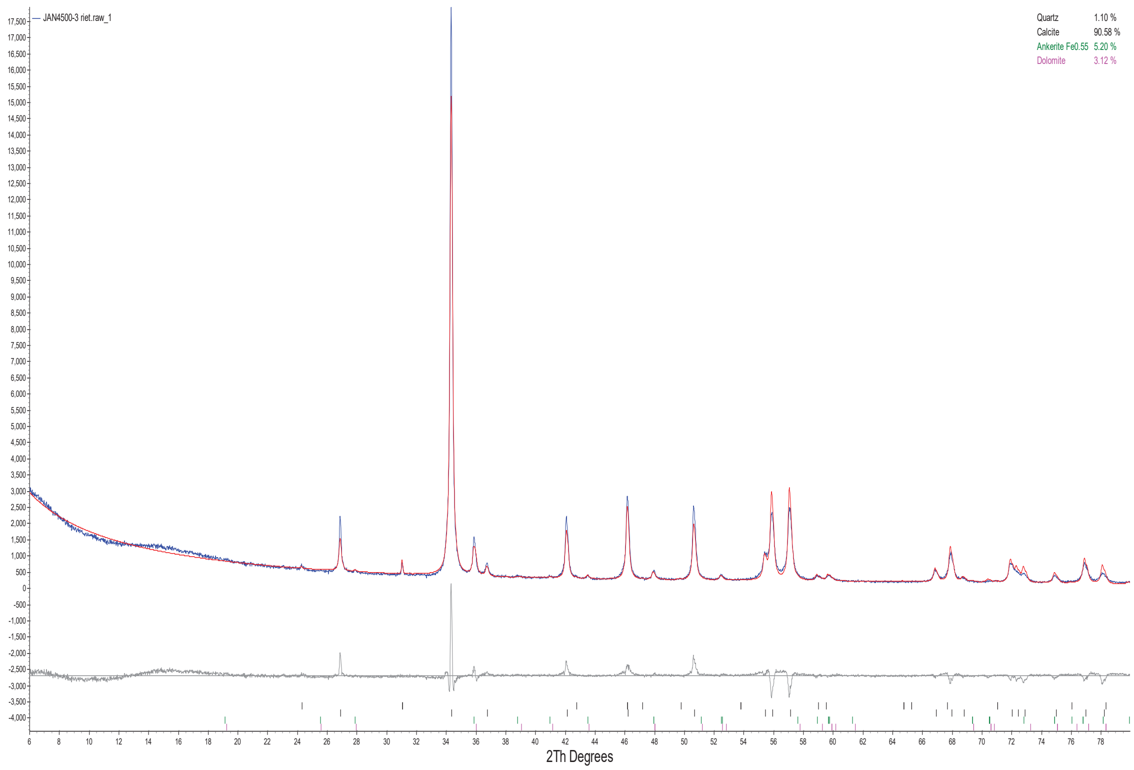
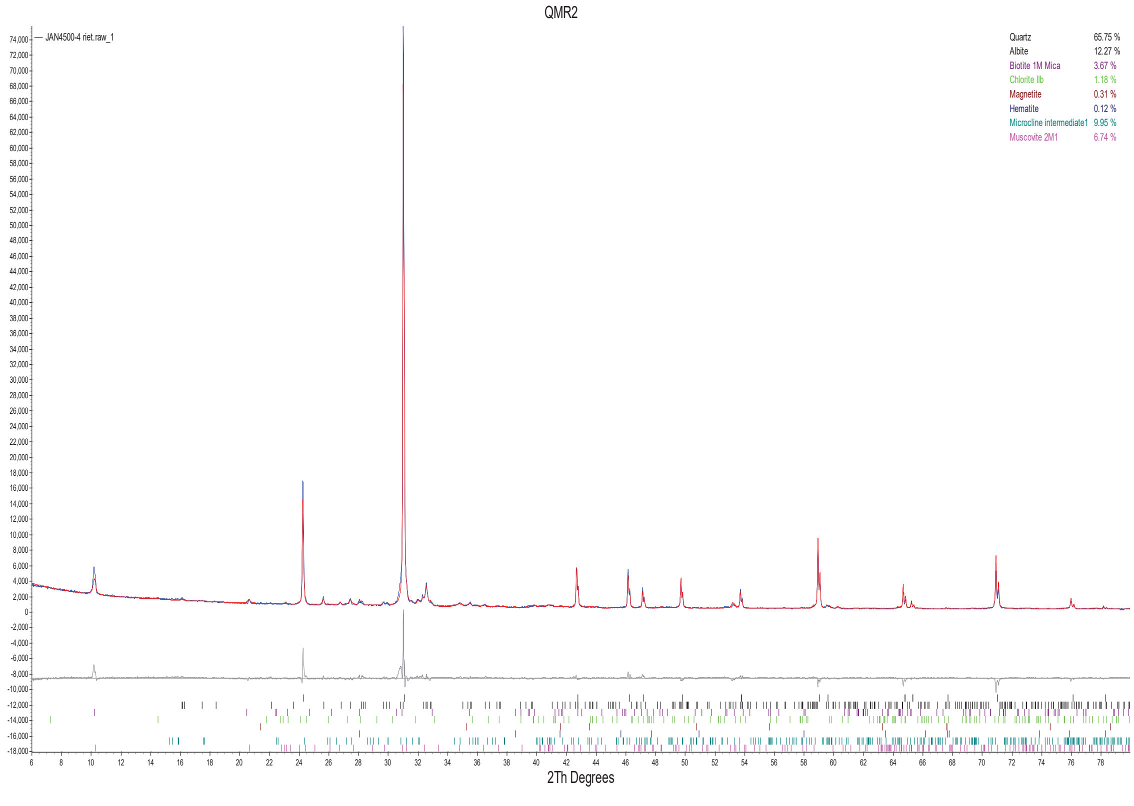
Custom XRD/MI4500-JAN19
15-Jan-19

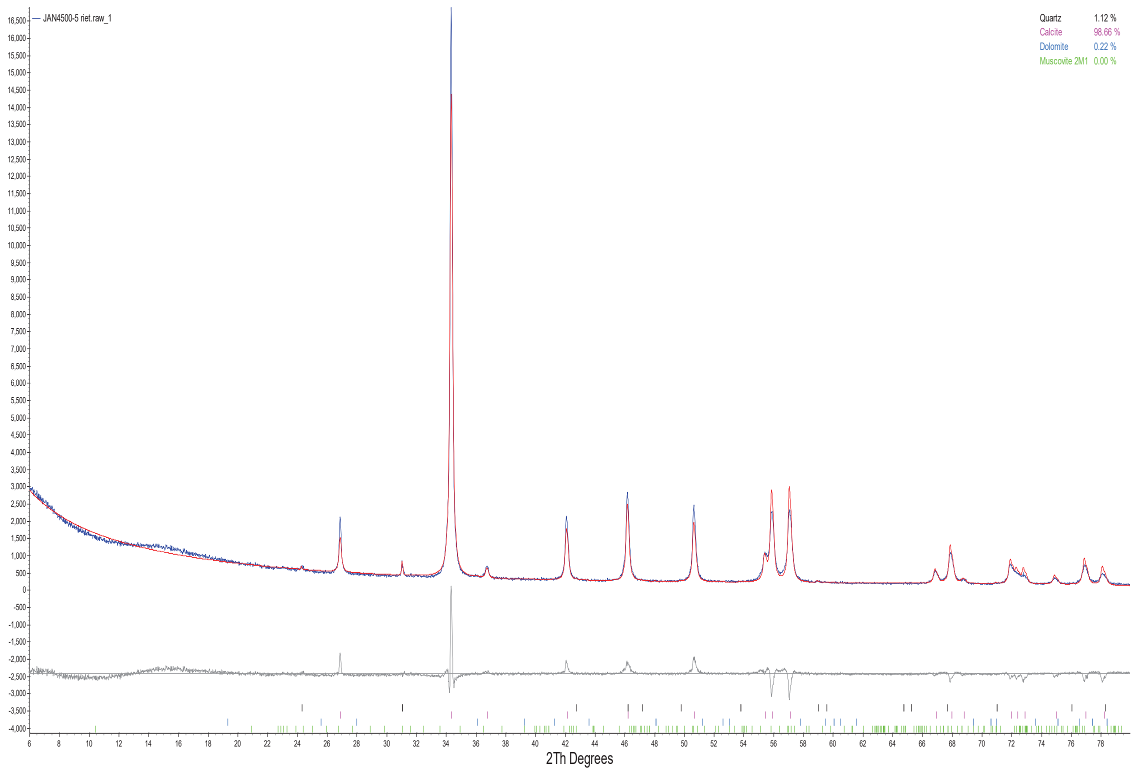
Q24

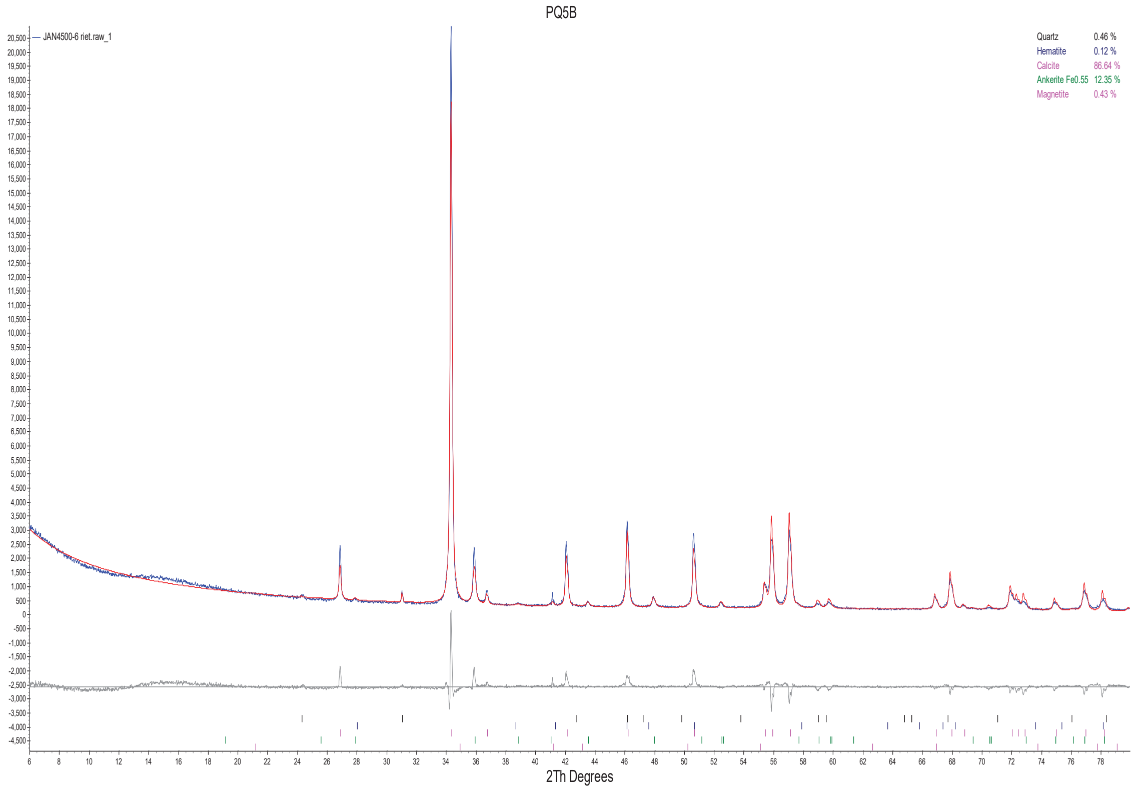



QMR2
JAN4500-4 riet.raw_1
Quartz 65.75 %
Albite 12.27 %
Biotite 1M Mica 3.67 %
Chlorite IIb 1.18 %
Magnetite 0.31 %
Hematite 0.12 %
Microcline intermediate1 9.95 %
Muscovite 2M1 6.74 %
2Th Degrees

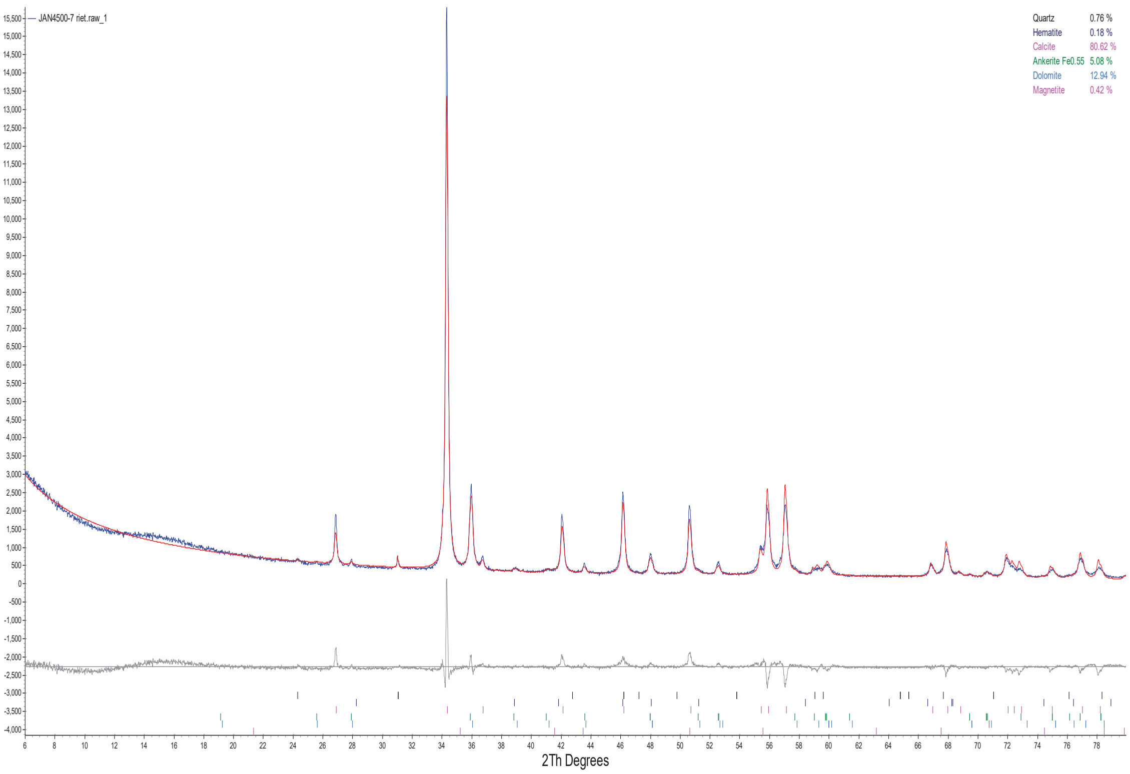
Environmental -Analytical
Custom XRD/MI4500-JAN19
15-Jan-19

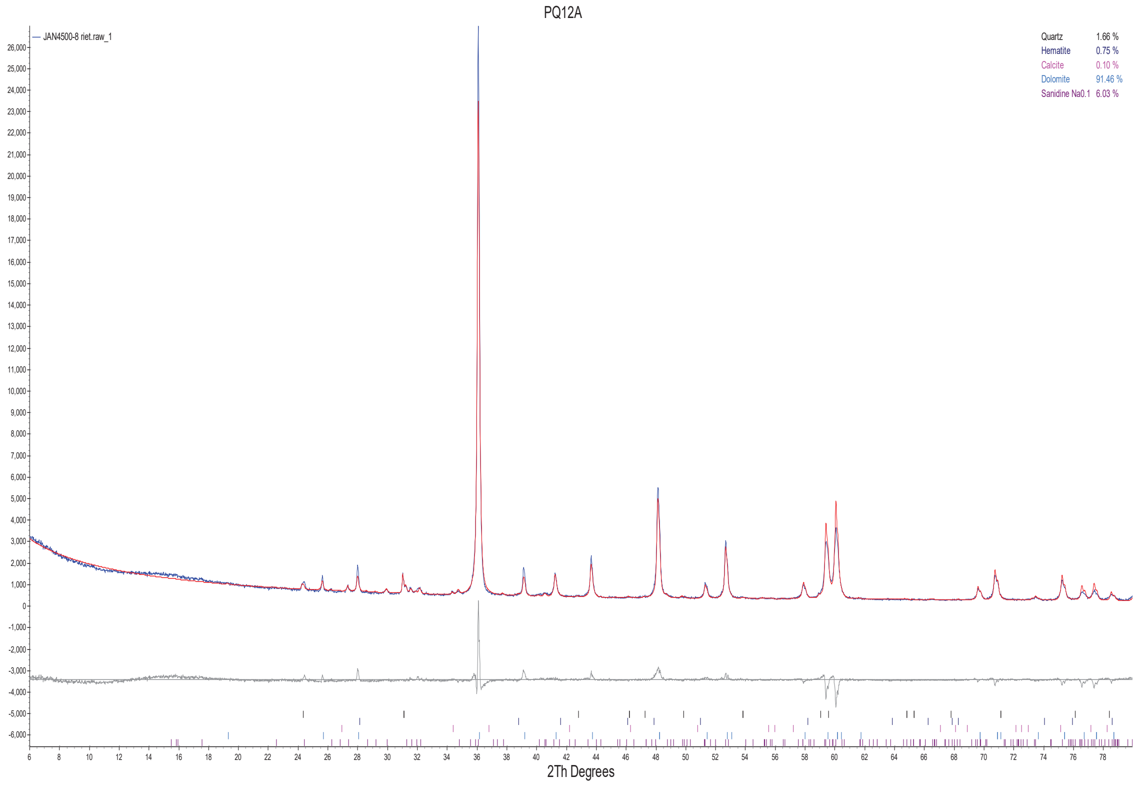
PQ4B



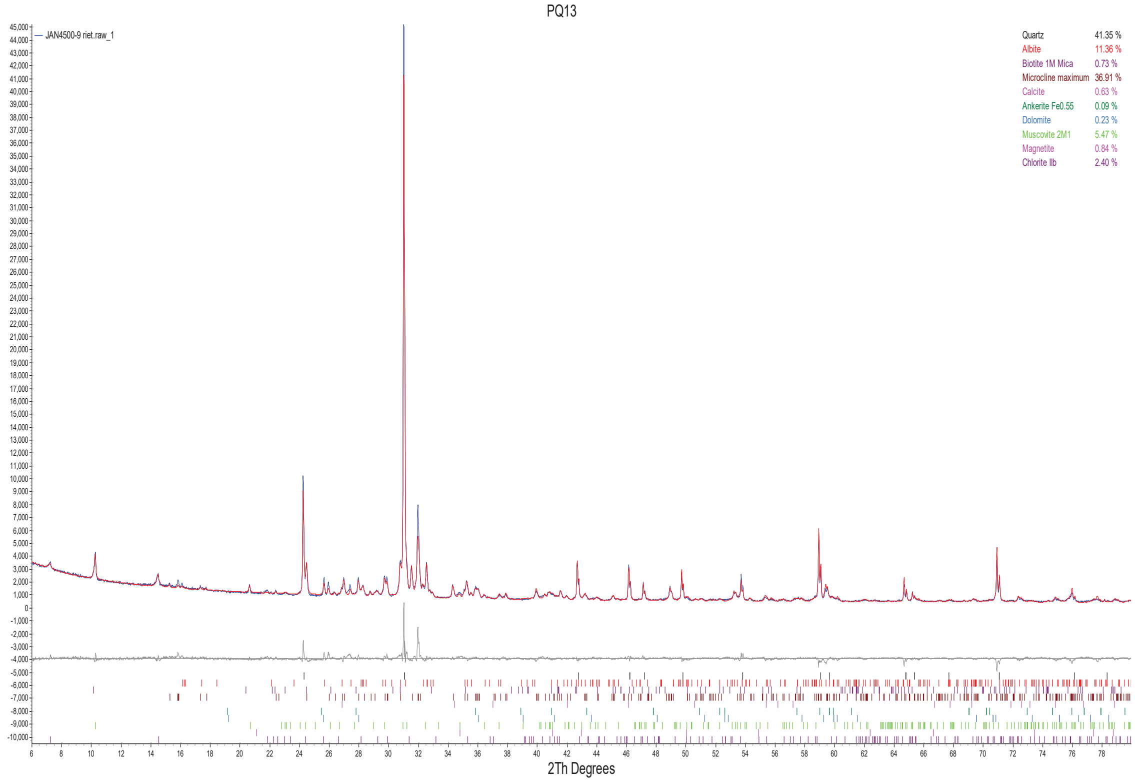

PQ5B
JAN4500-6 riet.raw_1
Quartz 0.46 %
Hematite 0.12 %
Calcite 86.64 %
Ankerite Fe0.55 12.35 %
Magnetite 0.43 %
2Th Degrees

PQ6B

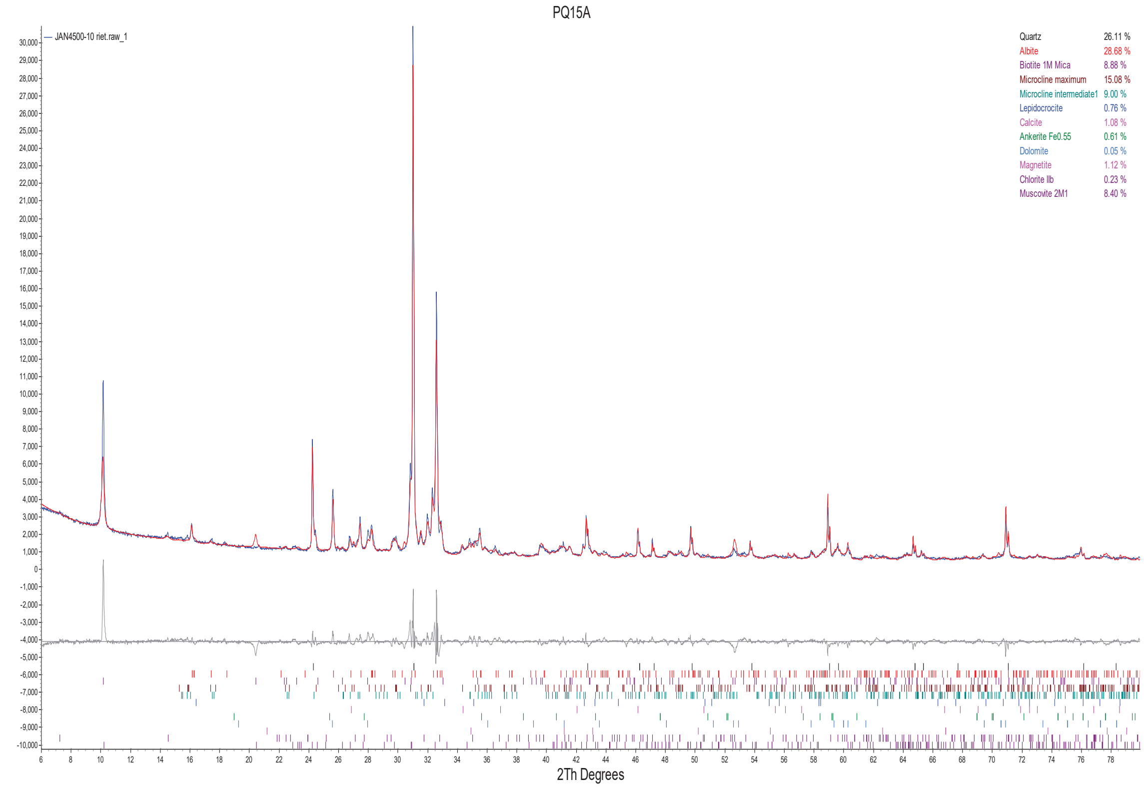

JAN4500-7 riet.raw_1
Quartz 0.76 %
Hematite 0.18 %
Calcite 80.62 %
Ankerite Fe0.55 5.08 %
Dolomite 12.94 %
Magnetite 0.42 %
2Th Degrees


PQ12A
JAN4500-8 riet.raw_1
Quartz 1.66 %
Hematite 0.75 %
Calcite 0.10 %
Dolomite 91.46 %
Sanidine Na0.1 6.03 %
2Th Degrees

PQ13

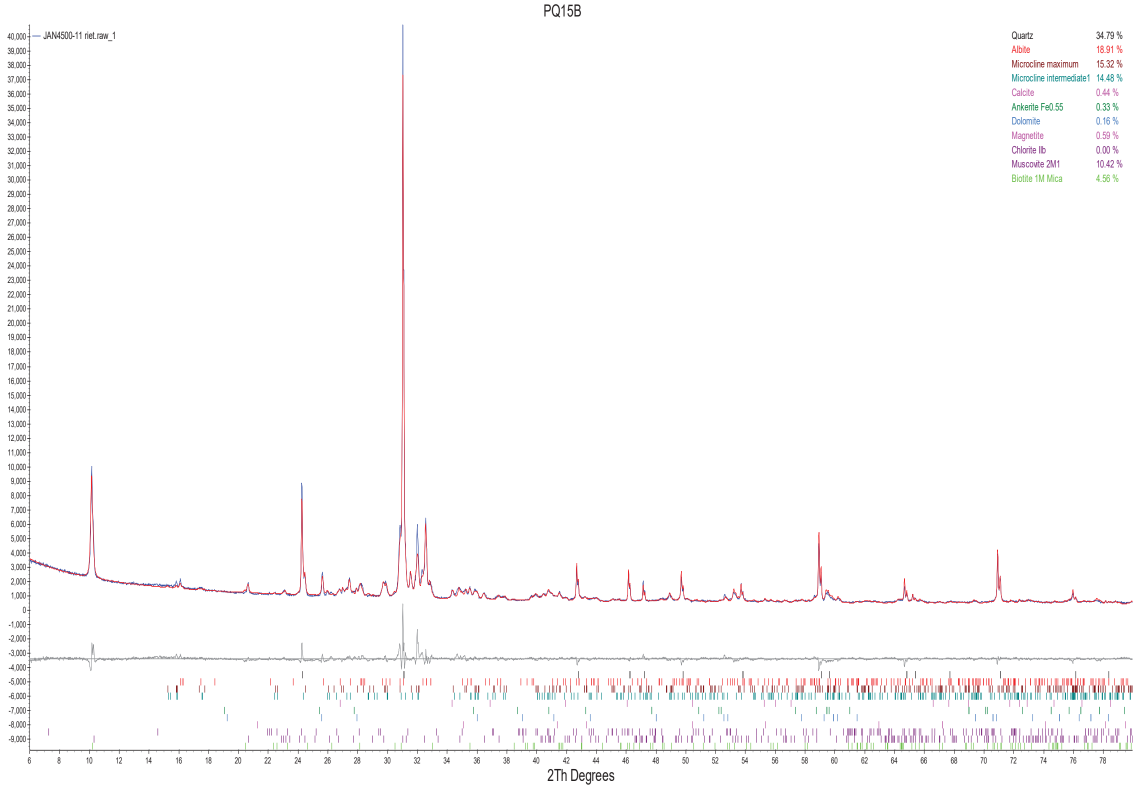

JAN4500-9 riet.raw_1
Quartz 41.35 %
Albite 11.36 %
Biotite 1M Mica 0.73 %
Microcline maximum 36.91 %
Calcite 0.63 %
Ankerite Fe0.55 0.09 %
Dolomite 0.23 %
Muscovite 2M1 5.47 %
Magnetite 0.84 %
Chlorite IIb 2.40 %
2Th Degrees

Environmental -Analytical
Custom XRD/MI4500-JAN19
15-Jan-19



Environmental -Analytical
Custom XRD/MI4500-JAN19
15-Jan-19

PQ15B



HATCH

ASTM D-5731-08 Determination of Point Load Strength Index of Rock and Application to Rock Strength Classifications.

Point Load Test Results Summary

Project H/353004 - PCCR4091, Propose Quarry Sampling & Lab Testing Program
Date : March.3,2019
Test By: RS & XZ

Proposed Quarry Location	Sample	Test Type	Loading Relative to Bedding	W (W1+W2)/2	D	D/W	Equiv. Diameter D_e, mm	Diameter Squared D_e^2, mm²	Pressure at break (kPa)	(P) Point Load Newtons	Uncorrected Point Load Strength Index (Is) mPa	Correction Factor (F)	Corrected Point Load Strength Index (Is50)	Correlation Factor (K)	ASTM Generalized UCS (mPa)
PQ6B	01	lump	perpendicular	76	42.00	0.55	63.75	4064.15	16000	8096	1.99	1.12	2.22	24.5	**48.81**
	02	lump	perpendicular	63	43.00	0.68	58.73	3449.18	7500	3795	1.10	1.08	1.18	24.0	**26.41**
	03	lump	perpendicular	79	46.00	0.58	68.02	4626.91	20000	10120	2.19	1.15	2.51	24.5	**53.59**
	04	lump	perpendicular	85	45.00	0.53	69.79	4870.10	13000	6578	1.35	1.16	1.57	24.5	**33.09**
	05	lump	perpendicular	94	36.00	0.38	65.64	4308.61	14000	7084	1.64	1.13	1.86	24.5	**40.28**
	06	lump	perpendicular	75	25.00	0.33	48.86	2387.30	16000	8096	3.39	0.99	3.36	21.0	**71.22**
	07	lump	perpendicular	72	29.00	0.40	51.56	2658.50	12000	6072	2.28	1.01	2.32	23.0	**52.53**
	08	lump	perpendicular	100	28.00	0.28	59.71	3565.04	25000	12650	Non-conforming, invalid D/W ratio				
	09	lump	perpendicular	101	51.00	0.50	80.98	6558.40	12500	6325	0.96	1.24	1.20	24.5	**23.63**
	10	lump	perpendicular	103	45.00	0.44	76.82	5901.41	1700	860	0.15	1.21	0.18	24.5	**3.57**
	11	lump	perpendicular	73	46.00	0.63	65.39	4275.50	24000	12144	2.84	1.13	3.20	24.5	**69.59**
	12	lump	perpendicular	70	37.00	0.53	57.43	3297.66	12000	6072	1.84	1.06	1.96	24.0	**44.19**
	13	lump	perpendicular	67	61.00	0.91	72.14	5203.68	18000	9108	1.75	1.18	2.06	24.5	**42.88**
	14	lump	perpendicular	84	66.00	0.79	84.02	7058.78	18000	9108	1.29	1.26	1.63	24.5	**31.61**
	15	lump	perpendicular	65	30.00	0.46	49.83	2482.80	11000	5566	2.24	1.00	2.24	21.0	**47.08**

Notes:
1. All samples tested were irregular lumps as per ASTM D-5731-08 Fig. 3 / Type D
2. Samples were stored to preserve natural moisture contents before testing. Tests were at natural moisture content.
3. Most recent calibration of point load tester on April 24, 2018
4. Strength conversion factor K determined as per ASTM D-5731-08 / Table 1

HATCH

ASTM D-5731-08 Determination of Point Load Strength Index of Rock and Application to Rock Strength Classifications.

Point Load Test Results Summary

Project H/353004 - PCCR4091, Propose Quarry Sampling & Lab Testing Program
Date : March.3,2019
Test By: RS & XZ

Proposed Quarry Location	Sample	Test Type	Loading Relative to Bedding	W (W1+W2)/2	D	D/W	Equiv. Diameter D_e, mm	Diameter Squared D_e^2, mm²	Pressure at break (kPa)	(P) Point Load Newtons	Uncorrected Point Load Strength Index (Is) mPa	Correction Factor (F)	Corrected Point Load Strength Index (Is50)	Correlation Factor (K)	ASTM Generalized UCS (mPa)
PQ15A	01	lump	parallel	73	37	0.51	58.64	3438.99	26000.00	13156.00	3.83	1.07	4.11	24	**91.81**
	02	lump	perpendicular	66	51	0.77	65.47	4285.69		Non-conforming, invalid failure plane					
	03	lump	perpendicular	65	40	0.62	57.54	3310.39	30000.00	15180.00	4.59	1.07	4.88	24	**110.05**
	04	lump	parallel	42	33	0.79	42.01	1764.69	17000.00	8602.00	4.87	0.92	4.51	21	**102.36**
	05	lump	perpendicular	73	56	0.77	72.15	5204.96	44000.00	22264.00	4.28	1.18	5.04	24.5	**104.80**
	06	lump	parallel	58	40	0.69	54.35	2953.89	16000.00	8096.00	2.74	1.04	2.85	24	**65.78**
	07	lump	perpendicular	91	51	0.56	76.87	5909.05	30000.00	15180.00	2.57	1.21	3.12	24.5	**62.94**
	08	lump	parallel	64	51	0.80	64.47	4155.82	22000.00	11132.00	2.68	1.12	3.00	24.5	**65.63**
	09	lump	perpendicular	77	53	0.69	72.08	5196.05	55000.00	27830.00	5.36	1.18	6.31	24.5	**131.22**
	10	lump	perpendicular	75	49	0.65	68.40	4679.11	31000.00	15686.00	3.35	1.15	3.86	24.5	**82.13**
	11	lump	perpendicular	54	43	0.80	54.37	2956.44	24000.00	12144.00	4.11	1.04	4.27	24	**98.58**
	12	lump	parallel	60						Non-conforming, failure before testing					
	13	lump	perpendicular	67	50	0.75	65.31	4265.32	26000.00	13156.00	3.08	1.13	3.48	24.5	**75.57**
	14	lump	parallel	48	31	0.65	43.53	1894.56	25000.00	12650.00	6.68	0.94	6.27	21	**140.22**
	15	lump	perpendicular	62	58	0.94	67.66	4578.53	26000.00	13156.00	2.87	1.15	3.29	24.5	**70.40**

Notes:

1. All samples tested were irregular lumps as per ASTM D-5731-08 Fig. 3 / Type D
2. Samples were stored to preserve natural moisture contents before testing. Tests were at natural moisture content.
3. Most recent calibration of point load tester on April 24, 2018
4. Strength conversion factor K determined as per ASTM D-5731-08 / Table 1

ASTM D-5731-08 Determination of Point Load Strength Index of Rock and Application to Rock Strength Classifications.

Point Load Test Results Summary

Project H/353004 - PCCR4091, Propose Quarry Sampling & Lab Testing Program
Date : March.3,2019
Test By: RS & XZ

Proposed Quarry Location	Sample	Test Type	Loading Relative to Bedding	W (W1+W2)/2	D	D/W	Equiv. Diameter D_e, mm	Diameter Squared D_e^2, mm²	Pressure at break (kPa)	(P) Point Load Newtons	Uncorrected Point Load Strength Index (Is) mPa	Correction Factor (F)	Corrected Point Load Strength Index (Is50)	Correlation Factor (K)	ASTM Generalized UCS (mPa)
Q24	1	lump	perpendicular	69	111	1.61	98.75	9751.66	29000	14674	1.50	1.36	2.04	24.5	**36.87**
	2	lump	perpendicular	82	98	1.20	101.15	10231.66	24000	12144	1.19	1.37	1.63	24.5	**29.08**
	3	lump	perpendicular	77	103	1.34	100.49	10097.97	38000	19228	1.90	1.37	2.61	24.5	**46.65**
	4	lump	perpendicular	67	113	1.69	98.18	9639.61	18000	9108	0.94	1.35	1.28	24.5	**23.15**
	5	lump	parallel	68	112	1.65	98.47	9696.91		Non-conforming, invalid failure plane					
	6	lump	perpendicular	57	123	2.16	94.48	8926.60	30000	15180	1.70	1.33	2.26	24.5	**41.66**
	7	lump	parallel	72	108	1.50	99.50	9900.62	17000	8602	0.87	1.36	1.18	24.5	**21.29**
	8	lump	parallel	72	108	1.50	99.50	9900.62	24000	12144	1.23	1.36	1.67	24.5	**30.05**
	9	lump	parallel	45	135	3.00	87.95	7734.86	22000	11132	1.44	1.29	1.86	24.5	**35.26**
	10	lump	perpendicular	51	129	2.53	91.52	8376.57	18000	9108	1.09	1.31	1.43	24.5	**26.64**
	11	lump	parallel	85	95	1.12	101.40	10281.32	26000	13156	1.28	1.37	1.76	24.5	**31.35**
	12	lump	perpendicular	70	110	1.57	99.01	9803.86	6000	Non-conforming, invalid failure plane					
	13	lump	parallel	87	93	1.07	101.50	10301.69	24000	Non-conforming, invalid failure plane					
	14	lump	parallel	68	112	1.65	98.47	9696.91	26000	Non-conforming, invalid failure plane					
	15	lump	parallel	60	120	2.00	95.75	9167.24	29000	14674	1.60	1.34	2.14	24.5	**39.22**
	16	lump	parallel	55	125	2.27	93.56	8753.45	18000	9108	1.04	1.33	1.38	24.5	**25.49**
	17	lump	parallel	60	120	2.00	95.75	9167.24	30000	15180	1.66	1.34	2.22	24.5	**40.57**

Notes:
1. All samples tested were irregular lumps as per ASTM D-5731-08 Fig. 3 / Type D
2. Samples were stored to preserve natural moisture contents before testing. Tests were at natural moisture content.
3. Most recent calibration of point load tester on April 24, 2018
4. Strength conversion factor K determined as per ASTM D-5731-08 / Table 1

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ASTM D-5731-08 Determination of Point Load Strength Index of Rock and Application to Rock Strength Classifications.

Point Load Test Results Summary

Project H/353004 - PCCR4091, Propose Quarry Sampling & Lab Testing Program
Date : March.3,2019
Test By: RS & XZ

Proposed Quarry Location	Sample	Test Type	Loading Relative to Bedding	W (W1+W2)/2	D	D/W	Equiv. Diameter D_e, mm	Diameter Squared D_e^2, mm²	Pressure at break (kPa)	(P) Point Load Newtons	Uncorrected Point Load Strength Index (Is) mPa	Correction Factor (F)	Corrected Point Load Strength Index (Is50)	Correlation Factor (K)	ASTM Generalized UCS (mPa)
PQ12A	1	lump	perpendicular	61	39	0.64	55.04	3029.01	43000	21758	7.18	1.04	7.50	24.00	**172.40**
	2	lump	perpendicular	83	62	0.75	80.94	6552.03	47000	23782	Maximum load exceeded				
	3	lump	perpendicular	84	52	0.62	74.58	5561.46	48000	24288	4.37	1.20	5.23	24.50	**107.00**
	4	lump	perpendicular	82	65	0.79	82.38	6786.31	54000	27324	Maximum load exceeded				
	5	lump	perpendicular	72	32	0.44	54.16	2933.52	17000	8602	2.93	1.04	3.04	24.00	**70.38**
	6	lump	perpendicular	72	31	0.43	53.31	2841.85	19000	9614	3.38	1.03	3.48	23.00	**77.81**
	7	lump	perpendicular	77	38	0.49	61.04	3725.47	33000	16698	4.48	1.09	4.90	24.50	**109.81**
	8	lump	perpendicular	71	34	0.48	55.44	3073.57	17000	8602	2.80	1.05	2.93	24.00	**67.17**
	9	lump	perpendicular	79	28	0.35	53.07	2816.38	22000	11132	3.95	1.03	4.06	23.00	**90.91**
	10	lump	perpendicular	90	38	0.42	65.99	4354.44	29000	14674	3.37	1.13	3.82	24.50	**82.56**
	11	lump	perpendicular	46	36	0.78	45.92	2108.47	29000	14674	6.96	0.96	6.70	21.00	**146.15**
	12	lump	parallel	42	42	1.00	47.39	2245.98	22000	11132	4.96	0.98	4.84	21.00	**104.08**
	13	lump	perpendicular	72	39	0.54	59.79	3575.23	37000	18722	5.24	1.08	5.68	24.00	**125.68**
	14	lump	parallel	40	32	0.80	40.37	1629.73	23000	11638	7.14	0.91	6.49	19.00	**135.68**
	15	lump	parallel	39	38	0.97	43.44	1886.92	17000	8602	4.56	0.94	4.28	21.00	**95.73**

Notes:
1. All samples tested were irregular lumps as per ASTM D-5731-08 Fig. 3 / Type D
2. Samples were stored to preserve natural moisture contents before testing. Tests were at natural moisture content.
3. Most recent calibration of point load tester on April 24, 2018
4. Strength conversion factor K determined as per ASTM D-5731-08 / Table 1

HATCH

ASTM D-5731-08 Determination of Point Load Strength Index of Rock and Application to Rock Strength Classifications.

Point Load Test Results Summary

Project H/353004 - PCCR4091, Propose Quarry Sampling & Lab Testing Program
Date : March.3,2019
Test By: RS & XZ

Proposed Quarry Location	Sample	Test Type	Loading Relative to Bedding	W (W1+W2)/2	D	D/W	Equiv. Diameter D_e, mm	Diameter Squared D_e^2, mm²	Pressure at break (kPa)	(P) Point Load Newtons	Uncorrected Point Load Strength Index (Is) mPa	Correction Factor (F)	Corrected Point Load Strength Index (Is50)	Correlation Factor (K)	ASTM Generalized UCS (mPa)
PQ4B	01	lump	perpendicular	69	33	0.48	53.84	2899.14	6000	3036	Non-conforming, invalid failure plane				
	02	lump	perpendicular	89	34	0.38	62.07	3852.79	16000	8096	2.10	1.10	2.32	24.50	**51.48**
	03	lump	perpendicular	87	30	0.34	57.65	3323.13	1000	506	0.15	1.07	0.16	24.00	**3.65**
	04	lump	perpendicular	105	33	0.31	66.42	4411.74	6000	3036	0.69	1.14	0.78	24.50	**16.86**
	05	lump	perpendicular	68	32	0.47	52.64	2770.55	8000	4048	1.46	1.02	1.50	23.00	**33.60**
	06	lump	perpendicular	59	44	0.75	57.49	3305.30	20000	10120	3.06	1.06	3.26	24.00	**73.48**
	07	lump	perpendicular	96	42	0.44	71.65	5133.66	20000	10120	1.97	1.18	2.32	24.50	**48.30**
	08	lump	perpendicular	55	38	0.69	51.59	2661.05	12000	6072	2.28	1.01	2.31	23.00	**52.48**
	09	lump	perpendicular	60	33	0.55	50.21	2520.99	10000	5060	2.01	1.00	2.01	23.00	**46.16**
	10	lump	perpendicular	55	42	0.76	54.23	2941.16	12000	6072	2.06	1.04	2.14	24.00	**49.55**
	11	lump	perpendicular	94	43	0.46	71.74	5146.39	34000	17204	3.34	1.18	3.93	24.50	**81.90**
	12	lump	perpendicular	54	40	0.74	52.44	2750.17	20000	10120	3.68	1.02	3.76	23.00	**84.63**
	13	lump	perpendicular	96	47	0.49	75.79	5744.81	8000	4048	Non-conforming, invalid failure plane				
	14	lump	perpendicular	49	36	0.73	47.39	2245.98	22000	11132	4.96	0.98	4.84	21.00	**104.08**
	15	lump	perpendicular	55	35	0.64	49.51	2450.96	12000	6072	Non-conforming, invalid failure plane				

Notes:
1. All samples tested were irregular lumps as per ASTM D-5731-08 Fig. 3 / Type D
2. Samples were stored to preserve natural moisture contents before testing. Tests were at natural moisture content.
3. Most recent calibration of point load tester on April 24, 2018
4. Strength conversion factor K determined as per ASTM D-5731-08 / Table 1

HATCH

ASTM D-5731-08 Determination of Point Load Strength Index of Rock and Application to Rock Strength Classifications.

Point Load Test Results Summary

Project H/353004 - PCCR4091, Propose Quarry Sampling & Lab Testing Program
Date : March.3,2019
Test By: RS & XZ

Proposed Quarry Location	Sample	Test Type	Loading Relative to Bedding	W (W1+W2)/2	D	D/W	Equiv. Diameter D_e, mm	Diameter Squared D_e^2, mm²	Pressure at break (kPa)	(P) Point Load Newtons	Uncorrected Point Load Strength Index (Is) mPa	Correction Factor (F)	Corrected Point Load Strength Index (Is50)	Correlation Factor (K)	ASTM Generalized UCS (mPa)
PQ5B	01	lump	perpendicular	65	30	0.46	49.83	2482.80	14000	7084	2.85	1.00	2.85	21.00	**59.92**
	02	lump	perpendicular	85	41	0.48	66.61	4437.20	20000	10120	2.28	1.14	2.59	24.50	**55.88**
	03	lump	perpendicular	41	35	0.85	42.74	1827.08	16000	8096	4.43	0.93	4.13	21.00	**93.05**
	04	lump	perpendicular	62	32	0.52	50.26	2526.09	12000	6072	2.40	1.00	2.41	23.00	**55.29**
	05	lump	perpendicular	73	36	0.49	57.85	3346.04	20000	10120	3.02	1.07	3.23	24.00	**72.59**
	06	lump	perpendicular	50	30	0.60	43.70	1909.84	18000	9108	4.77	0.94	4.49	21.00	**100.15**
	07	lump	perpendicular	85	53	0.62	75.74	5735.89	21000	10626	1.85	1.21	2.23	24.50	**45.39**
	08	lump	perpendicular	84	57	0.68	78.08	6096.22	14000	7084	1.16	1.22	1.42	24.50	**28.47**
	09	lump	perpendicular	94	55	0.59	81.13	6582.59	19000	9614	1.46	1.24	1.82	24.50	**35.78**
	10	lump	perpendicular	96	54	0.56	81.24	6600.42	18000	9108	Non-conforming, invalid failure plane				
	11	lump	perpendicular	70	40	0.57	59.71	3565.04	10000	5060	1.42	1.08	1.54	24.00	**34.06**
	12	lump	perpendicular	44	51	1.16	53.45	2857.12	16000	8096	Non-conforming, invalid failure plane				
	13	lump	perpendicular	38	57	1.50	52.51	2757.81	14000	7084	2.57	1.02	2.63	23.00	**59.08**
	14	lump	parallel	75	41	0.55	62.57	3915.18	8000	4048	1.03	1.11	1.14	24.50	**25.33**
	15	lump	perpendicular	43	42	0.98	47.95	2299.45	12000	6072	2.64	0.98	2.59	21.00	**55.45**

Notes:
1. All samples tested were irregular lumps as per ASTM D-5731-08 Fig. 3 / Type D
2. Samples were stored to preserve natural moisture contents before testing. Tests were at natural moisture content.
3. Most recent calibration of point load tester on April 24, 2018
4. Strength conversion factor K determined as per ASTM D-5731-08 / Table 1

HATCH

ASTM D-5731-08 Determination of Point Load Strength Index of Rock and Application to Rock Strength Classifications.

Point Load Test Results Summary

Project H/353004 - PCCR4091, Propose Quarry Sampling & Lab Testing Program
Date : March.3,2019
Test By: RS & XZ

Proposed Quarry Location	Sample	Test Type	Loading Relative to Bedding	W (W1+W2)/2	D	D/W	Equiv. Diameter D_e, mm	Diameter Squared D_e^2, mm^2	Pressure at break (kPa)	(P) Point Load Newtons	Uncorrected Point Load Strength Index (Is) mPa	Correction Factor (F)	Corrected Point Load Strength Index (Is50)	Correlation Factor (K)	ASTM Generalized UCS (mPa)
QMR2	01	lump	perpendicular	69	30	0.43	51.34	2635.58	44000.00	22264.00	8.45	1.01	8.55	23.00	**194.29**
	02	lump	perpendicular	55	39	0.71	52.26	2731.08	18000.00	9108.00	3.33	1.02	3.40	23.00	**76.70**
	03	lump	perpendicular	82	38	0.46	62.99	3967.38	42000.00	21252.00	5.36	1.11	5.94	24.50	**131.24**
	04	lump	perpendicular	79	45	0.57	67.28	4526.33	33000.00	16698.00	3.69	1.14	4.22	24.50	**90.38**
	05	lump	perpendicular	79	45	0.57	67.28	4526.33	33000.00	16698.00	3.69	1.14	4.22	24.50	**90.38**
	06	lump	perpendicular	86	38	0.44	64.51	4160.91	29000.00	14674.00	3.53	1.12	3.95	24.50	**86.40**
	07	lump	perpendicular	72	33	0.46	55.00	3025.19	26000.00	13156.00	4.35	1.04	4.54	24.00	**104.37**
	08	lump	perpendicular	83	40	0.48	65.02	4227.12	20000.00	10120.00	2.39	1.13	2.69	24.50	**58.65**
	09	lump	perpendicular	86	30	0.35	57.31	3284.93	40000.00	20240.00	6.16	1.06	6.55	24.00	**147.88**
	10	lump	perpendicular	85	30	0.35	56.98	3246.73	28000.00	14168.00	4.36	1.06	4.63	24.00	**104.73**
	11	lump	perpendicular	101	44	0.44	75.22	5658.23	34000.00	17204.00	3.04	1.20	3.65	24.50	**74.49**
	12	lump	perpendicular	63	30	0.48	49.06	2406.40	30000.00	15180.00	6.31	0.99	6.25	21.00	**132.47**
	13	lump	perpendicular	59	35	0.59	51.28	2629.22	39000.00	19734.00	7.51	1.01	7.59	23.00	**172.63**
	14	lump	perpendicular	58	37	0.64	52.27	2732.35	30000.00	15180.00	5.56	1.02	5.67	23.00	**127.78**
	15	lump	perpendicular	71	30	0.42	52.08	2711.98	22000.00	11132.00	4.10	1.02	4.18	23.00	**94.41**

Notes:

1. All samples tested were irregular lumps as per ASTM D-5731-08 Fig. 3 / Type D
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ASTM D-5731-08 Determination of Point Load Strength Index of Rock and Application to Rock Strength Classifications.

Point Load Test Results Summary

Project H/353004 - PCCR4091, Propose Quarry Sampling & Lab Testing Program
Date : March.3,2019
Test By: RS & XZ

Proposed Quarry Location	Sample	Test Type	Loading Relative to Bedding	W (W1+W2)/2	D	D/W	Equiv. Diameter D_e, mm	Diameter Squared D_e^2, mm²	Pressure at break (kPa)	(P) Point Load Newtons	Uncorrected Point Load Strength Index (Is) mPa	Correction Factor (F)	Corrected Point Load Strength Index (Is50)	Correlation Factor (K)	ASTM Generalized UCS (mPa)
	01	lump	perpendicular	51	43	0.84	52.84	2792.19	8000	4048	1.45	1.03	1.49	23.00	**33.34**
	02	lump	perpendicular	83	37	0.45	62.53	3910.08	17000	8602	2.20	1.11	2.43	24.50	**53.90**
	03	lump	perpendicular	104	35	0.34	68.08	4634.55	23000	11638	2.51	1.15	2.89	24.50	**61.52**
	04	lump	perpendicular	67	38	0.57	56.94	3241.64	24000	12144	3.75	1.06	3.97	24.00	**89.91**
	05	lump	perpendicular	66	41	0.62	58.70	3445.36	10000	5060	1.47	1.07	1.58	24.00	**35.25**
	06	lump	perpendicular	59	34	0.58	50.54	2554.10	10000	5060	1.98	1.00	1.99	23.00	**45.57**
	07	lump	parallel	70	38	0.54	58.20	3386.79	9000	4554	1.34	1.07	1.44	24.00	**32.27**
Q5	08	lump	parallel	59	35	0.59	51.28	2629.22	16000	8096	3.08	1.01	3.11	23.00	**70.82**
	09	lump	parallel	43	35	0.81	43.77	1916.21	24000	12144	6.34	0.94	5.97	21.00	**133.09**
	10	lump	parallel	38	37	0.97	42.31	1790.16	18000	9108	5.09	0.93	4.72	21.00	**106.84**
	11	lump	perpendicular	40	38	0.95	43.99	1935.31	17000	8602	4.44	0.94	4.20	21.00	**93.34**
	12	lump	perpendicular	52	38	0.73	50.16	2515.90	16000	8096	3.22	1.00	3.22	23.00	**74.01**
	13	lump	perpendicular	60	32	0.53	49.44	2444.60	24000	12144	4.97	0.99	4.94	21.00	**104.32**
	14	lump	perpendicular	58	40	0.69	54.35	2953.89	20000	10120	Non-conforming, invalid failure plane				
	15	lump	parallel	47	45	0.96	51.89	2692.88	16000	8096	3.01	1.02	3.06	23.00	**69.15**

Notes:

1. All samples tested were irregular lumps as per ASTM D-5731-08 Fig. 3 / Type D
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3. Most recent calibration of point load tester on April 24, 2018
4. Strength conversion factor K determined as per ASTM D-5731-08 / Table 1

HATCH

ASTM D-5731-08 Determination of Point Load Strength Index of Rock and Application to Rock Strength Classifications.

Point Load Test Results Summary

Project H/353004 - PCCR4091, Propose Quarry Sampling & Lab Testing Program
Date : March.3,2019
Test By: RS & XZ

Proposed Quarry Location	Sample	Test Type	Loading Relative to Bedding	W (W1+W2)/2	D	D/W	Equiv. Diameter D_e, mm	Diameter Squared D_e^2, mm²	Pressure at break (kPa)	(P) Point Load Newtons	Uncorrected Point Load Strength Index (Is) mPa	Correction Factor (F)	Corrected Point Load Strength Index (Is50)	Correlation Factor (K)	ASTM Generalized UCS (mPa)
Q15B	01	lump	perpendicular	75	65	0.87	78.78	6206.99	66000	33396	Maximum load exceeded				
	02	lump	perpendicular	100	73	0.73	96.41	9294.57	26000	13156	1.42	1.34	1.90	24.50	**34.68**
	03	lump	perpendicular	75	75	1.00	84.63	7161.91	26000	13156	1.84	1.27	2.33	24.50	**45.01**
	04	lump	perpendicular	53	77	1.45	72.08	5196.05	24000	12144	2.34	1.18	2.76	24.50	**57.26**
	05	lump	perpendicular	96	69	0.72	91.84	8433.87	22000	11132	1.32	1.31	1.74	24.50	**32.34**
	06	lump	perpendicular	42	71	1.69	61.62	3796.77	20000	10120	2.67	1.10	2.93	24.50	**65.30**
	07	lump	parallel	73	74	1.01	82.93	6877.98	19000	9614	1.40	1.26	1.76	24.50	**34.25**
	08	lump	parallel	74	45	0.61	65.11	4239.85	27000	13662	3.22	1.13	3.63	24.50	**78.95**
	09	lump	perpendicular	55	36	0.65	50.21	2520.99	29000	14674	5.82	1.00	5.83	23.00	**133.88**
	10	lump	parallel	75	47	0.63	66.99	4488.13	22000	11132	2.48	1.14	2.83	24.50	**60.77**
	11	lump	perpendicular	62	39	0.63	55.49	3078.67	38000	19228	6.25	1.05	6.55	24.00	**149.89**
	12	lump	perpendicular	76	40	0.53	62.21	3870.61	10000	5060	1.31	1.10	1.44	24.50	**32.03**

Notes:
1. All samples tested were irregular lumps as per ASTM D-5731-08 Fig. 3 / Type D
2. Samples were stored to preserve natural moisture contents before testing. Tests were at natural moisture content.
3. Most recent calibration of point load tester on April 24, 2018
4. Strength conversion factor K determined as per ASTM D-5731-08 / Table 1

HATCH

ASTM D-5731-08 Determination of Point Load Strength Index of Rock and Application to Rock Strength Classifications.

Point Load Test Results Summary

Project H/353004 - PCCR4091, Propose Quarry Sampling & Lab Testing Program
Date : March.3,2019
Test By: RS & XZ

Proposed Quarry Location	Sample	Test Type	Loading Relative to Bedding	W (W1+W2)/2	D	D/W	Equiv. Diameter D_e, mm	Diameter Squared D_e^2, mm²	Pressure at break (kPa)	(P) Point Load Newtons	Uncorrected Point Load Strength Index (Is) mPa	Correction Factor (F)	Corrected Point Load Strength Index (Is50)	Correlation Factor (K)	ASTM Generalized UCS (mPa)
PQ13	01	lump	parallel	92	60	0.65	83.83	7028.22	53000	26818	Maximum load exceeded				
	02	lump	perpendicular	74	45	0.61	65.11	4239.85	42000	21252	5.01	1.13	5.65	24.50	**122.80**

Notes:

1. All samples tested were irregular lumps as per ASTM D-5731-08 Fig. 3 / Type D
2. Samples were stored to preserve natural moisture contents before testing. Tests were at natural moisture content.
3. Most recent calibration of point load tester on April 24, 2018
4. Strength conversion factor K determined as per ASTM D-5731-08 / Table 1
5. Due to the high strength of rock and limited sub-samples, only 2 tests were possible.

HATCH

ASTM D-5731-08 Determination of Point Load Strength Index of Rock and Application to Rock Strength Classifications.

Point Load Test Results Summary

Project H/353004 - PCCR4091, Propose Quarry Sampling & Lab Testing Program
Date : March.3,2019
Test By: RS & XZ

Proposed Quarry Location	Sample	Test Type	Loading Relative to Bedding	W (W1+W2)/2	D	D/W	Equiv. Diameter D_e, mm	Diameter Squared D_e^2, mm²	Pressure at break (kPa)	(P) Point Load Newtons	Uncorrected Point Load Strength Index (Is) mPa	Correction Factor (F)	Corrected Point Load Strength Index (Is50)	Correlation Factor (K)	ASTM Generalized UCS (mPa)
Q1	01	lump	parallel	66	52	0.79	66.10	4369.72	20000	10120	2.32	1.13	2.63	24.50	**56.74**
	02	lump	perpendicular	63	44	0.70	59.41	3529.39	32000	16192	4.59	1.08	4.96	24.00	**110.11**
	03	lump	parallel	99	70	0.71	93.93	8823.47	12000	6072	0.69	1.33	0.91	24.50	**16.86**
	04	lump	perpendicular	81	32	0.40	57.45	3300.21	29000	14674	4.45	1.06	4.73	24.00	**106.71**
	05	lump	perpendicular	60	33	0.55	50.21	2520.99	29000	14674	5.82	1.00	5.83	23.00	**133.88**
	06	lump	perpendicular	73	62	0.85	75.91	5762.63	26000	13156	2.28	1.21	2.75	24.50	**55.93**
	07	lump	parallel	59	37	0.63	52.72	2779.46	37000	18722	6.74	1.02	6.90	23.00	**154.92**
	08	lump	perpendicular	102	46	0.45	77.29	5973.99	40000	20240	3.39	1.22	4.12	24.50	**83.01**
	09	lump	parallel	69	45	0.65	62.88	3953.37	34000	17204	4.35	1.11	4.82	24.50	**106.62**
	10	lump	perpendicular	96	36	0.38	66.33	4400.28	38000	19228	4.37	1.14	4.96	24.50	**107.06**
	11	lump	parallel	72	38	0.53	59.02	3483.55	28000	14168	4.07	1.08	4.38	24.00	**97.61**
	12	lump	perpendicular	71	57	0.80	71.78	5152.76	54000	27324	Maximum load exceeded				
	13	lump	perpendicular	82	35	0.43	60.45	3654.17	30000	15180	4.15	1.09	4.52	24.50	**101.78**
	14	lump	perpendicular	81	35	0.43	60.08	3609.60	30000	15180	Non-conforming, invalid failure plane				
	15	lump	perpendicular	58	38	0.66	52.97	2806.20	32000	16192	5.77	1.03	5.92	23.00	**132.71**

Notes:
1. All samples tested were irregular lumps as per ASTM D-5731-08 Fig. 3 / Type D
2. Samples were stored to preserve natural moisture contents before testing. Tests were at natural moisture content.
3. Most recent calibration of point load tester on April 24, 2018
4. Strength conversion factor K determined as per ASTM D-5731-08 / Table 1

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ABA - Modified Sobek

09-January-2019

Hatch LTD
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Fax:905-374-0701

Date Rec. : 20 December 2018
LR Report: **CA15343-DEC18**
Reference: PO#

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Analysis	**1: Analysis Start Date**	**2: Analysis Start Time**	**3: Analysis Completed Date**	**4: Analysis Completed Time**	**5: Q1**	**6: Q5**	**7: Q24**	**8: QMR2**	**9: PQ4B**	**10: PQ5B**	**11: PQ6B**	**12: PQ12A**	**13: PQ13**	**14: PQ15A**	**15: PQ15B**
Paste pH	07-Jan-19	08:23	09-Jan-19	17:29	9.74	9.25	8.19	9.53	8.19	8.27	8.18	8.81	9.14	9.28	9.13
Fizz Rate [---]	07-Jan-19	08:23	09-Jan-19	10:26	1	1	4	1	4	4	4	4	1	1	1
Sample weight [g]	07-Jan-19	08:23	09-Jan-19	10:26	1.97	1.98	1.97	1.98	2.00	1.99	2.03	2.00	2.01	2.01	2.01
HCl Added [mL]	07-Jan-19	08:23	09-Jan-19	10:26	20.00	20.00	80.00	20.00	82.00	99.20	95.00	74.00	20.00	20.00	20.00
HCl [Normality]	07-Jan-19	08:23	09-Jan-19	10:26	0.10	0.10	0.50	0.10	0.50	0.50	0.50	0.50	0.10	0.10	0.10
NaOH [Normality]	07-Jan-19	08:23	09-Jan-19	10:26	0.10	0.10	0.50	0.10	0.50	0.50	0.50	0.50	0.10	0.10	0.10
NaOH to pH=8.3 [mL]	07-Jan-19	08:23	09-Jan-19	10:26	15.47	15.37	3.14	18.28	5.33	4.88	2.84	4.43	17.84	18.06	17.76
Final pH	07-Jan-19	08:23	09-Jan-19	10:26	1.15	1.15	1.62	0.94	1.52	1.57	1.84	1.80	0.72	0.97	0.78
NP [t CaCO3/1000 t]	07-Jan-19	08:23	09-Jan-19	10:26	12	12	975	4.3	958	1185	1135	870	5.4	4.8	5.6
AP [t CaCO3/1000 t]	09-Jan-19	10:26	09-Jan-19	10:27	0.62	0.62	0.62	0.62	0.62	0.62	0.62	1.25	0.62	0.62	0.62
Net NP [t CaCO3/1000 t]	09-Jan-19	10:26	09-Jan-19	10:27	10.9	11.1	975	3.68	958	1184	1134	868	4.78	4.18	4.98
NP/AP [ratio]	09-Jan-19	10:26	09-Jan-19	10:27	18.5	18.9	1561	6.94	1546	1911	1831	696	8.71	7.74	9.03
Sulphur (total) [%]	02-Jan-19	12:36	07-Jan-19	16:49	< 0.005	0.006	0.020	0.005	< 0.005	0.006	< 0.005	0.032	< 0.005	< 0.005	< 0.005
Acid Leachable SO4-S [%]	07-Jan-19	16:49	07-Jan-19	16:49	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Sulphide [%]	03-Jan-19	13:17	07-Jan-19	16:49	< 0.02	< 0.02	0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.04	< 0.02	< 0.02	< 0.02
Carbon (total) [%]	02-Jan-19	12:36	07-Jan-19	16:49	0.106	0.048	11.0	0.033	11.4	11.3	11.1	11.2	0.070	0.032	0.050
Carbonate [%]	03-Jan-19	10:39	04-Jan-19	14:18	0.145	< 0.025	52.9	0.070	50.9	54.0	52.0	42.1	0.105	0.035	0.100

OnLine LIMS

0001626442

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ABA - Modified Sobek

LR Report : **CA15343-DEC18**

```
*NP (Neutralization Potential)
 = 50 x (N of HCL x Total HCL added - N NaOH x NaOH added)
   -------------------------------------------------------
                     Weight of Sample

*AP (Acid Potential) = % Sulphide Sulphur x 31.25
*Net NP (Net Neutralization Potential) = NP-AP
NP/AP Ratio = NP/AP
*Results expressed as tonnes CaCO3 equivalent/1000 tonnes of material
Samples with a % Sulphide value of <0.02 will be calculated using a 0.02 value.
```

ASSOCIATION OF THE CHEMICAL PROFESSION OF ONTARIO
CHARTERED
Christopher Sullivan
CHEMIST

Chris Sullivan, B.Sc., C.Chem
Project Specialist
Environmental Services, Analytical

OnLine LIMS

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11-January-2019

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Date Rec. : 20 December 2018
LR Report: **CA15344-DEC18**

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CERTIFICATE OF ANALYSIS

Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Completed Date	4: Analysis Completed Time	5: Q1	6: Q5	7: Q24	8: QMR2	9: PQ4B	10: PQ5B	11: PQ6B	12: PQ12A	13: PQ13	14: PQ15A	15: PQ15B
Silver [µg/g]	09-Jan-19	13:24	10-Jan-19	10:15	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Aluminum [µg/g]	09-Jan-19	13:24	10-Jan-19	10:15	76000	76000	3000	39000	3700	2900	3000	9000	57000	86000	69000
Arsenic [µg/g]	09-Jan-19	13:24	10-Jan-19	10:15	1.1	0.6	< 0.5	0.6	0.6	< 0.5	< 0.5	2.0	1.9	0.9	0.9
Barium [µg/g]	09-Jan-19	13:24	10-Jan-19	10:15	750	650	13	150	14	12	12	51	270	1200	1900
Beryllium [µg/g]	09-Jan-19	13:24	10-Jan-19	10:15	1.8	2.3	0.11	1.6	0.11	0.11	0.11	0.25	2.0	1.9	1.2
Bismuth [µg/g]	09-Jan-19	13:24	10-Jan-19	10:15	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	0.09	0.33	< 0.09	0.09
Calcium [µg/g]	09-Jan-19	13:24	10-Jan-19	10:15	9200	7000	360000	3700	380000	370000	340000	200000	1800	8500	4300
Cadmium [µg/g]	09-Jan-19	13:24	10-Jan-19	10:15	0.03	0.03	< 0.02	0.03	< 0.02	< 0.02	< 0.02	< 0.02	0.03	0.05	0.07
Cobalt [µg/g]	09-Jan-19	13:24	10-Jan-19	10:15	2.4	4.1	0.57	2.0	0.66	0.50	0.52	2.7	1.7	7.0	3.2
Chromium [µg/g]	09-Jan-19	13:24	10-Jan-19	10:15	92	80	4.8	99	3.3	2.1	2.3	4.6	98	83	75
Copper [µg/g]	09-Jan-19	13:24	10-Jan-19	10:15	2.7	6.4	0.9	4.2	1.2	1.1	1.2	6.2	3.4	3.2	3.5
Iron [µg/g]	09-Jan-19	13:24	10-Jan-19	10:15	11000	16000	2100	10000	2600	2000	2300	5300	14000	28000	17000
Potassium [µg/g]	09-Jan-19	13:24	10-Jan-19	10:15	33000	34000	1800	20000	2300	1700	1900	9900	53000	41000	47000
Lithium [µg/g]	09-Jan-19	13:24	10-Jan-19	10:15	28	31	5	10	6	5	5	27	28	28	19
Magnesium [µg/g]	09-Jan-19	13:24	10-Jan-19	10:15	3700	7200	14000	4800	5000	17000	25000	120000	5500	9800	6400
Manganese [µg/g]	09-Jan-19	13:24	10-Jan-19	10:15	230	230	72	190	110	70	68	150	130	520	240
Molybdenum [µg/g]	09-Jan-19	13:24	10-Jan-19	10:15	6.2	6.7	0.5	11	0.2	0.1	0.2	0.8	8.3	6.4	7.8
Sodium [µg/g]	09-Jan-19	13:24	10-Jan-19	10:15	33000	28000	220	9500	210	220	220	390	10000	30000	16000
Nickel [µg/g]	09-Jan-19	13:24	10-Jan-19	10:15	25	9.6	3.8	8.5	4.0	3.3	3.0	4.6	5.1	17	5.9
Phosphorus [µg/g]	09-Jan-19	13:24	10-Jan-19	10:15	110	280	64	85	110	40	38	130	58	400	240

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LR Report : **CA15344-DEC18**

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Completed Date	4: Analysis Completed Time	5: Q1	6: Q5	7: Q24	8: QMR2	9: PQ4B	10: PQ5B	11: PQ6B	12: PQ12A	13: PQ13	14: PQ15A	15: PQ15B
Lead [µg/g]	09-Jan-19	13:24	10-Jan-19	10:15	52	24	0.91	8.8	1.4	0.95	0.75	4.8	22	20	28
Antimony [µg/g]	09-Jan-19	13:24	10-Jan-19	10:15	< 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]	09-Jan-19	13:24	10-Jan-19	10:15	< 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]	09-Jan-19	13:24	10-Jan-19	10:15	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6
Strontium [µg/g]	09-Jan-19	13:24	10-Jan-19	10:15	250	170	310	27	290	390	350	67	28	160	98
Titanium [µg/g]	09-Jan-19	13:24	10-Jan-19	10:15	700	1300	170	660	210	160	160	330	660	1800	1400
Thallium [µg/g]	09-Jan-19	13:24	10-Jan-19	10:15	0.65	0.48	0.06	0.28	0.03	0.03	< 0.02	0.18	0.92	0.72	0.50
Uranium [µg/g]	09-Jan-19	13:24	10-Jan-19	10:15	3.1	2.4	0.42	2.7	0.47	0.37	0.42	1.0	5.2	1.9	2.2
Vanadium [µg/g]	09-Jan-19	13:24	10-Jan-19	10:15	8	21	4	11	5	5	4	12	5	27	15
Yttrium [µg/g]	09-Jan-19	13:24	10-Jan-19	10:15	5.4	5.5	1.9	7.9	2.6	1.4	1.5	3.3	11	7.1	6.4
Zinc [µg/g]	09-Jan-19	13:24	10-Jan-19	10:15	26	35	2.8	21	3.2	3.5	2.7	3.8	17	59	39

Chris Sullivan

ASSOCIATION OF THE CHEMICAL PROFESSION OF ONTARIO
CHARTERED
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CHEMIST

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OnLine LIMS

0001630003

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SFE 3:1 ratio 24hr (MEND) prefilter pH

Hatch LTD
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Phone: 905-374-5200
Fax:905-374-0701

11-January-2019

Date Rec. : 20 December 2018
LR Report: **CA15345-DEC18**

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CERTIFICATE OF ANALYSIS

Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Completed Date	4: Analysis Completed Time	5: Q1	6: Q5	7: Q24	8: QMR2	9: PQ4B	10: PQ5B
Sample weight [g]	03-Jan-19	07:42	07-Jan-19	10:34	250	250	250	250	250	250
Volume D.I. Water [mL]	03-Jan-19	07:42	07-Jan-19	10:34	750	750	750	750	750	750
Final pH	04-Jan-19	16:07	08-Jan-19	14:22	9.40	8.92	8.80	9.06	8.79	9.34
pH [no unit]	07-Jan-19	15:50	09-Jan-19	14:41	9.16	8.01	8.47	9.03	8.44	8.34
Alkalinity [mg/L as CaCO3]	07-Jan-19	15:50	09-Jan-19	14:41	28	32	28	37	26	26
Conductivity [uS/cm]	07-Jan-19	15:50	09-Jan-19	14:41	68	79	106	126	81	81
Chloride [mg/L]	08-Jan-19	14:25	09-Jan-19	12:46	3	4	11	4	8	7
Sulphate [mg/L]	08-Jan-19	14:32	09-Jan-19	12:46	2	< 2	6	< 2	< 2	< 2
Mercury [mg/L]	09-Jan-19	16:05	10-Jan-19	08:46	< 0.00001	< 0.00001	< 0.00001	0.00018	< 0.00001	< 0.00001
Silver [mg/L]	07-Jan-19	12:44	11-Jan-19	14:03	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Aluminum [mg/L]	07-Jan-19	12:44	11-Jan-19	14:03	0.771	0.420	0.196	0.445	0.235	0.149
Arsenic [mg/L]	07-Jan-19	12:44	11-Jan-19	14:03	0.0011	0.0003	< 0.0002	0.0013	< 0.0002	< 0.0002
Barium [mg/L]	07-Jan-19	12:44	11-Jan-19	14:03	0.00454	0.00277	0.00151	0.00193	0.00075	0.00074
Boron [mg/L]	07-Jan-19	12:44	11-Jan-19	14:03	0.009	0.022	0.085	0.026	0.047	0.059
Beryllium [mg/L]	07-Jan-19	12:44	11-Jan-19	14:03	0.000008	0.000017	< 0.000007	0.000012	< 0.000007	< 0.000007
Bismuth [mg/L]	07-Jan-19	12:44	11-Jan-19	14:03	< 0.000007	0.000010	< 0.000007	< 0.000007	0.000032	0.000020
Calcium [mg/L]	07-Jan-19	12:44	11-Jan-19	14:03	3.33	4.37	11.2	3.84	10.5	7.92

OnLine LIMS

0001630012

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SFE 3:1 ratio 24hr (MEND) prefilter pH

LR Report : CA15345-DEC18

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Completed Date	4: Analysis Completed Time	5: Q1	6: Q5	7: Q24	8: QMR2	9: PQ4B	10: PQ5B
Cadmium [mg/L]	07-Jan-19	12:44	11-Jan-19	14:03	< 0.000003	0.000003	0.000009	0.000009	< 0.000003	< 0.000003
Cobalt [mg/L]	07-Jan-19	12:44	11-Jan-19	14:03	0.000044	0.000034	< 0.000004	0.000069	0.000007	0.000109
Chromium [mg/L]	07-Jan-19	12:44	11-Jan-19	14:03	0.00017	0.00015	0.00022	0.00007	0.00035	0.00023
Copper [mg/L]	07-Jan-19	12:44	11-Jan-19	14:03	0.00038	0.00637	0.00876	0.00048	0.00091	0.00041
Iron [mg/L]	07-Jan-19	12:44	11-Jan-19	14:03	0.105	0.079	0.008	0.061	< 0.007	< 0.007
Potassium [mg/L]	07-Jan-19	12:44	11-Jan-19	14:03	7.36	6.41	1.96	15.4	2.14	1.35
Lithium [mg/L]	07-Jan-19	12:44	11-Jan-19	14:03	0.0126	0.0047	0.0042	0.0061	0.0038	0.0024
Magnesium [mg/L]	07-Jan-19	12:44	11-Jan-19	14:03	0.496	1.29	4.08	1.14	1.62	3.33
Manganese [mg/L]	07-Jan-19	12:44	11-Jan-19	14:03	0.00320	0.00137	0.00002	0.00147	0.00002	< 0.00001
Molybdenum [mg/L]	07-Jan-19	12:44	11-Jan-19	14:03	0.00039	0.00174	0.00111	0.00345	0.00156	0.00052
Sodium [mg/L]	07-Jan-19	12:44	11-Jan-19	14:03	5.96	6.07	1.24	8.84	0.96	0.84
Nickel [mg/L]	07-Jan-19	12:44	11-Jan-19	14:03	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Lead [mg/L]	07-Jan-19	12:44	11-Jan-19	14:03	0.00079	0.00010	0.00006	0.00022	0.00002	< 0.00001
Antimony [mg/L]	07-Jan-19	12:44	11-Jan-19	14:03	0.0004	0.0004	0.0003	0.0004	0.0003	0.0003
Selenium [mg/L]	07-Jan-19	12:44	11-Jan-19	14:03	< 0.00004	0.00011	0.00006	0.00049	< 0.00004	< 0.00004
Tin [mg/L]	07-Jan-19	12:44	11-Jan-19	14:03	0.00022	0.00015	0.00022	0.00022	0.00012	0.00009
Strontium [mg/L]	07-Jan-19	12:44	11-Jan-19	14:03	0.0153	0.00593	0.129	0.00681	0.111	0.111
Titanium [mg/L]	07-Jan-19	12:44	11-Jan-19	14:03	0.00719	0.00332	0.00074	0.00449	0.00005	< 0.00005
Thallium [mg/L]	07-Jan-19	12:44	11-Jan-19	14:03	0.000009	< 0.000005	0.000006	0.000008	< 0.000005	0.000005
Uranium [mg/L]	07-Jan-19	12:44	11-Jan-19	14:03	0.00963	0.00121	0.000046	0.00818	0.000048	0.000022
Vanadium [mg/L]	07-Jan-19	12:44	11-Jan-19	14:03	0.00314	0.00370	0.00047	0.00618	0.00065	0.00049
Tungsten [mg/L]	07-Jan-19	12:44	11-Jan-19	14:03	0.00017	0.00024	0.00004	0.00045	0.00022	0.00022
Yttrium [mg/L]	07-Jan-19	12:44	11-Jan-19	14:03	0.000079	0.000110	0.000005	0.000163	0.000003	< 0.000002
Zinc [mg/L]	07-Jan-19	12:44	11-Jan-19	14:03	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002

Analysis	11: PQ6B	12: PQ12A	13: PQ13	14: PQ15A	15: PQ15B
Sample weight [g]	250	250	250	250	250

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

SFE 3:1 ratio 24hr (MEND) prefilter pH

LR Report : **CA15345-DEC18**

Analysis	11: PQ6B	12: PQ12A	13: PQ13	14: PQ15A	15: PQ15B
Volume D.I. Water [mL]	750	750	750	750	750
Final pH	9.21	8.34	8.17	8.61	8.35
pH [no unit]	8.51	9.32	7.97	7.78	7.51
Alkalinity [mg/L as CaCO3]	29	88	39	22	46
Conductivity [uS/cm]	100	272	90	50	109
Chloride [mg/L]	9	35	2	1	2
Sulphate [mg/L]	< 2	3	< 2	< 2	< 2
Mercury [mg/L]	< 0.00001	< 0.00001	< 0.00001	< 0.00001	0.00002
Silver [mg/L]	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Aluminum [mg/L]	0.128	0.026	0.448	1.06	0.389
Arsenic [mg/L]	0.0004	0.0010	0.0016	0.0010	0.0005
Barium [mg/L]	0.00080	0.00269	0.00194	0.00801	0.00920
Boron [mg/L]	0.078	0.071	0.033	0.041	0.035
Beryllium [mg/L]	< 0.000007	< 0.000007	0.000034	0.000020	0.000015
Bismuth [mg/L]	0.000051	< 0.000007	0.000027	< 0.000007	0.000012
Calcium [mg/L]	8.69	9.20	4.98	0.21	7.25
Cadmium [mg/L]	0.000021	0.000004	0.000007	0.000007	< 0.000003
Cobalt [mg/L]	0.000015	0.000052	0.000055	0.000099	0.000202
Chromium [mg/L]	0.00110	0.00011	0.00004	0.00023	0.00006
Copper [mg/L]	0.00097	0.00110	0.00198	0.00299	0.01076
Iron [mg/L]	0.016	0.007	0.190	0.353	0.139
Potassium [mg/L]	1.49	6.58	13.4	10.3	16.9
Lithium [mg/L]	0.0030	0.0239	0.0035	0.0019	0.0013
Magnesium [mg/L]	4.36	22.1	1.84	0.236	1.16
Manganese [mg/L]	0.00005	0.00007	0.00192	0.00610	0.00740
Molybdenum [mg/L]	0.00230	0.00301	0.00068	0.00095	0.00198
Sodium [mg/L]	1.15	6.10	2.68	4.41	2.57
Nickel [mg/L]	< 0.0001	0.0004	< 0.0001	0.0002	< 0.0001
Lead [mg/L]	< 0.00001	0.00002	0.00018	0.00019	0.00039

OnLine LIMS

0001630012

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

SFE 3:1 ratio 24hr (MEND) prefilter pH

LR Report : **CA15345-DEC18**

Analysis	11: PQ6B	12: PQ12A	13: PQ13	14: PQ15A	15: PQ15B
Antimony [mg/L]	0.0002	0.0003	0.0005	0.0005	0.0005
Selenium [mg/L]	< 0.00004	0.00009	0.00007	0.00006	0.00010
Tin [mg/L]	0.00051	0.00008	0.00008	0.00040	0.00033
Strontium [mg/L]	0.108	0.0498	0.00497	0.00093	0.00928
Titanium [mg/L]	0.00048	0.00006	0.00346	0.0189	0.00650
Thallium [mg/L]	< 0.000005	0.000171	0.000013	0.000011	< 0.000005
Uranium [mg/L]	0.000035	0.000127	0.00250	0.000184	0.00161
Vanadium [mg/L]	0.00052	0.00198	0.00045	0.00398	0.00119
Tungsten [mg/L]	0.00017	0.00020	0.00074	0.00013	0.00026
Yttrium [mg/L]	0.000005	0.000019	0.000639	0.000139	0.000229
Zinc [mg/L]	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002

Chris Sullivan

ASSOCIATION OF THE CHEMICAL PROFESSION OF ONTARIO
CHARTERED
Christopher Sullivan
CHEMIST

Chris Sullivan, B.Sc., C.Chem
Project Specialist
Environmental Services, Analytical

OnLine LIMS

0001630012

Appendix C

Rock Strength Criteria

List of Abbreviations and Terms Used in the Borehole Reports

(Sheet 1)

General

Elevations
Elevations are referenced to datum indicated.

Depth
All depths are given in meters (feet) measured from the ground surface unless otherwise noted.

Sample Recovery
Indicates the length retained in millimeters (inches) in a split spoon sampler or percentage recovery of sample retained in the core barrel sampler.

Sample Number
Samples are numbered consecutively in the order in which they were obtained in the borehole.

Sampler Size
Dimension is in millimetres and refers to the outside diameter of the sampler.

Sample Type
The first letter describes the sampling method and the second, the shipping container.

Sampling Method

A – Split Tube	E – Auger
B – Thin Wall Tube	F – Wash
C – Piston Sampler	G – Shovel Grab Sample
D – Core Barrel	K – Slotted Sampler

Shipping Container

N – Insert (split spoon)	S – Plastic Bag
O – Tube	U – Wooden Box
P – Water Content Tin	X – Plastic & PVC Sleeve (Sonic)
Q – Jar	Y – Core Box
R – Cloth Bag	Z – Discarded

Abbreviations
N/A – Not applicable
N/E – Not encountered
N/O – Not observed

Soil

Soil Description, Label and Symbol
Soil description under the "Description" column conforms generally, but not rigorously , to the Unified Soils Classification System. For a given soil unit, defined by depth boundaries, the descriptive text constitutes the definitive soil unit description and takes precedence over both the brief label and the symbol used to graphically represent the soil unit.

Grain Size

Clay	<0.002 mm
Silt	0.002 – 0.075 mm
Sand	0.075 – 4.75 mm
Gravel	4.75 – 75 mm
Cobbles	75 – 300 mm
Boulder	>300 mm

Relative Quantities

Term	***Example***	***(%)***
Trace	Trace sand	1 – 10
Some	Some sand	10 – 20
With	With Sand	20 – 35
And	And sand	>35
Noun	Sand	>50

Standard Penetration Test (SPT)
The test is carried out in accordance with ASTM D-1586 and the 'N' value corresponds to the sum of the number of blows required by a 63.5-kg (140-lb) hammer, dropped 760 mm (30 in.), to drive a 50-mm (2-in.) diameter split tube sampler the second and third 150 mm (6 in.) of penetration.

Density (Granular Soils)

	N(SPT)
Very loose	0 – 4
Loose	4 – 10
Compact	10 – 30
Dense	30 – 50
Very dense	>50

Consistency (Cohesive Soils)

	N(SPT)
Very soft	<2
Soft	2 – 4
Firm	4 – 8
Stiff	8 – 15
Very stiff	15 – 30
Hard	>30

Plasticity/Compressibility

		Liquid Limit (%)
Low plasticity clays	Low compressibility silts	<30
Medium plasticity clays	Medium compressibility silts	30 – 50
High plasticity clays	High compressibility silts	>50

Dilatancy

None	-	No visible change.
Slow	-	Water appears slowly on surface of specimen during shaking and does not disappear or disappears slowly upon squeezing.
Rapid	-	Water appears quickly on the surface of specimen during shaking and disappears quickly upon squeezing.

Sensitivity

Insensitive	<2
Low	2 – 4
Medium	4 – 8
High	8 – 16
Quick	>16

List of Abbreviations and Terms Used in the Borehole Reports

(Sheet 2)

Rock

Core Recovery
Sum of lengths of rock core recovered from a core run, divided by the length of the core run and expressed as a percentage.

RQD (Rock Quality Designation)
Sum of lengths of hard, sound pieces of rock core equal to or greater than 100 mm from a core run, divided by the length of the core run and expressed as a percentage. Measured along centerline of core. Core fractured by drilling is considered intact. RQD normally quoted for N-size core.

RQD (%) Rock Quality

RQD (%)	Rock Quality
90 - 100	Excellent
75 - 90	Good
50 - 75	Fair
25 - 50	Poor
0 - 25	Very Poor

Grain Size

Term	*Grain Size*
Very coarse-grained	>60 mm
Coarse-grained	2 mm - 60 mm
Medium-grained	60 µm - 2 mm
Fine-grained	2 µm - 60 µm
Very fine-grained	< 2 µm

Bedding

Term	*Bed Thickness*	
Very thickly bedded	>2 m	>6.50 ft
Thickly bedded	600 mm - 2 m	2.00 - 6.50 ft
Medium bedded	200 mm - 600 mm	0.65 - 2.00 ft
Thinly bedded	60 mm - 200 mm	0.20 - 0.65 ft
Very thinly bedded	20 mm - 60 mm	0.06 - 0.20 ft
Laminated	6 mm - 20 mm	0.02 - 0.06 ft
Thinly laminated	<6 mm	<0.02 ft

Discontinuity Frequency
Expressed as the number of discontinuities per metre or discontinuities per foot. Excludes drill-induced fractures and fragmented zones.

Discontinuity Spacing

Term	*Average Spacing*	
Extremely widely spaced	>6 m	>20.00 ft
Very widely spaced	2 m - 6 m	6.50 - 20.00 ft
Widely spaced	600 mm - 2 m	2.00 - 6.50 ft
Moderately spaced	200 mm - 600 mm	0.65 - 2.00 ft
Closely spaced	60 mm - 200 mm	0.20 - 0.65 ft
Very closely spaced	20 mm - 60 mm	0.06 - 0.20 ft
Extremely closely spaced	<20 mm	<0.06 ft

Note: Excludes drill-induced fractures and fragmented rock.

Broken Zone
Zone of full diameter core of very low RQD which may include some drill-induced fractures.

Fragmented Zone
Zone where core is less than full diameter and RQD = 0.

Strength

Term	*Description*	*Unconfined Compressive Strength (MPa)*	*(psi)*
Extremely weak rock	Indented by thumbnail	0.25 – 1.0	36 – 145
Very weak	Crumbles under firm blows with point of geological hammer, can be peeled by a pocket knife	1.0 – 5.0	145 – 725
Weak rock	Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer	5.0 – 25	725 – 3625
Medium strong rock	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with single firm blow of geological hammer to facture it	25 – 50	3625 –7250
Strong rock	Specimen requires more than one blow of geological hammer to fracture it	50 – 100	7250 – 14500
Very strong rock	Specimen requires many blows of geological hammer to fracture it	100 – 250	14500 – 36250
Extremely strong rock	Specimen can only be chipped with geological hammer	>250	>36250

Weathering

Term	*Description*
Fresh	No Visible sign of rock material weathering
Faintly weathered	Discoloration on major discontinuity surfaces.
Slightly weathered	Discoloration indicates weathering of rock material and discontinuity surfaces. All the rock material may be discolored by weathering and may be somewhat weaker than in its fresh condition.
Moderately weathered	Less than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a continuous framework or as corestones.
Highly weathered	More than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a discontinuous framework or as corestones.
Completely weathered	All rock material is decomposed and/or disintegrated to a soil. The original mass structure is still largely intact.
Residual soil	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.

Appendix D

Job Hazard Analysis

Job Hazard Analysis Form

PROJECT/TASK: 2018 Quarry Sampling Program		Department: Projects						JOB No.: 353004
SUPERVISOR:		LOCATION:						DATE:
JOB STEP Break the job into steps. Listing work which may be hazardous.	HAZARDS List the hazard or type of harm identified with each step.	Inherent			CONTROL MEASURE List the necessary control measures to be followed to eliminate/reduce the identified hazards.	Residual			ACTION Person who will ensure this happens
		Consequence	Likelihood	Risk Ranking		Consequence	Likelihood	Risk Ranking	Bruno Lavalée
1. Pre-job JHA Review.	Missing critical items on the JHA that can lead to an incident	3	2	5	Conduct a pre-job JHA review with Safety and critical team members. All workers will have the opportunity to identify changes needed. Any changes will be added to this document	1	1	2	Marlon Coakley/ Michael Yang/ Darren Gardiner
2. Workers to complete FLRA card in the field at location prior to starting work.	Additional hazards in the area that may not have been identified on the JHA may pose additional danger to the health and safety of workers, the environment and property	3	3	6	Look at immediate work area for hazards that may exist, not identified on the JHA. Have other workers in the group sign off on the FLHA	1	1	2	All workers

3. Access points to quarry locations that are off road	BIM does not want any tundra being disturbed any more than is necessary. Risk of Polar Bear encounters when outside of trucks Long distances to walk Exposure to cold White Out conditions	3	3	6	Polar bear monitor to travel with the group The use of snow mobiles is to be used once enough snow is present. Proper warm winter wear to be used Sat phones and digital radio use. Buddy system is important to verify presence of frost bite or other cold related concerns. Notify BIM ERT crew is working in this area	1	1	2	All workers
4. Refueling of equipment	Fuel spills Regulatory or social impacts Spills into water bodies	3	2	5	Use of duck ponds with any refueling Have spill cleanup on hand to handle more than a potential spill No refueling within 31 m of any high water mark	3	1	4	All workers
5. Extreme weather exposure when working outdoors or driving to and from location to road.	Stranded work crew in white out conditions Cold emergencies or cold injuries Mechanical equipment failure	3	3	6	BIM has a procedure that is designed for white out conditions – it would be announced on the digital radio (TOTE DIGITAL TOTE ROAD / D-10) Crew follow tote road notices. Changes will be communicated on digital and analog to take survival bags with them Crews to radio from Hatch leads Buddy system to watch out for fellow workers who may not realize they are developing frost bite. Workers to dress in arctic gear and layered clothing Proper PPE required . Equipment check list	2	1	3	All workers Marlon Coakley/ Michael Yang / Darren Gardiner

					Workers to take warm up breaks to stay warm and alert. At toolbox review weather forecast with crew and prepare accordingly				
6. Waste management	Risk of wildlife encounters due to improper waste controls Regulatory non compliance	3	2	5	Crews will collect waste daily and transport it back to camp Crews will follow BIM waste management guidelines No placing or storing of food in the back of pickup trucks	1	1	2	Hatch Geotech
7. Flying debris	Work crews can be struck by flying debris (pieces of rock) when sampling	3	3	6	Use of proper PPE when quarry sampling (Safety glasses/goggles, hard hat, gloves, safety boots) Keep 2 m away from the personnel conducting the quarry sampling	1	1	2	Hatch Geotech, Polar bear monitor
8. Ground vegetation and cultural sensitive areas	Risk of causing damage to archeological areas Destroying vegetation Sensitive wildlife and marine life areas Regulatory and reputation damage	3	3	6	Crews have been educated to watch for staked areas that are around identified archeological sites. Crews to assess each off road area before entering to ensure proper path with the least amount of impact. Crews are not to build or alter any inuksuk's or other rock formations on the tundra Permits will be required for the work Any unforeseen changes will need to be evaluated by the EHS tech and may require a work stoppage	2	2	4	Hatch Geotech

					Access to quarry locations will be by foot or by snow mobile				
9. Working around personating using hand tools	Entanglement injuries, Workers being struck by hand tools (pick axe, sledge hammer, pry bar, etc.)	3	3	6	Be aware of other personnel in the sampling area, communicate that hand tools will be used No loose clothing or drawstrings that can get pulled by the hand tools Keep 2 m away from the personnel conducting the quarry sampling	3	1	4	Hatch Geotech, Polar Bear monitor
10. Vehicle driving / mobile equipment	Ore haulers and light vehicles on the tote road, slippery road conditions and blind spots, rough terrain	3	4	7	Use tote road call out requirements Tote road and light vehicle training Follow all BIM tote road rules Be constantly aware of road conditions Drive according to road and weather conditions Vehicle pre use inspection to be performed before each use Defensive driving training Use of spotters when backing up equipment Estops to be in good working order and easily accessible	1	1	2	Hatch Geotech, EHS techs

11. Rough terrain, steep slopes and unstable formations	Risk of tripping or falling	3	3	6	FLRAs completed daily Plan route to be followed for access to quarry locations Perform site specific hazard assessments before entering the areas	2	1	3	Hatch Geotech EHS techs
12. Inadequate communications	Crew unable to gain assistance in emergency situation Crews not alerted to tote road changes, code ones or white out conditions	3	3	6	Crews are required to have : • Digital radios (Tote Road Analog and Tote Road Digital) • Monitor Tote Rd Digital at all times Use call-in system at pre-arranged times, to confirm communication system is working and crew is safe. Implement rescue plan if communication call-in/call-out failure for more than 2 hours	1	1	2	Hatch Geotech EHS techs
13. Remote Injury	Crew member injured.	3	3	6	Perform site first aid If serious injury requiring immediate evacuation declare Code 1 Emergency for EHS response	2	2	3	Hatch BIM EHS
14. Wildlife encounters	Foxes, raven and polar bears, wolves	3	2	5	Wildlife awareness training is provided A polar bear monitor is assigned to the crew Waste management guideline to be followed No feeding of wildlife Secure all small tools and PPE as foxes may carry away small articles from the site.	1	1	2	Hatch Geotech EHS techs

15. Manual lifting	Pinch point, back injuries, muscle and joint sprains and strains, Dropping load	2	3	5	Work in pairs, good FLRA reviews, Work with a buddy on heavy or awkward lifts Use proper lifting techniques Gloves to be worn Signal if load is slipping	1	1	2	Hatch Geotech EHS techs
16. Walking	Slips and trip injuries	3	2	5	Training provided for slip and trip hazards, place cards and placards around hazards, Daily site assessments conducted to identify hazards. Traction aids at all times to used.	1	1	2	Hatch Geotech Polar Bear monitor EHS techs
17. Falling objects	Potential exists for falling rocks from the quarry locations	3	2	5	Perform good FLRA Survey quarry locations for areas of increased risk of falling rocks to avoid Periodically survey the area when sampling for increased rockfall risk Wear proper PPE (hard hat)	1	1	2	Hatch Geotech EHS techs
18. Housekeeping	Potential exists for poor housekeeping causing slip/trips and other hazards	3	2	5	Daily site assessments and toolbox meetings by site supervisors BIM EHS techs to perform daily inspections				Hatch Geotech EHS techs
19. Fatigue	Potential exists for crew fatigue	2	2	4	Fit for duty confirmation required for all employees, daily FLRA reviews and BLY 3in1 reporting Micro breaks to stretch Proper rest during off shift period	1	1	2	Hatch Geotech EHS techs

20. Crossing Creeks Lakes and River Beds	Risk of cold water immersion Falling through ice or into water Potential ground erosion Slip Trip Falls				Maps will be consulted to identify areas with large bodies of water. These areas will be marked out in the GPS and routes will be planned to avoid these areas Workers will stay 3 meters from water's edge where possible If a risk of deep water, PFDs to be worn when in the 3 meter boundary An assessment of the ice condition will be required before accessing the ice surface. The ice assessment will completed by drilling through the ice to determine ice thickness. An assessment is required prior to crossing any dry or frozen creek bed Follow the Environmental Working On Ice Procedure Proper PPE Emergency shelter				Hatch Geotech EHS techs
21. Travel to remote areas on Snow Mobiles / Side By Side Can AM bikes	Collison with other Snow Mobiles / Can Am Side by side bikes or mobile equipment Steep Slopes, Uneven ground conditions, open water Equipment failure				Proper PPE BIM Training required Review of Air Photos .Review maps and Drawings. Operate equipment at a speed according to conditions and allow time to assess conditions ahead Ensure that emergency back up equipment is in place for rescue Equipment check list completed on a daily basis.				Marlon Coakley/ Michael Yang / Darren Gardiner

22. Rescue Plan	Rough terrain Further injuries to casualty during transit. Snow storm, white out conditions. Darkness Unmarked trail to/from remote work area.				The snowmobile, or side-by-side, pulling the qamutik (sled) for remote locations. When an incident in this nature has occurred, the Geotech must call a Code 1. MRT will be dispatched to the tote road access point. MRT will transport the casualty by ambulance after the casualty has been transported to the rendezvous point. All scenarios mentioned above must have a casualty attendant in communication with equipment operator. While in transition with casualty the snowmobile will have to travel at slow speeds with respect to the rough terrain. Access trail will be marked with delineators and way points stored on GPS. Have experience snowmobile operator and GPs user available to operate the snowmobile. In the event where the casualty needs to be stabilized, the medic will be required to be brought to site. always follow delineators and GPS coordinates, because tracks from track unit are unreliable, If all options mentioned above the Emergency Management Team Lead will call the Nunavut Rescue Unit, insert contact number here.				Marlon Coakley/ Michael Yag / Darren Gardiner

					Emergency Measures 24 Hour TOLL FREE 1-800-693-1666 **Emergency Services Response 24 Hours** 1-867-979-6262 Visibility (whiteout conditions) will hinder rescue time, rescuers will have to wait out the storm, or until the whiteout conditions have subsided.				

Comments:

Score	CONSEQUENCE		
	People	Plant	Environment
5 – Very High/ Catastrophic	Multiple Fatalities.	Greater than $10 Million Loss	Catastrophe, destruction of sensitive environment, worldwide attention. Likely EPA prosecution. More than 30 days delay.
4 – High/ Major	Fatality or Permanent Disabilities.	$1 Million to $10 Million Loss	Disaster, high levels of media attention, high cost of clean-up. Offsite environmental harm; more than 10 days delay.
3 – Moderate	Major Injuries – Incapacitations or requiring time of work.	$100 Thousand to $1 Million Loss	Major spills, onsite release, substantial environmental nuisance, more than 1day delay. (Leads to an additional resources call out i.e. SES).
2 – Low/ Minor	Significant Injuries – Medical Treatments, non-permanent injury.	$10 Thousand to $100 Thousand Loss	Significant spills. (Leads to a call out of Site Emergency Response Group).
1 – Very Low/ Insignificant	Minor Injuries – First Aid Treatments (cuts/bruises).	Less than $10 Thousand Loss	Low environmental impact. Minor Spills less than 80 Litres.

Score	LIKELIHOOD
5 – Almost Certain	The event is expected to occur in most circumstances. Likely to occur frequently - More than 1 per year.
4 – Likely/ Probable	The event will probably occur in most circumstances. Likely to occur several times – 1 per year.
3 – Moderate/ Occasional	The event should occur at some time. Likely to occur at some time – 1 per 5 years.
2 – Remote/ Unlikely	The event could occur at some time. Unlikely but possible. 1 per 10 years.
1 – Rare/ Very Unlikely	The event may occur only in exceptional circumstances. Assumed it may not be experienced. 1 per 100 years.

Job Hazard Analysis Attendees:

	Name	Signature	Date
Written by:	Michael Yang	[signature]	Oct 15, 2018
Reviewed by:	Marlon Coakley Bruno Lavallee Darren Gardiner	[signature] [signature]	Oct 15, 2018 Oct 15, 2018

Risk Rating = Consequence + Likelihood

Consequence	Risk Rating				
5	6	7	8	9	10
4	5	6	7	8	9
3	4	5	6	7	8
2	3	4	5	6	7
1	2	3	4	5	6
	1	2	3	4	5
	Likelihood				

Risk Rating - Definitions

Risk Rating	Definitions	*Action Required*
8 - 10	Intolerable	Task not to start till the risk is eliminated or reduced. Bring to the immediate attention of management. Formal assessment required. MUST reduce the risk as a matter of priority.
7	High	Bring to the immediate attention of management. Task not to start till the risk is eliminated or reduced. Further Assessment required. MUST reduce the risk as a matter of priority.
6	Significant Risk	Bring to the attention of supervision. Review risks and ensure that they are reduced to as low as reasonably practicable. To be dealt with as soon as possible, preferably before the task commences. Introduce some form of hardware to control risk.
5	Moderate Risk	Needs to be controlled but not necessarily immediately, an action plan to control the risk should be drawn up. Review effectiveness of controls. Ensure responsibilities for control are specified.
2-4	Low Risk	If practical reduce the risk. Ensure personnel are competent to do the task. Manage by routing procedure. Monitor for change

A JHA considers a variety of activities/tasks involved in a job scope and analyses the key hazards (sources of harm) and their consequences (types of harm) eg. Sources of harm – lifting a heavy pipe - manual handling. Types of harm – Back strain.

Main Points – On how to write a JHA.

1. Define the task – what is to be done.
2. Review previous JHA if any – have we done it before?
3. Identify the steps – what is to be done.
4. Identify the hazards of each step.
5. Identify who or what could be harmed.
6. Give the task a risk rating – Consequence + Frequency
7. Develop solutions to eliminate or control hazards in each step.
8. Review the risk rating after the control system has been implemented.
9. If risk rating unacceptable review the solutions till risk rating acceptable.
10. Agree who will implement the control system.
11. Document the JHA and discuss with the relevant personnel.

Hierarchy of Hazard Management – Control Measures

These steps outline what should be planned for when deciding what control measures are to be put in place. Whenever possible the highest step should be used first and then progress down the list.

1. Eliminate the hazard.
2. Substitution.
3. Reducing the frequency of a hazardous task.
4. Enclosing the hazard.
5. Additional procedures.
6. Additional supervision.
7. Additional training.
8. Instructions / information.
9. Some personal protective equipment.

Worker / Visitor review	Signature
Dean Ezekiel	[signature]

Appendix E

Laboratory Certification

Canadian Council of Independent Laboratories

CERTIFICATE OF CONFORMANCE

AGGREGATE LABORATORY CERTIFICATION

This is to certify that

Hatch Geotechnical Laboratory

Located at:

Niagara Falls ON

Has met the Standardization and Interlaboratory Testing Requirements of the CCIL/OSSGA AGGREGATE LABORATORY CERTIFICATION PROGRAM and has qualified under the following categories and test methods:

AGGREGATE QUALITY CONTROL LABORATORY (TYPE C)

LS-600/C-702; LS-601/C-117; LS-602/C-136; LS-607; LS-608; LS-621

AGGREGATE PHYSICAL PROPERTY LABORATORY (TYPE D)

LS-706/D698; LS-702/AASHTO T88; LS-703,704/D4318; LS-705/D854; LS-709/D2434

GIB MCINTEE, P. ENG.
CHAIRMAN, CERTIFICATION PROGRAM ADMINISTRATION COMMITTEE

May 1, 2018 - April 30, 2019
Date

GORDON H. LEAMAN, P. ENG.
PRESIDENT

Canadian Association for Laboratory Accreditation Inc.

CALA

Certificate of Accreditation

SGS Environmental Services
SGS Canada Inc.
185 Concession Street
Lakefield, Ontario

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communiqué dated April 2017).

CALA

Accreditation No.: A1999
Issued On: September 25, 2018
Accreditation Date: February 2, 2005
Expiry Date: March 25, 2021

ilac-MRA CALA

President & CEO

Canadian Council of Independent Laboratories

CERTIFICATE OF CONFORMANCE

AGGREGATE LABORATORY CERTIFICATION

This is to certify that

WOOD ENVIRONMENT & INFRASTRUCTURE SOLUTIONS, A DIVISION OF WOOD CANADA LIMITED

Located at:

Burlington ON

Has met the Standardization and Interlaboratory Testing Requirements of the CCIL/OSSGA AGGREGATE LABORATORY CERTIFICATION PROGRAM and has qualified under the following categories and test methods:

AGGREGATE QUALITY CONTROL LABORATORY (TYPE C)

LS-600/C-702; LS-601/C-117; LS-602/C-136; LS-607; LS-608; LS-621

AGGREGATE PHYSICAL PROPERTY LABORATORY (TYPE D)

LS-412/CSA A23.2-2C,-4C; LS-603/C131&535; LS-604/C127; LS-605/C128; LS-606/C88; LS-609 (Petrographic Analysts: Martin Little, Amy McCulloch, Holly McNeill & Jesse Stickles); LS-610/C40; LS-613/D3042; LS-614/CSA A23.2-24A; LS-615/CSA A23.2-26A; LS-617; LS-618/D6928; LS-619/D7428; LS-620/CSA A23.2-25A; LS-706/D698; LS-702/AASHTO T88; LS-703,704/D4318; LS-705/D854; LS-709/D2434

Superpave Aggregate Consensus Properties

June 15, 2018 - April 30, 2019

Date

GIB MCINTEE, P. ENG.
CHAIRMAN, CERTIFICATION PROGRAM ADMINISTRATION COMMITTEE

GORDON H. LEAMAN, P. ENG.
PRESIDENT

Canadian Council of Independent Laboratories

CERTIFICATE OF QUALIFICATION

This is to certify that

WOOD ENVIRONMENT & INFRASTRUCTURE SOLUTIONS
A DIVISION OF WOOD CANADA LIMITED

Located at

3450 Harvester Road, Suite 100
Burlington ON L7N 3W5

Has been examined and certified under the "QUALIFICATION CODE FOR CONCRETE TESTING LABORATORIES" CSA STANDARD A283-06 - as qualified to test concrete within the classification of

CATEGORY "II" ADVANCED CERTIFICATION

AND THE FOLLOWING ADDITIONAL TESTS:

A23.2-9A, 14A, 16A, 17A, 23A, 24A, 25A, 29A, 1B, 4B, 6B (PROCEDURE A), 3C, 8C, 10C, 13C, 21C, 23C AND ASTM C457

As defined in the standard, subject to conditions of issuance of this certificate

April 16, 2018 – December 31, 2018

Date

GIB MCINTEE, P. ENG.
CHAIRMAN, CERTIFICATION PROGRAM ADMINISTRATION COMMITTEE

GORDON H. LEAMAN, P. ENG.
PRESIDENT

Canadian Council of Independent Laboratories

CERTIFICATE OF CONFORMANCE

ASPHALT LABORATORY CERTIFICATION

This is to certify that

WOOD ENVIRONMENT & INFRASTRUCTURE SOLUTIONS, A DIVISION OF WOOD CANADA LIMITED

Located at

Burlington ON

Has met the Standardization and Interlaboratory Testing Requirements of the

CCIL ASPHALT LABORATORY CERTIFICATION PROGRAM

and has qualified under the following categories and test methods:

ASPHALT MIX COMPLIANCE – MARSHALL & SUPERPAVE METHODS (TYPE B)

SOLVENT EXTRACTION – LS-282/D2172; IGNITION METHOD – LS-292/D6307

ASPHALT MIX DESIGN – MARSHALL & SUPERPAVE METHODS (TYPE A)

PENETRATION OF ASPHALT CEMENT RECOVERED FROM HOT MIX (TYPE E)

May 1, 2018 - April 30, 2019

Date

GIB MCINTEE, P. ENG.
CHAIRMAN, CERTIFICATION PROGRAM ADMINISTRATION COMMITTEE

GORDON H. LEAMAN, P. ENG.
PRESIDENT

Appendix F

Ballast Testing Results

f. Slags are materials formed during the metal making process by the fusion of fluxstones, coke and other metallic particles and are generally of two types; iron blast furnace slag and steel furnace slag. Iron blast furnace slag is produced during the blast furnace operation and is essentially a composition of silicates and alumino silicates of lime and other bases. Steel furnace slag is a by-product of the open hearth, electric or oxygen steel furnace and is composed primarily of oxides and silicates.

Chap TOC

VOL 1

VOL 2

VOL 3

VOL 4

SECTION 2.4 PROPERTY REQUIREMENTS

2.4.1 PHYSICAL ANALYSIS (1991)

The methods of sampling and testing as defined by this specification are those in effect April 1985 and may be revised or altered by the individual railway company.

2.4.1.1 Method of Sampling

Field samples shall be secured in accordance with the current ASTM Methods of Sampling, designation D 75. Test samples shall be reduced from field samples by the means of ASTM C 702.

2.4.1.2 Sieve Analysis

Sieve analysis shall be made in accordance with ASTM Method of Test, designation C 136.

2.4.1.3 Material Finer Than No. 200 Sieve

Material finer than the No. 200 sieve shall be determined in accordance with the ASTM Method of Test, designation C 117.

2.4.1.4 Bulk Specific Gravity and Absorption

The bulk specific gravity and percentage of absorption shall be determined in accordance with the ASTM Method of Test, designation C 127.

2.4.1.5 Percentage of Clay Lumps and Friable Particles

The percentage of clay lumps and friable particles shall be determined in accordance with the ASTM Method of Test, designation C 142.

2.4.1.6 Resistance to Degradation

The resistance to degradation shall be determined in accordance with the ASTM Method of Test, designation C 131 or C 535 using the grading as specified in Note # 1, Table 1-2-1. Materials having gradations containing particles retained on the 1 inch sieve shall be tested by ASTM C 535. Materials having gradations with 100% passing the 1 inch sieve shall be tested by ASTM C 131.

2.4.1.7 Sodium Sulfate Soundness

Sodium Sulfate Soundness tests shall be made in accordance with the ASTM Method of Test, designation C 88.

2.4.1.8 Unit Weight

The weight per cubic foot shall be determined in accordance with the ASTM Method of Test, designation C 29.

2.4.1.9 Percent of Flat and/or Elongated Particles

The percent of flat or elongated particles shall be determined in accordance with ASTM Standard Test Method, designated D4791. The dimension ratio used in this test method shall be 1:3.

2.4.2 CHEMICAL ANALYSIS (1988)

a. No specific chemical analysis is considered essential for the evaluation of granite, traprocks or quartzite type materials provided that the materials are properly defined by applicable methods. For carbonate materials, dolomitic limestones are defined as those materials which have a magnesium carbonate ($MgCo_3$) content of 28% to 36%. Those carbonate materials indicating magnesium carbonate values above 36% shall be defined as dolomites and carbonate materials indicating magnesium carbonate values below 28% shall be defined as limestones.

b. The magnesium carbonate ($MgCo_3$) content of carbonate materials shall be tested and defined in accordance with ASTM C 25.

c. Standard Methods of Chemical Analysis of Limestone, Quick Lime and Hydrated Lime, or other test methods as may be approved and directed by the Engineer.

d. Steel furnace slags consist essentially of calcium silicates and ferrites combined with fused oxides of iron, aluminum, manganese, calcium and magnesium.

e. Steel furnace slags having a content of more than 45% calcium oxide and/or a combined composition of more than 30% of the oxides of iron and aluminum should not be used.

f. Iron blast furnace slags consist essentially of silicates and aluminosilicates of calcium and other bases.

g. Iron blast furnace slags having a content of more than 45% of the oxides of calcium or a combined composition of more than 17% of the oxides of iron and aluminum should not be used.

2.4.3 LIMITING TEST VALUES (1997)

Table 1-2-1 outlines the limiting values of testing as may be defined by the designated test specifications. The values for unit weight and bulk specific gravity are minimum values while the remainder are maximum values.

Table 1-2-1. Recommended Limiting Values of Testing for Ballast Material

Property	Ballast Material							
	Granite	Traprock	Quartzite	Limestone	Dolomitic Limestone	Blast Furnace Slag	Steel Furnace Slag	ASTM Test
Percent Material Passing No. 200 Sieve	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	C 117
Bulk Specific Gravity (See Note 2)	2.60	2.60	2.60	2.60	2.65	2.30	2.90	C 127
Absorption Percent	1.0	1.0	1.0	2.0	2.0	5.0	2.0	C 127
Clay Lumps and Friable Particles	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	C 142

Table 1-2-1. Recommended Limiting Values of Testing for Ballast Material

Property	Ballast Material							
	Granite	Traprock	Quartzite	Limestone	Dolomitic Limestone	Blast Furnace Slag	Steel Furnace Slag	ASTM Test
Degradation	35%	25%	30%	30%	30%	40%	30%	See Note 1
Soundness (Sodium Sulfate) 5 Cycles	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	C 88
Flat and/or Elongated Particles	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	D 4791

Note 1: Materials having gradations containing particles retained on the 1 inch sieve shall be tested by ASTM C 535. Materials having gradations with 100% passing the 1 inch sieve shall be tested by ASTM C 131. Use grading most representative of ballast material gradation.
Note 2: The limit for bulk specific gravity is a minimum value. Limits for the remainder of the tests are maximum values.

2.4.4 GRADATIONS (1988)

Table 1-2-2 outlines the recommended gradations to which the materials are to be processed for use as track and yard ballast. The grading of the processed ballast shall be determined with laboratory sieves having square openings conforming to ASTM specification E 11.

2.4.5 BALLAST MATERIALS FOR CONCRETE TIE TRACK INSTALLATION (1988)

The ballast materials as defined by this specification include the applicable test requirements for ballast materials for the purpose of providing support to the rail-cross tie arrangement of a concrete tie track system except that carbonate materials and slags as defined in Article 2.3.1 and gradation No. 57 as defined in Article 2.4.4 shall be excluded.

Appendix G

Summary of Findings and Results for Total Metals by ICP-MS Test

Parameter	Average Continental Crust Concentration	10x Average Continental Crust Concentration	Quarry Sample ID										
			Q1	Q5	Q24	QMR2	PQ4B	PQ5B	PQ6B	PQ12A	PQ13	PQ15A	PQ15B
Silver (µg/g)	0.075	0.75	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Aluminum (µg/g)	82300	823000	76000	76000	3000	39000	3700	2900	3000	9000	57000	86000	69000
Arsenic (µg/g)	1.8	18	1.1	0.6	< 0.5	0.6	0.6	< 0.5	< 0.5	2	1.9	0.9	0.9
Barium (µg/g)	425	4250	750	650	13	150	14	12	12	51	270	1200	1900
Beryllium (µg/g)	3	30	1.8	2.3	0.11	1.6	0.11	0.11	0.11	0.25	2	1.9	1.2
Bismuth (µg/g)	0.0085	0.085	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	< 0.09	0.09	0.33	< 0.09	0.09
Calcium (µg/g)	41500	415000	9200	7000	360000	3700	380000	370000	340000	200000	1800	8500	4300
Cadmium (µg/g)	3	30	0.03	0.03	< 0.02	0.03	< 0.02	< 0.02	< 0.02	< 0.02	0.03	0.05	0.07
Cobalt (µg/g)	25	250	2.4	4.1	0.57	2	0.66	0.5	0.52	2.7	1.7	7	3.2
Chromium (µg/g)	102	1020	92	80	4.8	99	3.3	2.1	2.3	4.6	98	83	75
Copper (µg/g)	60	600	2.7	6.4	0.9	4.2	1.2	1.1	1.2	6.2	3.4	3.2	3.5
Iron (µg/g)	56300	563000	11000	16000	2100	10000	2600	2000	2300	5300	14000	28000	17000
Potassium (µg/g)	20850	208500	33000	34000	1800	20000	2300	1700	1900	9900	53000	41000	47000
Lithium (µg/g)	20	200	28	31	5	10	6	5	5	27	28	28	19
Magnesium (µg/g)	23300	233000	3700	7200	14000	4800	5000	17000	25000	120000	5500	9800	6400
Manganese (µg/g)	950	9500	230	230	72	190	110	70	68	150	130	520	240
Molybdenum (µg/g)	1.2	12	6.2	6.7	0.5	11	0.2	0.1	0.2	0.8	8.3	6.4	7.8
Sodium (µg/g)	23550	235500	33000	28000	220	9500	210	220	220	390	10000	30000	16000
Nickel (µg/g)	84	840	25	9.6	3.8	8.5	4	3.3	3	4.6	5.1	17	5.9
Phosphorus (µg/g)	1050	10500	110	280	64	85	110	40	38	130	58	400	240
Lead (µg/g)	14	140	52	24	0.91	8.8	1.4	0.95	0.75	4.8	22	20	28
Antimony (µg/g)	0.2	2	< 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)	0.05	0.5	< 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)	2.3	23	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6
Strontium (µg/g)	370	3700	250	170	310	27	290	390	350	67	28	160	98
Titanium (µg/g)	5650	56500	700	1300	170	660	210	160	160	330	660	1800	1400
Thallium (µg/g)	0.85	8.5	0.65	0.48	0.06	0.28	0.03	0.03	< 0.02	0.18	0.92	0.72	0.5

Parameter	Average Continental Crust Concentration	10x Average Continental Crust Concentration	Quarry Sample ID										
			Q1	Q5	Q24	QMR2	PQ4B	PQ5B	PQ6B	PQ12A	PQ13	PQ15A	PQ15B
Uranium (µg/g)	2.7	27	3.1	2.4	0.42	2.7	0.47	0.37	0.42	1	5.2	1.9	2.2
Vanadium (µg/g)	120	1200	8	21	4	11	5	5	4	12	5	27	15
Yttrium (µg/g)	33	330	5.4	5.5	1.9	7.9	2.6	1.4	1.5	3.3	11	7.1	6.4
Zinc (µg/g)	70	700	26	35	2.8	21	3.2	3.5	2.7	3.8	17	59	39

Appendix H

Summary of Findings and Results for Shake Flask Extraction Test

Parameter	MMER*	CWQG (PAL)**	Sample ID										
			Q1	Q5	Q24	QMR2	PQ4B	PQ5B	PQ6B	PQ12A	PQ13	PQ15A	PQ15B
Sample weight (g)			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
Final pH			9.4	8.92	8.8	9.06	8.79	9.34	9.21	8.34	8.17	8.61	8.35
pH			9.16	8.01	8.47	9.03	8.44	8.34	8.51	9.32	7.97	7.78	7.51
Alkalinity (mg/L as CaCO3)			28	32	28	37	26	26	29	88	39	22	46
Conductivity (uS/cm)			68	79	106	126	81	81	100	272	90	50	109
Chloride (mg/L)			3	4	11	4	8	7	9	35	2	1	2
Sulphate (mg/L)			2	< 2	6	< 2	< 2	< 2	< 2	3	< 2	< 2	< 2
Mercury (mg/L)		0.000026	0.00001	0.00001	0.00001	0.00018	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00002
Silver (mg/L)		0.00025	< 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)		0.005 - 0.1	0.771	0.42	0.196	0.445	0.235	0.149	0.128	0.026	0.448	1.06	0.389
Arsenic (mg/L)	0.15	0.005	0.0011	0.0003	< 0.0002	0.0013	< 0.0002	< 0.0002	0.0004	0.001	0.0016	0.001	0.0005
Barium (mg/L)			0.00454	0.00277	0.00151	0.00193	0.00075	0.00074	0.0008	0.00269	0.00194	0.00801	0.0092
Boron (mg/L)		1.5	0.009	0.022	0.085	0.026	0.047	0.059	0.078	0.071	0.033	0.041	0.035
Beryllium (mg/L)			0.000008	0.000017	< 0.000007	0.000012	< 0.000007	< 0.000007	< 0.000007	< 0.000007	0.000034	0.00002	0.000015
Bismuth (mg/L)			< 0.000007	0.00001	< 0.000007	< 0.000007	0.000032	0.00002	0.000051	< 0.000007	0.000027	< 0.000007	0.000012
Calcium (mg/L)			3.33	4.37	11.2	3.84	10.5	7.92	8.69	9.2	4.98	0.21	7.25
Cadmium (mg/L)		0.00009	0.000003	0.000003	0.000009	0.000009	0.000003	0.000003	0.000021	0.000004	0.000007	0.000007	0.000003
Cobalt (mg/L)			0.000044	0.000034	< 0.000004	0.000069	0.000007	0.000109	0.000015	0.000052	0.000055	0.000099	0.000202
Chromium (mg/L)		0.001	0.00017	0.00015	0.00022	0.00007	0.00035	0.00023	0.0011	0.00011	0.00004	0.00023	0.00006
Copper (mg/L)	0.15	0.002	0.00038	0.00637	0.00876	0.00048	0.00091	0.00041	0.00097	0.0011	0.00198	0.00299	0.01076
Iron (mg/L)		0.3	0.105	0.079	0.008	0.061	< 0.007	< 0.007	0.016	0.007	0.19	0.353	0.139
Potassium (mg/L)			7.36	6.41	1.96	15.4	2.14	1.35	1.49	6.58	13.4	10.3	16.9
Lithium (mg/L)			0.0126	0.0047	0.0042	0.0061	0.0038	0.0024	0.003	0.0239	0.0035	0.0019	0.0013
Magnesium (mg/L)			0.496	1.29	4.08	1.14	1.62	3.33	4.36	22.1	1.84	0.236	1.16
Manganese (mg/L)			0.0032	0.00137	0.00002	0.00147	0.00002	< 0.00001	0.00005	0.00007	0.00192	0.0061	0.0074

Parameter	MMER*	CWQG (PAL)**	Sample ID										
			Q1	Q5	Q24	QMR2	PQ4B	PQ5B	PQ6B	PQ12A	PQ13	PQ15A	PQ15B
Molybdenum (mg/L)		0.073	0.00039	0.00174	0.00111	0.00345	0.00156	0.00052	0.0023	0.00301	0.00068	0.00095	0.00198
Sodium (mg/L)			5.96	6.07	1.24	8.84	0.96	0.84	1.15	6.1	2.68	4.41	2.57
Nickel (mg/L)	0.38	0.025	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0004	0.0001	0.0002	0.0001
Lead (mg/L)	0.12	0.001	0.00079	0.0001	0.00006	0.00022	0.00002	< 0.00001	< 0.00001	0.00002	0.00018	0.00019	0.00039
Antimony (mg/L)			0.0004	0.0004	0.0003	0.0004	0.0003	0.0003	0.0002	0.0003	0.0005	0.0005	0.0005
Selenium (mg/L)		0.001	< 0.00004	0.00011	0.00006	0.00049	< 0.00004	< 0.00004	< 0.00004	0.00009	0.00007	0.00006	0.0001
Tin (mg/L)			0.00022	0.00015	0.00022	0.00022	0.00012	0.00009	0.00051	0.00008	0.00008	0.0004	0.00033
Strontium (mg/L)			0.0153	0.00593	0.129	0.00681	0.111	0.111	0.108	0.0498	0.00497	0.00093	0.00928
Titanium (mg/L)			0.00719	0.00332	0.00074	0.00449	0.00005	< 0.00005	0.00048	0.00006	0.00346	0.0189	0.0065
Thallium (mg/L)		0.0008	0.000009	< 0.000005	0.000006	0.000008	< 0.000005	0.000005	< 0.000005	0.000171	0.000013	0.000011	< 0.000005
Uranium (mg/L)		0.015	0.00963	0.00121	0.000046	0.00818	0.000048	0.000022	0.000035	0.000127	0.0025	0.000184	0.00161
Vanadium (mg/L)			0.00314	0.0037	0.00047	0.00618	0.00065	0.00049	0.00052	0.00198	0.00045	0.00398	0.00119
Tungsten (mg/L)			0.00017	0.00024	0.00004	0.00045	0.00022	0.00022	0.00017	0.0002	0.00074	0.00013	0.00026
Yttrium (mg/L)			0.000079	0.00011	0.000005	0.000163	0.000003	< 0.000002	0.000005	0.000019	0.000639	0.000139	0.000229
Zinc (mg/L)	0.6	0.007	0.002	0.002	0.002	0.002	0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002

* Metal and Diamond Mining Effluent Regulations

**Canadian Water Quality Guidelines for Aquatic Life

Appendix I

Quarry Sample Photographs

Figure I1 – Q1 sampling location (detailed view)

Figure I2 – Q1 sampling location (general view)

Figure I3 – Q1 quarry location with scale

Figure I4 – Q4 sampling location with scale (detailed view)

Figure I5 – Q4 sampling location (general view)

Figure I6 – Q11 sampling location (detailed view) with scale

Figure I7 – Q11 sampling location (general view)

Figure I8 – QMR2 sampling location (detailed view)

Figure I9 – QMR2 sampling location (general view)

Figure I10 – PQ4B sampling location (detailed view)

Figure I11 – PQ4B sampling location (general view) with scale

Figure I12 – PQ4B sampling location (general view)

Figure I13 – PQ5B sampling location (detailed view) with scale

Figure I14 – PQ5B sampling location (general view)

Figure I15 – PQ6B sampling location (detailed view) with scale

Figure I16 – PQ6B sampling location (general view)

Figure I17 – PQ12A sampling location (detailed view) with scale

Figure I18 – PQ12A sampling location (general view)

Figure I19 – PQ13 sampling location (detailed view) with scale

Figure I120 – PQ13 sampling location (general view)

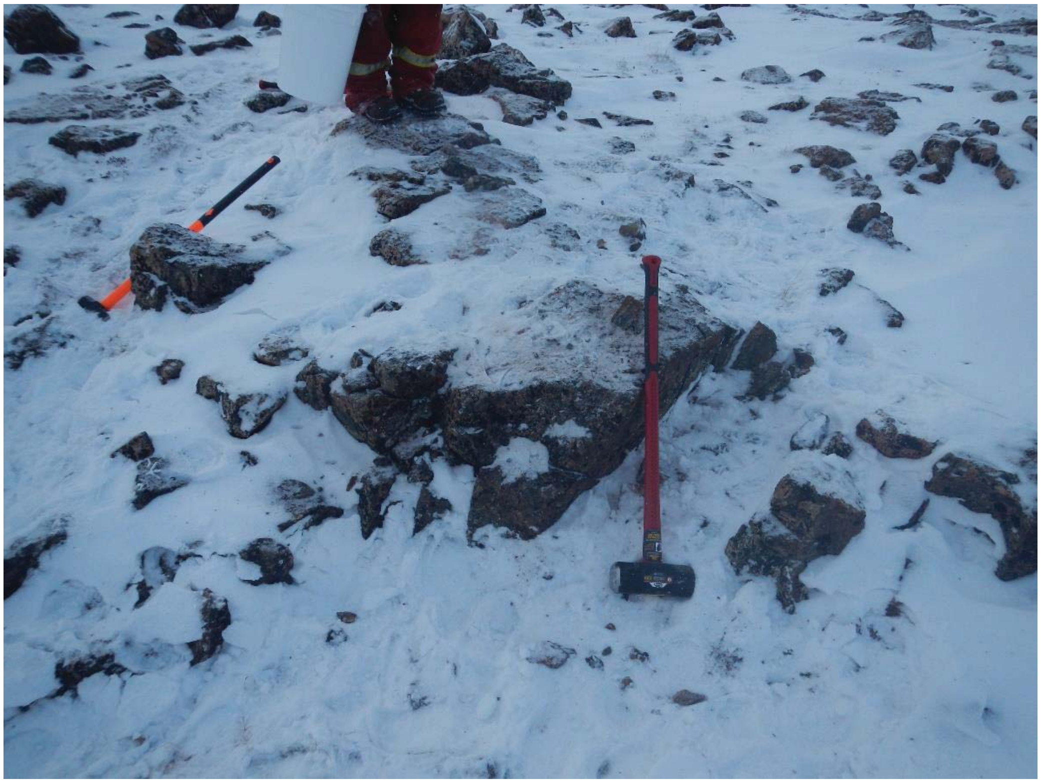

Figure I21 – PQ15A sampling location (detailed view) with scale

Figure I22 – PQ15A sampling location (general view)

Figure I23 – PQ15B sampling location (detailed view) with scale

Figure I24 – PQ15B sampling location (general view)

Figure I25 – Q5 sampling location (detailed view) with scale

Figure I26 – Q5 sampling location (general view)

Figure I27 – Q10 sampling location (detailed view) with scale

Figure I28 – Q10 sampling location (general view)

Figure I29 – Q24 sampling location (detailed view) with scale

Figure I30 – Q24 sampling location (general view)