ATLANTIC GOLD

Appendix D.1

Light Impact Assessment

Beaver Dam Mine Project - Revised Environmental Impact Statement Marinette, Nova Scotia

Light Impact Assessment

Beaver Dam Mine Project
Marinette, Nova Scotia

Prepared for: Atlantic Gold

GHD | 651 Colby Drive Waterloo Ontario N2V 1C2 Canada

088664 **|** 20 **|** Report No 8 **|** December 14, 2017

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1. Introduction

GHD has undertaken an analysis of the proposed lighting installations for the Beaver Dam Mine development (Site) in Marinette, Nova Scotia. The Site is in a rural, mostly wooded area. The impacts of the proposed lighting installations at the mine and along the haul route on nearby sensitive receptors were quantified and compared with the guidelines published by The Institution of Lighting Engineers (ILE) in the document entitled "Guidance Notes for the Reduction of Obtrusive Light".

Definitions

Light trespass is defined as the spilling of light beyond the boundary of the property or area being lit, and is primarily a concern at night. Excess obtrusive light can be a nuisance to others, wastes electricity, and indirectly results in unnecessary emissions of greenhouse gases. Light trespass, or light pollution, can also negatively impact the surrounding ecosystem by disrupting the habits of native species. As such, it is important to understand the potential light impacts from this development, and to endeavor to minimize them.

Luminous flux is the quantity of the energy of the light emitted per second in all directions. The unit of luminous flux is lumen (lm).

Illuminance refers to the amount of light that covers a surface. If Φ is the luminous flux and S is the area of the given surface then the illuminance E is determined by $E = \Phi/S$. Illumination is quantified in terms of lux. One lux is the illuminance of a 1 square metres (m^2) surface uniformly lit by 1 lm of luminous flux.

A residence that may experience an objectionable encroachment of light over the property line is referred to as a *residential receptor* or *sensitive receptor.* This undesirable light spill may include the entry of unwanted light through windows, or direct line of sight to bright light sources.

2. Baseline Conditions

The proposed Site is located in a historical mining area surrounded by forest, waterbodies, watercourses and wetlands. The nearest residential receptor to the mine is the Beaver Lake Indian Reserve (IR) located approximately 5 kilometres (km) southwest. A proposed haul route for transporting ore will connect the mine to the Touqouy Processing Plant, located approximately 19 km southwest of the mine, via a 30.7 km gravel road.

The ILE has developed an Environmental Zone classification system whereby the existing ambient light levels at a site are used to determine the recommended maximum amount of light trespass to nearby receptors. The classification for rural areas, small villages, or relatively dark urban locations is "E2 Low district brightness areas". Based upon this classification, the light trespass limit at an off-site receptor after curfew (typically considered to be 11 p.m.) is 1 lux, which is the accepted equivalent to moonlight. The after curfew (post-curfew) limit was used to assess the impact of lighting from the mine as mining operations under full-scale operation are scheduled to be 24 hours per day.

Furthermore, the ILE trespass limit at an offsite receptors before curfew is 5 lux. Atlantic Gold has indicated that trucking transport along the haul route will occur 12 to 16 hours a day, and not during post-curfew hours. No other proposed lighting will exist along the haul route. As such, the light trespass at receptors along the haul route was evaluated against the before curfew (pre-curfew) limit of 5 lux.

3. Proposed Lighting

Table 1 provides a complete listing of the proposed light sources to be installed at the Site. The mobile floodlights located at various points around the mine will be mounted on 8-metre (m) towers, facing downwards. Atlantic Gold provided model numbers for these mobile floodlight towers, and using manufacturer's specifications, GHD obtained the luminous flux for each floodlight tower. The LED walkway lights illuminating the Operational Facilities area will be positioned on 3-m poles surrounding the area, facing downwards. GHD used specifications of a typical 75 watt LED light used for site lighting applications to obtain the luminous flux for each pole mounted light. Since the exact locations of the lights are unknown at this stage, estimates were used.

Lighting was also considered along the haul route. As a worst-case scenario, the illuminance from two trucks at the closest location on the haul route to each nearby individual sensitive receptor were considered. Other than the hauling trucks, no other lighting sources will be present along the haul route (i.e. street lights, traffic lights). For simplicity, the two trucks were combined as a single stationary source, and were assumed to have six 65 watt halogen lights each.

4. Sensitive Receptors

The nearest permanent residential receptor to the mine is the Beaver Lake IR, at a distance of approximately 5 km southwest from the Open Pit area. Two other residential receptors, farther away from the mine and located along Highway 224, are also considered; the residence along River Lake and the seasonal residence located at the intersection with Beaver Damn Mines Road. These three residential receptors were used in the analysis of the impacts of light trespass from the mine.

Sensitive receptors were also considered along the proposed Haul Route. Three seasonal residences located within 150 m of the haul route were assessed for light impacts from hauling trucks travelling along the route; the residence along Second Rocky Lake, the residence along Ferry Lake and the residence located at the intersection with Highway 224 (as previously mentioned). These three residential receptors were used in the analysis of the impacts of light trespass from transport trucks travelling along the haul route. As previously mentioned, the illuminance from the haul route was evaluated against pre-curfew limits due to the hauling schedule.

5. Method of Assessment

Atlantic Gold provided GHD with a list of proposed lighting as indicated in Section 3 of this Report. From known information about the power output of the installations and typical efficiencies, the luminous flux of each light source was calculated:

$$Luminous\ Flux\ (lm) = Power\ Output\ (watts) \times Efficiency\ \left(\frac{lumens}{watt}\right)$$

The power output of the proposed lighting was known from manufacturer information, and the efficiency was based on typical industry published values, as presented in the following table.

Type of Light	Typical Efficiency (lumens/watt)
LED	58 – 113
Compact Fluorescent	70
Linear Fluorescent	108
Incandescent	15
Halogen	20
High Pressure Sodium	100

Sample Calculation:

There are 4 loaders to be operated around the Open Pit area, each with 6 mounted halogen lights having a power output of 65 watts each and with average efficiencies of 20 lumens/watt. The luminous flux of the trucks can be calculated as follows:

$$Power\ Output = 4\ loaders\ \times 6\frac{Lights}{Loader} \times 65\frac{W}{Light} = 1560\ W$$

$$Luminous\ Flux = 1560\ W\ \times 20\frac{lumens}{W} = 31{,}200\ lumens$$

After determining luminous flux estimates for each light source, the impacts of the incident light at the identified sensitive receptors can be determined. There are four main areas across the Site where lighting is to be located:

1. Open Pit
2. Operational Facilities
3. Waste Rock Storage
4. Haul Route

Table 1 indicates the estimated distance to the sensitive receptors from each of these areas. The illuminance level at a receptor is equal to the combined total from each light source. It has been conservatively assumed that 50 percent of the incident light will not reach the receptor due to the thick tree cover at the Site and surrounding area. The following equation was used to estimate the illuminance contribution from each light source:

$$E = \frac{\phi}{d^2} \times 50\%$$

Where:

E = illuminance (lux)

ϕ = luminous flux (lm)

d = distance to the receptor (m)

Sample Calculation:

The luminous flux from the four loaders at the open pit is an estimated 31,200 lm. The distance to the Beaver Lake IR receptor from the open pit is approximately 5,000 m. The illuminance contribution from the loaders to the Beaver Lake IR receptor can be estimated as follows:

$$Illuminance = \frac{31{,}200\ lumens}{(5000\ m)^2} \times 50\% = 6.24\ \times 10^{-4}\ lux$$

This method was used to determine the estimated illuminance at each receptor from each of the light sources. The sum of all contributions for each receptor represents the total estimated level of light that will be present at the receptor.

Table 1 provides a summary of the light sources at the Site, and the expected impacts from each source on the receptors. The combined effects of all the sources at each receptor were summed and compared to the illuminance limits recommended by the ILE, as shown in Table 2.

6. Results and Discussion

The calculated light levels at the identified sensitive receptors are below the limits recommended by the ILE guidelines during both post- and pre-curfew conditions, as shown in Table 2.

Illuminance from the haul route considers when two trucks are closest to each receptor and shining light towards each receptor, as a worst-case scenario. Because receptors along the haul route are not located on any road bends, with limited line of site to the travelling trucks, the assessed light impacts to these receptors are likely overestimated. Atlantic Gold has indicated that trucking operations will occur under daytime and pre-curfew conditions, and are unlikely to occur during dawn/dusk hours. As such, light impacts from trucks along the haul route are expected to be insignificant compared to baseline daylight illuminance.

The predicted illuminance levels represent the worst-case operating conditions of the mine. The assessment considers when all of the mobile equipment at the mine would be in use at the same time, illuminating towards receptors. The areas surrounding the Site are wooded with varying topography and inhibit the spread of light. It was conservatively assumed for screening purposes that 50 percent of the light will not reach the receptors due to directionality and line of sight obstructions. In reality the amount of light blocked by the surrounding woodland and topographic changes will likely be much greater than this (>90 percent), especially during the seasons when trees are in full bloom.

Sensitivity analysis was performed to determine the significance of a greater percentage of incident light reaching the nearest sensitive receptor during post curfew hours. If it were assumed that none of the light were obstructed and shining directly towards each receptor, the post curfew impact at the River Lake residence 6 km away remains less than 17 percent of the ILE standard, and the receptor at the Beaver Lake IR remains less than 17 percent of the ILE standard.

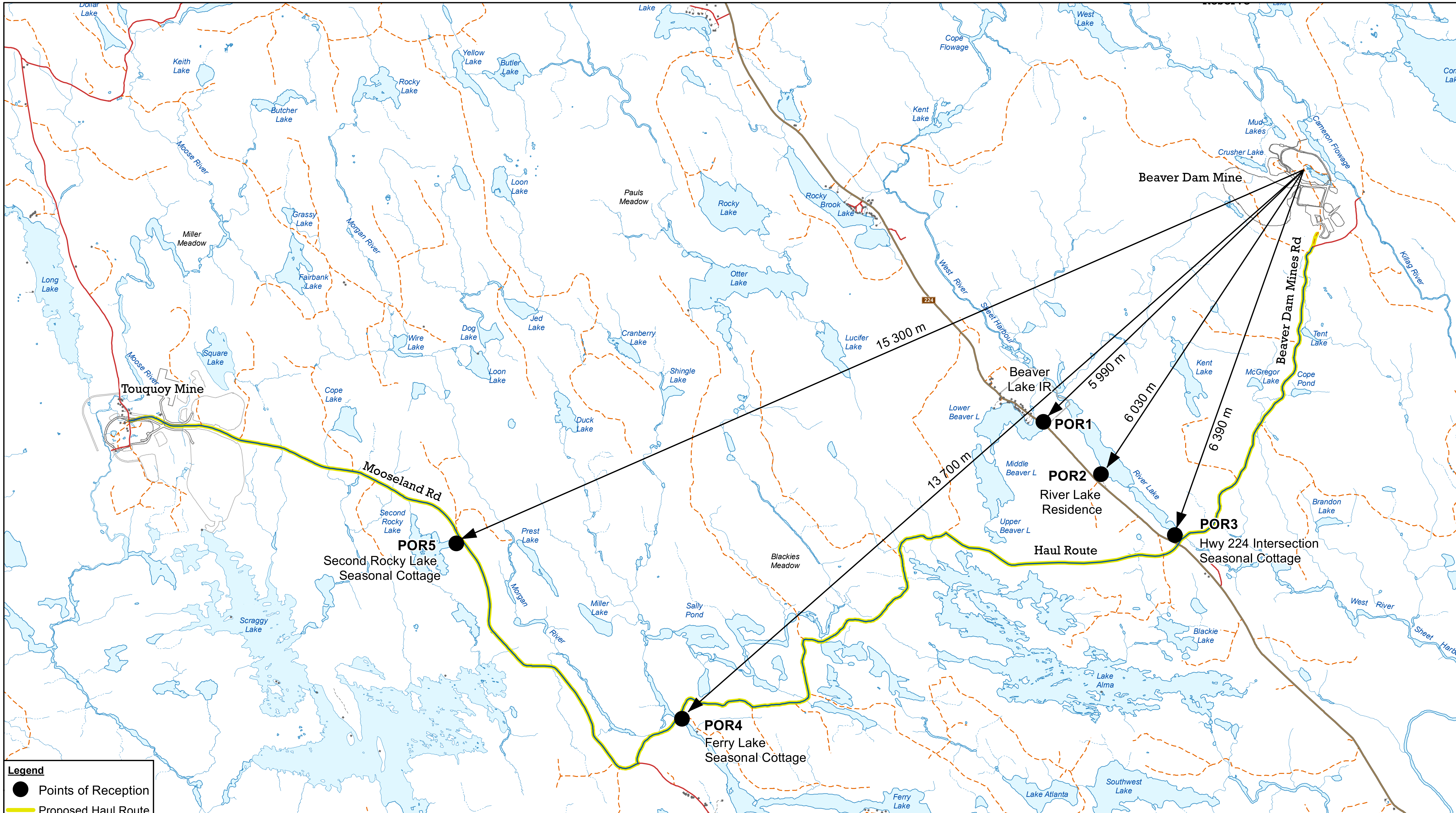
In a previous assessment under a separate cover, light impacts from the Touquoy Processing Plant were assessed against limits recommended by the ILE guidelines. This assessment determined that light impacts from the Touqouy facility were also below the ILE limits. Although the light impacts from the Touquoy facility and Beaver Dam Mine were not evaluated in combination, it is expected that the ILE limits at nearby receptors will not be exceeded from light trespass at both facilities. This is expected due to the low illuminance levels assessed at each receptor in both assessments (<30 percent of the ILE limits) and due to the large distances from the receptors to the sources of light at the other facilities.

7. Best Management Practices

Best management practices can minimize the light pollution incurred during the daily operation of a facility. Atlantic Gold has indicated that all of the floodlights on site will employ a "full horizontal cut off". A full horizontal cut off allows no direct light emissions above a horizontal plane through the luminaire's lowest light emitting part. This practice has been shown to significantly reduce light trespass in other applications. Where possible, all lighting fixtures will be facing towards the working area at the Site, to limit obtrusive light "spill" to nearby receptors. Also, Atlantic Gold has indicated that lighting not being utilized will be turned off when practical.

The majority of the light fixtures to be used on site will utilize LED Light. This is one of the more energy efficient types of light, yielding significantly more lumens per watt than traditional halogen and incandescent bulbs, in addition to having a longer lifespan. Where possible, Atlantic Gold will choose energy efficient for light replacements or additions,

Routine monitoring of the light levels at the Site, once constructed and operational, using a light meter will provide an opportunity to compare actual light levels with theoretical. More refined light level measurements could assist in further quantifying the effects of light sources on the sensitive receptors.



Source: Insert source text here.

0 600 1,200 1,800
Meters

Coordinate System:
NAD 1983 CSRS UTM Zone 20N

N

GHD

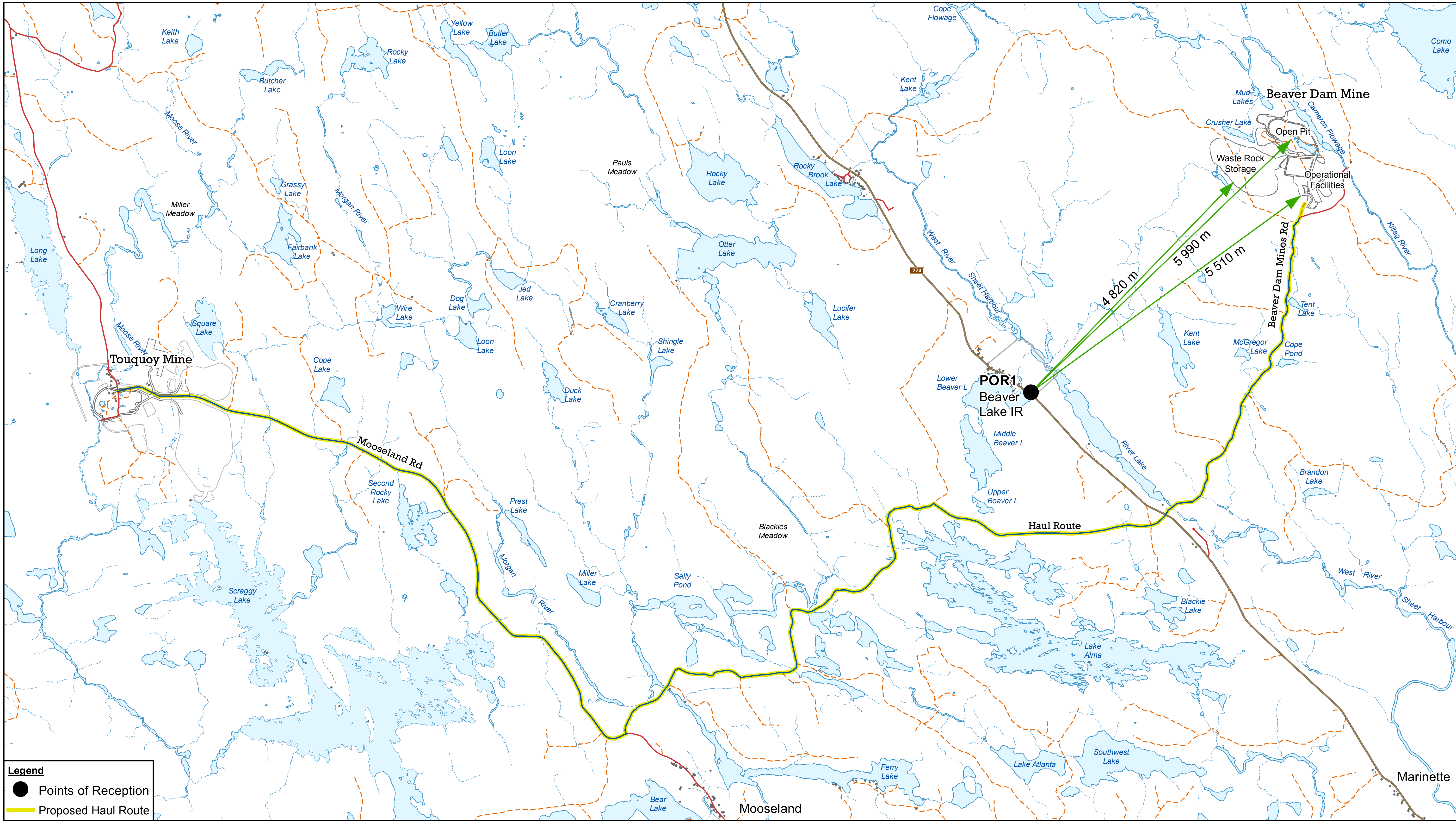
ATLANTIC GOLD CORPORATION
MARINETTE, HALIFAX CO., NOVA SCOTIA
ENVIRONMENTAL IMPACT STATEMENT - BEAVER DAM MINE

SITE AND POINT OF RECEPTION LOCATION PLAN

088664-20 (008)
Nov 17, 2017

FIGURE 1

GIS File: I:\GIS_DATA\Projects\6-chars\08----\088---\088664 Atlantic BD\088664(008)\088664(008)GIS-DA001.mxd



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0 600 1,200 1,800
Meters

Coordinate System:
NAD 1983 CSRS UTM Zone 20N

ATLANTIC GOLD CORPORATION
MARINETTE, HALIFAX CO., NOVA SCOTIA
ENVIRONMENTAL IMPACT STATEMENT - BEAVER DAM MINE

LIGHT SOURCE AND RECEPTOR SEPARATION DISTANCE PLAN - POR1

088664-20
Nov 9, 2017

FIGURE 2

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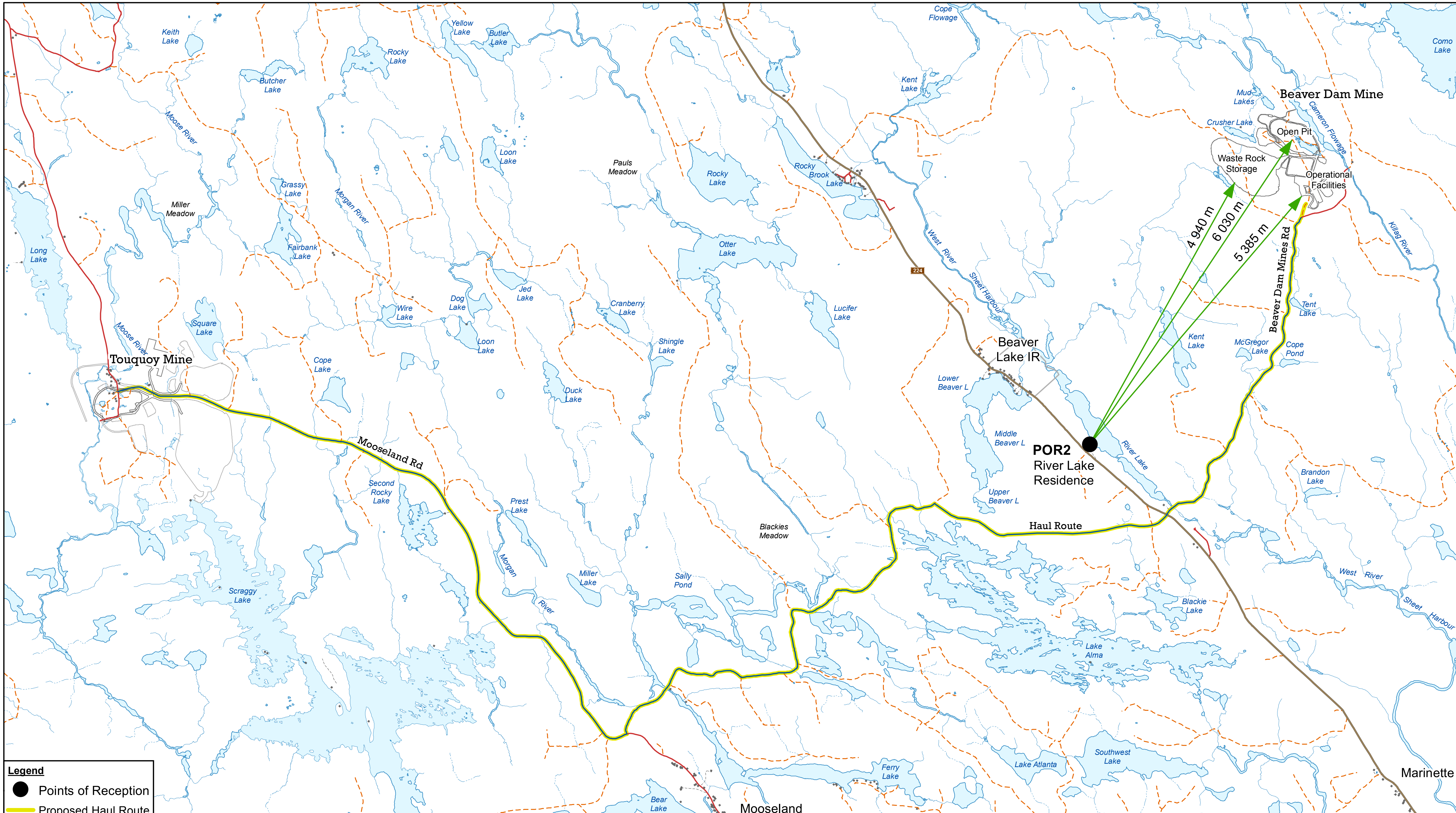

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0 600 1,200 1,800
Meters

Coordinate System:
NAD 1983 CSRS UTM Zone 20N

N

GHD

ATLANTIC GOLD CORPORATION
MARINETTE, HALIFAX CO., NOVA SCOTIA
ENVIRONMENTAL IMPACT STATEMENT - BEAVER DAM MINE

LIGHT SOURCE AND RECEPTOR SEPARATION
DISTANCE PLAN - POR2

088664-20 (008)
Nov 9, 2017

FIGURE 3

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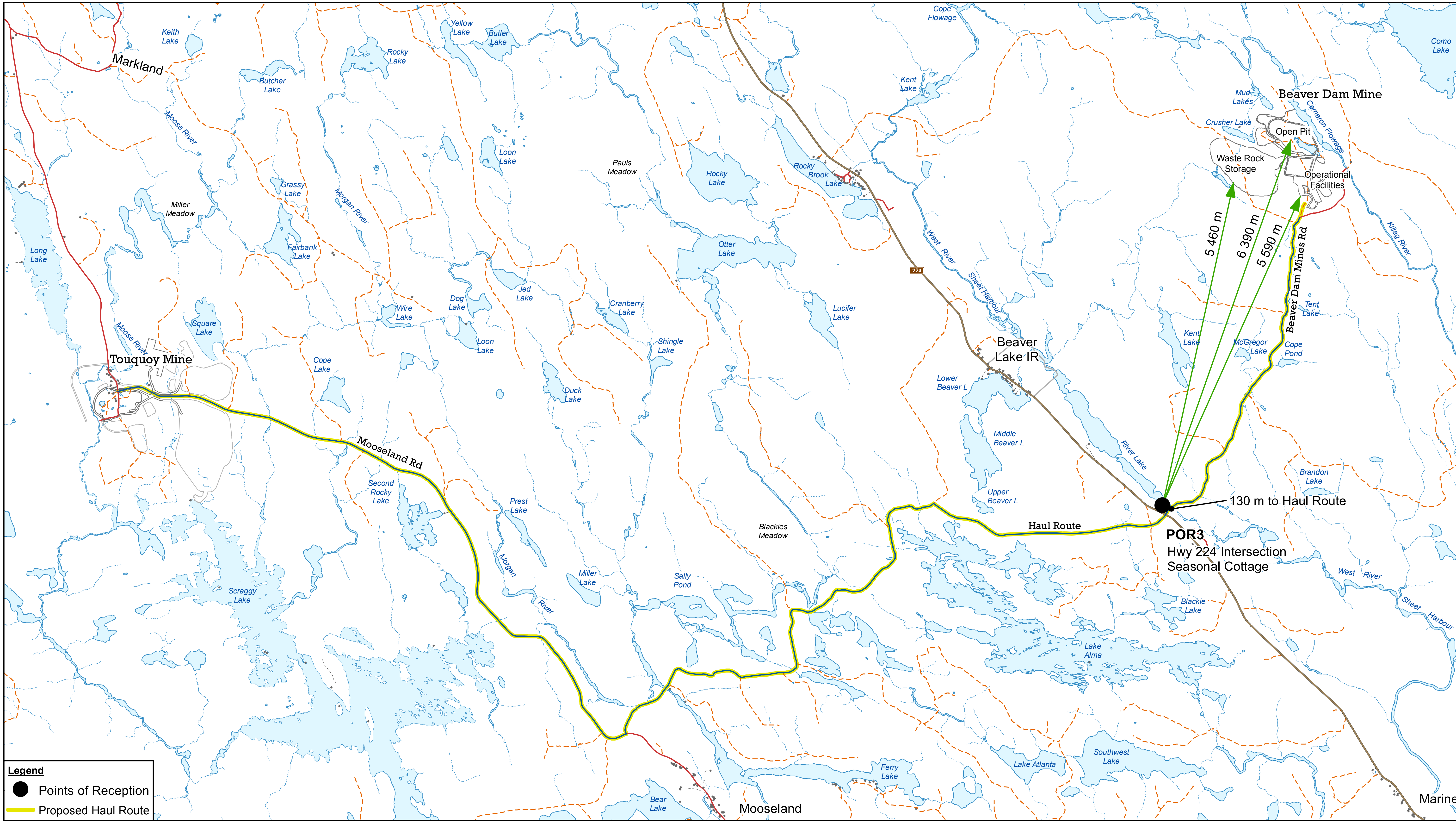


Source: Insert source text here.

0 600 1,200 1,800
Meters

Coordinate System:
NAD 1983 CSRS UTM Zone 20N

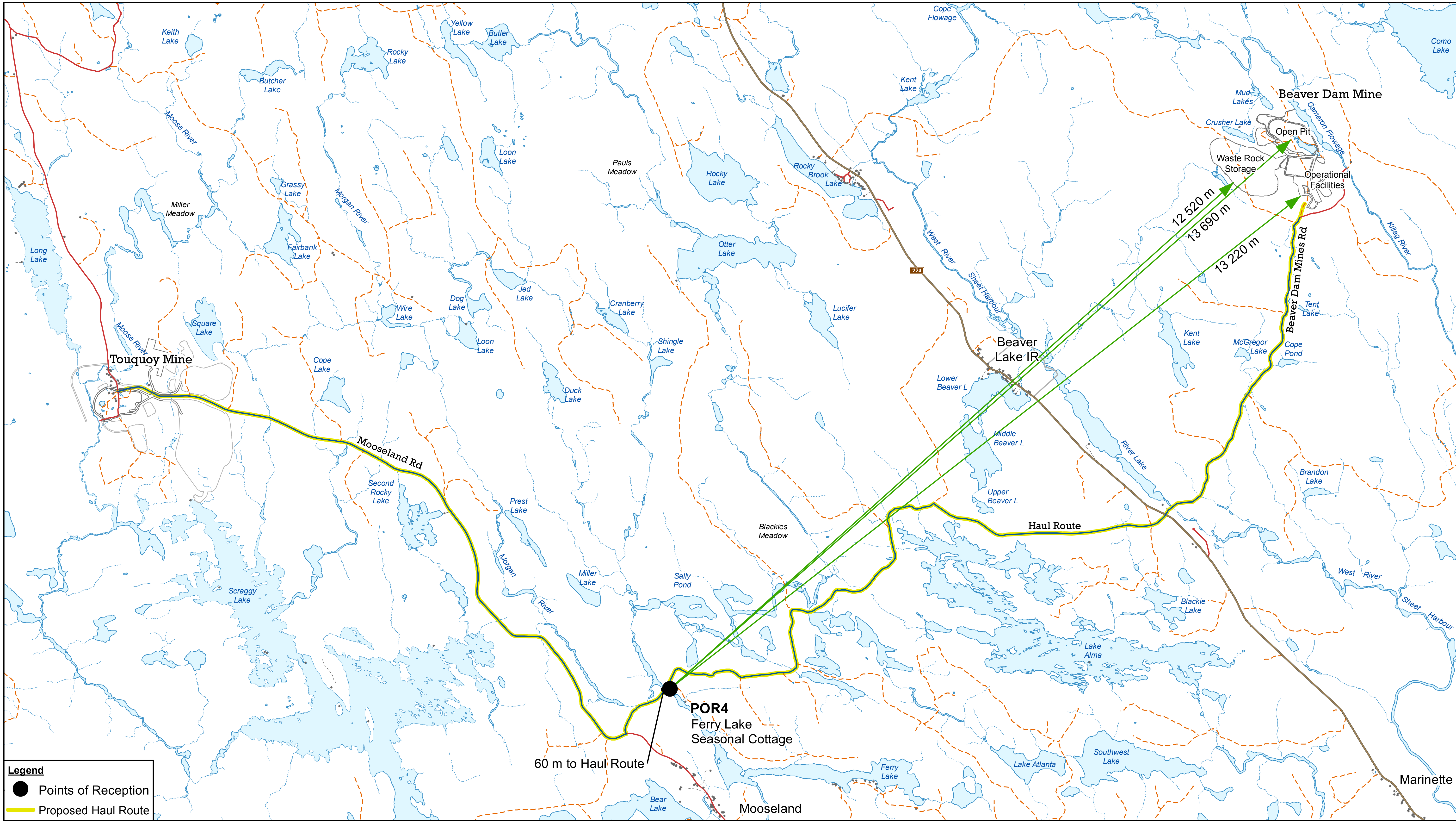
ATLANTIC GOLD CORPORATION
MARINETTE, HALIFAX CO., NOVA SCOTIA
ENVIRONMENTAL IMPACT STATEMENT - BEAVER DAM MINE

LIGHT SOURCE AND RECEPTOR SEPARATION DISTANCE PLAN - POR3

088664-20 (008)
Nov 9, 2017

FIGURE 4

GIS File: I:\GIS_DATA\Projects\6-chars\08----\088---\088664 Atlantic BD\088664(008)\088664(008)GIS-DA004.mxd



Source: Insert source text here.

0 600 1,200 1,800
Meters

Coordinate System:
NAD 1983 CSRS UTM Zone 20N

ATLANTIC GOLD CORPORATION
MARINETTE, HALIFAX CO., NOVA SCOTIA
ENVIRONMENTAL IMPACT STATEMENT - BEAVER DAM MINE

LIGHT SOURCE AND RECEPTOR SEPARATION DISTANCE PLAN - POR4

088664-20 (008)
Nov 9, 2017

FIGURE 5

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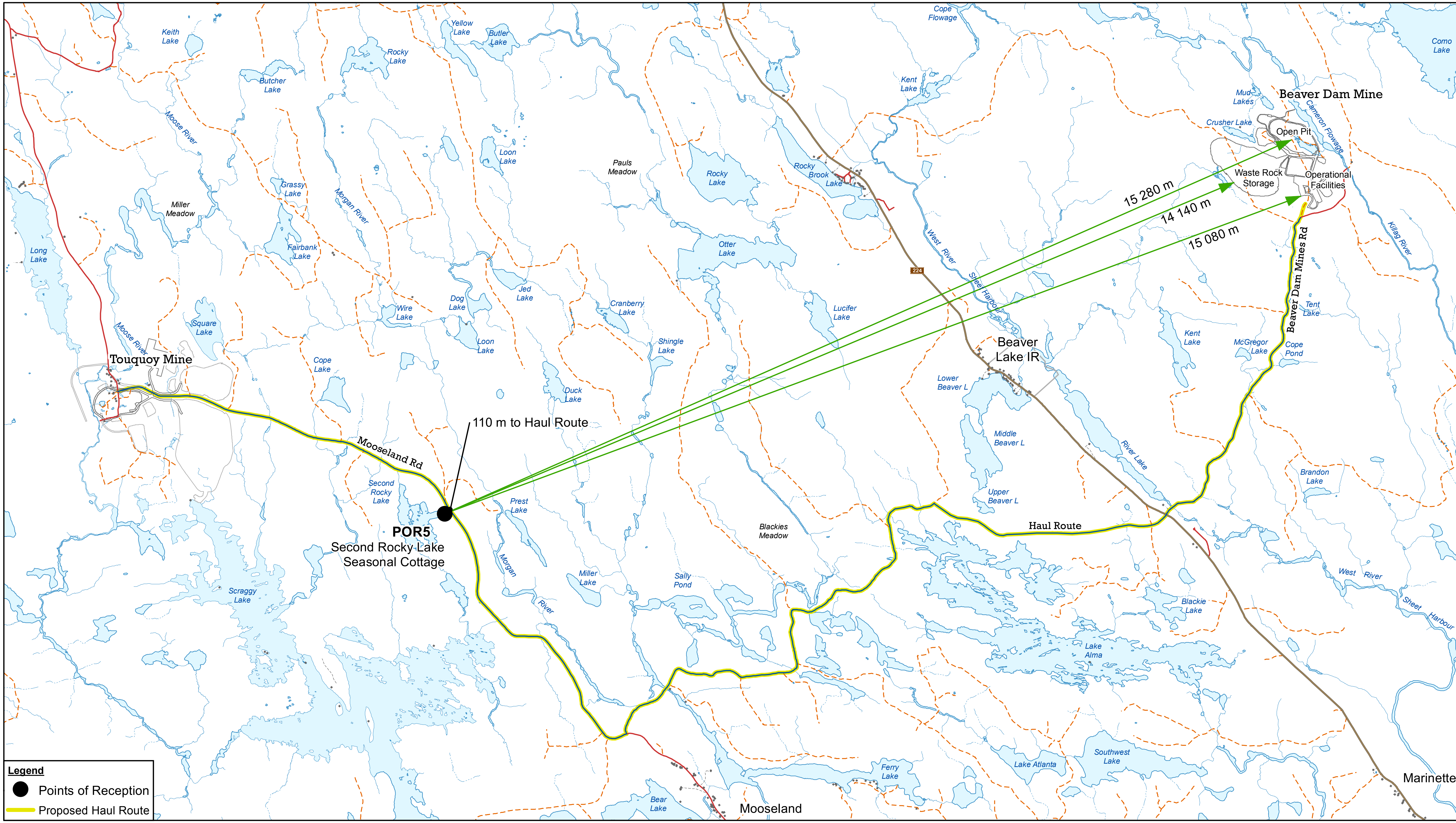

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0 600 1,200 1,800
Meters

Coordinate System:
NAD 1983 CSRS UTM Zone 20N

ATLANTIC GOLD CORPORATION
MARINETTE, HALIFAX CO., NOVA SCOTIA
ENVIRONMENTAL IMPACT STATEMENT - BEAVER DAM MINE

LIGHT SOURCE AND RECEPTOR SEPARATION DISTANCE PLAN - POR5

088664-20 (008)
Nov 9, 2017

FIGURE 6

GIS File: I:\GIS_DATA\Projects\6-chars\08----\088---\088664 Atlantic BD\088664(008)\088664(008)GIS-DA006.mxd

Table 1

Light Source Summary Tables
Beaver Dam Mine Project
Atlantic Gold Corporation
Marinette, Halifax Co., Nova Scotia

Percentage of incident lumens assumed to reach the receptor considering directionality and line of site obstructions: **50%**

							Receptor #1- Beaver Lake IR		Receptor #2 - River Lake Residence		Receptor #3 - Hwy 224 Intersection Residence		Receptor #4 - Ferry Lake Seasonal Cottage		Receptor #5 - Second Rocky Lake Seasonal Cottage	
Area	**Source**		**Power**	**Qty**	**Total Power**	**Luminous Flux (1)**	**Approx. Distance**	**Illuminance (2)**	**Approx. Distance**	**Illuminance**	**Approx. Distance**	**Illuminance**	**Approx. Distance**	**Illuminance**	**Approx. Distance**	**Illuminance**
			(watts)		(watts)	(lumens)	(m)	(lux)	(m)	(lux)	(m)	(lux)	(m)	(lux)	(m)	(lux)
Open Pit	Mobile Equipment (3)															
	Trucks (various)	6 mounted halogen lights	390	15	5850	117000	5990	1.63E-03	6030	1.61E-03	6390	1.43E-03	13690	3.12E-04	15280	2.51E-04
	Excavators	6 mounted halogen lights	390	6	2340	46800	5990	6.52E-04	6030	6.44E-04	6390	5.73E-04	13690	1.25E-04	15280	1.00E-04
	Loaders	6 mounted halogen lights	390	4	1560	31200	5990	4.35E-04	6030	4.29E-04	6390	3.82E-04	13690	8.32E-05	15280	6.68E-05
	Drills	6 mounted halogen lights	390	7	2730	54600	5990	7.61E-04	6030	7.51E-04	6390	6.69E-04	13690	1.46E-04	15280	1.17E-04
	Dozers	6 mounted halogen lights	390	5	1950	39000	5990	5.43E-04	6030	5.36E-04	6390	4.78E-04	13690	1.04E-04	15280	8.35E-05
	Grader	6 mounted halogen lights	390	1	390	7800	5990	1.09E-04	6030	1.07E-04	6390	9.55E-05	13690	2.08E-05	15280	1.67E-05
	Mobile Floodlight Tower (4)	4 metal halide lights	4200	6	25200	2772000	5990	3.86E-02	6030	3.81E-02	6390	3.39E-02	13690	7.40E-03	15280	5.94E-03
Operational Facilities																
	Mobile Floodlight Tower (4)	4 metal halide lights	4200	2	8400	924000	5510	1.52E-02	5385	1.59E-02	5590	1.48E-02	13220	2.64E-03	15080	2.03E-03
	Pole Mounted Lights (5)	LED roadway lights	75	28	2100	241500	5510	3.98E-03	5385	4.16E-03	5590	3.86E-03	13220	6.91E-04	15080	5.31E-04
Waste Rock Storage																
	Mobile Floodlight Tower (4)	4 metal halide lights	4200	2	8400	924000	4820	1.99E-02	4940	1.89E-02	5460	1.55E-02	12520	2.95E-03	14140	2.31E-03
Haul Route																
	Hauling Truck (6)	6 mounted halogen lights	390	2	780	15600	-	-	-	-	130	4.62E-01	60	2.17E+00	110	6.45E-01
						POST-CURFEW	**Total, R1:**	8.18E-02	**Total, R2:**	8.12E-02	**Total, R3:**	7.17E-02	**Total, R4:**	1.45E-02	**Total, R5:**	1.14E-02
						PRE-CURFEW	**Total, R1:**	8.18E-02	**Total, R2:**	8.12E-02	**Total, R3:**	5.33E-01	**Total, R4:**	2.18E+00	**Total, R5:**	6.56E-01

Notes:

(1) Unless specified, the average Lumens /Watt used were as follows:
LED lights typically are 58-113 lumens/ per watt.
Compact Fluorescent lights are typically 70 lumens/watt.
Linear Fluorescent lights are typically 108 lumens/watt.
Incandescent lights are typically 15 lumens/watt.
Halogen lights are typically 20 lumens/watt.
High Pressure Sodium lights are typically 108 lumens/watt.

Source: United States Department of Energy, Solid-State Lighting LED Basics https://energy.gov/eere/ssl/led-basics

(2) Illuminance = Luminous Flux/square of distance travelled; therefore 1 Lux = 1 lumen/m2.

(3) Mobile equipment with headlights was assumed to be stationary for simplicity. It was assumed that each piece of equipment has 6 mounted halogen lamp lights, 65 watts each.

(4) Atlantic Gold indicated that Generac Magnum MLT3060M floodlight towers will be used on Site. Manufacturer's specification were used to determine a luminous flux of 462,000 lumens. See Appendix A for Mobile Floodlight Tower specifications.

(5) Illuminance for Pole Mounted Lights based on a 75 W LED light, with a luminous flux of 8625 lumens, typical for site lighting applications. See Appendix A for LED lighting specifications.

(6) As a worst-case scenario, the light impacts from two trucks were assessed at each receptor along the Haul Route. The trucks were both assumed to be at the closest location to each receptor along the Haul Route.

Table 2

Comparison of Light Levels at Receptors With Published Guidelines
Beaver Dam Mine Project
Atlantic Gold Corporation

Marinette, Halifax Co., Nova Scotia

Receptor	Description	Illuminance (lux)		ILE Guidance Limit (1) Pre-Curfew (2)	ILE Guidance Limit (1) Post-Curfew (2)	Percentage of Criteria (3) Pre-Curfew	Percentage of Criteria (3) Post-Curfew
		Pre-Curfew (2)	Post-Curfew	(lux)	(lux)	(%)	(%)
POR1	Beaver Lake IR	8.18E-02	8.18E-02	5	1	1.64%	8.18%
POR2	River Lake Residence	8.12E-02	8.12E-02	5	1	1.62%	8.12%
POR3	Hwy 224 Intersection Residence	5.33E-01	7.17E-02	5	1	10.67%	7.17%
POR4	Ferry Lake Seasonal Cottage	2.18E+00	1.45E-02	5	1	43.62%	1.45%
POR5	Second Rocky Lake Seasonal Cottage	6.56E-01	1.14E-02	5	1	13.12%	1.14%

Assumptions

(1) Based on an assumed classification of the area as Environmental Zone E2- Low district brightness areas.
Source: Guidance Notes for the Reduction of Obtrusive Light, The Institute of Lighting Engineers (2011).

(2) Curfew = the time after which stricter requirements for the control of obtrusive light will apply. If not defined by the local planning authority, the ILE suggests 11:00 p.m.
Source: Guidance Notes for the Reduction of Obtrusive Light, "Table 1-Obtrusive Light Limitations for Exterior Lighting Installations", The Institute of Lighting Engineers (2011).

(3) Based on conservative assumption of 50% reduced light due to directionality and line of site obstructions.

Appendices

Appendix A
Supporting Information

MLT3060M

MOBILE LIGHT TOWER

SPECIFICATIONS

ENGINE

- Mitsubishi® L3E-W461ML - liquid cooled, diesel engine; Final Tier 4
  - Standby - 12.2 hp @ 1800 rpm
  - Prime - 10.5 hp @ 1800 rpm
  - 3 cylinder
  - 0.95 L displacement
- Polyethylene Fuel Tank:
  - Fuel Type: Diesel
  - Fuel Capacity: 33.6 gal. (127.9 L)
  - 3.5 in. (88.9 mm) fill port
- Fuel Consumption:
  - Full Load: 0.47 gph (1.78 Lph)*
  - Lights Only: 0.24 gph (1.78 Lph)*
  - Maximum Runtime (Lights Only): 140 hours*
- 60 Hz engine/generator
- Cooling system capable of operating at 120°F (49°C) ambient
- 750 hour service interval**
- Full flow oil filter, spin on type
- Fuel filter with replaceable element
- Dry type cartridge air filter
- Wind Rating: 65 mph (105 kph)

**Results based on engine manufacturer and field test data after 100-hour engine break-in period and may vary based on factors including age and maintenance of equipment, environmental conditions and fuel density. Consult the Owner's Manual for fuel and maintenance recommendations.*
***To achieve maximum service interval, replacement of oil filter after 50-hour break-in period is required. Consult Owner's Manual for required oil filter model number.*

GENERATOR

- Marathon Electric®
  - Brushless
- 6 kW standby output
- 120/240 VAC – 50/25A
- +/-6% capacitor voltage regulation

ENGINE CONTROLS

- Engraved, aluminum punched and anodized control panel
- Four position keyed switch – glow plugs (preheat, off, run, start)
- Hour meter
- Automatic low oil/high temperature shutdown system

ELECTRICAL AND SYSTEM CONTROLS

- Individual floodlight circuits with 15A breakers
- Ballast indicator lights
- 30A start limit breaker (assures no load condition exists before starting)
- Standard individually breakered convenience outlets:
  - (1) 120 VAC 20 Amp GFCI duplex outlets (NEMA 5-20R type)
  - (1) 240 VAC 30 Amp Twistlock outlets (NEMA L6-30R type)
- 440CCA wet cell battery

FLOODLIGHTS

- Four (4) 1050 watt metal halide; 462,000 total lumens
- Oval aluminum reflector
- Tempered glass lens
- Silicone gaskets for moisture and dust protection
- Friction disc mounting for tool less positioning
- Individual floodlight On/Off switches

MAST

- Horizontal mast; 30 ft. (9.14 m) maximum extension, 3-section
- Tubular steel frame – 3 in. (76.2 mm) square tube with 3/16 in. (4.78 mm) wall
- Urethane guides on all sides of mast tubes
- Industrial black powder coat finish
- Dual winch system located at ergonomic height allowing single person operation
- 359° ground-level rotation with locking system
- Coiled mast cord

ENCLOSURE

- Steel enclosure – 14-gauge
    - UV & fade resistant, high temperature cured, white polyester powder paint
    - 68 dB(A) at 23 ft. (7 m) – prime power
- Stainless steel hinges on doors
- Multi-lingual operating/safety decals
- License plate holder with light
- Manual holder with operating manual
- Equipped with single lifting eye and fork pockets

TRAILER

- Removable tongue – 48 in. (1219.20 mm) long
- (4) 2000 lb. (907.18 kg) adjustable leveling jacks – 4 point stance
- All jacks transport and lock in horizontal position for storage
- Side outriggers – 96.25 in. (2.45 m) span
- 7800 lb. (3538 kg) safety chains with spring loaded safety hooks
- 2 in. (50.8 mm) ball hitch
- Single wall polyethylene fenders
- DOT approved tail, side, brake, and directional lights
    - Recessed rear lights
- 2200 lb. (997.90 kg) leaf spring axle
- ST175/80D13 – 6 ply
- 40.75 in. (1035.05 mm) axle span

WEIGHT & DIMENSIONS

- Dry weight: 1640 lbs. (744 kg)
- Operating weight: 1856 lbs. (842 kg)
- Mast stowed: 170 x 49 x 68 in. (4.32 x 1.25 x 1.73 m)

WARRANTY
2 Years / 2000 Hours

CERTIFICATIONS
CSA Certified

OPTIONS
Contact sales representative or factory for a list of current available options.

For more information, consult the Owner's Manual at http://www.generacmobileproducts.com/resources-tools/manuals naturaled®

Turning Light into Savings

SAL
Slim Area Light

29W, 50W, 75W, 100W 180W, 240W, 360W

naturaLED® Slim Area Light constructed with durable, die-cast aluminum housing and excellent thermal design. Our SAL series are low profile replacements for up to 1,000 watt existing Metal Halide and HPS area lighting. Our SAL features a high efficiency LED driver with high lumens and long life LED chip. With excellent optical design improvies light distribution and evenness. Perfect for parking lots, streets, walkways, streetscape, and providing you with uniform and consistant color.

Our fixtures are DLC 4.0 Premium and IP65 rated with four installation methods including: Swivel Bracket, Slip Fitter, 6” Extruded Arm and Yoke Mount. Compatible Integrated automomous and photocell motion sensors are available as options to address your needs.

5 YEAR WARRANTY

Dimmable 1-10V | TYPE ANGLE 3 | TYPE ANGLE 5 | 50,000 Rated Life Hours

Key Features & Benefits

- DLC 4.0 Premium
- IP65
- Uniform and consistent color
- Aluminum die cast housing
- Excellent thermal design
- CRI:70
- Universal Voltage 120-277V
- Operating Temp: -22°F~122°F
- 50,000 Hours rated average life
- 1-10V dimming
- Motion sensor compatible
- Photocell sensor compatible

Applications

- Parking Lot Lighting
- Street Lighting
- Site Lighting
- Streetscape Lighting
- Area Lighting

2 Color Choices

Dark Bronze White

Qualifications

IP65 outdoor rated, DLC Premium, cULus, FC, LM 79, LM 80, RoHS COMPLIANT, Title 24

ORDERING INFORMATION

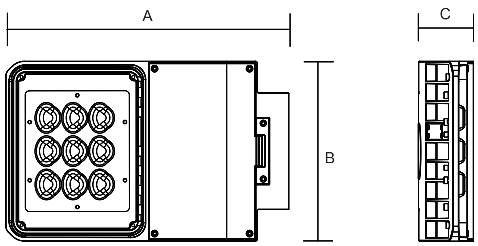
Item Code	Description	Color Temp	Wattage	Lumen Output	Equivalent Wattage	Voltage (V)	CRI	Beam Angle	Color	24	DLC Premium	IP65
29W - 100W												
7616	LED-FXSAL29/40K/DB/3S	4000K	29	3190	100-150	120-277	70	Type 3	Dark Bronze	•	•	•
7617	LED-FXSAL29/50K/DB/3S	5000K	29	3190	100-150	120-277	70	Type 3	Dark Bronze	•	•	•
7618	LED-FXSAL29/40K/WH/3S	4000K	29	3190	100-150	120-277	70	Type 3	White	•	•	•
7619	LED-FXSAL29/50K/WH/3S	5000K	29	3190	100-150	120-277	70	Type 3	White	•	•	•
7620	LED-FXSAL50/40K/DB/3S	4000K	50	5750	250	120-277	70	Type 3	Dark Bronze	•	•	•
7621	LED-FXSAL50/50K/DB/3S	5000K	50	5750	250	120-277	70	Type 3	Dark Bronze	•	•	•
7622	LED-FXSAL50/40K/WH/3S	4000K	50	5750	250	120-277	70	Type 3	White	•	•	•
7623	LED-FXSAL50/50K/WH/3S	5000K	50	5750	250	120-277	70	Type 3	White	•	•	•
7624	LED-FXSAL75/40K/DB/3S	4000K	75	8625	250-400	120-277	70	Type 3	Dark Bronze	•	•	•
7625	LED-FXSAL75/50K/DB/3S	5000K	75	8625	250-400	120-277	70	Type 3	Dark Bronze	•	•	•
7626	LED-FXSAL75/40K/WH/3S	4000K	75	8625	250-400	120-277	70	Type 3	White	•	•	•
7627	LED-FXSAL75/50K/WH/3S	5000K	75	8625	250-400	120-277	70	Type 3	White	•	•	•
7628	LED-FXSAL100/40K/DB/3S	4000K	100	12000	400	120-277	70	Type 3	Dark Bronze	•	•	•
7629	LED-FXSAL100/50K/DB/3S	5000K	100	12000	400	120-277	70	Type 3	Dark Bronze	•	•	•
7630	LED-FXSAL100/40K/WH/3S	4000K	100	12000	400	120-277	70	Type 3	White	•	•	•
7631	LED-FXSAL100/50K/WH/3S	5000K	100	12000	400	120-277	70	Type 3	White	•	•	•
7644	LED-FXSAL29/40K/DB/5S	4000K	29	3190	100-150	120-277	70	Type 5	Dark Bronze	•	•	•
7645	LED-FXSAL29/50K/DB/5S	5000K	29	3190	100-150	120-277	70	Type 5	Dark Bronze	•	•	•
7646	LED-FXSAL29/40K/WH/5S	4000K	29	3190	100-150	120-277	70	Type 5	White	•	•	•
7647	LED-FXSAL29/50K/WH/5S	5000K	29	3190	100-150	120-277	70	Type 5	White	•	•	•
7648	LED-FXSAL50/40K/DB/5S	4000K	50	5750	250	120-277	70	Type 5	Dark Bronze	•	•	•
7649	LED-FXSAL50/50K/DB/5S	5000K	50	5750	250	120-277	70	Type 5	Dark Bronze	•	•	•
7650	LED-FXSAL50/40K/WH/5S	4000K	50	5750	250	120-277	70	Type 5	White	•	•	•
7651	LED-FXSAL50/50K/WH/5S	5000K	50	5750	250	120-277	70	Type 5	White	•	•	•
7652	LED-FXSAL75/40K/DB/5S	4000K	75	8625	250-400	120-277	70	Type 5	Dark Bronze	•	•	•
7653	LED-FXSAL75/50K/DB/5S	5000K	75	8625	250-400	120-277	70	Type 5	Dark Bronze	•	•	•
7654	LED-FXSAL75/40K/WH/5S	4000K	75	8625	250-400	120-277	70	Type 5	White	•	•	•
7655	LED-FXSAL75/50K/WH/5S	5000K	75	8625	250-400	120-277	70	Type 5	White	•	•	•
7656	LED-FXSAL100/40K/DB/5S	4000K	100	12000	400	120-277	70	Type 5	Dark Bronze	•	•	•
7657	LED-FXSAL100/50K/DB/5S	5000K	100	12000	400	120-277	70	Type 5	Dark Bronze	•	•	•
7658	LED-FXSAL100/40K/WH/5S	4000K	100	12000	400	120-277	70	Type 5	White	•	•	•
7659	LED-FXSAL100/50K/WH/5S	5000K	100	12000	400	120-277	70	Type 5	White	•	•	•
180W - 360W												
7632	LED-FXSAL180/40K/DB/3S	4000K	180	21600	400-575	120-277	70	Type 3	Dark Bronze	•	•	•
7633	LED-FXSAL180/50K/DB/3S	5000K	180	21600	400-575	120-277	70	Type 3	Dark Bronze	•	•	•
7634	LED-FXSAL180/40K/WH/3S	4000K	180	21600	400-575	120-277	70	Type 3	White	•	•	•
7635	LED-FXSAL180/50K/WH/3S	5000K	180	21600	400-575	120-277	70	Type 3	White	•	•	•
7636	LED-FXSAL240/40K/DB/3S	4000K	240	28800	750-1000	120-277	70	Type 3	Dark Bronze	•	•	•
7637	LED-FXSAL240/50K/DB/3S	5000K	240	28800	750-1000	120-277	70	Type 3	Dark Bronze	•	•	•
7638	LED-FXSAL240/40K/WH/3S	4000K	240	28800	750-1000	120-277	70	Type 3	White	•	•	•
7639	LED-FXSAL240/50K/WH/3S	5000K	240	28800	750-1000	120-277	70	Type 3	White	•	•	•
7640	LED-FXSAL360/40K/DB/3S	4000K	360	43200	1000-1250	120-277	70	Type 3	Dark Bronze	•	•	•
7641	LED-FXSAL360/50K/DB/3S	5000K	360	43200	1000-1250	120-277	70	Type 3	Dark Bronze	•	•	•
7642	LED-FXSAL360/40K/WH/3S	4000K	360	43200	1000-1250	120-277	70	Type 3	White	•	•	•
7643	LED-FXSAL360/50K/WH/3S	5000K	360	43200	1000-1250	120-277	70	Type 3	White	•	•	•
7660	LED-FXSAL180/40K/DB/5S	4000K	180	21600	400-575	120-277	70	Type 5	Dark Bronze	•	•	•
7661	LED-FXSAL180/50K/DB/5S	5000K	180	21600	400-575	120-277	70	Type 5	Dark Bronze	•	•	•
7662	LED-FXSAL180/40K/WH/5S	4000K	180	21600	400-575	120-277	70	Type 5	White	•	•	•
7663	LED-FXSAL180/50K/WH/5S	5000K	180	21600	400-575	120-277	70	Type 5	White	•	•	•

Item Code	Description	Color Temp	Wattage	Lumen Output	Equivalent Wattage	Voltage (V)	CRI	Beam Angle	Color	Title 24	DLC Premium	IP65
7664	LED-FXSAL240/40K/DB/5S	4000K	240	28800	750-1000	120-277	70	Type 5	Dark Bronze	•	•	•
7665	LED-FXSAL240/50K/DB/5S	5000K	240	28800	750-1000	120-277	70	Type 5	Dark Bronze	•	•	•
7666	LED-FXSAL240/40K/WH/5S	4000K	240	28800	750-1000	120-277	70	Type 5	White	•	•	•
7667	LED-FXSAL240/50K/WH/5S	5000K	240	28800	750-1000	120-277	70	Type 5	White	•	•	•
7668	LED-FXSAL360/40K/DB/5S	4000K	360	43200	1000-1250	120-277	70	Type 5	Dark Bronze	•	•	•
7691	LED-FXSAL360/50K/DB/5S	5000K	360	43200	1000-1250	120-277	70	Type 5	Dark Bronze	•	•	•
7670	LED-FXSAL360/40K/WH/5S	4000K	360	43200	1000-1250	120-277	70	Type 5	White	•	•	•
7671	LED-FXSAL360/50K/WH/5S	5000K	360	43200	1000-1250	120-277	70	Type 5	White	•	•	•

Mounting

P10101	MT-SAL/SF/DB	Slip Fitter
P10103	MT-SAL/SB/DB	Swivel Bracket
P10105	MT-SAL/EA6/DB	6" Extended Arm Dark
TBD	TBD	Yoke Mount

Dimensions

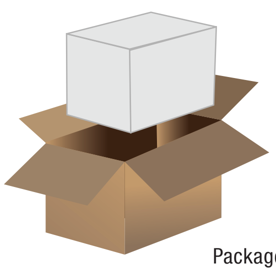


Wattage	A	B	C	Weight
29 50 75 100	13.38-in	8.66-in	2.56-in	- lbs

Coming soon

Wattage	A	B	C	Weight
180 240 360				

Master Carton Package



Package (Master)
1

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Appendix E.1

Sediment Baseline Analytical Results

Beaver Dam Mine Project - Revised Environmental Impact Statement Marinette, Nova Scotia

Table 1: Metals

		CCME ISQG	CCME PEL	21-Jul-16								
Sampling Location				**SED1**	**SED2**	**SED3**	**SED4**	**SED5**	**SED6**	**SED7**	**SED8**	**SED9**
Metals	**Units**											
Total Aluminum (Al)	mg/kg			15000	8800	18000	20000	22000	18000	18000	2600	12000
Total Antimony (Sb)	mg/kg			<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Arsenic (As)	mg/kg	**5.9**	**17**	78	110	73	58	41	400	300	<2.0	5.1
Total Barium (Ba)	mg/kg			69.0	24.0	32.0	28.0	61.0	29.0	32.0	7.5	36.0
Total Beryllium (Be)	mg/kg			<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Bismuth (Bi)	mg/kg			<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Boron (B)	mg/kg			<50	<50	<50	<50	<50	<50	<50	<50	<50
Total Cadmium (Cd)	mg/kg	**0.6**	3.5	<0.30	<0.30	<0.30	<0.30	1.8	<0.30	<0.30	<0.30	<0.30
Total Chromium (Cr)	mg/kg	**37.3**	90	23	12	26	25	23	23	25	4.7	16
Total Cobalt (Co)	mg/kg			7	3.1	8	18	6.2	17	15	<1.0	2.9
Total Copper (Cu)	mg/kg	**35.7**	**197**	12	4.5	6.6	15	56	9.2	14	2.2	8.7
Total Iron (Fe)	mg/kg			28000	11000	34000	35000	12000	36000	28000	2400	6300
Total Lead (Pb)	mg/kg	**35**	**91.3**	7.8	7.2	13	23	12	26	9.6	13.00	24
Lithium	mg/kg			40	18	28	37	34	23	40	<2.0	12
Total Manganese (Mn)	mg/kg			420	200	420	1000	200	670	690	40	160
Total Mercury (Hg)	mg/kg	**0.17**	0.486	0.014	0.027	0.31	0.1	0.077	0.04	0.015	0.088	0.13
Total Molybdenum (Mo)	mg/kg			<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Nickel (Ni)	mg/kg			16	8.8	15	16	30.0	12	19	2.5	6.5
Rubidium	mg/kg			12	6.0	16.0	8.1	6.3	11	15	3	9
Total Selenium (Se)	mg/kg			<1.0	<1.0	<1.0	<1.0	3.7	<1.0	<1.0	<1.0	1.7
Total Silver (Ag)	mg/kg			<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Total Strontium (Sr)	mg/kg			5.9	8.2	<5.0	6.5	21.0	<5.0	6.7	<5.0	7.7
Total Thallium (Tl)	mg/kg			<0.10	<0.10	0.14	0.21	0.14	0.18	0.12	<0.10	0.18
Total Tin (Sn)	mg/kg			<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Uranium (U)	mg/kg			0.77	0.43	0.44	0.66	3.4	0.61	0.69	0.32	1.2
Total Vanadium (V)	mg/kg			24	12	35	31	22	42	27	3.5	17
Total Zinc (Zn)	mg/kg	**123**	**315**	49.0	29.0	55.0	63.0	89	54.0	53.0	<5.0	21

Notes

CCME ISQG - Canadian Council of Ministers of the Environment, Interim Sediment Quality Guidelines

CCME PEL - Canadian Council of Ministers of the Environment, Probable Effects Level

Appendix E.2

Beaver Dam Project – ML/ARD Assessment Report

Beaver Dam Mine Project - Revised Environmental Impact Statement Marinette, Nova Scotia

Beaver Dam Project – ML/ARD Assessment Report

Prepared for:
Atlantic Gold Corporation
Suite 3083, 595 Burrard St.
Vancouver, BC, V7X 1L3

Prepared by:
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2289 Burrard St.
Vancouver, BC, V6J 3H9

Project No. A458-3

20 December 2018

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1. Introduction

1 Introduction

The Beaver Dam project is a proposed gold mine owned by Atlantic Mining Nova Scotia Corporation (AMNS) who is preparing a revised Environmental Impact Statement (EIS) that will be submitted to the Canadian Environmental Assessment Agency (CEAA) and Nova Scotia Environment (NSE) as part of the project's regulatory requirements. Lorax Environmental Services Ltd. (Lorax) was retained by AMNS to conduct a geochemical study to characterize mine material such as waste rock, ore, tailings and overburden. This study considers material properties that may change water quality attributed to metal leaching and acid rock drainage (ML/ARD). The geochemical characterization of Beaver Dam samples will also support the development of geochemical source terms for water quality modelling.

ML/ARD is typically associated with the weathering of sulphide-bearing geologic materials. While this is a natural process, the exposure of fresh particle surfaces produced by mining activity enhances the reaction rates associated with ML/ARD.

Following the introduction, a brief background of the geology of the area is provided in Section 2. Section 3 describes the methodology related to the sample selection/collection as well as geochemical analyses and Section 4 discusses the analytical results. Conclusions are provided in Section 5.

2. Geology

2 Geology

2.1 Regional Geology

Nova Scotia is divided into two terranes along the east-west trending Cobequid-Chedabucto Fault Zone (FSSI, 2015). The Beaver Dam site is within the southern Meguma Terrane, while the Avalon Terrane is located to the north of the fault zone. The Meguma Terrane includes the Cambrian to Ordovician Meguma Group and Late Ordovician to Early Devonian volcanic and sedimentary rocks (FSSI, 2015). After the collision of the Meguma and Avalon terranes in the mid-Devonian period, sedimentary material was deposited over both terranes during the Carboniferous to Early Cretaceous period. The sedimentary units include siliciclastic rocks, calcareous rocks, evaporites, coal, kaolinitic clay and silica sand (FSSI, 2015).

The majority of the gold mineralization occurs within the units of the Meguma Group. The Meguma Group is divided into the Goldenville Formation and the overlying Halifax Formation. The metamorphic facies in both Meguma Group units vary from greenschist to amphibolite facies. The Goldenville Formation is a greywacke unit that is > 5,600m thick, while the Halifax Formation is primarily argillite with an average thickness of approximately 4,400 m. Both the Goldenville Formation and the Halifax Formation are made up of deep marine turbidite deposits.

2.2 Site Geology

The Meguma Group is the dominant unit occurring in the area near the Beaver Dam site. The Goldenville Formation is further subdivided, from oldest to youngest, into the Moose River Member, the Tangier Member and the Taylors Head Member. Claystone and siltstone are present in the Moose River and Tangier Members but are minor in the Taylors Head Member. Overall there is a decrease in the proportion of fine-grained sediments from the oldest to the youngest units within the Goldenville Formation.

The site of the Beaver Dam project is within the northeast trending Moose River-Beaver Dam Anticline. The metamorphic facies in this region are amphibolite to staurolite facies. The main unit at the project site is the Moose River Member of the Goldenville Formation which is comprised of alternating argillite and greywacke units (FSSI, 2015). While many unique lithologies and geologic structures are tracked during core logging, argillite and greywacke along with two interbedded intermediates (argillite- and greywacke-dominated) represent the four major rock types by volume identified on site. In an effort to be consistent with the geological observations from site while simultaneously allowing for a representative and simplified geo-environmental model, these four major rock types are being carried forward in this ML/ARD assessment. A more detailed description of these units is given in Table 3-1.

3. Samples and Analytical Methods

3 Samples and Analytical Methods

3.1 Sample Selection and Collection

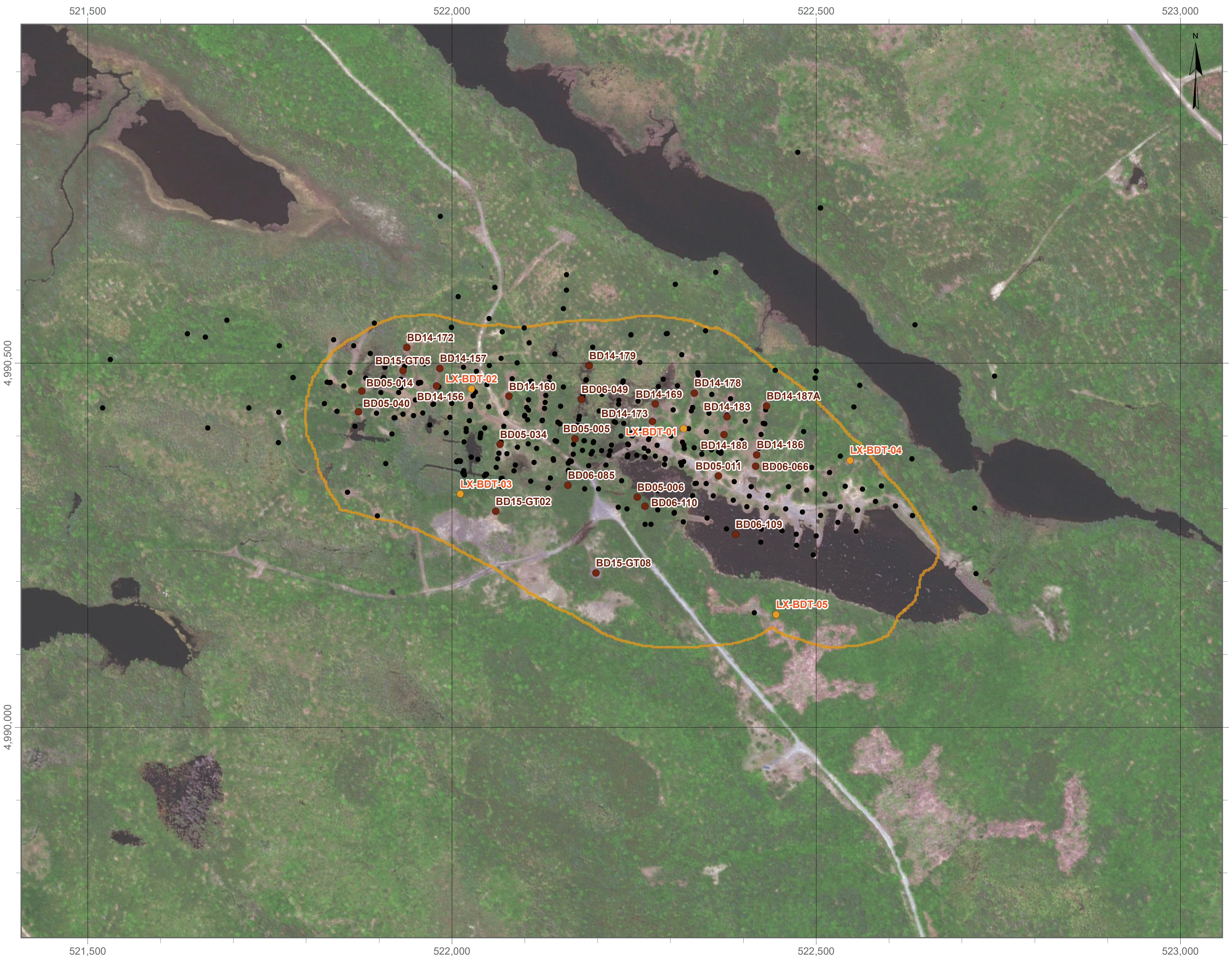
3.1.1 Mine Rock Samples

A total of 30 Beaver Dam drill core samples were collected by Lorax in November 2017 to supplement the existing mine rock geochemical data set based on 40 drill core samples previously collected by Atlantic Gold in support of the 2017 EIS submission. Static test analyses were carried out on all samples; however, the initial 40 samples were only evaluated for acid base accounting (ABA) characteristics. All Lorax samples were analyzed for ABA and solid phase elements, and based on these results, a subset of samples was selected for kinetic testwork. The kinetic test subsamples were additionally assessed for mineralogy and particle size distribution. The Beaver Dam geologic units and sample descriptions are provided in Table 3-1, whereas the sample locations and drill core details are presented in Appendix 3-1. Eight of the samples collected for the EIS submission could not be classified by lithology as the corresponding logs were not made available. The results from these samples are not included in the report. The location of the sampled drill holes is provided in Figure 3-1.

Eight humidity cells (HC1 through HC8) were initiated using crushed drill core material covering median and high sulphur content ranges for each of the four lithologies, as summarized in Table 3-2. The objective of the program is to provide sulphide oxidation and metal leaching rates for a range of sulphide contents under varying pH conditions to be used as input for the geochemical source term model.

Table 3-1:
Beaver Dam Geologic Units and Sample Descriptions

Geologic Unit	Description	Code	No. Samples
Argillite	argillite with < 5% greywacke interbeds	AR	10
Argillite-Greywacke	argillite with 5-49% greywacke interbeds	AG	11
Greywacke-Argillite	greywacke with 20-50% argillite interbeds	GA	14
Greywacke	greywacke with < 20% argillite interbeds	GW	24
Quartz Vein	quartz vein	QTZV	3
Unknown	Core logs were not available	-	8



LEGEND

- Overburden Sample
- Drill Hole Location (sampled)
- Drill Hole Location (unsampled)
- Pit Outline

Coordinate System: *NAD 1983 UTM Zone 20N*
Projection: *Transverse Mercator*
Datum: *North American 1983*
Units: *Meter*

1:5,000

0 100 200 Meters

DATE SAVED:	Nov 08, 2018
DRAWN BY:	GM
REVIEWED:	JO
VERSION:	1

CLIENT:

ATLANTIC GOLD

LORAX ENVIRONMENTAL

PROJECT:

Beaver Dam Phase II Geochemical Assessment

TITLE:

Beaver Dam Drill Hole and Overburden Sample Locations.

PROJECT #:	A458-2	*FIGURE:*	3-1

P:\@Drafting\Touquoy\Drafting Figures\MXD\Sample Selection\BD Pit Sample Locations.mxd

Table 3-2:
Summary of humidity cell testwork

HC ID	Lithology	Rational	Hole ID	Interval (m)		Sample ID
				From	*To*	
HC1	Argillite	Median sulphur	BD14-178	7	7.9	LX17-12
HC2	Argillite	High sulphur	BD14-188	22	23	LX17-24
			BD15-GT05	57	58	LX17-22
HC3	Argillite-Greywacke	Median sulphur	BD14-172	140	141	LX17-10
			BD15-GT02	15	16	LX17-02
HC4	Argillite-Greywacke	High sulphur	BD15-GT02	26	27	LX17-03
			BD15-GT02	31	32	LX17-04
HC5	Greywacke-Argillite	Median sulphur	BD14-188	10	11	LX17-23
			BD15-GT02	10	11	LX17-01
HC6	Greywacke-Argillite	High sulphur	BD14-178	161	162	LX17-17
			BD15-GT05	15	16	LX17-19
HC7	Greywacke	Median sulphur	BD14-178	49	50	LX17-16
HC8	Greywacke	High sulphur	BD15-GT05	25	26	LX17-20
			BD15-GT05	41	42	LX17-21

3.1.2 Overburden Samples

Five overburden samples were collected in September 2018 from within the Beaver Dam pit footprint (Figure 3-1). The samples were collected from shallow (30-45 cm) test pits dug by hand using a shovel. In general, the overburden was silty sand with minor gravel and varying amounts of cobbles (Table 3-3). Cobbles greater than approximately 5 cm in diameter were removed from the sample submitted to the lab. The analyses for these samples included ABA, solid phase elements and shake flask extractions (SFE).

Table 3-3:
Summary of overburden samples

Sample ID	Test Pit Depth (cm)	Sample Description
LX-BDT-01	30	Silty sand with some clay, minor gravel and cobbles
LX-BDT-02	36	Silty sand, minor gravel
LX-BDT-03	43	High organic content, silty with some cobbles
LX-BDT-04	33	Silty sand with gravel and several cobbles
LX-BDT-05	34	Silty sand with gravel and cobbles

3.1.3 Haul Road Samples

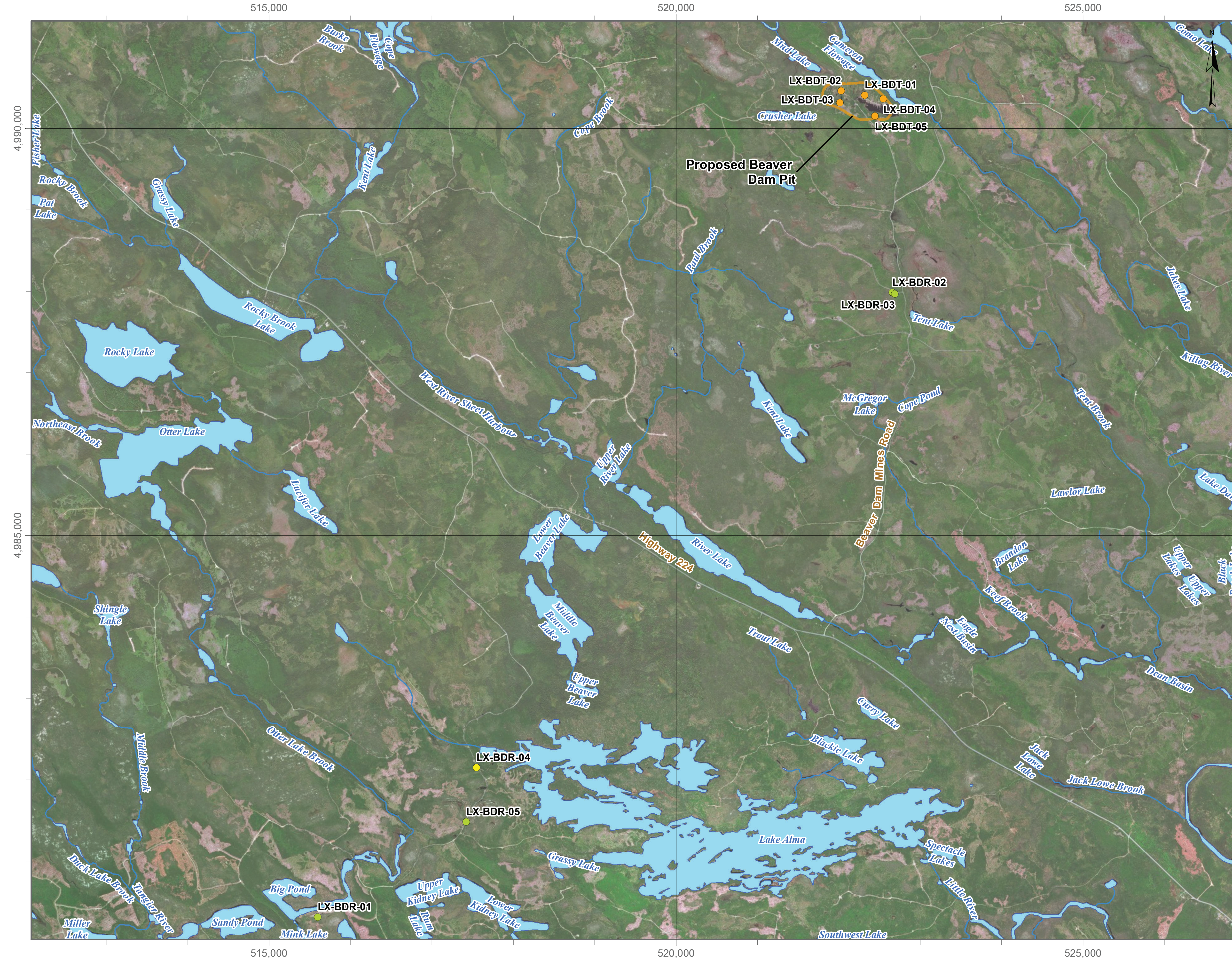
Five rock samples were collected along the Beaver Dam haul road in September 2018 (Figure 3-2 Table 3-4). The geology along the haul road was fairly consistent and all samples collected were greywacke. Samples were collected from outcrops and blasted rock fragments by breaking off rock chips using a rock hammer. These samples were analyzed for ABA and solid phase elements.

3.2 Static Test Methods

Static tests carried out to characterize rock and overburden samples include acid base accounting (ABA), aqua-regia digestible elemental abundance, mineralogical investigations, and shake flask extraction (SFE). The SFE tests were only conducted on the five overburden samples. The following sections provide a brief overview of these methods. Static testing was conducted at ALS Laboratories. All analytical procedures were conducted following standard protocols.

3.2.1 Acid-Base Accounting

Acid-base accounting (ABA) consists of a series of static tests (paste pH, sulphur species, neutralization potential and acid potential) which are used to evaluate the acid rock drainage (ARD) potential of materials. As materials undergo weathering, the competing influences of acid-generating and alkalinity-producing reactions will determine whether ARD will result. Acidic drainage at mine sites is typically generated from the oxidation of sulphide minerals, whereas neutralization is typically provided by the dissolution of carbonate minerals. The sulphide sulphur content is estimated by the difference between the total sulphur and sulphate sulphur and is used to derive the acid potential (AP) of site materials. The modified neutralization potential (NP) is used to represent the NP of the materials for this site. It is a bulk NP measurement that considers NP from other minerals (*e.g.,* the aluminosilicates) in addition to carbonates. The carbonate NP (CaNP) is calculated using the assumption that the total inorganic carbon (TIC) content is present as calcium carbonate. The relative amounts of NP and AP of a sample can be used to evaluate the potential for acid generation giving consideration to standard regulatory criteria classifying mine solid waste as either PAG (potentially acid generating) or NAG (non acid generating). Consistent with the criteria proposed in Price (2009) to evaluate the likelihood of ARD, materials with a net potential ratio (NPR = NP/AP) less than 2 are classified as PAG, while samples with an NPR value greater than 2 are designated as NAG.



LEGEND

- Bedrock Sample
- Blasted Rock Sample
- Overburden Sample
- Pit Outline

Coordinate System: *NAD 1983 UTM Zone 20N*
Projection: *Transverse Mercator*
Datum: *North American 1983*
Units: *Meter*

1:45,000

0 1 2 Km

DATE SAVED:	Nov 08, 2018
DRAWN BY:	GM
REVIEWED:	JO
VERSION:	1

CLIENT:

ATLANTIC GOLD

LORAX ENVIRONMENTAL

PROJECT:

Beaver Dam Phase II Geochemical Assessment

TITLE:

Beaver Dam Haul Road Sample Locations

PROJECT #: A458-2 *FIGURE:* 3-2

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Table 3-4:
Summary of haul road samples

Sample ID	Lithology	Sample Type
LX-BDR-01	Greywacke	Bedrock from outcrop
LX-BDR-02	Greywacke	Bedrock from existing quarry
LX-BDR-03	Greywacke	Bedrock from existing quarry
LX-BDR-04	Greywacke	Blasted rock from old quarry
LX-BDR-05	Greywacke	Bedrock from outcrop

3.2.2 Aqua-Regia Digestible Elemental Abundance

Solid phase elemental abundance analyses are conducted on pulverized samples by digesting a sample in aqua regia. The extract is then diluted and analyzed for metals by inductively coupled plasma mass spectrometry (ICP-MS). The data are used to characterize materials and to identify elements of potential environmental concern. The degree of enrichment as compared to average upper continental crust concentrations (AUCCC, Rudnick and Gao, 2014) can provide a general indication of the overall metal enrichment. However, enrichment does not necessarily indicate that the element will become problematic, since the leaching rate is highly dependent on other factors, including the metal-phase associations, grain size, the geochemistry of infiltrating waters and the depositional environment. The solid phase elemental results are also considered when selecting humidity cell samples in order to ensure that representative material is selected to represent the material being characterized by the humidity cell test.

3.2.3 Shake Flask Extractions

Metal contents measured in shake flask extractions (SFE) provide a measure of the mass of readily soluble metals which will be immediately available for leaching upon exposure to infiltrating water. The procedure consists of agitating a representative sample in water, typically at a water to solids ratio of 3:1, for 24 hours. The leachate chemistry can be used as a cursory tool in determining the potential leachate chemistry of water in contact with disturbed rock.

3.3 Mineralogy

Mineralogical analyses are useful in determining the significant forms of acid producing minerals (*i.e.*, sulphides) and acid neutralizing minerals (*i.e.*, carbonates and silicates) in a sample. X-ray Diffraction (XRD) with Rietveld-refinement is a standard technique which provides quantitative mineralogical information. All eight humidity cell subsamples were submitted to the Electron Microbeam & X-Ray Diffraction Facility at the University of British Columbia for mineralogical assessment. Thin sections of the same samples were also investigated by petrographic microscopy using a Nikon Optiphot polarizing microscope with transmitted and reflected light capabilities. Photomicrographs were taken using a Nikon EOS 70D camera.

3.4 Particle Size Distribution

Particle size distribution (PSD) analyses were carried out to quantify the relative distribution of grain sizes of material placed in the humidity cell tests. It is important to have an estimate of the specific surface area of the humidity cell samples as the kinetic rate at which a material will react is in part dependent on the specific surface area of the sample. The specific surface area is also required when scaling between laboratory and field conditions. Standard mechanical sieving methods were used to characterize the general PSD of samples.

3.5 Kinetic Test Methods

Kinetic testing is used to mimic the natural weathering processes that act on crushed rock or tailings material. The results are used as the basis to predict geochemical loading rates from these materials when stored in surface facilities under oxidizing conditions. Laboratory-based humidity cells are typically composed of a plexiglass cylinder filled with approximately 1 kg of sample crushed to 80% passing <6.4 mm. Beaver Dam materials used for kinetic testing had already been crushed to 80% passing < 2 mm, such that this reduced particle size was used for this test program. The contents of the cells are subjected to moist air for three days, followed by dry air for three days (< 10% relative humidity). At the end of each wet/dry cycle, the contents of the cell are leached with 500 mL distilled de-ionized water on the seventh day (Price, 1997; Lapakko, 2003). The purpose of the leaching step is to recover any readily soluble products that have formed due to mineral dissolution or sulphide oxidation in order to determine the dissolved load contributed from the previous week's test. The leachate is then analyzed for pH, alkalinity and any solutes of interest. Humidity cell tests are usually run for a minimum of 20 cycles (weeks), but it is usually more desirable to continue testing until the rates of sulphate generation and metal leaching have stabilized, which can take up to 120 weeks or more (Lapakko, 2003). These experiments provide data on the primary weathering rates of waste materials and, therefore, the results from this type of testing may be used to estimate the rate of acid generation and metal release to the environment on a weekly basis. As well, after geochemical modeling and careful consideration, these data may be used to estimate drainage chemistry.

4. Results

ATLANTIC GOLD

4 Results

The Beaver Dam geochemical test results are herein presented for three different sets of samples: 1) mine rock; 2) overburden; and 3) haul road material. Static test analyses were carried out on all samples to determine the geochemical characteristics of materials to be disturbed during development of the proposed Beaver Dam Mine. Kinetic tests were carried out on a subset of mine rock samples to predict geochemical behaviour as weathering proceeds. The geochemical results presented have been used to develop source terms for a site-wide water quality model, which is presented under separate cover (Lorax, 2018).

4.1 Mine Rock

4.1.1 Static Test Results

4.1.1.1 Mineralogy

Mineralogical investigations as part of the ML/ARD characterization program helps provide information on the identity of acid-producing and acid-neutralizing minerals to help interpret static test results and provide a better foundation on which predictions may be based.

Results of the XRD analyses for mine rock samples are summarized in Table 4-1, with the full report results provided in Appendix 4-1. The mineralogical investigation determined that samples are composed primarily of quartz, plagioclase, illite-muscovite, biotite and chlorite with lesser amounts of calcite, pyrite and ilmenite. It is noteworthy that pyrite is the only sulphide phase detected in the Beaver Dam samples by XRD analysis and only detected in 6 of the 8 samples. Calcite is the dominant carbonate mineral in Beaver Dam mine rock, comprising up to 1.9 %. Additional neutralization capacity may be afforded by silicate phases, including plagioclase, chlorite, and biotite, which are present in all samples.

Petrographic analysis of the same eight humidity cell subsamples sheds light on textural relationships within Beaver Dam waste rock and allows the identification of trace minerals that may fall below the detection limit of XRD analysis. Since it is known from site observations and the review of drill hole logs that the greywacke and argillite end-members can be finely-interbedded and occur along a continuum of grain sizes with both material types being represented in all samples, a clear textural distinction had to be made for the purpose of this description. Upon detailed microscopical review, any rock fragments (clasts) within the thin sections that contain primary (*i.e.,* not formed by post-depositional hydrothermal processes) sediment grains of >0.07 mm length or diameter are herein defined as greywacke clasts. For a waste rock fragment to classify as argillite, all primary minerals in a given clast must fall below this threshold. Note that a threshold grain size of 0.07 mm also roughly corresponds with the transition from the silt to sand particle size.

An overview of the petrographic results is shown in Table 4-2 and illustrates that samples HC3 and HC7 have the highest relative proportions of argillite and greywacke clasts, respectively. This breakdown also illustrates that the geologic unit assigned to the eight subsamples may not coincide with the relative greywacke to argillite proportions observed on a thin section scale. In the following, textural relationships will be discussed across the various subsamples specific unless observations were made in particular samples.

Both end-member material types show a similar mineral inventory, although the relative mineral abundances vary. As shown by XRD analysis and confirmed by optical methods, argillite-rich HC subsamples generally contain higher relative amounts of muscovite/illite and chlorite, while showing smaller quartz and feldspar contents. The occurrence of muscovite/illite, chlorite and biotite as matrix (clay) replacement phases in both greywacke and argillite suggests low prograde metamorphism, potentially related to the ore genesis phase.

Greywacke fragments are moderately- to well-sorted and primarily composed of rounded quartz and feldspar grains making up >70% of the volume of most fragments. The groundmass (matrix) is typically composed of fine grained sericite, clay, and chlorite filling interstices (Figure 4-1A). Biotite commonly occurs as a medium- to coarse-grained (0.1 – 0.5 mm) hydrothermal alteration phase that may be anhedral or subhedral, although the anhedral variety of biotite is more common in greywacke material. Generally, when present as anhedral patches, biotite typically shows irregular grain boundaries. Grain orientation/foliation is noticeable in the moderately-sorted greywacke clasts (Figure 4-1B) and minor or absent in the coarser-grained well-sorted occurrences (Figure 4-1A). Individual quartz and feldspar grains typically make up a range in grain sized from 0.75 to 0.2 mm, however individual monomineralic grain fragments can reach > 0.5 mm in length.

Argillite aggregates are characterized by an overall finer grain size distribution with a higher relative content of sericite/muscovite and clay minerals. Feldspar and quartz appear as rounded grains and are moderately- to well-sorted. Due to the larger proportion of clay and mica minerals a higher observed degree of foliation is generally observed in argillite fragments (Figure 4-1C), although more randomly-oriented textures are present as well. In some HC subsamples, most notably in HC6, clasts with strongly foliated clay-rich layers (Figure 4-1D) are observed while lacking the typical mica-chlorite matrix replacement pattern typically seen in other argillite fragments. This suggests that portions of the argillite may have undergone less intense hydrothermal alteration than others since the originally deposited clay-rich groundmass is unaltered. Another common textural feature is the retrograde clay-alteration of argillite clasts giving the particle surface a turbid appearance that apparently overprints any prograde mica-alteration patterns. Biotite in argillite samples is commonly distinctly larger-grained than the surrounding groundmass (Figure 4-1C) and forms tabular grains that seem to have grown independently of the sedimentary orientation of within the matrix. Distinct clusters of biotite grains in many are associated with and seem to emanate from secondary ilmenite and magnetite (±rutile,

±hematite) grains (Figure 4-2 A,B) which make up a significant portion (>50%) of the opaque mineral inventory in most samples and generally display spongy texture.

Sulphides are primarily represented by pyrrhotite (>90%) with minor arsenopyrite, pyrite, and chalcopyrite being observed as accessory sulphide phases. Pyrrhotite occurs as dispersed an- to subhedral grains that may be elongated along the foliation of argillite clasts or as randomly-oriented replacement phases of primary minerals and matrix (Figure 4-2C). Discrete arsenopyrite was only identified in HC8 where, in one instance, it formed a coarse (1.2 mm) subhedral crystal (Figure 4-2D). Chalcopyrite was exclusively identified as minute exsolution blebs in contact with pyrrhotite. Minor pyrite appears to occur primarily as vein fill with only few occurrences as dispersed grain in the argillite groundmass. Both pyrite and pyrrhotite commonly exhibit minor weathering rims along grain boundaries and cracks, however, overall, the degree of oxidation can be described as minor. Due to their fine grain-size, sulphide weathering phases could not be conclusively identified by optical methods alone, however it is assumed that a mixture of poorly crystalline or amorphous hydrous ferric oxides (HFO) and clay minerals make up the observed alteration rims. Notably, two relatively coarse (0.25 mm) pyrite grains observed in HC1 were largely (>50%) weathered by a dark-red, semi-opaque mineral that is identified as goethite.

Carbonate phases were identified in subsamples HC5 and HC7 where they may form large euhedral aggregates (Figure 4-2F) or as anhedral hydrothermal replacement phases, preferentially within the matrix of greywacke clasts (Figure 4-2E). Where observed, carbonate tend to be locally concentrated which may have direct effects on its capacity to buffer acid generated by sulphides.

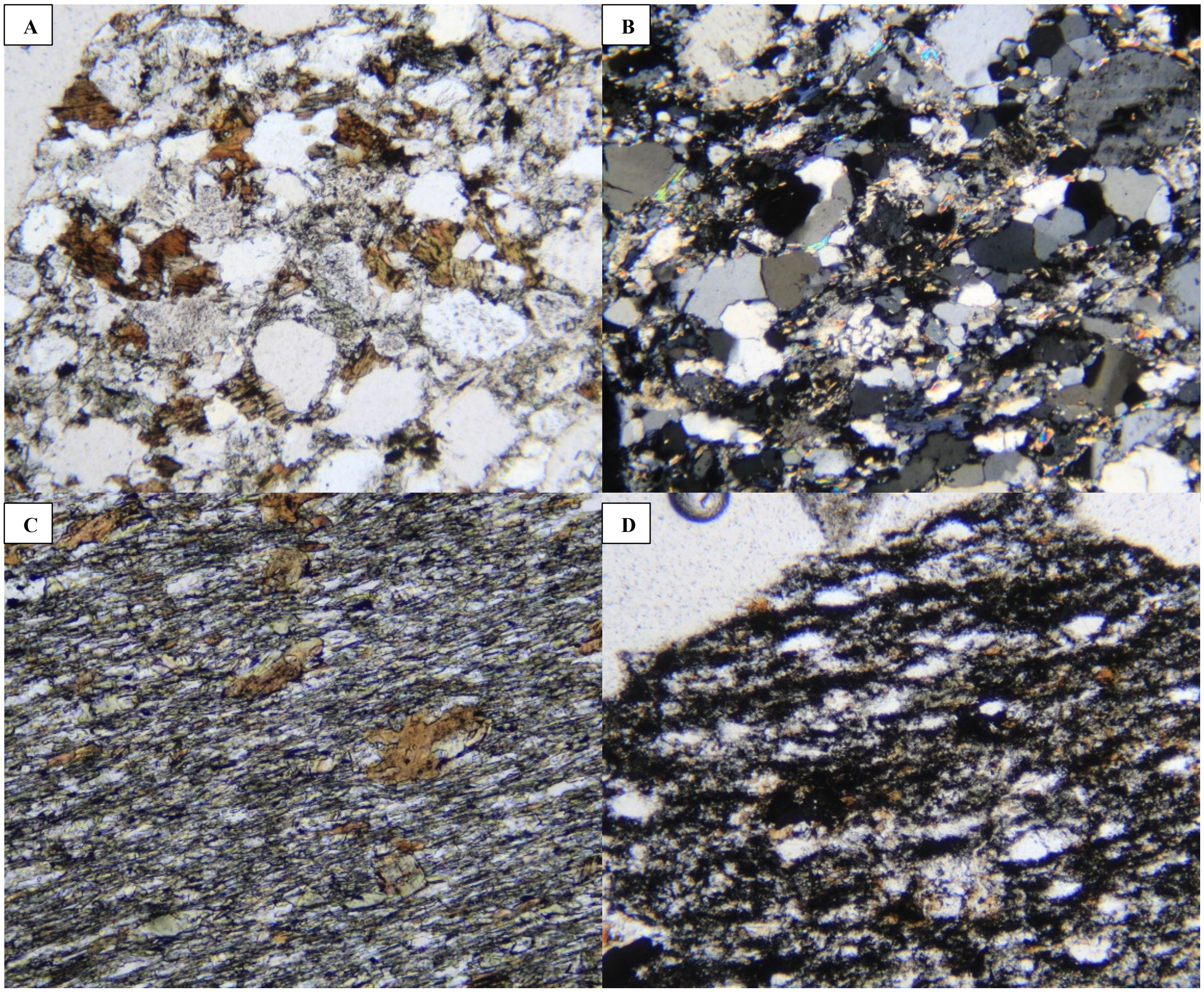


Figure 4-1: Photomicrographs from thin sections of Beaver Dam material. (A) Typical examples of a moderately-sorted greywacke clast (plane-polarized light = PPL). Biotite (brown) and muscovite/sericite fill interstices between rounded feldspar and quartz grains (colourless). Minor chlorite is observed as matrix replacement phase (pale green); FOV = 1.5 mm. (B) Greywacke clast (crossed polars = XPL) that shows minor grain orientation; FOV = 0.65 mm. (C) Typical example of a strongly oriented/foliated argillite clast containing hydrothermal biotite; FOV = 0.65 mm. (D) Argillite clast with very fine-grained clay-minerals (instead of muscovite and chlorite) making up the matrix in between quartz and feldspar grains; FOV = 1.5 mm.

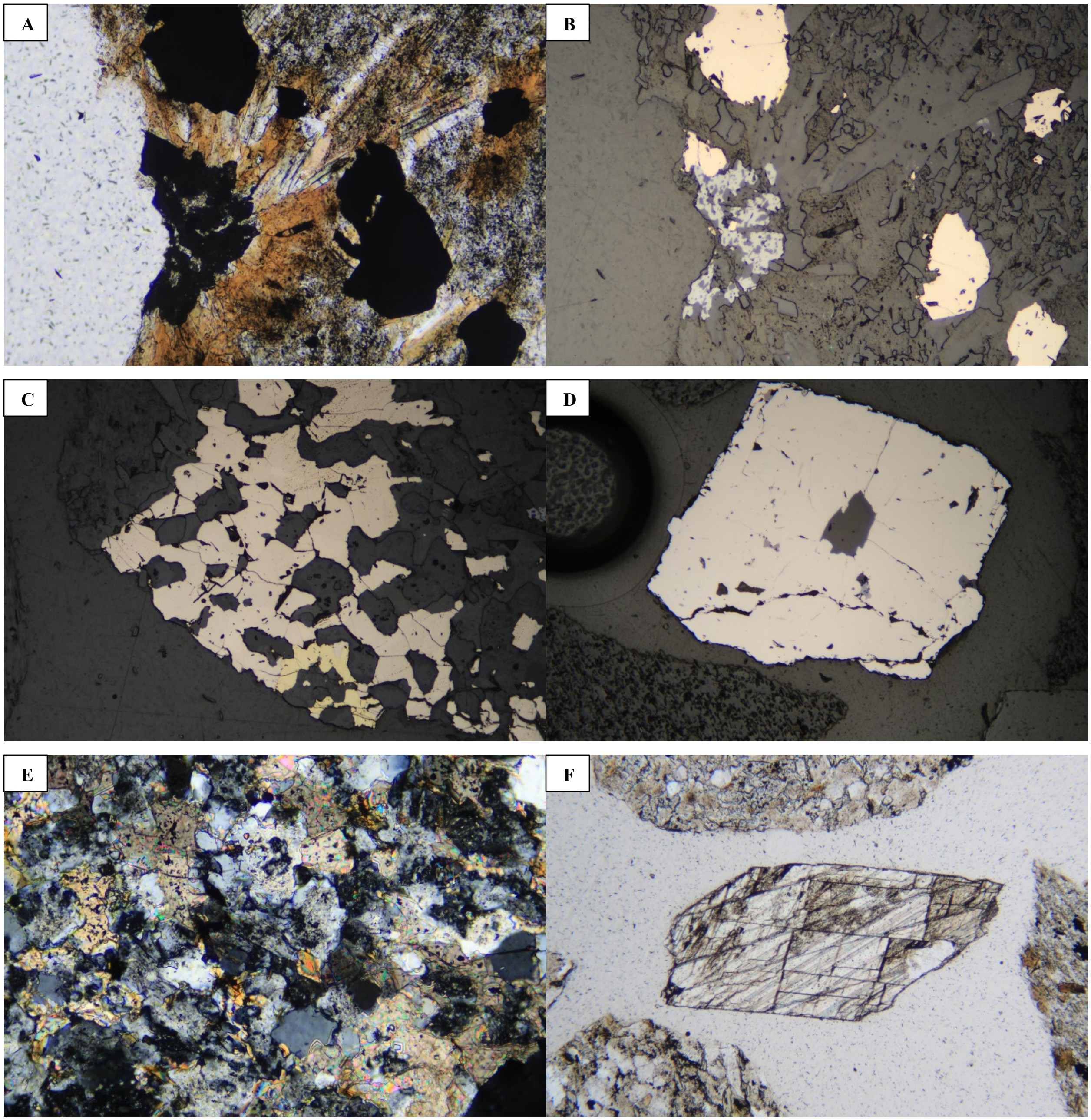


Figure 4-2: Photomicrographs from thin sections of Beaver Dam material. (A) Spongy ilmenite ± magnetite (opaque, center left) and pyrrhotite (other opaque phases) associated with cluster of coarse hydrothermal biotite (brown sheaves) under PPL; FOV = 0.74 mm. (B) same as (A) but under reflected light. (C) Cluster of twinned, anhedral pyrrhotite aggregates (light brown) and associated chalcopyrite (bright yellow) filling interstices between quartz and feldspar; FOV = 0.74 mm. (D) Subhedral, fresh arsenopyrite grain observed in HC8; FOV = 1.8 mm. (E) Greywacke clast displaying pervasive carbonate (XPL; brown grains with high interference colours) weathering; FOV = 0.74 mm. (F) Individual, euhedral carbonate grain, likely isolated from vein material; FOV = 1.8 mm.

Table 4-1: X-Ray Diffraction Results of Subsamples from the Humidity Cell Test Material

Mineral Phase	Ideal Formula	Argillite		Argillite-Greywacke		Greywacke		Greywacke-Argillite	
		HC 1	HC 2	HC 3	HC 4	HC 5	HC 6	HC 7	HC 8
		Median S	High S	Median S	High S	Median S	High S	Median S	High S
Quartz low	SiO_2	31	35	27	33	34	37	51	35
Plagioclase	$NaAlSi_3O_8 – CaAl_2Si_2O_8$	21	27	18	19	37	19	29	21
Illite/Muscovite 2M1	$K_{0.65}Al_{2.0}Al_{0.65}Si_{3.35}O_{10}(OH)_2/KAl_2(AlSi_3O_{10})(OH)_2$	29	22	33	29	17	29	11	27
Biotite 1M	$K(Mg,Fe)_3(AlSi_3O_{10})(OH)_2$	9.9	8.8	8.4	11	5.7	6.8	1.2	9.4
Chamosite	(Fe,Al,Mg)6(Si,Al)4O10(OH)8	8.2	6.1	12	7.8	4.0	7.6	5.5	7.0
Calcite	$CaCO_3$	-	0.28	0.81	0.25	1.7	-	1.9	0.30
Pyrite[a]	FeS_2	0.14	0.19	0.098	0.48	0.22	0.29	-	-
Ilmenite	$Fe^{2+}TiO_3$	0.20	0.51	0.45	-	0.22	0.37	-	0.60

Notes: A hyphen indicates the phase was not detected
[a]Although pyrite was identified by XRD, the petrographic observations show that pyrrhotite is the more common sulphide mineral

Table 4-2: Subsample Summary of Petrographic Observations from the Humidity Cell Test Samples

Sample ID	Description	Greywacke clasts	Argillite clasts	Sulphides			Carbonates
				Abundance	Type (by abundance)	Weathering	N/A
HC 1	AR - median S	43%	57%	trace (<1%)	Subhedral pyrite (0.05 - 0.25 mm)	Partially replace HFO (>50%), some grains unweathered	N/A
HC 2	AR - high S	50%	50%	trace (<1%)	Anhedral pyrrhotite & pyrite (0.1 - 0.3 mm)	Commonly clay and HFO-weathered rims	N/A
HC 3	AG - median S	20%	80%	1-2%	Anhedral pyrrhotite & pyrite (0.1 - 1 mm)	Mostly unweathered, some grains partially weathered to clay, HFO	N/A
HC 4	AG - high S	42%	58%	2-3%	Anhedral pyrrhotite (0.05 - 0.7 mm) & chalcopyrite	Mostly unweathered, some grains partially weathered to clay, HFO	N/A
HC 5	GA - median S	75%	25%	trace (<1%)	Anhedral pyrrhotite (0.05 - 0.15 mm) & chalcopyrite	Commonly clay and HFO-weathered rims	Matrix replacement patches
HC 6	GA - high S	30%	70%	trace (<1%)	Anhedral pyrrhotite & chalcopyrite (0.1 - 0.2 mm)	Mostly unweathered, some grains partially weathered to clay, HFO	N/A
HC 7	GW - median S	100%	0%	trace (<1%)	Anhedral pyrite (0.02 - 0.05 mm) & chalcopyrite	Mostly unweathered, some grains partially weathered to clay, HFO	Matrix replacement patches, large detached grains
HC 8	GW - high S	50%	50%	trace (<1%)	Anhedral pyrrhotite (0.05 - 0.3 mm), subhedral arsenopyrite (0.2 - 1.1 mm) & chalcopyrite	Mostly unweathered, some grains partially weathered to clay, HFO	N/A

4.1.1.2 Acid Base Accounting Results

The main purpose of ABA characterization is to identify acid-producing and acid-neutralizing phases. ARD will only result from the weathering of sulphide-bearing rocks if there is insufficient alkalinity produced to buffer the acidity generated by the sulphide oxidation process. The oxidation of pyrite produces two sources of acid; one from the oxidation of sulphide and the other from the oxidation/hydrolysis of iron. If reactive neutralizing minerals are present, they will not stop the oxidation reactions but may buffer the pH to prevent the development of ARD. While many mineral dissolution reactions can be thought of as acid buffering, the minerals most typically responsible for acid neutralization are fast dissolving carbonates such as calcite and dolomite. At a pH < 6.3, the sulphide oxidation and carbonate neutralization reaction is typically expressed as:

$$FeS_2 + 2CaCO_3 + 3.75\ O_2 + 3.5\ H_2O \rightarrow Fe(OH)_3 + 2SO_4^{2-} + 2Ca^{2+} + 2H_2CO_3$$

However, it should be noted that not all carbonate minerals neutralize acid as effectively as others. For example, Fe-bearing carbonate minerals, such as ankerite and siderite, are much less effective at neutralizing acid compared to calcite due to the fact that the Fe^{2+} liberated is oxidized to Fe^{3+}, which then precipitates as $Fe(OH)_3$ producing acidity in the process. As a result, the net capacity of a sample to neutralize acid decreases as the amounts of Fe-bearing carbonates increases (Jambor *et al.,* 2003). Silicate minerals may also contribute to the total neutralizing capacity of a sample; however, rates of silicate dissolution are much slower and thus may limit the ability of these minerals to buffer acid generation.

The full set of ABA analyses for all mine rock samples is presented in Appendix 4-2 and includes paste pH, total S, sulphate S, sulphide S, acid potential (AP), total inorganic C, total C, modified neutralization potential (NP) and fizz rating. A summary of the mine rock ABA results is provided in Table 4-3, with the humidity cell test subsample results presented in Table 4-4.

4.1.1.2.1 Paste pH

Paste pH provides an indication of whether a sample is currently generating acidity at the time of sampling. Paste pH values for the all samples range from 7.9 to 9.5, indicating that these samples are not currently acid generating. The GA samples show the widest range of pH values, ranging between 7.9 and 9.5, with a median pH value of 9.0 (Table 4-3).

Table 4-3:
Summary of acid-base accounting results for mine rock lithologies

Sample ID	Paste pH	Total S	Sulphate S	Sulphide S	Total C	CaNP	Modified NP	NPR
		%	%	%	%	kg $CaCO_3$/t	kg $CaCO_3$/t	ModNP/AP
ARGILLITE (AR) n = 10								
Min	8.2	0.020	0.010	0.020	*<0.05*	*<4.5*	6.0	0.27
Median	9.0	0.44	0.020	0.44	*<0.05*	*<4.5*	8.5	0.64
Max	9.5	1.0	0.060	0.94	*<0.05*	*<4.5*	37	17
ARGILLITE-GREYWACKE (AG) n =11								
Min	7.9	0.010	*<0.01*	0.010	*<0.05*	*<4.5*	7.0	0.23
Median	9.1	0.12	0.020	0.12	*<0.05*	*<4.5*	8.0	8.0
Max	9.5	1.1	0.060	1.1	0.17	14	177	47
GREYWACKE-ARGILLITE (GA) n = 14								
Min	7.9	0.010	0.010	0.010	*<0.05*	*<4.5*	5.0	0.40
Median	9.0	0.16	0.020	0.14	0.11	9.1	9.0	2.5
Max	9.5	1.7	0.060	1.5	0.57	48	58	46
GREYWACKE (GW) n = 24								
Min	8.9	*<0.01*	*<0.01*	*<0.01*	*<0.05*	*<4.5*	6.0	0.16
Median	9.2	0.025	0.020	0.030	0.10	9.1	14	22
Max	9.5	1.2	0.060	1.2	0.60	50	160	512
QUARTZ VEIN (QTZV) n = 3								
BD157-070	9.2	0.160	0.020	0.140	-	-	145	33
BD156-108	9.3	0.060	0.010	0.050	-	-	10	6.4
BD160-089	8.9	0.040	0.010	0.040	-	-	30	24

Notes: n = number of samples used in statistical distribution
A hyphen indicates the parameter was not analyzed.
Values in grey italics are below the analytical detection limit. Values were set at the detection limit for calculation of NP, AP and NPR values.
Sulphate S is calculated using the HCl method.
AP (acid potential) calculated using sulphide sulphur (% non-sulphate sulphur x 31.25);
CaNP (carbonate neutralization potential) calculated using total inorganic carbon (% TIC x (100.09/12.01) x 10);
Modified NP is obtained by the modified Sobek method.
NPR = neutralization potential ratio; calculated as Modified NP / AP.

Table 4-4:
Summary of acid-base accounting results for humidity cell subsamples

HC ID	Description	Paste pH	Total S	Sulphate S	Sulphide S	Total C	CaNP	Modified NP	NPR
			%	*%*	*%*	*%*	*kg $CaCO_3$/t*	*kg $CaCO_3$/t*	*ModNP/AP*
ARGILLITE (AR)									
HC1	Median-S	8.9	0.02	0.02	0.02	*<0.05*	*<4.5*	6	9.6
HC2[a]	High-S	8.7	0.25	0.015	0.25	*<0.05*	*<4.5*	7.5	1.1
ARGILLITE-GREYWACKE (AG)									
HC3[a]	Median-S	8.7	0.20	0.02	0.18	0.11	9.1	15	5.6
HC4[a]	High-S	8.2	0.77	0.015	0.76	*<0.05*	4.5	8.0	0.45
GREYWACKE-ARGILLITE (GA)									
HC5[a]	Median-S	8.5	0.21	0.015	0.19	0.18	15	22	11
HC6[a]	High-S	8.6	0.39	0.015	0.39	*<0.05*	*<4.5*	5.5	0.47
GREYWACKE (GW)									
HC7	Median-S	9.1	0.03	*<0.01*	0.03	0.2	15.9	23	25
HC8[a]	High-S	9.3	0.36	0.03	0.35	0.05	4.5	8.0	0.74

Notes:
[a]Humidity cell is made up of two samples. An average value is presented and a 1:1 mixture is assumed.
Values in grey italics are below the analytical detection limit. Values were set at the detection limit for calculation of NP, AP and NPR values.
Sulphate S is calculated using the HCl method.
AP (acid potential) calculated using sulphide sulphur (% non-sulphate sulphur x 31.25);
CaNP (carbonate neutralization potential) calculated using total inorganic carbon (% TIC x (100.09/12.01) x 10);
Modified NP is obtained by the modified Sobek method.
NPR = neutralization potential ratio; calculated as Modified NP / AP

4.1.1.2.2 Sulphur Species and Acid Potential

The total sulphur (T-S) contents of the Beaver Dam samples vary from below detection (0.01%) to 1.7% (Table 4-3). Of the four main rock types, the AR samples have the highest total median sulphur content (0.44%) and the GW samples have the lowest (0.025%). The three quartz vein samples analysed had low sulphur contents with a mean value of 0.087%. The sulphate S contents are generally low in most samples and typically fall below detection (0.01%) but can reach up to 0.06%. The sulphide S contents are strongly correlated with T-S (Figure 4-3) and indicate that most of the sulphur present in samples is in the form of sulphide. The sulphide S contents range from less than detection level values (0.01%) up to a maximum value of 1.5%, as measured in a GA sample (Figure 4-3). The AR samples have the highest median sulphide S contents (0.44%), whereas the GW samples have the lowest median sulphide S contents (0.030%).

The mineralogy results indicate that the sulphide S is primarily in the form of pyrrhotite, which is acid generating. The acid potential (AP) of samples is calculated based on the sulphide S values and used in the determination of the neutralization potential ratio (NP/AP) discussed in Section 4.1.1.2.4.

In general, the humidity cell test subsamples are considered to be representative of median and high S contents for the different lithologies; however, it is noted that the HC1 and HC2 have low sulphide S contents as compared to the median AR value (0.44%). These cells also have low NP contents and were specifically composited to generate acidic leachates in a timely manner.

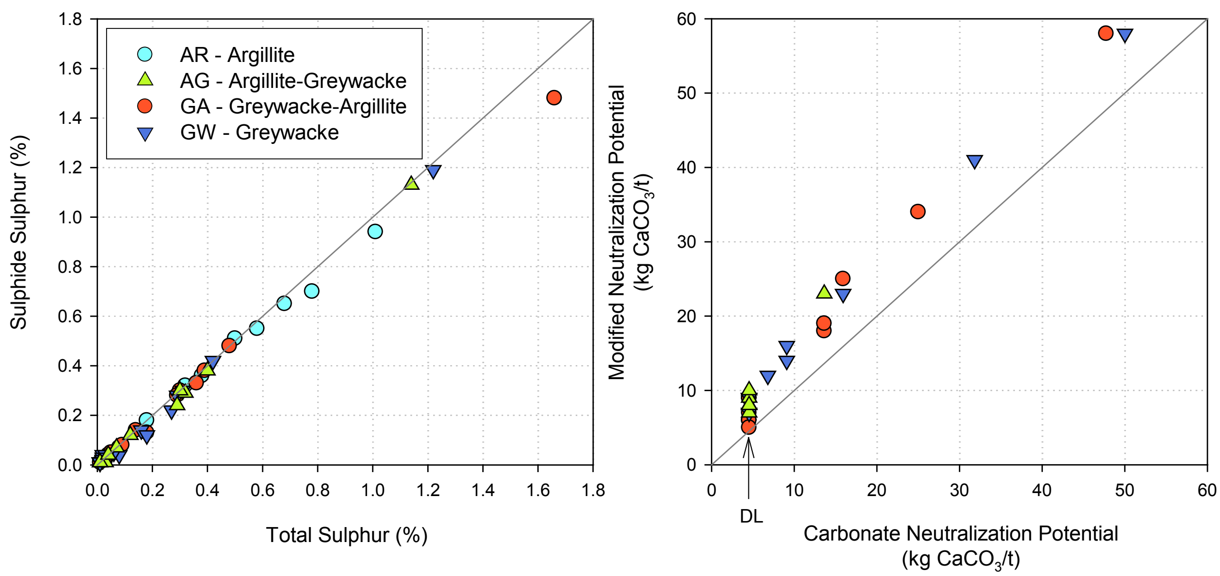


Figure 4-3: Plots showing total sulphur *versus* sulphide sulphur and carbonate neutralization potential *versus* modified neutralization potential for the Beaver Dam mine rock samples.

4.1.1.2.3 Neutralization Potential

The total inorganic carbon (TIC) content of Beaver Dam samples ranges from detection level values (<0.05%) up to 0.60%, with the highest median values measured in the GW and GA samples (0.10 % and 0.11%, respectively; Table 4-3). It is assumed that the inorganic C is present as carbonate minerals and thus TIC values are used to calculate the carbonate neutralization potential (CaNP). The CaNP values of Beaver Dam samples range from detection level values (<4.5 kg $CaCO_3$/t) up to 50 kg $CaCO_3$/t. The GW and GA samples have the highest median CaNP values at 9.1 kg $CaCO_3$/t, while the AR samples have the lowest median CaNP values (< 4.5 kg $CaCO_3$/t; Table 4-3).

The CaNP values are generally comparable to the modified NP values (Figure 4-3), although the modified NP values are consistently higher suggesting that minerals other than carbonate (*i.e.*, aluminosilicates) are available for acid-neutralization. This NP is not as readily available as the carbonate NP; however, when sulphide values are low, as is the case at Beaver Dam, the NP from the dissolution of non-carbonate minerals will contribute to the to the neutralization of the low rates of acid production. Silicate minerals that act as neutralizing agents may include plagioclase, biotite, chlorite, and certain clay minerals, all of which were identified in the mineralogical analysis. For the remainder of this assessment, modified NP is used as the basis for NPR (NP/AP) calculations in order to quantify a material's ARD potential.

4.1.1.2.4 Neutralization potential ratio

The neutralization potential ratio (NPR) is calculated as the ratio of NP to AP and is presented based on the ModNP (Table 4-3; Figure 4-4). In the absence of long-term kinetic test data, the NPR value is the most important parameter in the evaluation of a material's likelihood to generate ARD. In accordance with guidelines set out in Price (2009), a value >2 is considered to be NAG, whereas a value <2 is considered to be PAG. Based on the results, a significant number of samples covering all four major lithologies are PAG (Table 4-5).

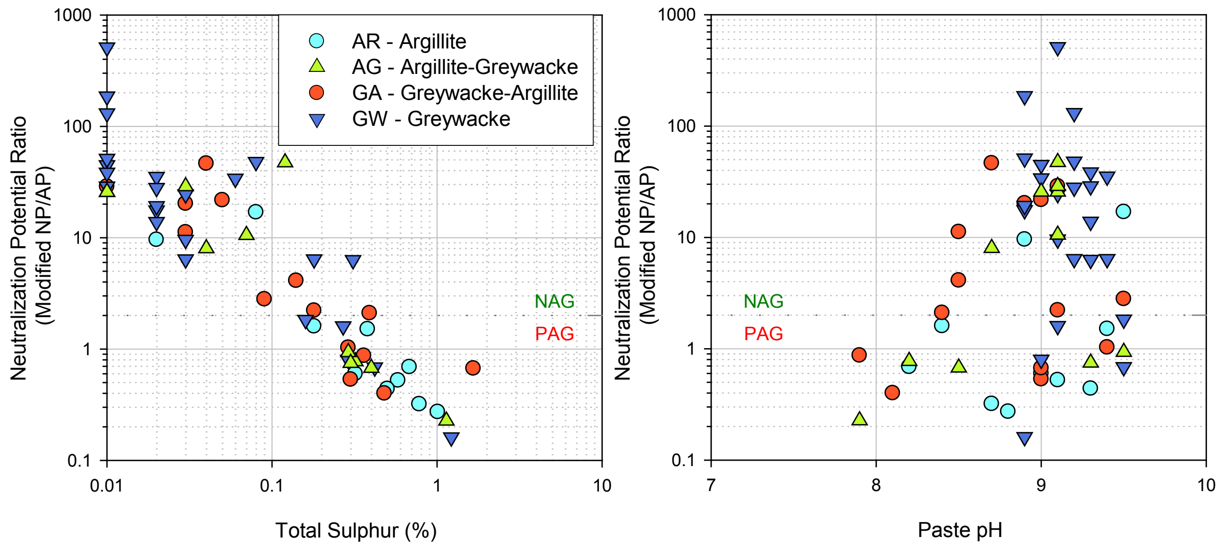


Figure 4-4: Plots showing neutralization potential ratio (NPR) *versus* total sulphur for the Beaver Dam mine rock samples, showing the potentially acid generating (PAG) boundaries (dark grey dashed line). Plot (A) presents NPR values as modified neutralization potential (NP) versus total sulphur. Plot (B) presents NPR values as Modified NP versus paste pH. Lithology codes defined in Table 3-1.

Table 4-5:
PAG Proportions for the Beaver Dam mine rock

Lithology	% PAG	% NAG
Argillite (AR)	80	20
Argillite-Greywacke (AG)	45.5	54.5
Greywacke-Argillite (GA)	35.7	64.3
Greywacke (GW)	20.8	79.2
Total	*39.0*	*61.0*

4.1.1.3 Total Solid Phase Elemental Analysis Results

The results of the total solid phase elemental analysis are presented in Appendix 4-3 and summarized in Table 4-6. Elements that are greater than 3× their respective AUCCC values (Rudnick and Gao, 2014) and greater than 2x the detection limit are listed in Table 4-6 and include Ag, As, Cu, Mn, and Pb. Solid phase concentrations of Ag, As, Mn, and Pb are enriched by a factor greater than 10 above the AUCCC in one or more samples. It is noteworthy that the elevated As concentrations (>10× AUCCC) occur in all Beaver Dam lithologies. Elevated Mn values (>10× AUCCC) occur in three of the 4 lithologies, whereas elevated Ag and Pb (>10× AUCCC) are limited to the AG samples. The AUCCC for Ag (0.053 ppm) is considerably lower that the analytical detection limit of 0.2 ppm so any values above or equal to the detection limit are flagged by the 3x the AUCCC screening criteria. Only two samples in the dataset have Ag values above 2x the detection limit.

A summary of the humidity cell total solid phase elemental results is included in Table 4-7. The concentrations of key metals of potential concern (As and Mn) in humidity cell subsamples are presented as compared to the range for each of the major rock types (Figure 4-5). Arsenic specifically is highest in HC 6 and HC 8.

The elemental enrichments highlight elements that require additional scrutiny in leaching tests. However, an element present at an elevated concentration in the solid phase may not become a metal leaching issue and vice versa. There are several factors that influence the leaching rates of elements, including the mineral association and stability, as well as the chemistry of the water in contact with the rocks. Kinetic test results provide a better indication of the leaching potential.

Table 4-6:
Summary of solid phase element results for Beaver Dam mine rock samples.

AUCCC	*0.053*	*8.2*	*4.8*	*2.1*	*2.6*	*17*	*92*	*28*	*3.9*	*2.3*	*1.5*	*77*	*2.4*	*47*	*17*	*0.38*	*97*	*67*
Sample ID	**Ag**	**Al**	**As**	**Be**	**Ca**	**Co**	**Cr**	**Cu**	**Fe**	**K**	**Mg**	**Mn**	**Na**	**Ni**	**Pb**	**Ti**	**V**	**Zn**
	ppm	*%*	*ppm*	*ppm*	*%*	*ppm*	*ppm*	*ppm*	*%*	*%*	*%*	*ppm*	*%*	*ppm*	*ppm*	*%*	*ppm*	*ppm*
ARGILLITE (AR) n = 3																		
LX17-12	*<0.2*	2.7	17	0.50	0.20	20	41	28	4.6	1.1	1.4	534	0.030	44	11	0.17	44	89
LX17-22	*<0.2*	1.2	116	*<0.5*	0.15	9.0	36	18	2.5	0.64	0.75	312	0.050	15	20	0.13	40	57
LX17-24	*<0.2*	2.9	22	0.70	0.36	19	41	44	4.9	1.0	1.6	621	0.030	42	6.0	0.15	45	120
ARGILLITE-GREYWACKE (AG) n = 8																		
Min	*<0.2*	2.6	8.0	*<0.5*	0.20	19	37	4.0	4.5	0.63	1.3	601	0.020	37	*<2.0*	0.090	42	89
Median	*<0.2*	2.9	16	*<0.5*	0.25	21	47	41	5.2	0.88	1.7	679	0.035	44	6.0	0.15	52	103
Max	6.6	3.2	157	0.80	0.85	29	62	155	6.2	1.1	1.9	774	0.050	59	179	0.18	72	143
GREYWACKE-ARGILLITE (GA) n = 10																		
Min	*<0.2*	0.69	9.0	*<0.5*	0.12	4.0	21	6.0	1.5	0.16	0.40	274	0.020	6.0	2.0	0.030	20	43
Median	*<0.2*	2.1	16	0.50	0.54	14	41	23	3.8	0.77	1.1	545	0.045	32	7.5	0.14	49	68
Max	0.5	3.3	2800	0.90	2.3	25	60	67	5.7	1.2	1.6	800	0.11	48	54	0.20	76	111
GREYWACKE (GW) n = 9																		
Min	*<0.2*	1.1	7.0	*<0.5*	0.16	7.0	24	9.0	2.1	0.15	0.58	310	0.020	15	2.0	0.020	23	25
Median	*<0.2*	1.6	11	*<0.5*	0.57	15	37	24	3.2	0.22	0.89	461	0.040	25	4.0	0.090	36	66
Max	0.3	2.7	1205	0.70	2.2	25	50	35	5.2	0.92	1.4	1045	0.050	38	33	0.16	57	105

Notes: Values in grey italics are below the analytical detection limit. Values were set at the limit for calculation of statistical distributions.
AUCCC = average upper continental crust concentrations (Rudnick and Gao, 2014);
Values greater than 3x the AUCCC are shaded in light grey; values greater than 10x the AUCCC are shaded in dark grey.

Table 4-7:
Summary of solid phase element results for humidity cell subsamples

	AUCCC	*0.053*	*8.2*	*4.8*	*2.1*	*2.6*	*17*	*92*	*28*	*3.9*	*2.3*	*1.5*	*77*	*2.4*	*47*	*17*	*0.38*	*97*	*67*
HC ID	**Description**	**Ag**	**Al**	**As**	**Be**	**Ca**	**Co**	**Cr**	**Cu**	**Fe**	**K**	**Mg**	**Mn**	**Na**	**Ni**	**Pb**	**Ti**	**V**	**Zn**
		ppm	*%*	*ppm*	*ppm*	*%*	*ppm*	*ppm*	*ppm*	*%*	*%*	*%*	*ppm*	*%*	*ppm*	*ppm*	*%*	*ppm*	ppm
ARGILLITE (AR)																			
HC1	Median-S	*<0.2*	2.74	17	0.50	0.20	20	41	28	4.6	1.1	1.43	534	0.030	44	11	0.17	44	89
HC2[a]	High-S	*<0.2*	2.09	69	0.60	0.26	14	39	31	3.7	0.82	1.19	467	0.040	29	13	0.14	43	89
ARGILLITE-GREYWACKE (AG)																			
HC3[a]	Median-S	*<0.2*	2.93	16	0.50	0.53	22	43	23	5.3	0.84	1.59	704	0.035	43	8.5	0.15	48	113
HC4[a]	High-S	3.4	2.72	84	0.55	0.26	24	44	105	5.7	1.0	1.42	638	0.035	48	95	0.15	52	123
GREYWACKE-ARGILLITE (GA)																			
HC5[a]	Median-S	0.35	1.75	17.5	0.55	0.87	13	40	36	3.2	0.71	0.93	480	0.055	29	31	0.13	46	70
HC6[a]	High-S	*<0.2*	2.34	1833	0.55	0.19	20	39	36	4.4	0.82	1.21	487	0.045	37	6.0	0.12	42	89
GREYWACKE (GW)																			
HC7	Median-S	*<0.2*	1.13	10	0.70	0.93	7.0	31	18	2.1	0.21	0.58	372	0.040	15	2.0	0.090	29	34
HC8[a]	High-S	0.25	2.15	718	*<0.5*	0.22	21	38	30	4.2	0.89	1.16	439	0.035	32	18	0.15	42	86

Notes: [a]Humidity cell is made up of two samples. An average value is presented and a 1:1 mixture is assumed.
Values in grey italics are below the analytical detection limit. Values were set at the limit for calculation of statistical distributions.
AUCCC = average upper continental crust concentrations (Rudnick and Gao, 2014);
Values greater than 3x the AUCCC are shaded in light grey; values greater than 10x the AUCCC are shaded in dark grey.

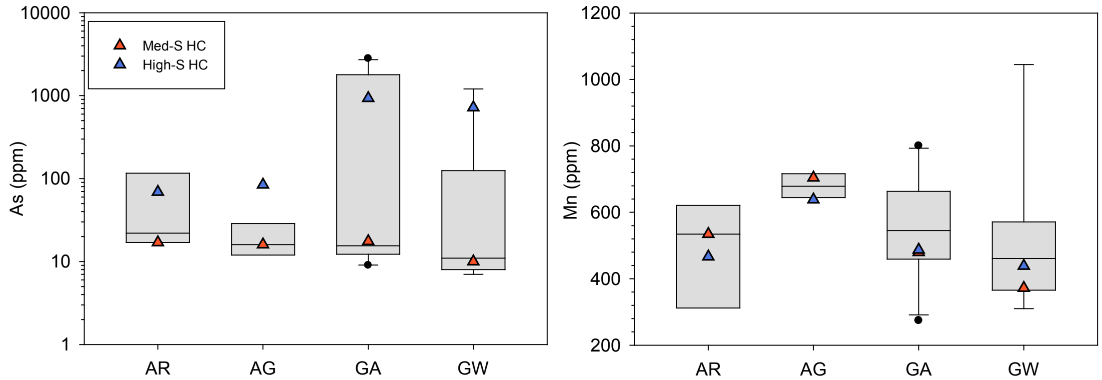


Figure 4-5: Box plots showing the range of As and Mn concentrations as compared to median and high sulphur humidity cell subsamples. Note that the box limits represent 25th and 75th percentile levels, the horizontal bar represents the median level and the whiskers represent the 5th and 95th percentile values.

4.1.1.4 Particle Size Distribution Results

The particle size distribution results for the humidity cell subsamples are presented in Appendix 4-4 and summarized in Figure 4-6. All humidity cell samples were mechanically crushed to P_{80} < 2 mm by the laboratory prior to placement in the humidity cells. This was done erroneously as the standard particle size to be placed into humidity cells should be P_{80} < 6.4 mm (Price, 2009). The finer particle size will be accounted for in the use of humidity cell data for source term development. The PSD results show that samples HC1 (AR) and HC3 (GA) have relatively higher proportions of fines as compared to other humidity cell samples.

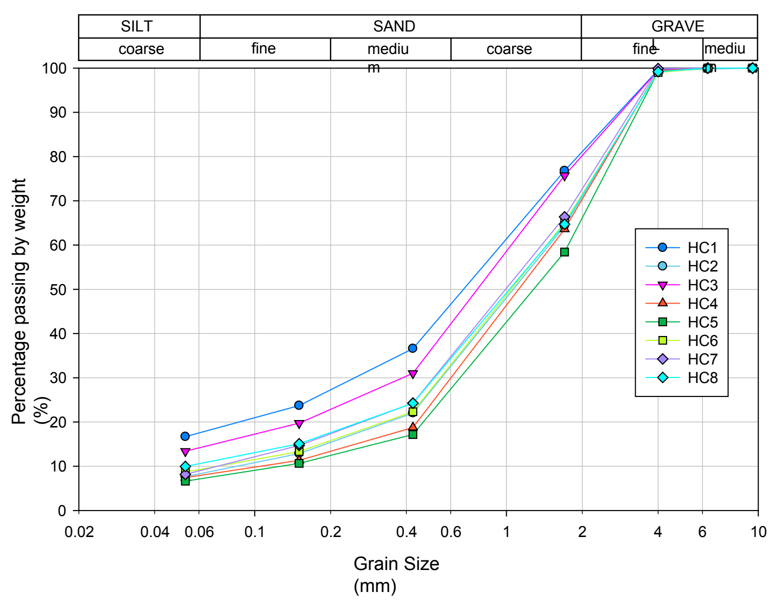


Figure 4-6: Particle Size Distribution results for humidity cell test samples presented as percent passing by weight versus grain size.

4.1.2 Kinetic Test Results

Laboratory kinetic test procedures are designed to quantify weathering rates under standardized conditions. During the initial cycles of laboratory kinetic testing, sulphate and metals often have highly variable release rates before stabilizing at a relatively constant rate (Sapsford *et al.,* 2009). This variability is a response to exposure of fresh surfaces of crushed samples and the dissolution of stored oxidation products that may have accumulated on the samples during storage prior to being placed in a humidity cell. Once exposed mineral surfaces have equilibrated to this environment, stable reaction rates can be determined. Humidity cells often require many weeks to approach geochemical stability, and reaction rates rarely remain constant on a week-to-week basis. It should be noted that aqueous concentrations in the weekly/biweekly rinse water should not be considered as direct predictions of on-site drainage chemistry due to the high water to solid ratio used in this type of testing (Sapsford *et al.,* 2009). In reality, conditions within large-scale mine rock storage facilities are much different with lower water/rock ratios, incomplete flushing of particle surfaces, and secondary minerals frequently reaching saturation and precipitating out of solution.

The kinetic test program for the Beaver Dam mine rocks consists of eight humidity cells covering the four main lithologies (AR, GA, AG and GW). Samples descriptions are provided in Table 3-2 and experimental methods are described in Section 3.5. Static characterization testwork, including mineral identification, ABA, solid phase element determination and PSD were completed on subsamples of each of the kinetic tests (presented in Section 4.1.1. Results of the static testwork show that the subsamples are considered to be representative of the respective lithologies. This report provides interim results from the ongoing humidity cell tests that were initiated in April 2018 and have been running for 24 weeks (at the time of reporting) with weekly flushing (500 mL) and sampling events. The full set of interim leachate results are presented in Appendix 4-5 and summarized in the sections below.

4.1.2.1 pH and Sulphate Loading

The leachate from all humidity cells remains circum-neutral. All pH values are between 7.1 and 8.6 (Figure 4-7). In general, when comparing the pH values for humidity cells composed of the same lithology, the median S humidity cell has a higher pH, relative to the high S humidity cell. The two AR humidity cells are an exception as the pH from HC1 (median S) is slightly lower than the pH from HC2 (high S), although the pH values from these two humidity cells are comparable. HC1 also has lower total alkalinity relative to HC2 (Figure 4-7). Overall, HC7 (median S, GW) has the highest pH values (range: 7.8 to 8.6) and HC6 (high S, GA) has the lowest pH values (range: 7.3 to 7.7). Note that the minimum pH for the dataset (7.1) was in cycle 0 in HC1.

Leachate concentrations from laboratory kinetic tests represent primary sulphate and metal release rates that do not fully account for the influence of field conditions that govern the actual sulphate and metal concentrations in mine drainage. In addition, concentrations measured from humidity cells are susceptible to changes in the volume of water added and collected at the end of each cycle, and hence, concentration data do not provide a strictly quantitative estimate of drainage chemistry. To provide a more functional parameter which can be used to compare results between different humidity cells, sulphate and metal concentrations in mine rock leachate are normalized to the mass of sample in the humidity cell and the volume of leachate collected each week, producing weekly mass loadings (mg solute/kg sample/wk).

For example, the rate of sulphide oxidation in mine rock samples is estimated from sulphate loadings calculated from the humidity cell leachates. To obtain sulphide oxidation rates, weekly leachate sulphate concentrations are multiplied by the volume of leachate collected from each column and cell to obtain a mass loading which is independent of the volume of leachate collected from each humidity cell. These loadings are then normalized to the mass of sample in the humidity cell. This normalized loading calculation is an important step because it allows the direct comparison of leachate data between cycles within the same humidity cell, as well as between different humidity cells.

The majority of the humidity cells initially show high sulphate loading rates that decrease and begin to stabilize between weeks 5 and 10 (Figure 4-8). The elevated values in the first few weeks of the tests are due to dissolution and flushing of readily soluble surface oxidation products (*e.g.*, secondary sulphates). HC1 and HC7 have the lowest sulphate loading rates, with loads decreasing to less than 2 mg/kg/wk after week 5. These humidity cells also have the lowest sulphide S (0.02% and 0.03%, respectively). HC2 through HC6 have shown relatively stable or slightly decreasing sulphate loading rates in the later cycles with loading rates between approximately 10 and 20 mg/kg/wk. HC4 has the highest sulphate loading rates with values remaining above 15 mg/kg/wk. Sulphide S is also highest in this humidity cell (0.76%). HC8 initially had a lower sulphate loading rate (<15 mg/kg/wk) but has shown an increasing trend up to 18.3 mg/kg/wk in week 23. Further cycles will determine if this trend continues or if the sulphate loading rates will stabilize. The average sulphate loading rate for the last 8 cycles is plotted with sulphide S content (Figure 4-9). There is some positive correlation between the sulphate loading rate and sulphide S.

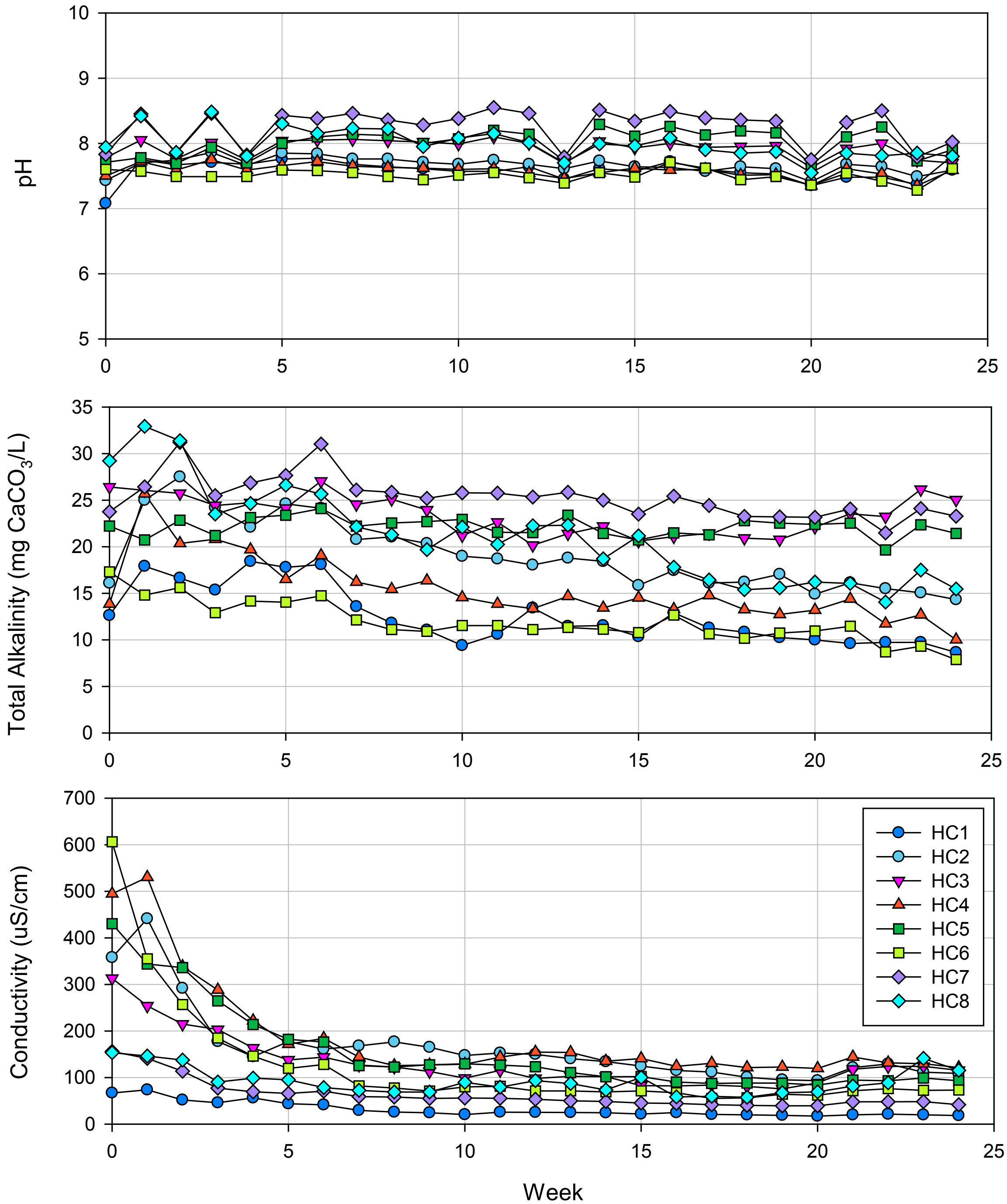


Figure 4-7: pH, total alkalinity, conductivity and sulphate in leachates from Beaver Dam humidity cells

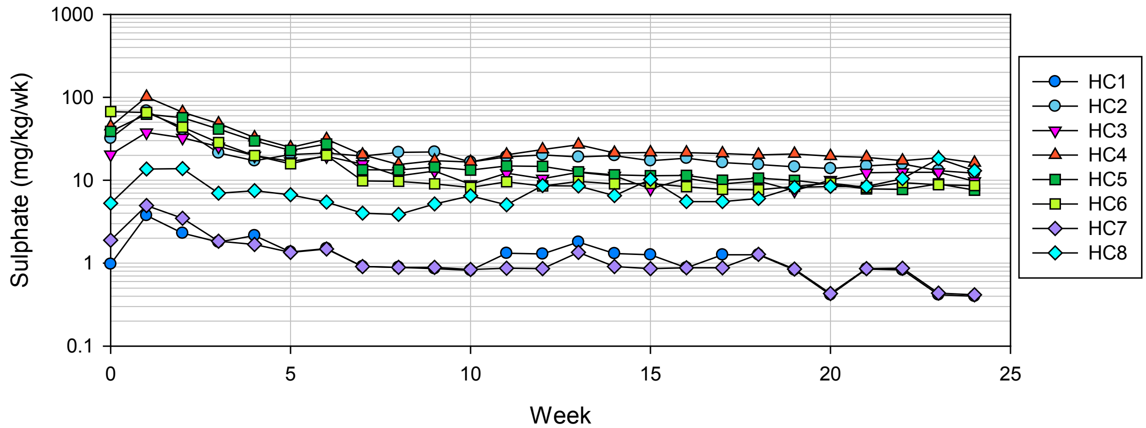


Figure 4-8: Sulphate loading rates in Beaver Dam humidity cell leachates

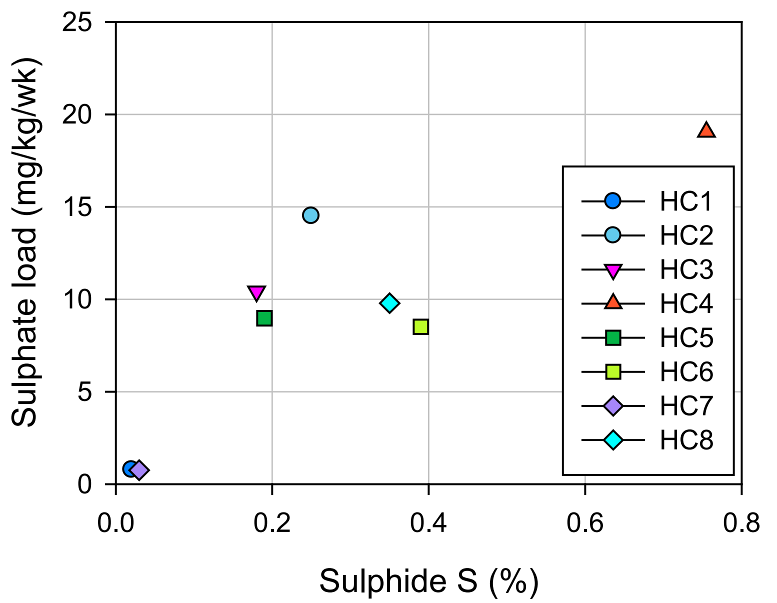


Figure 4-9: Average sulphate loading rate versus sulphide S. Sulphate load is an average from weeks 17-24.

4.1.2.2 Carbonate Molar Ratio

The carbonate molar ratio (CMR) is a proxy for the rate of carbonate dissolution (NP depletion) and sulphide oxidation occurring in the laboratory test reactor, assuming that the base cations are derived only from the NP source and the sulphate is derived from the oxidation of pyrite. The CMR is calculated as:

$$CMR = \frac{[Ca^{2+}] + [Mg^{2+}]}{[SO_4^{2-}]}$$

When reactive sulphides are present, the dominant NP consumption reaction is that of acid neutralization. In the most simplistic scenario, when carbonate minerals are present, the oxidation-neutralization reaction is pH-dependent. Assuming no Ca and SO_4 are lost to gypsum precipitation, two carbonate consumption reactions can describe the process, including:

at pH < 6.3:

$$FeS_2 + {}^{15}\!/_4\, O_2 + {}^{7}\!/_2\, H_2O + 2\left[Ca^{2+}, Mg^{2+}\right]CO_3 \longrightarrow Fe(OH)_3 + 2SO_4^{2-} + 2H_2CO_3^0 + 2\left[Ca^{2+}, Mg^{2+}\right]$$

at 6.3<pH<10.3:

$$FeS_2 + {}^{15}\!/_4\, O_2 + {}^{7}\!/_2\, H_2O + 4\left[Ca^{2+}, Mg^{2+}\right]CO_3 \longrightarrow Fe(OH)_3 + 2SO_4^{2-} + 4HCO_3^- + 4\left[Ca^{2+}, Mg^{2+}\right]$$

Neutralization of acidity up to pH levels of 6.3 produce one mole of Ca (+ Mg) for each mole of SO_4 released, producing a CMR = 1.0. At pH levels above 6.3, H_2CO_3 is not the dominant form of inorganic carbon in an aqueous solution and the bicarbonate ion (HCO_3^-) is by far the most abundant. Thus, at near-neutral pH levels, calcium carbonate is less efficient at neutralizing acidity and twice as much carbonate is required to produce a balanced solution. Under these conditions, 4 moles of Ca (+ Mg) are theoretically released relative to 2 moles of SO_4 producing a CMR = 2.0. The relationships derived from these chemical equations assume that pyrite oxidation is the sole source of sulphur and iron in the product that take the form of sulphate and iron hydroxide, respectively. Thus, the oxidation of other sulphide minerals, dissolution of soluble sulphate minerals, the formation of other secondary products, or dissolution of carbonates by dilute waters in the absence of significant sulphide oxidation may alter the relationship (Mattson, 2005).

The CMR for the majority of the humidity cells is between 1 and 2 (Figure 4-10). HC1 and HC8 have slightly higher CMR values between 1 and 3. HC7 has the highest CMR values which have increased from approximately 2.5 up to 20.

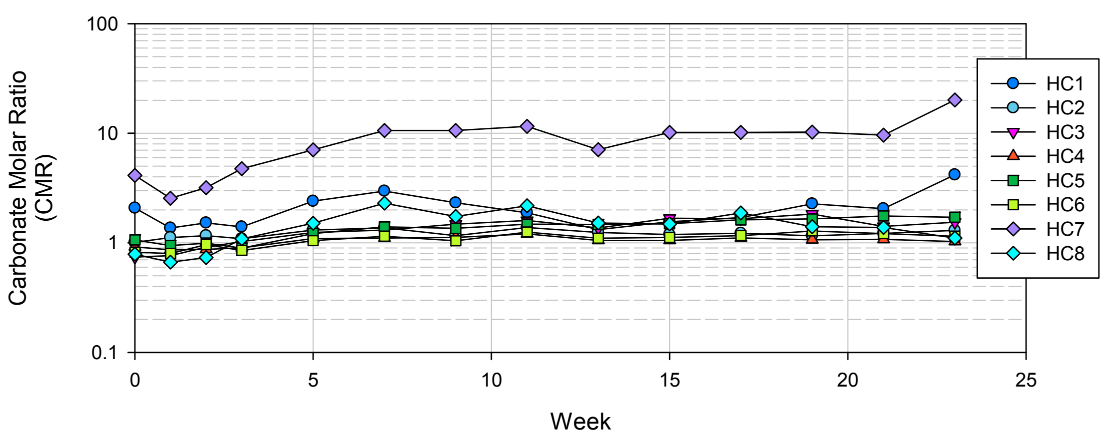


Figure 4-10: CMR values for Beaver Dam humidity cell leachate.

The CMR can be used to calculate the CaNP depletion rate which can in turn be used to calculate the amount of time required to consume all available CaNP from the humidity cell samples. Theoretically, once carbonate is depleted and non-carbonate phases are responsible for buffering the pH, the CMR will equilibrate around a value of 1, which allows for a slower depletion of the remaining NP. For the purpose of this high-level assessment, it was conservatively assumed that the CMR and carbonate depletion rate can also be applied to all NP sources that were quantified by the ModNP method used for the Beaverdam ABA analyses. The NP depletion rate is calculated as follows:

NP depletion rate = CMR x Sulphate loading rate (in kg $CaCO_3$/t/wk equivalents)

For the PAG humidity cells that are expected to become acidic, the time to NP depletion theoretically corresponds to the time to onset of acid generating conditions, although the grain liberation is an important factor. Note that for the purposes of calculating NP depletion rates and the time for complete depletion of NP, the initial sulphate production rates, which reflect the flushing of non-acid generating surface oxidation products such as gypsum, were not incorporated in the calculation. Rather the relatively stable NP depletion rates in later cycles of the tests more appropriately reflect depletion based on sulphate produced by sulphide oxidation. This will prevent underestimating the amount of available NP and the lag time to the onset of acidic conditions. The model results suggest that NP will be depleted between around 7 to 11 years for the PAG humidity cells. To provide a more realistic estimate that considers the slowing of sulphide oxidation at the Beaver Dam site in response to colder temperatures and/or freezing near-surface rock, the sulphate leaching rate was corrected by a factor of 0.3. This value is consistent with the temperature-dependent sulphide oxidation rate and sulphate release rate observed around 10°C (Dockrey and Mattson, 2016), which is somewhat higher than the mean annual temperature measured at the Beaver Dam site. Note that this approximation is only applicable for waste rock exposed to ambient air temperatures such as pit walls, since waste rock piles may have a different temperature profile. Plotting humidity cell total sulphur (S_T) contents against the respective temperature-corrected NP depletion rates shows a positive correlation (Figure 4-11a) that can be written as:

$$\text{NP depletion rate} = 0.0013 \times \ln [S_T] + 0.0064$$

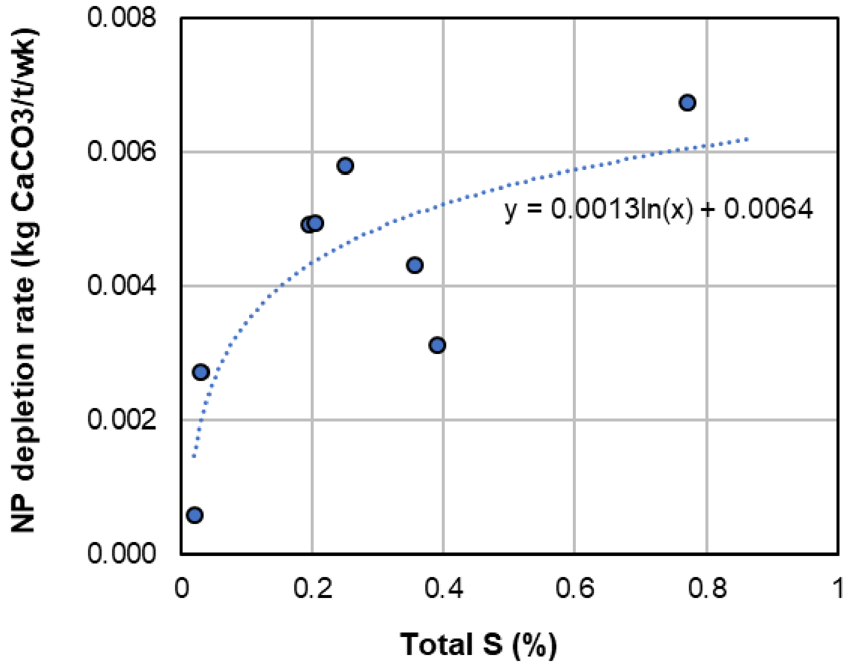
This function was then applied to the PAG samples within the Beaver Dam static test population to quantify a range of lag times that can be expected until these PAG samples release net acidic drainage. The results of this exercise are shown in Figure 4-11b and show that it will take around 20 years for 10% of all PAG samples and 28 years for 50% of all PAG samples to turn acidic.

4.1.2.3 Metal Leaching Trends

The trends in leachate mass loading rates over time are provided in Figure 4-12 for selected species. These species have elevated concentrations with respect to 3x the AUCCC in the mine rocks (Section 4.1.1) and include As, Cu, Mn and Pb. Although the Ag concentrations in the total solid phase elemental analysis were above 3 times the AUCCC, Ag is not included in the discussion in this section as all Ag concentrations in the humidity cell leachates remain below the analytical detection limit.

As and Mn have the highest loading rates of the selected elements, both with rates of up to 0.06 mg/kg/wk in one or more of the humidity cells in the early weeks of the tests. The initial flush of As reaches the highest rates in leachate from HC8 (up to 0.062 mg/kg/wk), although the rate decreases over time and is comparable to the rates in the other humidity cells by Week 17 (approximately 0.01 mg/kg/wk). HC1, HC2, HC3 and HC7 show gradually increasing As loading rates until approximately week 5 and have since shown a gradual decrease to more stable rates (Figure 4-12). Arsenic loading rates in HC4 have shown a consistent decrease over time from 0.0088 to 0.00068 mg/kg/wk. The two GA humidity cells (HC5 and HC6) release relatively stable and low As loading rates (<0.01 mg/kg/wk). The As loading rates do not show a correlation with the As content in the solid phase (Figure 4-13). The humidity cell with the highest average loading rate in the last four cycles of the test (HC1; 0.021 mg/kg), had relatively low As in the solid phase (17 ppm). In contrast, HC6 is composed of two high As samples (1,915 ppm and 1,750 ppm) and has a relatively low As average loading rate throughout the duration of the test (0.0030 mg/kg). It is worth noting that sample HC8, which produces the highest initial As loading rates, is the only sample in which arsenopyrite was identified on a thin section scale. Assuming that the sample splitting was representative, these trends suggest that the As association within the different humidity cell subsamples has a strong control over the respective leaching rates.

(a)



(b)

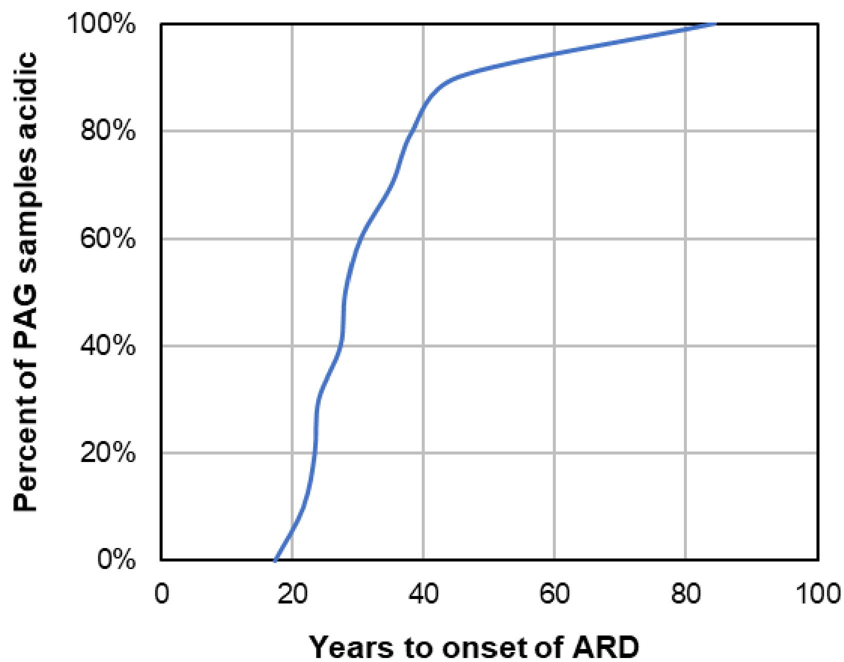


Figure 4-11: Relationship (a) and results (b) of model to estimate the time to onset of acidic conditions in Beaver Dam PAG samples

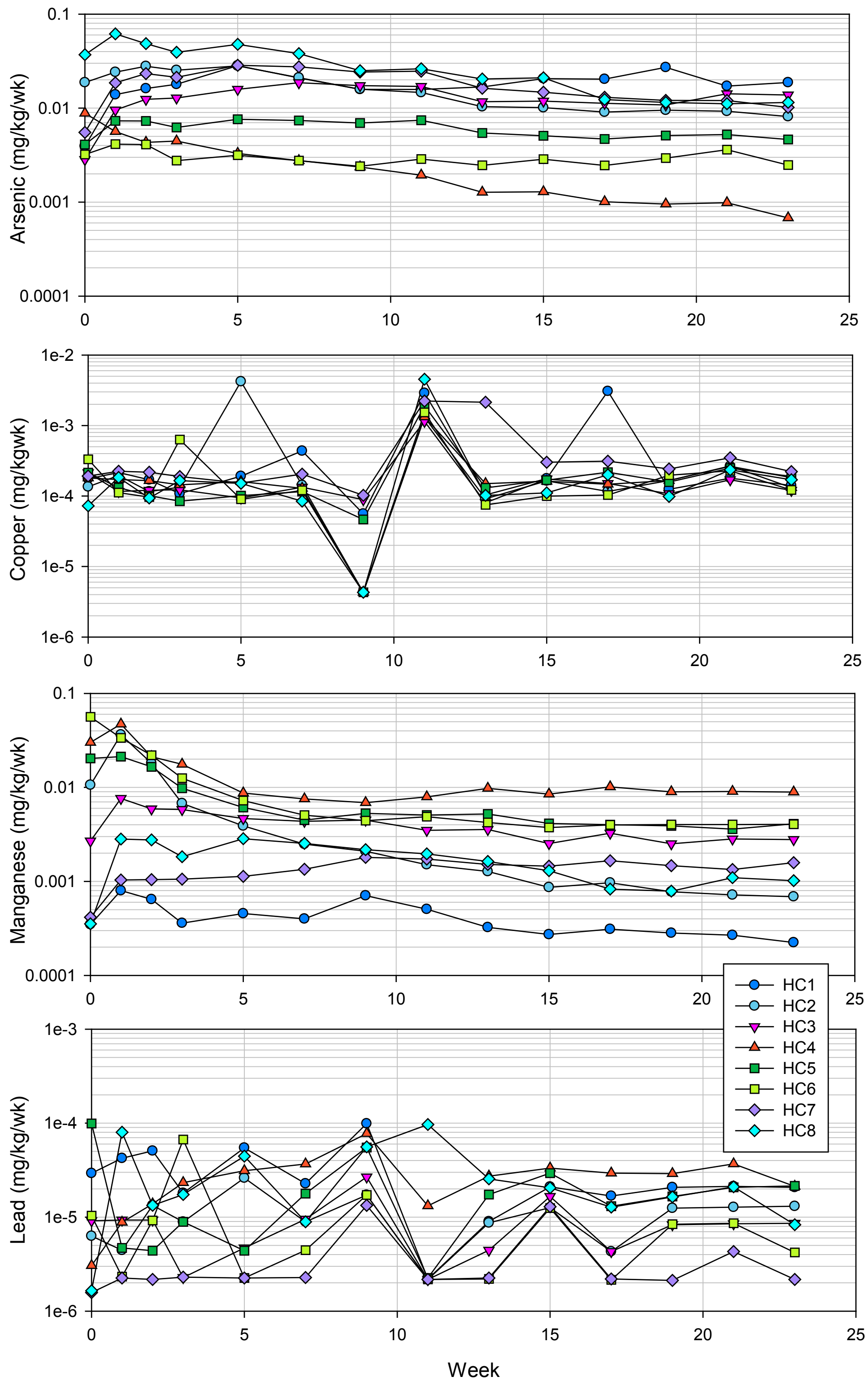


Figure 4-12: D-As, D-Cu, D-Mn and D-Pb in leachate from the Beaver Dam humidity cells

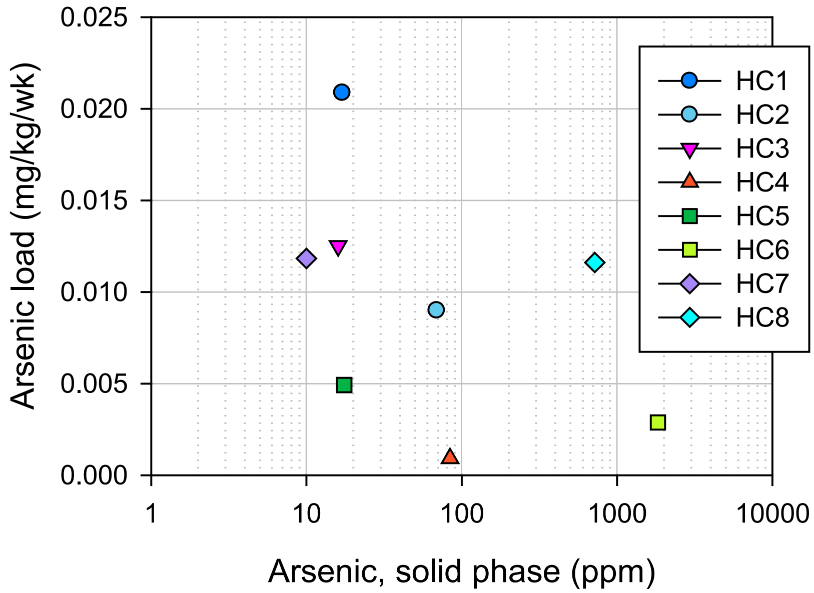


Figure 4-13: Average As loading rate vs solid phase As content. As load is an average from weeks 17-23.

Mn loading rates show an initial increase in the first few weeks in the majority of the humidity cell tests. The Mn loading rates are highest for leachate from HC2, HC4 and HC6. These are all the high S humidity cells for their respective lithologies. After Week 5, the Mn loading rates remain ≤0.01 mg/kg/wk for all humidity cells. Since Week 5, Mn loading rates for HC4 have been the highest. Mn loading rates from HC1 and HC7 remain low (<0.002 mg/kg/wk) over the course of the humidity cell tests. The loading rates for Cu and Pb are low (<0.005 mg/kg/wk) and do not display any obvious trends.

4.2 Overburden Samples

The paste pH values of the overburden samples are slightly acidic and range from pH 5.0 to pH 6.1 (Table 4-8; Appendix 4-2). One sample (LX-BDT-03) is currently acidic (pH < 5.5). The total S content of the overburden samples is low (<0.1%), with only sample LX-BDT-03 having a total S value above 0.05%. The majority of the S is present as sulphide S. This parameter is not measured but is calculated by subtracting the sulphate S, which is below the detection limit for these samples (<0.01%). There was no TIC detected in the overburden samples (<0.05%). The CaNP calculated from the TIC and the modified NP are both low, suggesting that the NP has been depleted from the overburden. Although the samples have a low NP, the risk for ARD is low due to the low sulphur content.

Table 4-8:
Summary of ABA results for Beaver Dam overburden samples.

Sample ID	Paste pH	Total S	Sulphate S	Sulphide S (calc)	Total C	CaNP	Modified NP	NPR
		%	%	%	%	kg $CaCO_3$/t	kg $CaCO_3$/t	Mod.NP/AP
LX-BDT-01	5.6	0.02	*<0.01*	0.02	*<0.05*	*<4.5*	-4	-6.4
LX-BDT-02	5.7	0.02	*<0.01*	0.02	*<0.05*	*<4.5*	-5	-8
LX-BDT-03	5	0.08	*<0.01*	0.08	*<0.05*	*<4.5*	-5	-2
LX-BDT-04	6.1	0.02	*<0.01*	0.02	*<0.05*	*<4.5*	-4	-6.4
LX-BDT-05	5.7	0.02	*<0.01*	0.02	*<0.05*	*<4.5*	-4	-6.4

Notes: Values in grey italics are below the analytical detection limit. Values were set at the limit for calculation of NP, AP and NPR values.
Sulphate S is calculated using the HCl method.
AP (acid potential) calculated using sulphide sulphur (% non-sulphate sulphur x 31.25);
CaNP (carbonate neutralization potential) calculated using total inorganic carbon (% TIC x (100.09/12.01) x 10);
Modified NP is obtained by the modified Sobek method.
NPR = neutralization potential ratio; calculated as Modified NP / AP

The results of the total solid phase elemental analysis are included in Appendix 4-3 with a summary provided in Table 4-9. Elements that are greater than 3× their respective AUCCC values (Rudnick and Gao, 2014) and greater than 2x the detection limit in at least one of the overburden samples include As and Mn (Table 4-9). Solid phase concentrations of As in 3 of the 5 samples are enriched by a factor greater than 10 above the AUCCC. The As and Mn values are also enriched in the waste rock.

Shake flask extraction (SFE) results for the five overburden samples are presented in Appendix 4-6 and summarized in Table 4-10 as compared to the CCME water quality guidelines for the protection of aquatic life (CCME, 2018). These guidelines are used for reference only to provide an indication of parameters which are of potential concern in runoff from the excavated material. It should be noted that, as per the test method protocol, the agitation of the overburden samples in water may release higher concentrations of certain species than what would be expected in contact water drainage.

Table 4-9:
Summary of solid phase element results for Beaver Dam overburden samples.

AUCCC	*0.053*	*4.8*	*2.57*	*17.3*	*28*	*3.92*	*77.4*	*47*	*17*	*67*
Sample ID	**Ag**	**As**	**Ca**	**Co**	**Cu**	**Fe**	**Mn**	**Ni**	**Pb**	**Zn**
	ppm	*ppm*	*%*	*ppm*	*ppm*	*%*	*ppm*	*ppm*	*ppm*	*ppm*
LX-BDT-01	0.2	225	0.06	13	27	3.88	490	33	13	74
LX-BDT-02	<0.2	24	0.04	5	16	2.63	245	17	9	28
LX-BDT-03	0.2	54	0.13	5	12	1.34	162	22	10	37
LX-BDT-04	<0.2	15	0.02	2	4	0.96	112	4	7	10
LX-BDT-05	0.2	105	0.05	10	15	4.51	441	19	9	64

Notes: Values in grey italics are below the analytical detection limit. Values were set at the limit for calculation of statistical distributions.
AUCCC = average upper continental crust concentrations (Rudnick and Gao, 2014).

Values greater than 3x the AUCCC are shaded in light grey; values greater than 10x the AUCCC are shaded in dark grey.

Table 4-10:
Summary of SFE results for Beaver Dam overburden samples.

Parameter	Units	CCME WQG		LX-BDT-01	LX-BDT-02	LX-BDT-03	LX-BDT-04	LX-BDT-05
		Short Term	Long Term					
pH	pH	6.5-9	-	5.27	5.15	4.88	4.54	5.83
Conductivity	µS/cm	-	-	12.6	15.7	89.1	36.7	19.5
Sulphate	mg/L	-	-	2.24	1.23	10.1	1.42	2.08
Leachable Metals								
Ag	mg/L	-	0.00025	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Al[a]	mg/L	-	0.1	***0.108***	***0.683***	***1.51***	***1.26***	***0.483***
As	mg/L	-	0.005	0.0012	0.0012	***0.315***	0.0038	***0.0084***
B	mg/L	29	1.5	<0.010	<0.010	0.015	<0.010	<0.010
Cd	mg/L	0.001	0.00009	<0.000050	<0.000050	***0.000217***	0.000075	<0.000050
Co	mg/L	-	-	0.00084	0.00042	0.00761	0.00054	0.00101
Cr	mg/L	-	0.001	<0.00050	0.00088	***0.00118***	***0.00126***	0.00064
Cu[b]	mg/L	-	0.002	<0.0010	<0.0010	***0.0085***	0.0014	***0.0033***
Fe	mg/L	-	0.3	<0.030	0.194	***0.425***	***0.490***	0.262
Hg	mg/L	-	0.000026	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Mn	mg/L	-	-	0.107	0.0446	0.131	0.0681	0.106
Mo	mg/L	-	0.073	<0.00010	<0.00010	0.00023	<0.00010	<0.00010
Ni[b]	mg/L	-	0.025	0.00098	0.00118	***0.0360***	0.00151	0.00179
Pb[b]	mg/L	-	0.001	<0.00010	0.00013	0.00090	***0.00129***	0.00012
Se	mg/L	-	0.001	<0.00050	0.00068	0.00079	***0.00101***	0.00085
Tl	mg/L	-	0.0008	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
U	mg/L	0.033	0.015	0.000020	0.000087	0.000101	0.000073	0.000103
Zn	mg/L	0.037	0.007	<0.010	<0.010	***0.045***	***0.012***	<0.010

Notes: Values shaded in grey are above the short-term CCME guideline
Values in bold italics are above the long-term CCME guideline
[a]Aluminum guideline is based on pH > 6.5
[b]Hardness dependent guidelines are based on a hardness of 10 mg/L.

Parameters that were elevated relative to the CCME guidelines in the leachate from the samples (n=5) include Al (5 samples), As (2 samples), Cd (1 sample), Cr (2 samples), Cu (2 samples), Fe (2 samples), Pb (1 sample), Ni (1 sample), Se (1 sample) and Zn (2 samples). In addition, all samples have pH values less than 6.5 and four of the samples are acidic (pH < 5.5). Metals enriched above 10 times their respective guidelines include Al in two samples and As in one sample. Al is highly sensitive to pH and the elevated Al concentrations are likely related to the low in-situ pH of the samples. The highest As concentration in the SFE tests was measured in sample LX-BDT-03. This sample produced

As concentrations of 0.315 mg/L, while the other four overburden samples produced As concentrations ranging from 0.0012 to 0.0084 mg/L. Arsenic was identified as an element enriched in the overburden by the solid phase analysis, however, sample LX-BDT-03 does not have the highest As concentration in the solid phase. The higher As in the leachate from this sample is likely due to the low pH which would result in increased leaching from the overburden material. Given the highly weathered nature of overburden significant metal leaching potential is not expected from this unit. The cause of the elevated As concentration in LX-BDT-03 is unclear, but shows that further overburden characterization may be required.

4.3 Haul Road Samples

The samples collected along the Beaver Dam haul road have paste pH values ranging from 7.4 to 8.8 and are not currently acid generating. All total S and TIC values are below their respective detection limits for these samples (Table 4-11; Appendix 4-2). The NPR values are high due to the low acid potential, indicating that the samples are not potentially acid generating. The low total S and TIC values suggest that the samples are weathered. Fresher samples could be obtained in the future to verify these results if drilling is conducted along the road alignment.

The solid phase elements are compared to the AUCCC (Rudnick and Gao, 2014; Appendix 4-3). The only elements that are above 3x the AUCCC and greater than 2x the detection limit are As (2 samples) and Mn (4 samples) (Table 4-12). Both As and Mn were also identified as elements enriched in the mine rock. As discussed above (Section 4.1.1.3), elements enriched in the solid phase may not necessarily become a metal leaching issue as there are many factors that influence leaching rates.

Table 4-11:
Summary of ABA results for Beaver Dam haul road samples.

Sample ID	Paste pH	Total S	Sulphate S	Sulphide S (calc)	Total C	CaNP	Modified NP	NPR
		%	%	%	%	kg $CaCO_3$/t	kg $CaCO_3$/t	Mod.NP/AP
LX-BDR-01	7.4	*<0.01*	*<0.01*	*<0.01*	*<0.05*	*<4.5*	3	9.6
LX-BDR-02	8.7	*<0.01*	*<0.01*	*<0.01*	*<0.05*	*<4.5*	5	16.0
LX-BDR-03	8.7	*<0.01*	0.01	*<0.01*	*<0.05*	*<4.5*	4	12.8
LX-BDR-04	8.8	*<0.01*	0.01	*<0.01*	*<0.05*	*<4.5*	4	12.8
LX-BDR-05	7.7	*<0.01*	0.01	*<0.01*	*<0.05*	*<4.5*	8	25.6

Notes: Values in grey italics are below the analytical detection limit. Values were set at the limit for calculation of NP, AP and NPR values.
Sulphate S is calculated using the HCl method.
AP (acid potential) calculated using sulphide sulphur (% non-sulphate sulphur x 31.25);
CaNP (carbonate neutralization potential) calculated using total inorganic carbon (% TIC x (100.09/12.01) x 10);
Modified NP is obtained by the modified Sobek method.
NPR = neutralization potential ratio; calculated as Modified NP / AP

Table 4-12:
Summary of solid phase element results for Beaver Dam haul road samples.

AUCCC	*0.053*	*4.8*	*2.57*	*17.3*	*28*	*3.92*	*77.4*	*47*	*17*	*67*
Sample ID	**Ag**	**As**	**Ca**	**Co**	**Cu**	**Fe**	**Mn**	**Ni**	**Pb**	**Zn**
	ppm	*ppm*	*%*	*ppm*	*ppm*	*%*	*ppm*	*ppm*	*ppm*	*ppm*
LX-BDR-01	<0.2	21	0.14	4	9	1.92	212	15	3	38
LX-BDR-02	<0.2	<2	0.14	13	20	2.87	392	31	5	62
LX-BDR-03	<0.2	2	0.17	7	17	2.08	302	18	7	45
LX-BDR-04	<0.2	<2	0.12	8	11	2.12	336	21	<2	39
LX-BDR-05	<0.2	18	0.78	13	28	3.63	625	38	7	66

Notes: Values in grey italics are below the analytical detection limit. Values were set at the limit for calculation of statistical distributions.
AUCCC = average upper continental crust concentrations (Rudnick and Gao, 2014).
Values greater than 3x the AUCCC are shaded in light grey; values greater than 10x the AUCCC are shaded in dark grey.

4.4 Quality Assurance and Quality Control

Each set of samples submitted for analyses is subjected to an internal laboratory quality assurance and quality control (QA/QC) program. This program includes duplicate samples and analytical standard analysis. Any laboratory duplicate result or standard that does not adhere to the precision specifications for the different parameters triggers a re-analysis.

5. Conclusions and Recommendations

5 Conclusions and Recommendations

The ML/ARD characterization of the Beaver Dam samples included static test characterization of the Beaver Dam mine rock, overburden from the proposed pit area and samples from along the Beaver Dam haul road. In addition, kinetic testing was undertaken on mine rock samples. The major conclusions and recommendations of the geochemical characterization include:

- Total S in the mine rock samples varies from below the detection limit (<0.01%) up to 1.7%. The AR unit has the highest median total S (0.44%) and the GW unit has the lowest median total S (0.025%). The GA and GW units have the highest median TIC (0.11% and 0.10%, respectively) and the highest median modified NP (9.0 and 14 kg $CaCO_3$/t, respectively), while the AR and AG units have the lowest median TIC (<0.05%) and modified NP (8.5 and 8.0 kg $CaCO_3$/t, respectively). The mine rock samples were not currently acid generating (paste pH: 7.9 to 9.5).
- All four of the main lithologies for Beaver Dam mine rock include PAG samples, however, all samples with total S less than 0.1% are NAG. The overall proportion of PAG rock identified in the static test population is 39%; AR has the highest relative proportion of PAG samples (80%) while the GW unit has the lowest (21%).
- Parameters of potential concern identified by the total solid phase elemental analysis include As, Cu, Mn and Pb. Elevated As concentrations (>10× AUCCC) occur in all Beaver Dam lithologies. Elevated Mn values (>10× AUCCC) occur in 3 of the 4 lithologies, whereas elevated Ag and Pb (>10× AUCCC) are limited to the AG samples. Cu is not above 10x the AUCCC in any of the lithologies.
- The static test results indicate that the humidity cell samples provide a good representation of the range of geochemical characteristics within each lithologic unit. However, HC1 and HC2 have low S contents as compared to the median argillite value.
- The leachate from the kinetic tests remains circumneutral for the initial 24 weeks of data available at the time of reporting. The sulphate loading rates are lowest for HC1 (AR, median S) and HC7 (GW, median S) and highest for HC4 (AG, high S). The CMR for the majority of the humidity cells is between 1 and 2 with values up to 3 in HC1 and HC8.
- As and Mn have the highest loading rates of the parameters of potential concern identified by the solid phase analysis. Arsenic loading rates are comparable in the last weeks of the available data for the AR humidity cells (HC1 and HC2), the

median S AG humidity cell (HC3), and the GW humidity cells (HC7 and HC8). Both GA humidity cells (HC5 and HC6) have lower As loading rates and As loading rates from the high S AG humidity cell (HC4) have shown a decreasing trend over the length of the test. Mn loading rates are highest for HC4 in the later weeks of the tests. Mn loading rates from HC1 and HC7 have remained low. Mn loading rates appear to be correlated with the sulphate loading rates. The loading rates for this element are typically higher for the high S pair for each lithology.

- Based on the relationship between total S content and the NP depletion rate and in consideration of Beaver Dam site climatic conditions, it is estimated that it will take at least 17 years for the Beaver Dam PAG samples to produce ARD and around 28 years for half of all PAG samples to do so. This rate may be accelerated in ARD "hotspots" within waste rock piles where increased temperatures may be attained in response to heat produced by sulphide oxidation.
- The overburden samples have low sulphur content; however, they lack any significant NP. Elements enriched in the overburden include As and Mn. The SFE tests indicate the potential for elevated Al and As in runoff, among other elements. However, significant metal leaching is not expected from this unit due to the high degree of weathering. Further characterization of the overburden material is recommended.
- Samples collected along the haul road have low total S and low NP and do not currently indicate a potential for ARD. It is assumed that these samples are surface-weathered and therefore, it is recommended that fresh, unweathered samples be collected to verify the results if drilling is conducted along the haul road. Elements of potential concern identified by the solid phase analysis include As and Mn.

6. Closure

6 Closure

This report has been prepared for AMNS for the ML/ARD assessment of the Beaver Dam Gold project. Please contact the undersigned should you require any additional information or clarification on the contents of this report.

Sincerely,

LORAX ENVIRONMENTAL SERVICES LTD.

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Appendices

ATLANTIC GOLD

Appendix 3-1: Sample Locations and Drill Core Details

ATLANTIC GOLD

Appendix 3-1 Sample Locations and Drill Core Details

Geologic Unit	Hole ID	Interval (m)		Sample ID
		From	*To*	
Argillite (AR)	BD14-178	7	7.9	LX17-12
	BD15-GT05	57	58	LX17-22
	BD14-188	22	23	LX17-24
	BD15-190	40	41	BD190-040
	BD05-005	54	55	BD005-054
	BD06-110	50	51	BD110-050
	BD15-190	43	44	BD190-043
	BD14-157	31	32	BD157-031
	BD06-085	46	47	BD085-046
	BD05-011	123	124	BD011-123
Argillite-Greywacke (AG)	BD15-GT02	15	16	LX17-02
	BD15-GT02	26	27	LX17-03
	BD15-GT02	31	32	LX17-04
	BD15-GT08	37	38	LX17-09
	BD14-172	140	141	LX17-10
	BD14-172	170	171	LX17-11
	BD14-178	15	16	LX17-13
	BD14-173	22	23	LX17-28
	BD14-160	140	141	BD160-140
	BD14-179	170	171	BD179-170
	BD14-169	136	137	BD169-136
Greywacke-Argillite (GA)	BD15-GT02	10	11	LX17-01
	BD15-GT02	46	47	LX17-05
	BD15-GT08	14	15	LX17-07
	BD14-178	30	31	LX17-14
	BD14-178	58	59	LX17-15
	BD14-178	161	162	LX17-17
	BD14-178	147	148	LX17-18
	BD15-GT05	15	16	LX17-19
	BD14-188	10	11	LX17-23
	BD14-173	37	38	LX17-29
	BD14-156	9	10	BD156-009
	BD14-187A	10	11	BD187A-010
	BD14-157	33	34	BD157-033
	BD14-169	187	188	BD169-187

Geologic Unit	Hole ID	Interval (m)		Sample ID
		From	*To*	
Greywacke (GW)	BD15-GT08	91	10	LX17-06
	BD15-GT08	23	24	LX17-08
	BD14-178	49	50	LX17-16
	BD15-GT05	25	26	LX17-20
	BD15-GT05	41	42	LX17-21
	BD14-156	75	76	BD156-075
	BD14-160	39	40	BD160-039
	BD14-179	45	46	BD179-045
	BD14-179	149	150	BD179-149
	BD05-006	12	13	BD006-012
	BD14-169	44	45	BD169-044
	BD14-169	88	89	BD169-088
	BD05-011	15	16	BD011-015
	BD14-183	70	71	BD183-070
	BD14-183	148	149	BD183-148
	BD06-049	140	141	BD049-140
	BD14-179	43	44	BD179-043
	BD05-006	13	14	BD006-013
	BD14-183	132	133	BD183-132
	BD14-186	149	150	BD186-149
	BD14-188	38	39	LX17-25
	BD14-188	51	52	LX17-26
	BD14-173	12	13	LX17-27
	BD14-173	53	54	LX17-30
Quartz Vein (QTZV)	BD14-157	70	71	BD157-070
	BD14-156	108	109	BD156-108
	BD14-160	89	90	BD160-089

Appendix 4-1: XRD Results

ATLANTIC GOLD

QUANTITATIVE PHASE ANALYSIS OF 8 POWDER SAMPLES USING THE RIETVELD METHOD AND X-RAY POWDER DIFFRACTION DATA.

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July 10, 2018

EXPERIMENTAL METHOD

The samples of **Project 1821 Beaver Dam** were reduced to the optimum grain-size range for quantitative X-ray analysis (<10 μm) by grinding under ethanol in a vibratory McCrone Micronizing Mill for 10 minutes. Continuous-scan X-ray powder-diffraction data were collected over a range 3-80°2θ with CoKα radiation on a Bruker D8 Advance Bragg-Brentano diffractometer equipped with an Fe monochromator foil, 0.6 mm (0.3°) divergence slit, incident- and diffracted-beam Soller slits and a LynxEye-XE detector. The long fine-focus Co X-ray tube was operated at 35 kV and 40 mA, using a take-off angle of 6°.

RESULTS

The X-ray diffractograms were analyzed using the International Centre for Diffraction Database PDF-4 and Search-Match software by Bruker. X-ray powder-diffraction data of the samples were refined with Rietveld program Topas 4.2 (Bruker AXS). The results of quantitative phase analysis by Rietveld refinements are given in Table 1 (separate file, ***SGS Canada Results July 10 2018 - Project 1821 Beaver Dam – PO43079 - 8 samples.xls***). These amounts represent the relative amounts of crystalline phases normalized to 100%. The Rietveld refinement plots are shown in Figures 1 - 8. The ideal formulae of the mineral phases are shown in Table 2.

Table 2.

Mineral	**Ideal Formula**
Biotite	$K(Mg,Fe)_3(AlSi_3O_{10})(OH)_2$
Calcite	$CaCO_3$
Chamosite	$(Fe,Al,Mg)_6(Si,Al)_4O_{10}(OH)_8$
Illite/Muscovite 2M1	$K_{0.65}Al_{2.0}Al_{0.65}Si_{3.35}O_{10}(OH)_2/KAl_2(AlSi_3O_{10})(OH)_2$
Ilmenite ?	$Fe^{2+}TiO_3$
Plagioclase	$NaAlSi_3O_8$ – $CaAl_2Si_2O_8$
Pyrite	FeS_2
Quartz	SiO_2

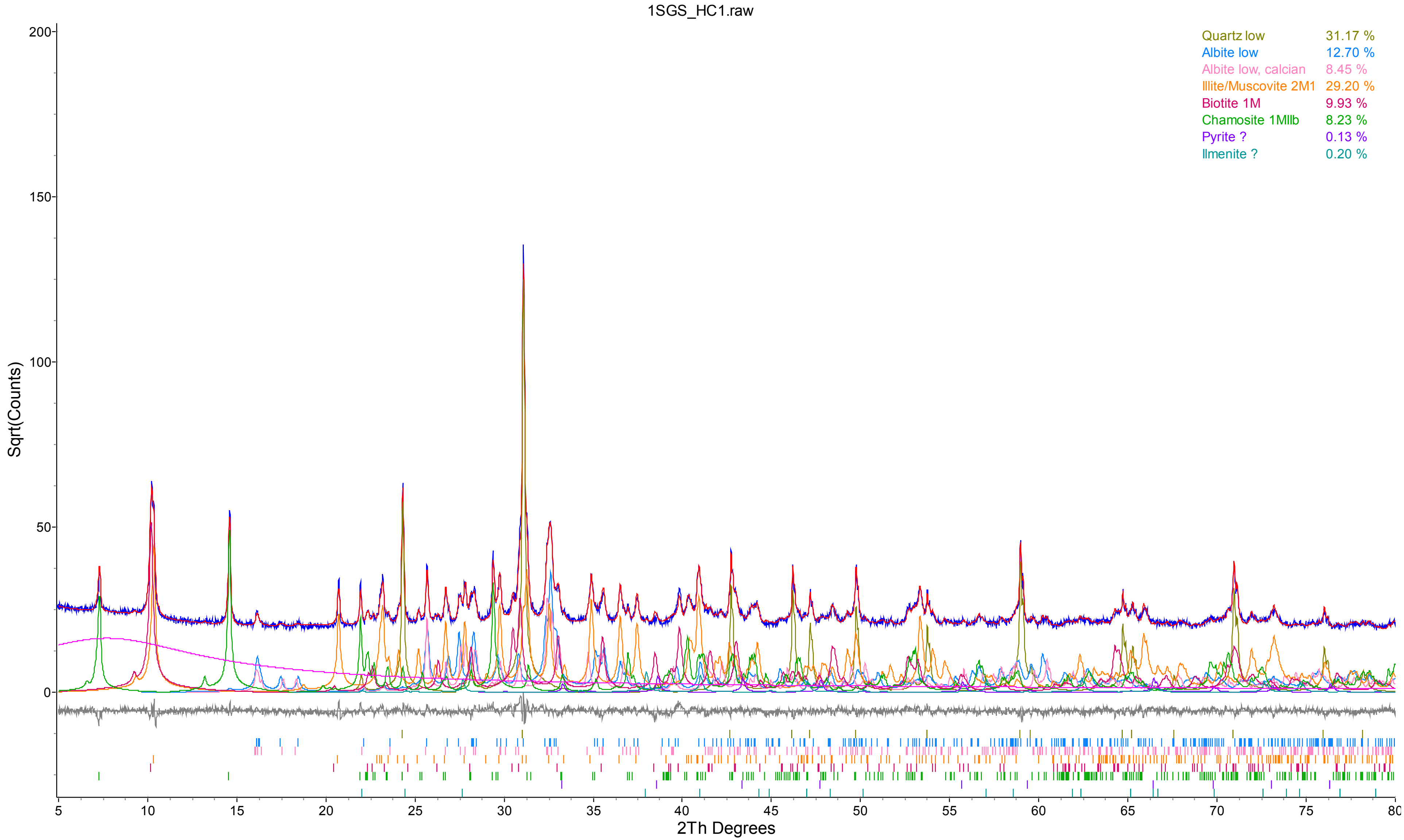

Figure 1. Rietveld refinement plot of sample **SGS CANADA HC 1** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below – difference between observed and calculated intensities; vertical bars, positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

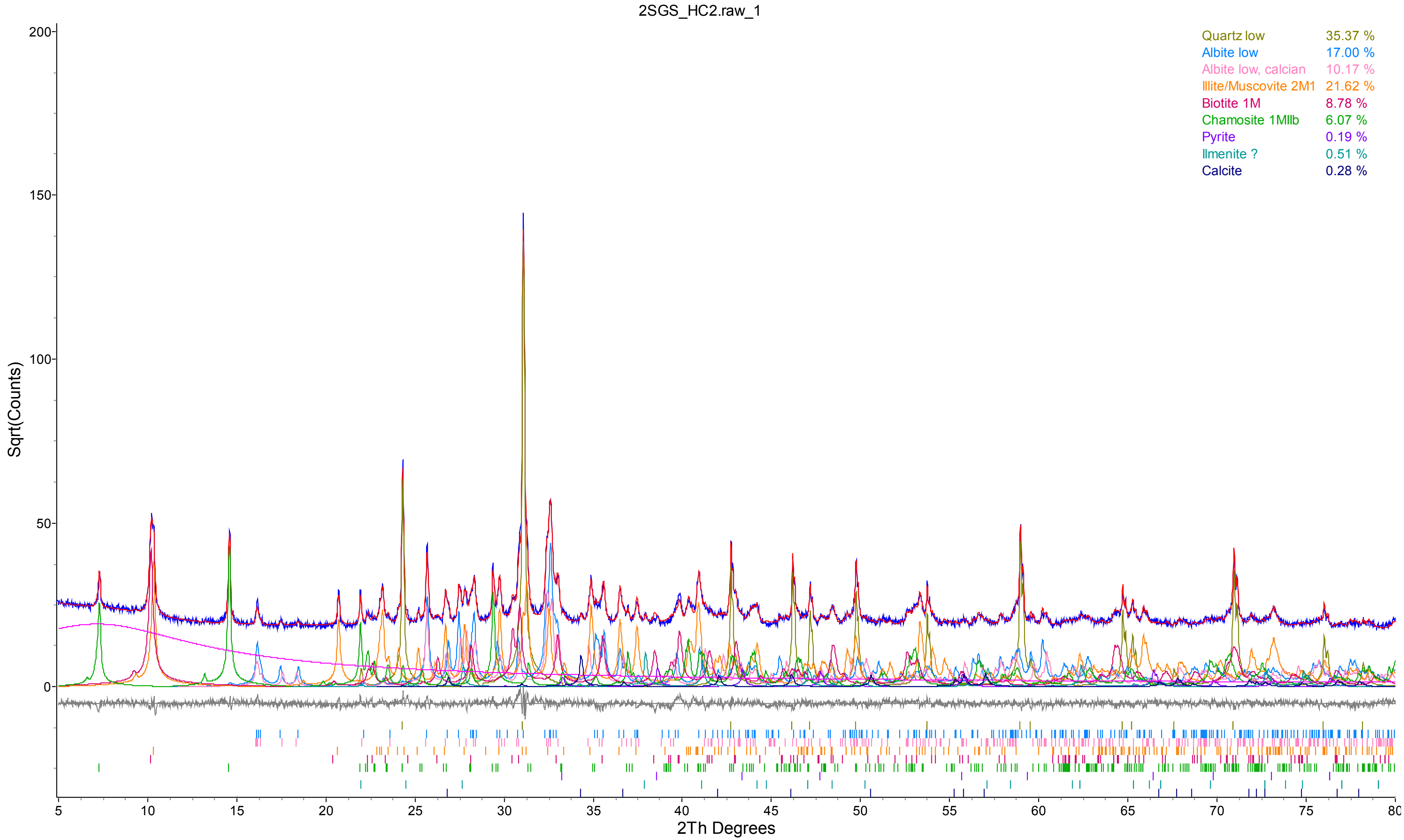

Figure 2. Rietveld refinement plot of sample **SGS CANADA HC 2** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below - difference between observed and calculated intensities; vertical bars - positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

Figure 3. Rietveld refinement plot of sample **SGS CANADA HC 3** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below - difference between observed and calculated intensities; vertical bars - positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

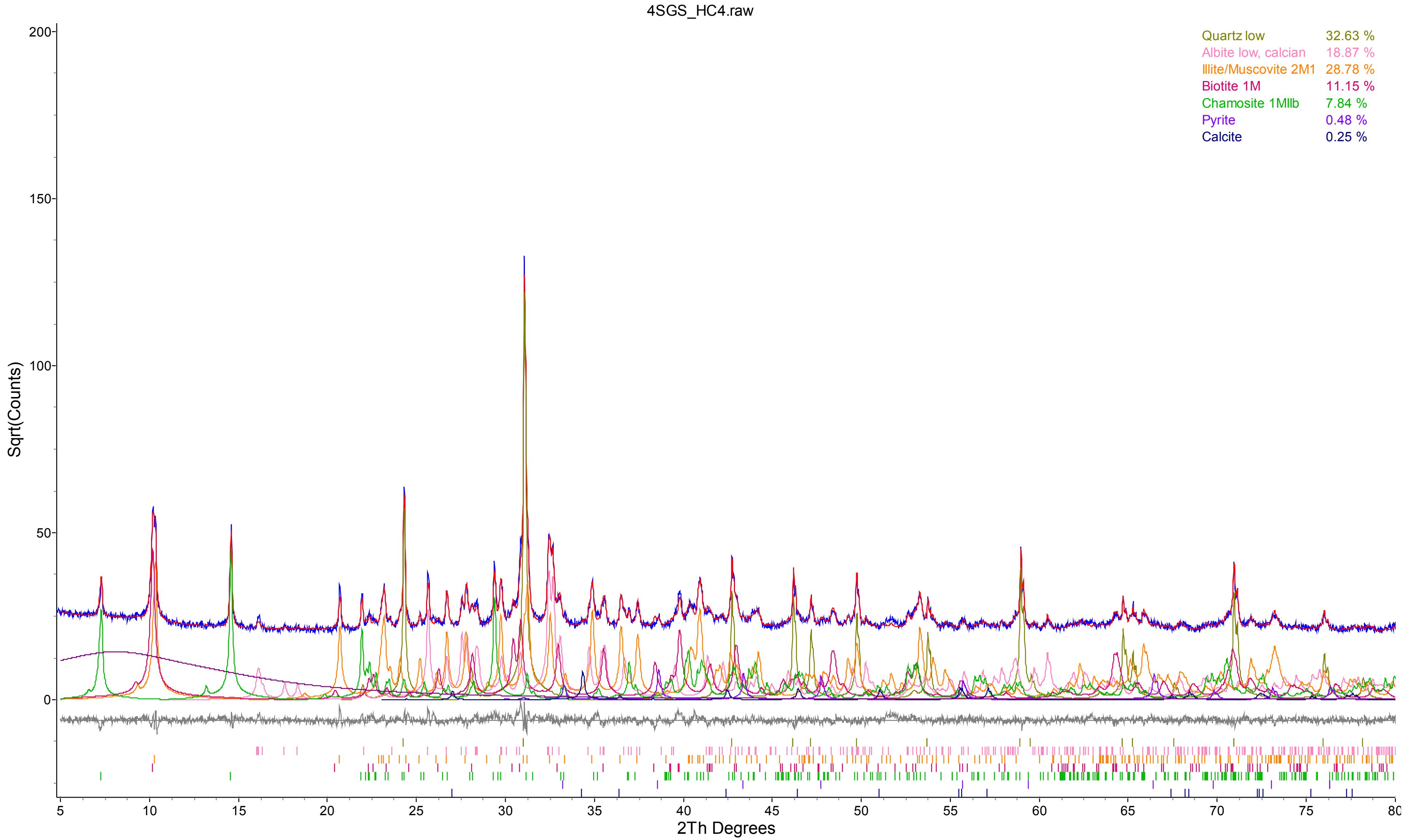

Figure 4. Rietveld refinement plot of sample **SGS CANADA HC 4** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below - difference between observed and calculated intensities; vertical bars - positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

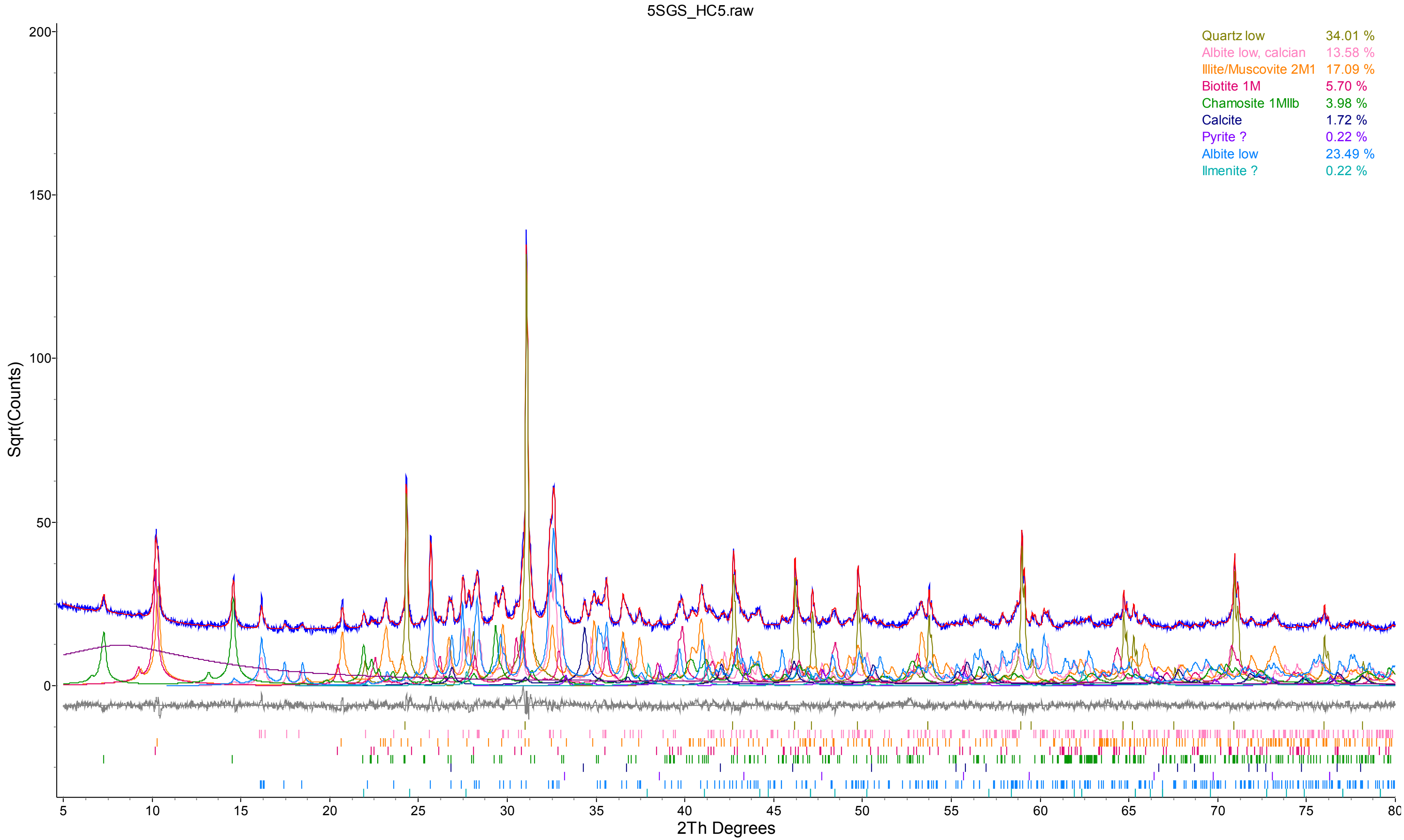

Figure 5. Rietveld refinement plot of sample **SGS CANADA HC 5** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below - difference between observed and calculated intensities; vertical bars - positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

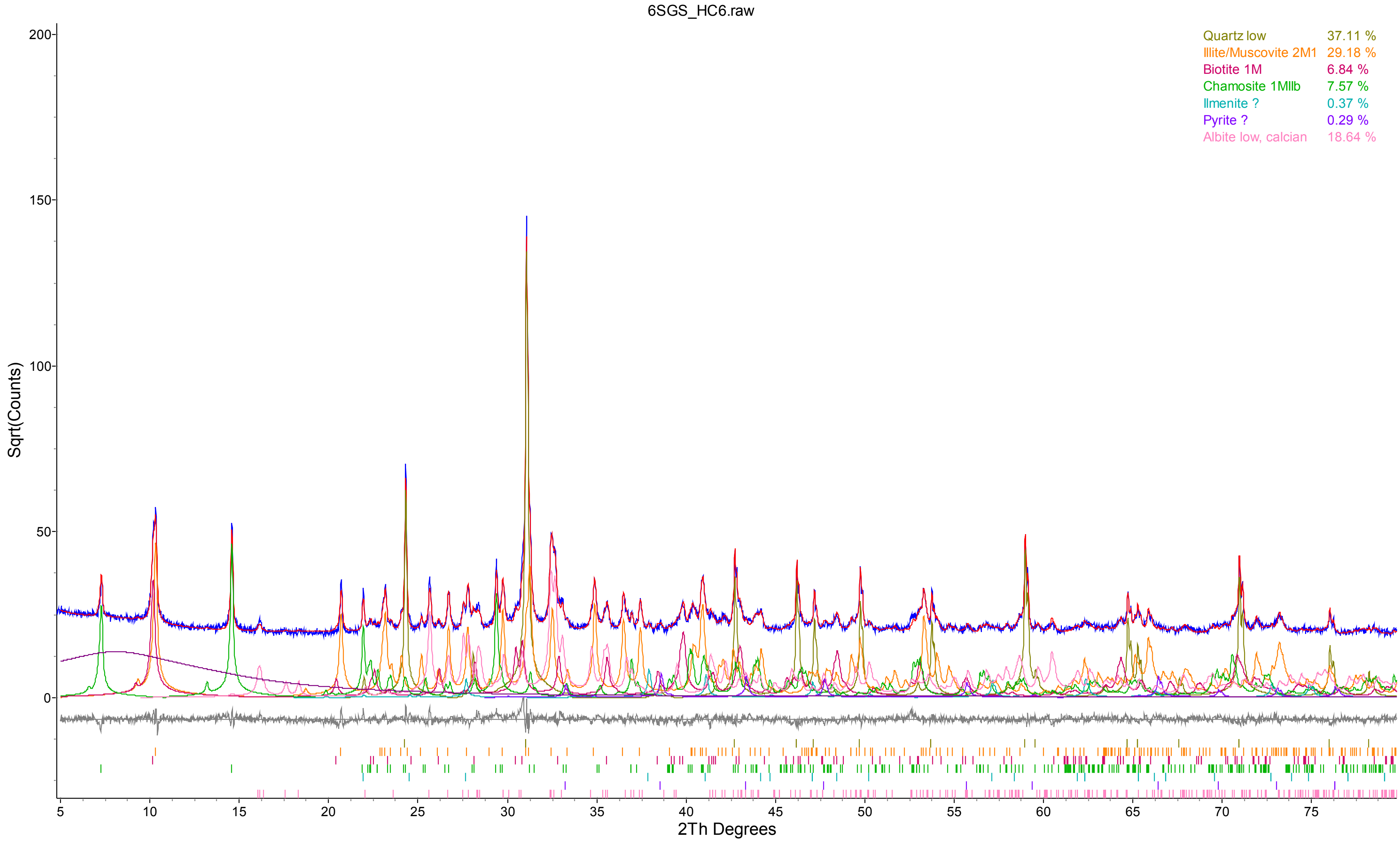

Figure 6. Rietveld refinement plot of sample **SGS CANADA HC 6** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below - difference between observed and calculated intensities; vertical bars - positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

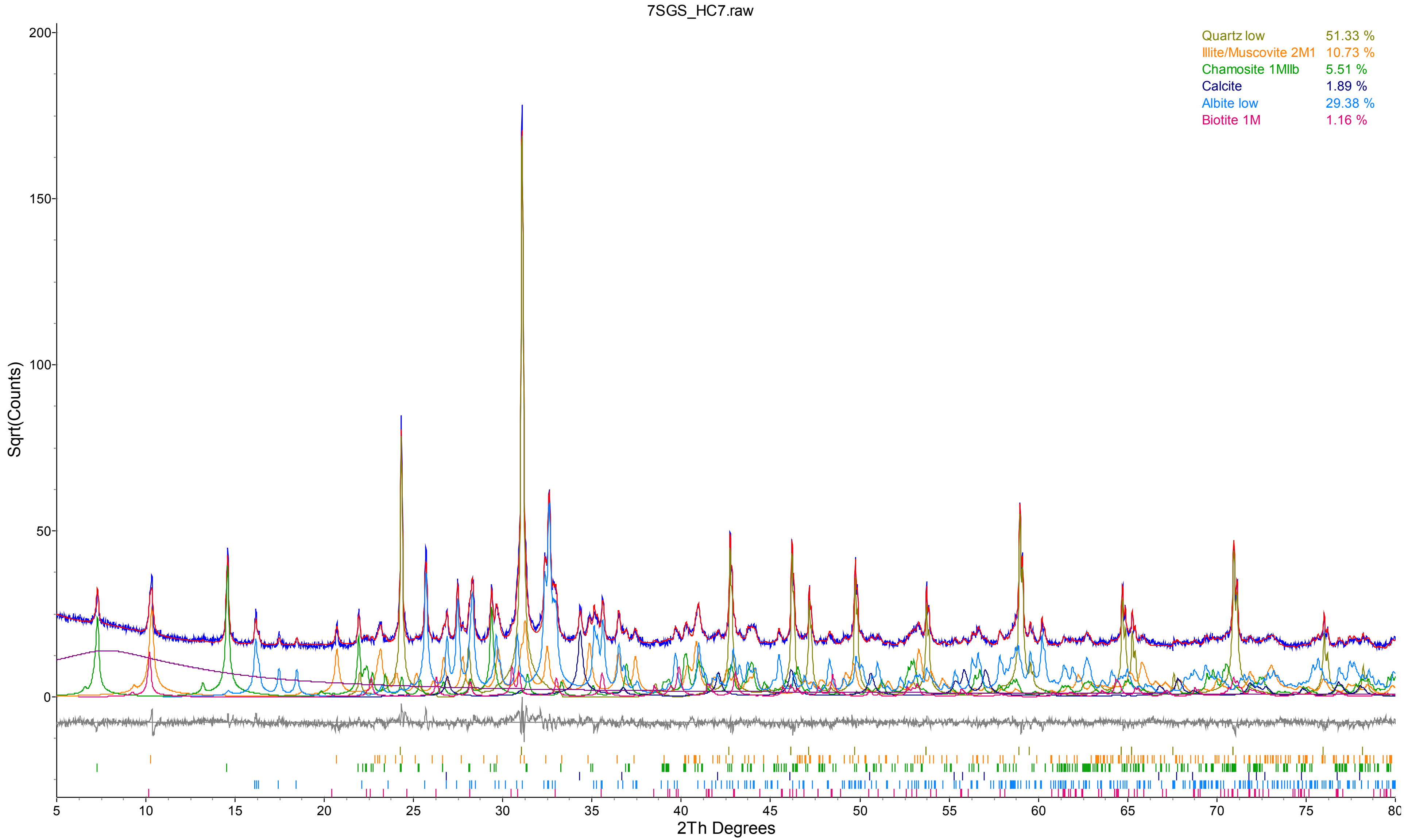

Figure 7. Rietveld refinement plot of sample **SGS CANADA HC 7** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below - difference between observed and calculated intensities; vertical bars - positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

Figure 8. Rietveld refinement plot of sample **SGS CANADA HC 8** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below - difference between observed and calculated intensities; vertical bars - positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

Appendix 4-2:
Acid-Base Accounting Results

Appendix 4-2, Table 1: Acid-Base Accounting Results - Mine Rock Samples

Sample ID	Hole ID	Interval		Paste pH	Total S	Sulphate S (CO_3)	Sulphate S (HCl)	Sulphide S (calc)	Total C	CO_2	CO_3	CaNP	Modified NP	NPR	NPR
		From	*To*		%	%	%	%	%	%	%	*kg $CaCO_3$/t*	*kg $CaCO_3$/t*	*CaNP/AP*	*Mod.NP/AP*
ARGILITE (AR)															
LX17-12	BD14-178	7	7.9	8.9	0.02	<0.01	0.02	0.02	<0.05	<0.2	<0.2	<4.5	6	<7.3	9.6
LX17-22	BD15-GT05	57	58	9	0.32	<0.01	0.01	0.32	<0.05	<0.2	<0.2	<4.5	6	<0.5	0.60
LX17-24	BD14-188	22	23	8.4	0.18	<0.01	0.02	0.18	<0.05	<0.2	<0.2	<4.5	9	<0.8	1.6
BD190-040	BD15-190	40	41	9.1	0.58	-	0.02	0.55	-	-	-	-	9	-	0.52
BD005-054	BD05-005	54	55	8.2	0.68	-	0.03	0.65	-	-	-	-	14	-	0.69
BD110-050	BD06-110	50	51	9.5	0.08	-	0.01	0.07	-	-	-	-	37	-	17
BD190-043	BD15-190	43	44	9.3	0.5	-	0.02	0.51	-	-	-	-	7	-	0.44
BD157-031	BD14-157	31	32	9.4	0.38	-	0.05	0.36	-	-	-	-	17	-	1.5
BD085-046	BD06-085	46	47	8.7	0.78	-	0.06	0.7	-	-	-	-	7	-	0.32
BD011-123	BD05-011	123	124	8.8	1.01	-	0.02	0.94	-	-	-	-	8	-	0.27
			Min	8.2	0.020	0.010	0.010	0.020	0.050	0.20	0.20	4.5	6.0	0.45	0.27
			Median	9.0	0.44	0.010	0.020	0.44	0.050	0.20	0.20	4.5	8.5	0.81	0.64
			Mean	8.9	0.45	0.010	0.026	0.43	0.050	0.20	0.20	4.5	12	2.8	3.2
			Max	9.5	1.0	0.010	0.060	0.94	0.050	0.20	0.20	4.5	37	7.3	17
ARGILITE-GREYWACKE (AG)															
LX17-02	BD15-GT02	15	16	8.2	0.32	0.03	0.02	0.29	<0.05	<0.2	<0.2	<4.5	7	<0.5	0.77
LX17-03	BD15-GT02	26	27	8.5	0.4	0.02	0.01	0.38	<0.05	<0.2	<0.2	<4.5	8	<0.4	0.67
LX17-04	BD15-GT02	31	32	7.9	1.14	0.01	0.02	1.13	<0.05	0.2	0.2	4.5	8	0.1	0.23
LX17-09	BD15-GT08	37	38	9.1	0.01	0.02	0.02	<0.01	<0.05	<0.2	<0.2	<4.5	8	<14.6	26
LX17-10	BD14-172	140	141	9.1	0.07	<0.01	0.02	0.07	0.17	0.6	0.8	13.6	23	6.2	11
LX17-11	BD14-172	170	171	9.1	0.03	0.02	0.03	0.01	<0.05	<0.2	<0.2	<4.5	9	<14.6	29
LX17-13	BD14-178	15	16	9	0.01	<0.01	0.01	0.01	<0.05	<0.2	<0.2	<4.5	8	<14.6	26
LX17-28	BD14-173	22	23	8.7	0.04	<0.01	0.04	0.04	<0.05	<0.2	<0.2	<4.5	10	<3.6	8.0
BD160-140	BD14-160	140	141	9.5	0.29	-	0.06	0.24	-	-	-	-	7	-	0.93
BD179-170	BD14-179	170	171	9.3	0.3	-	0.02	0.3	-	-	-	-	7	-	0.75
BD169-136	BD14-169	136	137	9.1	0.12	-	<0.01	0.12	-	-	-	-	177	-	47
			Min	7.9	0.010	0.010	0.010	0.010	0.050	0.20	0.20	4.5	7.0	0.13	0.23
			Median	9.1	0.12	0.015	0.020	0.12	0.050	0.20	0.20	4.5	8.0	4.9	8.0
			Mean	8.9	0.25	0.016	0.024	0.24	0.065	0.25	0.28	5.7	25	6.8	14
			Max	9.5	1.1	0.030	0.060	1.1	0.17	0.60	0.80	14	177	15	47
GREYWACKE-ARGILITE (GA)															
LX17-01	BD15-GT02	10	11	7.9	0.36	0.03	0.01	0.33	0.06	0.2	0.3	4.5	9	0.4	0.87
LX17-05	BD15-GT02	46	47	8.4	0.39	0.01	0.02	0.38	0.19	0.7	0.9	15.9	25	1.3	2.1
LX17-07	BD15-GT08	14	15	8.5	0.03	0.01	0.03	0.02	<0.05	<0.2	<0.2	<4.5	7	<7.3	11
LX17-14	BD14-178	30	31	9.1	0.01	<0.01	0.01	0.01	<0.05	<0.2	<0.2	<4.5	9	<14.6	29
LX17-15	BD14-178	58	59	8.7	0.04	<0.01	0.02	0.04	0.57	2.1	2.8	47.8	58	38.2	46
LX17-17	BD14-178	161	162	8.1	0.48	<0.01	0.01	0.48	<0.05	<0.2	<0.2	<4.5	6	<0.3	0.40
LX17-18	BD14-178	147	148	8.5	0.14	<0.01	0.01	0.14	0.16	0.6	0.8	13.6	18	3.1	4.1
LX17-19	BD15-GT05	15	16	9	0.3	<0.01	0.02	0.3	<0.05	<0.2	<0.2	<4.5	5	<0.5	0.53
LX17-23	BD14-188	10	11	9	0.05	<0.01	0.02	0.05	0.3	1.1	1.5	25.0	34	16.0	22
LX17-29	BD14-173	37	38	8.9	0.03	<0.01	0.02	0.03	0.16	0.6	0.8	13.6	19	14.6	20
BD156-009	BD14-156	9	10	9.4	0.29	-	0.02	0.28	-	-	-	-	9	-	1.0
BD187A-010	BD14-187A	10	11	9.1	0.18	-	0.06	0.13	-	-	-	-	9	-	2.2
BD157-033	BD14-157	33	34	9	1.66	-	0.04	1.48	-	-	-	-	31	-	0.67
BD169-187	BD14-169	187	188	9.5	0.09	-	0.02	0.08	-	-	-	-	7	-	2.8
			Min	7.9	0.010	0.010	0.010	0.010	0.050	0.20	0.20	4.5	5.0	0.30	0.40
			Median	9.0	0.16	0.010	0.020	0.14	0.11	0.40	0.55	9.1	9.0	5.2	2.5
			Mean	8.8	0.29	0.012	0.022	0.27	0.16	0.61	0.79	14	18	9.6	10
			Max	9.5	1.7	0.030	0.060	1.5	0.57	2.1	2.8	48	58	38	46

Appendix 4-2, Table 1: Acid-Base Accounting Results - Mine Rock Samples

Sample ID	Hole ID	Interval		Paste pH	Total S	Sulphate S (CO_3)	Sulphate S (HCl)	Sulphide S (calc)	Total C	CO_2	CO_3	CaNP	Modified NP	NPR	NPR
		From	*To*		*%*	*%*	*%*	*%*	*%*	*%*	*%*	*kg $CaCO_3$/t*	*kg $CaCO_3$/t*	*CaNP/AP*	*Mod.NP/AP*
GREYWACKE (GW)															
LX17-06	BD15-GT08	91	10	9	0.01	*<0.01*	0.02	0.01	0.1	0.4	0.5	9.1	14	29	45
LX17-08	BD15-GT08	23	24	8.9	*<0.01*	0.01	0.02	*<0.01*	0.12	0.4	0.6	9.1	16	29.1	51
LX17-16	BD14-178	49	50	9.1	0.03	*<0.01*	*<0.01*	0.03	0.2	0.7	1	15.9	23	17.0	25
LX17-20	BD15-GT05	25	26	9	0.29	0.01	0.03	0.28	*<0.05*	*<0.2*	*<0.2*	*<4.5*	7	*<0.5*	0.80
LX17-21	BD15-GT05	41	42	9.5	0.42	*<0.01*	0.03	0.42	0.05	0.2	0.2	4.5	9	0.3	0.69
BD156-075	BD14-156	75	76	9.4	0.02	-	0.01	0.02	-	-	-	-	22	-	35
BD160-039	BD14-160	39	40	9.5	0.16	-	0.02	0.14	-	-	-	-	8	-	1.8
BD179-045	BD14-179	45	46	9.1	0.01	-	0.01	*<0.01*	-	-	-	-	160	-	512
BD179-149	BD14-179	149	150	9.2	0.18	-	0.03	0.12	-	-	-	-	24	-	6.4
BD006-012	BD05-006	12	13	9.3	0.31	-	0.01	0.3	-	-	-	-	59	-	6.3
BD169-044	BD14-169	44	45	9.3	0.01	-	0.02	0.01	-	-	-	-	12	-	38
BD169-088	BD14-169	88	89	9.2	0.02	-	0.01	0.04	-	-	-	-	35	-	28
BD011-015	BD05-011	15	16	8.9	0.02	-	0.01	0.02	-	-	-	-	11	-	18
BD183-070	BD14-183	70	71	9.3	0.02	-	*<0.01*	0.03	-	-	-	-	13	-	14
BD183-148	BD14-183	148	149	9.2	0.08	-	0.06	0.04	-	-	-	-	60	-	48
BD049-140	BD06-049	140	141	9.4	0.03	-	*<0.01*	0.04	-	-	-	-	8	-	6.4
BD179-043	BD14-179	43	44	9.3	*<0.01*	-	0.01	*<0.01*	-	-	-	-	9	-	29
BD006-013	BD05-006	13	14	8.9	1.22	-	0.05	1.19	-	-	-	-	6	-	0.16
BD183-132	BD14-183	132	133	9	0.06	-	0.01	0.05	-	-	-	-	53	-	34
BD186-149	BD14-186	149	150	9.1	0.27	-	0.03	0.22	-	-	-	-	11	-	1.6
LX17-25	BD14-188	38	39	9.2	*<0.01*	*<0.01*	0.02	*<0.01*	0.39	1.4	1.9	31.8	41	102	131
LX17-26	BD14-188	51	52	9.1	0.03	*<0.01*	0.05	0.03	0.05	0.2	0.2	4.5	9	4.9	9.6
LX17-27	BD14-173	12	13	8.9	0.02	*<0.01*	0.02	0.02	0.09	0.3	0.4	6.8	12	10.9	19
LX17-30	BD14-173	53	54	8.9	0.01	*<0.01*	0.02	0.01	0.6	2.2	3	50.0	58	160	186
			Min	8.9	0.010	0.010	0.010	0.010	0.050	0.20	0.20	4.5	6.0	0.35	0.16
			Median	9.2	0.025	0.010	0.020	0.030	0.10	0.40	0.50	9.1	14	17	22
			Mean	9.2	0.14	0.010	0.022	0.13	0.18	0.67	0.89	15	28	39	52
			Max	9.5	1.2	0.010	0.060	1.2	0.60	2.2	3.0	50	160	160	512
QURTZ VEIN (QTZV)															
BD157-070	BD14-157	70	71	9.2	0.16	-	0.02	0.14	-	-	-	-	145	-	33
BD156-108	BD14-156	108	109	9.3	0.06	-	0.01	0.05	-	-	-	-	10	-	6.4
BD160-089	BD14-160	89	90	8.9	0.04	-	0.01	0.04	-	-	-	-	30	-	24
			Min	8.9	0.040		0.010	0.040					10		6.4
			Median	9.2	0.060		0.010	0.050					30		24
			Mean	9.1	0.087		0.013	0.077					62		21
			Max	9.3	0.16		0.020	0.14					145		33

Notes:
A hyphen indicates the parameter was not analyzed.
Values in grey italics are below the analytical detection limit. Values were set at the limit for calculation of NP, AP and NPR values.
Sulphate S is calculated using the sodium carbonate leach method (CO_3) and the HCl method (HCl).
AP (acid potential) calculated using sulfide sulfur (% non-sulfate sulfur x 31.25)
CaNP (carbonate neutralization potential) calculated using total inorganic carbon (% TIC x (100.09/12.01) x 10)
Modified NP is obtained by modified Sobek method.
NPR = neutralization potential ratio; calculated as CaNP / AP and as Modified NP / AP.

Appendix 4-2, Table 2: Acid-Base Accounting Results - Kinetic Test Samples

Humidity Cell ID	Description	Sample ID	Hole ID	Interval		Paste pH	Total S	Sulphate S (CO_3)	Sulphate S (HCl)	Sulphide S (calc)	Total C	CO_2	CO_3	CaNP	Modified NP	NPR	NPR
				From	*To*		*%*	*%*	*%*	*%*	*%*	*%*	*%*	*kg $CaCO_3$/t*	*kg $CaCO_3$/t*	*CaNP/AP*	*Mod.NP/AP*
HC1	Median-S AR	LX17-12	BD14-178	7	7.9	8.9	0.02	*<0.01*	0.02	0.02	*<0.05*	*<0.2*	*<0.2*	*<4.5*	6	*<7.3*	9.6
HC2	High-S AR	LX17-22	BD15-GT05	57	58	9.0	0.32	*<0.01*	0.01	0.32	*<0.05*	*<0.2*	*<0.2*	*<4.5*	6	*<0.5*	0.60
		LX17-24	BD14-188	22	23	8.4	0.18	*<0.01*	0.02	0.18	*<0.05*	*<0.2*	*<0.2*	*<4.5*	9	*<0.8*	1.6
	Average					8.7	0.25	*<0.01*	0.02	0.25	*<0.05*	*<0.2*	*<0.2*	*<4.5*	8	*<0.6*	1.1
HC3	Median-S AG	LX17-02	BD15-GT02	15	16	8.2	0.32	0.03	0.02	0.29	*<0.05*	*<0.2*	*<0.2*	*<4.5*	7	*<0.5*	0.77
		LX17-10	BD14-172	140	141	9.1	0.07	*<0.01*	0.02	0.07	0.17	0.6	0.8	14	23	6.2	11
	Average					8.7	0.20	0.02	0.02	0.18	0.11	0.4	0.5	9.1	15	3.4	5.6
HC4	High-S AG	LX17-03	BD15-GT02	26	27	8.5	0.4	0.02	0.01	0.38	*<0.05*	*<0.2*	*<0.2*	*<4.5*	8	*<0.4*	0.67
		LX17-04	BD15-GT02	31	32	7.9	1.1	0.01	0.02	1.1	*<0.05*	0.2	0.2	4.5	8	0.1	0.23
	Average					8.2	0.77	0.02	0.02	0.76	*<0.05*	0.2	0.2	4.5	8	0.3	0.45
HC5	Median-S GA	LX17-01	BD15-GT02	10	11	7.9	0.36	0.03	0.01	0.33	0.06	0.2	0.3	4.5	9	0.4	0.87
		LX17-23	BD14-188	10	11	9.0	0.05	*<0.01*	0.02	0.05	0.3	1.1	1.5	25	34	16	22
	Average					8.5	0.21	0.02	0.02	0.19	0.2	0.7	0.9	15	22	8.2	11.3
HC6	High-S GA	LX17-17	BD14-178	161	162	8.1	0.48	*<0.01*	0.01	0.48	*<0.05*	*<0.2*	*<0.2*	*<4.5*	6	*<0.3*	0.40
		LX17-19	BD15-GT05	15	16	9.0	0.30	*<0.01*	0.02	0.30	*<0.05*	*<0.2*	*<0.2*	*<4.5*	5	*<0.5*	0.53
	Average					8.6	0.39	*<0.01*	0.02	0.39	*<0.05*	*<0.2*	*<0.2*	*<4.5*	6	0.4	0.47
HC7	Median-S GW	LX17-16	BD14-178	49	50	9.1	0.03	*<0.01*	*<0.01*	0.03	0.2	0.7	1.0	16	23	17	25
HC8	High-S GW	LX17-20	BD15-GT05	25	26	9.0	0.29	0.01	0.03	0.28	*<0.05*	*<0.2*	*<0.2*	*<4.5*	7	*<0.5*	0.80
		LX17-21	BD15-GT05	41	42	9.5	0.42	*<0.01*	0.03	0.42	0.05	0.2	0.2	4.5	9	0.3	0.69
	Average					9.3	0.36	0.01	0.03	0.35	0.05	0.2	0.2	4.5	8	0.4	0.74

Notes:
For humidity cells made up of two samples, a 1:1 mixture is assumed
A hyphen indicates the parameter was not analyzed.
Values in grey italics are below the analytical detection limit. Values were set at the limit for calculation of NP, AP and NPR values.
Sulphate S is calculated using the sodium carbonate leach method (CO_3) and the HCl method (HCl).
AP (acid potential) calculated using sulfide sulfur (% non-sulfate sulfur x 31.25)
CaNP (carbonate neutralization potential) calculated using total inorganic carbon (% TIC x (100.09/12.01) x 10)
Modified NP is obtained by modified Sobek method.
NPR = neutralization potential ratio; calculated as CaNP / AP and as Modified NP / AP.

Appendix 4-2, Table 3: Acid-Base Accounting Results - Overburden

Sample ID	Paste pH	Total S	Sulphate S (CO_3)	Sulphate S (HCl)	Sulphide S (calc)	Total C	CO_2	CaNP	Modified NP	NPR	NPR
		%	*%*	*%*	*%*	*%*	*%*	*kg $CaCO_3$/t*	*kg $CaCO_3$/t*	*CaNP/AP*	*Mod.NP/AP*
LX-BDT-01	5.6	0.02	*<0.01*	*<0.01*	0.02	*<0.05*	*<0.2*	*<4.5*	-4	7.28	-6.4
LX-BDT-02	5.7	0.02	*<0.01*	*<0.01*	0.02	*<0.05*	*<0.2*	*<4.5*	-5	7.28	-8
LX-BDT-03	5	0.08	*<0.01*	*<0.01*	0.08	*<0.05*	*<0.2*	*<4.5*	-5	1.82	-2
LX-BDT-04	6.1	0.02	*<0.01*	*<0.01*	0.02	*<0.05*	*<0.2*	*<4.5*	-4	7.28	-6.4
LX-BDT-05	5.7	0.02	*<0.01*	*<0.01*	0.02	*<0.05*	*<0.2*	*<4.5*	-4	7.28	-6.4

Notes:
Values in grey italics are below the analytical detection limit. Values were set at the limit for calculation of NP, AP and NPR values.
Sulphate S is calculated using the sodium carbonate leach method (CO_3) and the HCl method (HCl).
AP (acid potential) calculated using sulfide sulfur (% non-sulfate sulfur x 31.25)
CaNP (carbonate neutralization potential) calculated using total inorganic carbon (% TIC x (100.09/12.01) x 10)
Modified NP is obtained by modified Sobek method.
NPR = neutralization potential ratio; calculated as CaNP / AP and as Modified NP / AP.

Appendix 4-1, Table 4: Acid-Base Accounting Results - Haul Road

Sample ID	Paste pH	Total S	Sulphate S (CO_3)	Sulphate S (HCl)	Sulphide S (calc)	Total C	CO_2	CaNP	Modified NP	NPR	NPR
		%	*%*	*%*	*%*	*%*	*%*	*kg $CaCO_3$/t*	*kg $CaCO_3$/t*	*CaNP/AP*	*Mod.NP/AP*
LX-BDR-01	7.4	*<0.01*	*<0.01*	*<0.01*	*<0.01*	*<0.05*	*<0.2*	*<4.5*	3	14.6	9.6
LX-BDR-02	8.7	*<0.01*	*<0.01*	*<0.01*	*<0.01*	*<0.05*	*<0.2*	*<4.5*	5	14.6	16.0
LX-BDR-03	8.7	*<0.01*	*<0.01*	0.01	*<0.01*	*<0.05*	*<0.2*	*<4.5*	4	14.6	12.8
LX-BDR-04	8.8	*<0.01*	*<0.01*	0.01	*<0.01*	*<0.05*	*<0.2*	*<4.5*	4	14.6	12.8
LX-BDR-05	7.7	*<0.01*	*<0.01*	0.01	*<0.01*	*<0.05*	*<0.2*	*<4.5*	8	14.6	25.6

Notes:
Values in grey italics are below the analytical detection limit. Values were set at the limit for calculation of NP, AP and NPR values.
Sulphate S is calculated using the sodium carbonate leach method (CO_3) and the HCl method (HCl).
AP (acid potential) calculated using sulfide sulfur (% non-sulfate sulfur x 31.25)
CaNP (carbonate neutralization potential) calculated using total inorganic carbon (% TIC x (100.09/12.01) x 10)
Modified NP is obtained by modified Sobek method.
NPR = neutralization potential ratio; calculated as CaNP / AP and as Modified NP / AP.

Appendix 4-3: Solid Phase Elemental Analysis Results

ATLANTIC GOLD

Appendix 4-3, Table 1: Solid Phase Elemental Analysis Results - Mine Rock

Sample ID	Ag	Al	As	B	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu	Fe	Hg	Hg	K	La
	ppm	%	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	%	ppm	ppm	%	ppm
ARGILLITE (AR)																	
LX17-12	<0.2	2.74	17	<10	90	0.5	<2	0.2	<0.5	20	41	28	4.57	<1	<0.005	1.08	30
LX17-22	<0.2	1.24	116	<10	90	<0.5	<2	0.15	<0.5	9	36	18	2.48	<1	<0.005	0.64	10
LX17-24	<0.2	2.94	22	<10	110	0.7	<2	0.36	<0.5	19	41	44	4.85	<1	<0.005	0.99	30
ARGILLITE-GREYWACKE (AG)																	
LX17-02	<0.2	3.22	17	<10	80	0.5	<2	0.2	<0.5	24	37	42	6.22	<1	<0.005	0.83	40
LX17-03	<0.2	2.72	157	<10	110	<0.5	<2	0.26	<0.5	19	44	55	5.3	<1	<0.005	0.98	30
LX17-04	6.6	2.72	11	<10	110	0.6	26	0.25	0.5	29	43	155	6.16	<1	<0.005	1.11	30
LX17-09	<0.2	3.02	15	<10	130	<0.5	<2	0.21	<0.5	21	62	67	5.09	1	<0.005	0.9	20
LX17-10	<0.2	2.64	15	<10	120	<0.5	<2	0.85	<0.5	19	48	4	4.45	1	<0.005	0.85	20
LX17-11	<0.2	3.21	28	10	100	<0.5	<2	0.24	<0.5	25	48	13	5.4	<1	<0.005	0.84	30
LX17-13	<0.2	2.97	8	<10	140	0.5	<2	0.24	<0.5	21	51	26	4.84	<1	<0.005	1.12	30
LX17-28	<0.2	2.9	29	<10	80	0.8	<2	0.34	<0.5	21	45	39	4.85	<1	<0.005	0.63	20
Min	0.20	2.6	8.0	10	80	0.50	2.0	0.20	0.50	19	37	4.0	4.5	1.0	0.0050	0.63	20
Median	0.20	2.9	16	10	110	0.50	2.0	0.25	0.50	21	47	41	5.2	1.0	0.0050	0.88	30
Mean	1.0	2.9	35	10	109	0.55	5.0	0.32	0.50	22	47	50	5.3	1.0	0.0050	0.91	28
Max	6.6	3.2	157	10	140	0.80	26	0.85	0.50	29	62	155	6.2	1.0	0.0050	1.1	40
GREYWACKE-ARGILLITE (GA)																	
LX17-01	0.5	1.5	10	<10	60	0.5	<2	0.4	<0.5	13	38	47	3.06	<1	<0.005	0.43	30
LX17-05	<0.2	3.3	13	<10	150	0.6	<2	1.54	<0.5	17	52	67	4.54	<1	<0.005	0.98	30
LX17-07	<0.2	3.12	9	<10	90	<0.5	<2	0.2	<0.5	23	50	57	5.65	<1	<0.005	0.76	20
LX17-14	<0.2	2.42	14	<10	190	<0.5	<2	0.33	<0.5	16	54	17	3.81	<1	<0.005	1.24	20
LX17-15	<0.2	2.07	17	<10	90	0.5	<2	2.3	<0.5	14	60	6	3.85	<1	<0.005	0.46	30
LX17-17	<0.2	1.97	1915	<10	120	0.6	<2	0.26	<0.5	14	38	51	3.63	<1	<0.005	0.78	20
LX17-18	<0.2	0.69	2800	<10	20	<0.5	<2	0.68	<0.5	4	21	13	1.5	<1	<0.005	0.16	20
LX17-19	<0.2	2.71	1750	<10	90	<0.5	<2	0.12	<0.5	25	39	21	5.12	<1	<0.005	0.86	30
LX17-23	<0.2	1.99	25	<10	130	0.6	<2	1.33	<0.5	13	41	25	3.28	<1	<0.005	0.98	30
LX17-29	<0.2	2.12	14	<10	30	0.9	<2	0.73	<0.5	14	40	21	3.91	<1	<0.005	0.16	30
Min	0.20	0.69	9.0	10	20	0.50	2.0	0.12	0.50	4.0	21	6.0	1.5	1.0	0.0050	0.16	20
Median	0.20	2.1	16	10	90	0.50	2.0	0.54	0.50	14	41	23	3.8	1.0	0.0050	0.77	30
Mean	0.23	2.2	657	10	97	0.57	2.0	0.79	0.50	15	43	33	3.8	1.0	0.0050	0.68	26
Max	0.50	3.3	2800	10	190	0.90	2.0	2.3	0.50	25	60	67	5.7	1.0	0.0050	1.2	30
GREYWACKE (GW)																	
LX17-06	<0.2	2.32	11	<10	130	<0.5	<2	0.57	<0.5	18	50	25	4.05	<1	<0.005	0.74	30
LX17-08	<0.2	2.2	8	10	40	<0.5	<2	0.67	<0.5	15	48	29	3.85	<1	<0.005	0.22	20
LX17-16	<0.2	1.13	10	<10	40	0.7	<2	0.93	<0.5	7	31	18	2.12	<1	<0.005	0.21	30
LX17-20	<0.2	2.68	231	<10	80	<0.5	<2	0.16	<0.5	25	37	35	5.23	<1	<0.005	0.85	20
LX17-21	0.3	1.61	1205	<10	130	<0.5	<2	0.28	<0.5	16	39	24	3.24	<1	<0.005	0.92	20
LX17-25	<0.2	1.33	8	<10	90	<0.5	<2	1.53	<0.5	9	31	28	2.29	<1	<0.005	0.65	20
LX17-26	<0.2	1.24	7	<10	30	<0.5	<2	0.34	<0.5	7	24	9	2.37	<1	<0.005	0.21	20
LX17-27	<0.2	1.32	19	<10	30	0.5	<2	0.51	<0.5	7	31	24	2.53	<1	<0.005	0.15	20
LX17-30	<0.2	2.29	12	<10	20	0.5	<2	2.2	<0.5	16	41	15	4.05	<1	<0.005	0.18	30
Min	0.20	1.1	7.0	10	20	0.50	2.0	0.16	0.50	7.0	24	9.0	2.1	1.0	0.0050	0.15	20
Median	0.20	1.6	11	10	40	0.50	2.0	0.57	0.50	15	37	24	3.2	1.0	0.0050	0.22	20
Mean	0.21	1.8	168	10	66	0.52	2.0	0.80	0.50	13	37	23	3.3	1.0	0.0050	0.46	23
Max	0.30	2.7	1205	10	130	0.70	2.0	2.2	0.50	25	50	35	5.2	1.0	0.0050	0.92	30

Note: Values in grey italics are below the analytical detection limit.

Appendix 4-3, Table 1: Solid Phase Elemental Analysis Results - Mine Rock

Sample ID	Mg	Mn	Mo	Na	Ni	P	Pb	S	Sb	Sc	Sr	Th	Ti	Tl	U	V	W	Zn
	%	*ppm*	*ppm*	*%*	*ppm*	*ppm*	*ppm*	*%*	*ppm*	*ppm*	*ppm*	*ppm*	*%*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*
ARGILLITE (AR)																		
LX17-12	1.43	534	*<1*	0.03	44	610	11	0.02	*<2*	6	10	*<20*	0.17	*<10*	*<10*	44	*<10*	89
LX17-22	0.75	312	*<1*	0.05	15	210	20	0.35	*<2*	6	5	*<20*	0.13	*<10*	*<10*	40	*<10*	57
LX17-24	1.63	621	*<1*	0.03	42	650	6	0.19	*<2*	5	16	*<20*	0.15	*<10*	*<10*	45	*<10*	120
ARGILLITE-GREYWACKE (AG)																		
LX17-02	1.65	634	1	0.02	43	520	10	0.33	*<2*	4	4	*<20*	0.13	*<10*	*<10*	42	*<10*	123
LX17-03	1.33	601	*<1*	0.04	37	490	11	0.43	*<2*	7	9	*<20*	0.15	*<10*	*<10*	54	*<10*	102
LX17-04	1.51	675	1	0.03	59	360	179	1.26	*<2*	7	7	*<20*	0.15	*<10*	*<10*	50	*<10*	143
LX17-09	1.75	680	*<1*	0.04	44	660	*<2*	0.01	*<2*	10	7	*<20*	0.15	*<10*	*<10*	72	*<10*	102
LX17-10	1.52	774	*<1*	0.05	43	640	7	0.06	*<2*	7	20	*<20*	0.16	*<10*	*<10*	54	*<10*	103
LX17-11	1.85	677	*<1*	0.03	51	670	5	0.03	*<2*	6	8	*<20*	0.14	*<10*	*<10*	50	*<10*	116
LX17-13	1.67	726	*<1*	0.04	45	710	3	0.01	*<2*	7	12	*<20*	0.18	*<10*	*<10*	62	*<10*	89
LX17-28	1.74	687	*<1*	0.03	43	690	4	0.04	*<2*	6	24	*<20*	0.09	*<10*	*<10*	49	*<10*	90
Min	1.3	601	1.0	0.020	37	360	2.0	0.010	2.0	4.0	4.0	20	0.090	10	10	42	10	89
Median	1.7	679	1.0	0.035	44	650	6.0	0.050	2.0	7.0	8.5	20	0.15	10	10	52	10	103
Mean	1.6	682	1.0	0.035	46	593	28	0.27	2.0	6.8	11	20	0.14	10	10	54	10	109
Max	1.9	774	1.0	0.050	59	710	179	1.3	2.0	10	24	20	0.18	10	10	72	10	143
GREYWACKE-ARGILLITE (GA)																		
LX17-01	0.8	447	15	0.06	27	560	54	0.41	*<2*	6	8	*<20*	0.09	*<10*	*<10*	40	*<10*	63
LX17-05	1.06	732	*<1*	0.11	45	500	8	0.42	*<2*	8	62	*<20*	0.16	*<10*	*<10*	56	*<10*	80
LX17-07	1.6	640	*<1*	0.03	48	640	4	0.04	*<2*	7	9	*<20*	0.14	*<10*	*<10*	51	*<10*	111
LX17-14	1.33	578	1	0.06	36	710	3	*<0.01*	*<2*	9	24	*<20*	0.2	*<10*	*<10*	66	*<10*	69
LX17-15	1.19	800	*<1*	0.04	30	750	33	0.04	*<2*	8	35	20	0.15	*<10*	*<10*	76	*<10*	65
LX17-17	1.04	511	*<1*	0.07	27	310	8	0.54	*<2*	6	10	*<20*	0.13	*<10*	*<10*	46	*<10*	67
LX17-18	0.4	274	1	0.04	6	180	17	0.15	2	2	6	*<20*	0.03	*<10*	*<10*	20	*<10*	43
LX17-19	1.38	463	1	0.02	46	400	4	0.31	*<2*	4	5	*<20*	0.11	*<10*	*<10*	37	*<10*	110
LX17-23	1.05	512	*<1*	0.05	30	650	7	0.05	*<2*	7	20	*<20*	0.17	*<10*	*<10*	51	*<10*	76
LX17-29	1.24	594	*<1*	0.03	33	680	2	0.03	*<2*	3	13	*<20*	0.03	*<10*	*<10*	42	*<10*	64
Min	0.40	274	1.0	0.020	6.0	180	2.0	0.010	2.0	2.0	5.0	20	0.030	10	10	20	10	43
Median	1.1	545	1.0	0.045	32	600	7.5	0.10	2.0	6.5	12	20	0.14	10	10	49	10	68
Mean	1.1	555	2.4	0.051	33	538	14	0.20	2.0	6.0	19	20	0.12	10	10	49	10	75
Max	1.6	800	15	0.11	48	750	54	0.54	2.0	9.0	62	20	0.20	10	10	76	10	111
GREYWACKE (GW)																		
LX17-06	1.18	624	*<1*	0.05	36	540	5	*<0.01*	*<2*	8	13	*<20*	0.16	*<10*	*<10*	54	*<10*	79
LX17-08	1.35	512	*<1*	0.05	36	630	5	*<0.01*	*<2*	6	10	*<20*	0.09	*<10*	*<10*	57	*<10*	78
LX17-16	0.58	372	1	0.04	15	520	2	0.03	*<2*	3	15	*<20*	0.09	*<10*	*<10*	29	*<10*	34
LX17-20	1.43	518	*<1*	0.02	38	340	3	0.33	*<2*	4	4	*<20*	0.14	*<10*	*<10*	36	*<10*	105
LX17-21	0.89	359	1	0.05	25	260	33	0.45	*<2*	6	7	*<20*	0.15	*<10*	*<10*	47	*<10*	66
LX17-25	0.69	461	*<1*	0.05	18	510	8	*<0.01*	*<2*	5	19	*<20*	0.13	*<10*	*<10*	35	*<10*	50
LX17-26	0.7	310	1	0.04	15	450	2	0.02	*<2*	3	10	*<20*	0.07	*<10*	*<10*	23	*<10*	38
LX17-27	0.71	388	*<1*	0.04	16	530	3	0.02	2	3	14	*<20*	0.06	*<10*	*<10*	32	*<10*	25
LX17-30	1.4	1045	*<1*	0.03	38	770	4	*<0.01*	*<2*	4	22	*<20*	0.02	*<10*	*<10*	42	*<10*	75
Min	0.58	310	1.0	0.020	15	260	2.0	0.010	2.0	3.0	4.0	20	0.020	10	10	23	10	25
Median	0.89	461	1.0	0.040	25	520	4.0	0.020	2.0	4.0	13	20	0.090	10	10	36	10	66
Mean	0.99	510	1.0	0.041	26	506	7.2	0.099	2.0	4.7	13	20	0.10	10	10	39	10	61
Max	1.4	1045	1.0	0.050	38	770	33	0.45	2.0	8.0	22	20	0.16	10	10	57	10	105

Note: Values in grey italics are below the analytical detection limit.

Appendix 4-3, Table 2: Solid Phase Elemental Analysis Results - Humidity Cell Samples

Humidity Cell ID	Description	Sample ID	Ag	Al	As	B	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu	Fe	Hg	Hg	K	La
			ppm	*%*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*%*	*ppm*	*ppm*	*ppm*	*ppm*	*%*	*ppm*	*ppm*	*%*	*ppm*
HC1	Median-S AR	LX17-12	*<0.2*	2.74	17	*<10*	90	0.5	*<2*	0.20	*<0.5*	20	41	28	4.57	*<1*	*<0.005*	1.08	30
HC2	High-S AR	LX17-22	*<0.2*	1.24	116	*<10*	90	*<0.5*	*<2*	0.15	*<0.5*	9	36	18	2.48	*<1*	*<0.005*	0.64	10
		LX17-24	*<0.2*	2.94	22	*<10*	110	0.7	*<2*	0.36	*<0.5*	19	41	44	4.85	*<1*	*<0.005*	0.99	30
	Average		*<0.2*	2.09	69	*<10*	100	0.6	*<2*	0.26	*<0.5*	14	39	31	3.67	*<1*	*<0.005*	0.82	20
HC3	Median-S AG	LX17-02	*<0.2*	3.22	17	*<10*	80	0.5	*<2*	0.20	*<0.5*	24	37	42	6.22	*<1*	*<0.005*	0.83	40
		LX17-10	*<0.2*	2.64	15	*<10*	120	*<0.5*	*<2*	0.85	*<0.5*	19	48	4	4.45	1	*<0.005*	0.85	20
	Average		*<0.2*	2.93	16	*<10*	100	0.5	*<2*	0.53	*<0.5*	22	43	23	5.34	1	*<0.005*	0.84	30
HC4	High-S AG	LX17-03	*<0.2*	2.72	157	*<10*	110	*<0.5*	*<2*	0.26	*<0.5*	19	44	55	5.3	*<1*	*<0.005*	0.98	30
		LX17-04	6.6	2.72	11	*<10*	110	0.6	26	0.25	0.5	29	43	155	6.16	*<1*	*<0.005*	1.11	30
	Average		3.4	2.72	84	*<10*	110	0.6	14	0.26	0.5	24	44	105	5.73	*<1*	*<0.005*	1.05	30
HC5	Median-S GA	LX17-01	0.5	1.5	10	*<10*	60	0.5	*<2*	0.40	*<0.5*	13	38	47	3.06	*<1*	*<0.005*	0.43	30
		LX17-23	*<0.2*	1.99	25	*<10*	130	0.6	*<2*	1.33	*<0.5*	13	41	25	3.28	*<1*	*<0.005*	0.98	30
	Average		0.4	1.75	18	*<10*	95	0.6	*<2*	0.87	*<0.5*	13	40	36	3.17	*<1*	*<0.005*	0.71	30
HC6	High-S GA	LX17-17	*<0.2*	1.97	1915	*<10*	120	0.6	*<2*	0.26	*<0.5*	14	38	51	3.63	*<1*	*<0.005*	0.78	20
		LX17-19	*<0.2*	2.71	1750	*<10*	90	*<0.5*	*<2*	0.12	*<0.5*	25	39	21	5.12	*<1*	*<0.005*	0.86	30
	Average		*<0.2*	2.34	1833	*<10*	105	0.6	*<2*	0.19	*<0.5*	20	39	36	4.38	*<1*	*<0.005*	0.82	25
HC7	Median-S GW	LX17-16	*<0.2*	1.13	10	*<10*	40	0.7	*<2*	0.93	*<0.5*	7	31	18	2.12	*<1*	*<0.005*	0.21	30
HC8	High-S GW	LX17-20	*<0.2*	2.68	231	*<10*	80	*<0.5*	*<2*	0.16	*<0.5*	25	37	35	5.23	*<1*	*<0.005*	0.85	20
		LX17-21	0.3	1.61	1205	*<10*	130	*<0.5*	*<2*	0.28	*<0.5*	16	39	24	3.24	*<1*	*<0.005*	0.92	20
	Average		0.3	2.15	718	*<10*	105	*<0.5*	*<2*	0.22	*<0.5*	21	38	30	4.24	*<1*	*<0.005*	0.89	20

Notes: For humidity cells made up of two samples, a 1:1 mixture is assumed
Values in grey italics are below the analytical detection limit.

Appendix 4-3, Table 2: Solid Phase Elemental Analysis Results - Humidity Cell Samples

Humidity Cell ID	Description	Sample ID	Mg	Mn	Mo	Na	Ni	P	Pb	S	Sb	Sc	Sr	Th	Ti	Tl	U	V	W	Zn
			%	ppm	ppm	%	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm
HC1	Median-S AR	LX17-12	1.43	534	<1	0.03	44	610	11	0.02	<2	6	10	<20	0.17	<10	<10	44	<10	89
HC2	High-S AR	LX17-22	0.75	312	<1	0.05	15	210	20	0.35	<2	6	5	<20	0.13	<10	<10	40	<10	57
		LX17-24	1.63	621	<1	0.03	42	650	6	0.19	<2	5	16	<20	0.15	<10	<10	45	<10	120
	Average		1.19	467	<1	0.04	29	430	13	0.27	<2	6	11	<20	0.14	<10	<10	43	<10	89
HC3	Median-S AG	LX17-02	1.65	634	1	0.02	43	520	10	0.33	<2	4	4	<20	0.13	<10	<10	42	<10	123
		LX17-10	1.52	774	<1	0.05	43	640	7	0.06	<2	7	20	<20	0.16	<10	<10	54	<10	103
	Average		1.59	704	1	0.04	43	580	9	0.20	<2	6	12	<20	0.15	<10	<10	48	<10	113
HC4	High-S AG	LX17-03	1.33	601	<1	0.04	37	490	11	0.43	<2	7	9	<20	0.15	<10	<10	54	<10	102
		LX17-04	1.51	675	1	0.03	59	360	179	1.26	<2	7	7	<20	0.15	<10	<10	50	<10	143
	Average		1.42	638	1	0.04	48	425	95	0.85	<2	7	8	<20	0.15	<10	<10	52	<10	123
HC5	Median-S GA	LX17-01	0.8	447	15	0.06	27	560	54	0.41	<2	6	8	<20	0.09	<10	<10	40	<10	63
		LX17-23	1.05	512	<1	0.05	30	650	7	0.05	<2	7	20	<20	0.17	<10	<10	51	<10	76
	Average		0.93	480	8	0.06	29	605	31	0.23	<2	7	14	<20	0.13	<10	<10	46	<10	70
HC6	High-S GA	LX17-17	1.04	511	<1	0.07	27	310	8	0.54	<2	6	10	<20	0.13	<10	<10	46	<10	67
		LX17-19	1.38	463	1	0.02	46	400	4	0.31	<2	4	5	<20	0.11	<10	<10	37	<10	110
	Average		1.21	487	1	0.05	37	355	6	0.43	<2	5	8	<20	0.12	<10	<10	42	<10	89
HC7	Median-S GW	LX17-16	0.58	372	1	0.04	15	520	2	0.03	<2	3	15	<20	0.09	<10	<10	29	<10	34
HC8	High-S GW	LX17-20	1.43	518	<1	0.02	38	340	3	0.33	<2	4	4	<20	0.14	<10	<10	36	<10	105
		LX17-21	0.89	359	1	0.05	25	260	33	0.45	<2	6	7	<20	0.15	<10	<10	47	<10	66
	Average		1.16	439	1	0.04	32	300	18	0.39	<2	5	6	<20	0.15	<10	<10	42	<10	86

Notes: For humidity cells made up of two samples, a 1:1 mixture is assumed
Values in grey italics are below the analytical detection limit.

Appendix 4-3, Table 3: Solid Phase Elemental Analysis Results - Overburden

Sample ID	Ag	Al	As	B	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu
	ppm	*%*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*%*	*ppm*	*ppm*	*ppm*	*ppm*
LX-BDT-01	0.2	3.17	225	*<10*	50	0.8	*<2*	0.06	*<0.5*	13	37	27
LX-BDT-02	*<0.2*	1.5	24	*<10*	30	*<0.5*	*<2*	0.04	*<0.5*	5	21	16
LX-BDT-03	0.2	0.98	54	*<10*	50	*<0.5*	*<2*	0.13	*<0.5*	5	14	12
LX-BDT-04	*<0.2*	0.53	15	*<10*	30	*<0.5*	*<2*	0.02	*<0.5*	2	8	4
LX-BDT-05	0.2	2.39	105	*<10*	50	0.9	*<2*	0.05	*<0.5*	10	30	15

Sample ID	Fe	Ga	Hg	K	La	Mg	Mn	Mo	Na	Ni	P	Pb
	%	*ppm*	*ppm*	*%*	*ppm*	*%*	*ppm*	*ppm*	*%*	*ppm*	*ppm*	*ppm*
LX-BDT-01	3.88	10	0.064	0.25	20	0.95	490	1	*<0.01*	33	440	13
LX-BDT-02	2.63	10	0.061	0.13	10	0.32	245	1	0.01	17	260	9
LX-BDT-03	1.34	10	0.053	0.19	30	0.32	162	1	0.01	22	220	10
LX-BDT-04	0.96	*<10*	0.038	0.1	*<10*	0.1	112	*<1*	0.01	4	110	7
LX-BDT-05	4.51	10	0.054	0.16	20	0.72	441	1	0.01	19	330	9

Sample ID	S	Sb	Sc	Sr	Th	Ti	Tl	U	V	W	Zn
	%	*ppm*	*ppm*	*ppm*	*ppm*	*%*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*
LX-BDT-01	0.01	*<2*	4	5	*<20*	0.09	*<10*	*<10*	39	*<10*	74
LX-BDT-02	0.02	*<2*	2	8	*<20*	0.05	*<10*	*<10*	27	*<10*	28
LX-BDT-03	0.08	*<2*	1	9	*<20*	0.04	*<10*	*<10*	13	*<10*	37
LX-BDT-04	*<0.01*	*<2*	1	4	*<20*	0.04	*<10*	*<10*	16	*<10*	10
LX-BDT-05	0.01	*<2*	3	6	*<20*	0.08	*<10*	*<10*	45	20	64

Note: Values in grey italics are below the analytical detection limit.

Appendix 4-3, Table 4: Solid Phase Elemental Analysis Results - Haul Road

Sample ID	Ag	Al	As	B	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu
	ppm	*%*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*%*	*ppm*	*ppm*	*ppm*	*ppm*
LX-BDR-01	*<0.2*	1.03	21	*<10*	60	*<0.5*	*<2*	0.14	*<0.5*	4	26	9
LX-BDR-02	*<0.2*	1.69	*<2*	*<10*	110	*<0.5*	*<2*	0.14	*<0.5*	13	30	20
LX-BDR-03	*<0.2*	1.1	2	*<10*	70	*<0.5*	*<2*	0.17	*<0.5*	7	26	17
LX-BDR-04	*<0.2*	1.21	*<2*	*<10*	120	*<0.5*	*<2*	0.12	*<0.5*	8	29	11
LX-BDR-05	*<0.2*	2.79	18	*<10*	190	0.5	*<2*	0.78	*<0.5*	13	52	28

Sample ID	Fe	Ga	Hg	K	La	Mg	Mn	Mo	Na	Ni	P	Pb
	%	*ppm*	*ppm*	*%*	*ppm*	*%*	*ppm*	*ppm*	*%*	*ppm*	*ppm*	*ppm*
LX-BDR-01	1.92	*<10*	*<0.005*	0.38	10	0.5	212	1	0.02	15	380	3
LX-BDR-02	2.87	10	*<0.005*	0.92	20	0.95	392	1	0.03	31	610	5
LX-BDR-03	2.08	*<10*	*<0.005*	0.56	10	0.65	302	1	0.02	18	550	7
LX-BDR-04	2.12	*<10*	*<0.005*	0.77	10	0.6	336	*<1*	0.03	21	440	*<2*
LX-BDR-05	3.63	10	*<0.005*	1.17	30	1.13	625	*<1*	0.11	38	1130	7

Sample ID	S	Sb	Sc	Sr	Th	Ti	Tl	U	V	W	Zn
	%	*ppm*	*ppm*	*ppm*	*ppm*	*%*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*
LX-BDR-01	*<0.01*	*<2*	2	12	*<20*	0.1	*<10*	*<10*	21	*<10*	38
LX-BDR-02	*<0.01*	3	3	10	*<20*	0.13	*<10*	*<10*	32	*<10*	62
LX-BDR-03	*<0.01*	*<2*	2	15	*<20*	0.11	*<10*	*<10*	25	*<10*	45
LX-BDR-04	*<0.01*	*<2*	3	7	*<20*	0.14	*<10*	*<10*	28	*<10*	39
LX-BDR-05	*<0.01*	*<2*	7	55	*<20*	0.18	*<10*	*<10*	53	*<10*	66

Note: Values in grey italics are below the analytical detection limit.

Appendix 4-4: Particle Size Distribution Results

ATLANTIC GOLD

HC 1

Sieve Designation	Aperture (mm)	Weight Retained (g)	(%)	Cumulative (%)
+3/8"	9.500	0.00	0.0%	0.0%
-3/8" + 1/4"	6.300	0.00	0.0%	0.0%
-1/4" + 5	4.000	0.40	0.4%	0.4%
5 + 10	1.700	22.70	22.8%	23.2%
-10 + 35	0.425	40.00	40.2%	63.4%
-48 + 100	0.150	12.80	12.9%	76.3%
-200 + 270	0.053	7.00	7.0%	83.3%
-270	-0.053	16.60	16.7%	100.0%
TOTAL		99.50	100.0%	

HC 2

Sieve Designation	Aperture (mm)	Weight Retained (g)	(%)	Cumulative (%)
+3/8"	9.500	0.00	0.0%	0.0%
-3/8" + 1/4"	6.300	0.20	0.2%	0.2%
-1/4" + 5	4.000	0.50	0.5%	0.7%
5 + 10	1.700	34.80	35.0%	35.7%
-10 + 35	0.425	42.10	42.3%	78.0%
-48 + 100	0.150	9.10	9.1%	87.1%
-200 + 270	0.053	5.20	5.2%	92.4%
-270	-0.053	7.60	7.6%	100.0%
TOTAL		99.50	100.0%	

HC 3

Sieve Designation	Aperture (mm)	Weight Retained (g)	(%)	Cumulative (%)
+3/8"	9.500	0.00	0.0%	0.0%
-3/8" + 1/4"	6.300	0.00	0.0%	0.0%
-1/4" + 5	4.000	0.50	0.5%	0.5%
5 + 10	1.700	23.60	23.8%	24.3%
-10 + 35	0.425	44.40	44.7%	69.0%
-48 + 100	0.150	11.20	11.3%	80.3%
-200 + 270	0.053	6.30	6.3%	86.6%
-270	-0.053	13.30	13.4%	100.0%
TOTAL		99.30	100.0%	

HC 4

Sieve Designation	Aperture (mm)	Weight Retained (g)	(%)	Cumulative (%)
+3/8"	9.500	0.00	0.0%	0.0%
-3/8" + 1/4"	6.300	0.00	0.0%	0.0%
-1/4" + 5	4.000	0.60	0.6%	0.6%
5 + 10	1.700	35.70	35.8%	36.4%
-10 + 35	0.425	44.70	44.8%	81.2%
-48 + 100	0.150	7.40	7.4%	88.7%
-200 + 270	0.053	3.90	3.9%	92.6%
-270	-0.053	7.40	7.4%	100.0%
TOTAL		99.70	100.0%	

HC 5

Sieve Designation	Aperture (mm)	Weight Retained (g)	(%)	Cumulative (%)
+3/8"	9.500	0.00	0.0%	0.0%
-3/8" + 1/4"	6.300	0.00	0.0%	0.0%
-1/4" + 5	4.000	0.80	0.8%	0.8%
5 + 10	1.700	40.60	40.8%	41.6%
-10 + 35	0.425	41.10	41.3%	82.8%
-48 + 100	0.150	6.50	6.5%	89.4%
-200 + 270	0.053	4.00	4.0%	93.4%
-270	-0.053	6.60	6.6%	100.0%
TOTAL		99.60	100.0%	

HC 6

Sieve Designation	Aperture (mm)	Weight Retained (g)	(%)	Cumulative (%)
+3/8"	9.500	0.00	0.0%	0.0%
-3/8" + 1/4"	6.300	0.00	0.0%	0.0%
-1/4" + 5	4.000	1.00	1.0%	1.0%
5 + 10	1.700	33.60	33.9%	34.9%
-10 + 35	0.425	42.40	42.8%	77.7%
-48 + 100	0.150	8.90	9.0%	86.7%
-200 + 270	0.053	4.60	4.6%	91.3%
-270	-0.053	8.60	8.7%	100.0%
TOTAL		99.10	100.0%	

HC 7

Sieve Designation	Aperture (mm)	Weight Retained (g)	(%)	Cumulative (%)
+3/8"	9.500	0.00	0.0%	0.0%
-3/8" + 1/4"	6.300	0.00	0.0%	0.0%
-1/4" + 5	4.000	0.10	0.1%	0.1%
5 + 10	1.700	33.30	33.5%	33.6%
-10 + 35	0.425	41.80	42.1%	75.7%
-48 + 100	0.150	9.50	9.6%	85.3%
-200 + 270	0.053	6.50	6.5%	91.8%
-270	-0.053	8.10	8.2%	100.0%
TOTAL		99.30	100.0%	

HC 8

Sieve Designation	Aperture (mm)	Weight Retained (g)	(%)	Cumulative (%)
+3/8"	9.500	0.00	0.0%	0.0%
-3/8" + 1/4"	6.300	0.00	0.0%	0.0%
-1/4" + 5	4.000	0.80	0.8%	0.8%
5 + 10	1.700	34.30	34.5%	35.3%
-10 + 35	0.425	40.20	40.4%	75.8%
-48 + 100	0.150	9.10	9.2%	84.9%
-200 + 270	0.053	5.10	5.1%	90.0%
-270	-0.053	9.90	10.0%	100.0%
TOTAL		99.40	100.0%	

Appendix 4-5: Kinetic Test Results

ATLANTIC GOLD

Appendix 4-5, Table 1: Kinetic Test Results - Cell Description

Cell No.	Sample ID	Sample Type	Method Reference	Column Dimensions		Column Packing			Total Volume of Initial Flushings	Flushing Rate/Weekly Input*	Temp	Sampling Frequency	Start-up Date	Sampling Day	Operation Procedure	Sample Prep for Flushings
				Inner Diameter (cm)	Length (cm)	Dry Wt. of Sample (kg)	Other Materials Used	Column Material	(mL)	(mL)	(°C)		**2018**			
HC 1	LX17-12	Waste Rock	MEND	10.00	20.00	1.00	Plexiglas perforated disk & nylon mesh	Plexiglas	500	500	20-22 °C	Weekly	**26-Apr**	Thursday	Flood Leach	None
HC 2	LX17-24 + LX17-22 Composite	Waste Rock	MEND	10.00	20.00	1.00	Plexiglas perforated disk & nylon mesh	Plexiglas	500	500	20-22 °C	Weekly	**26-Apr**	Thursday	Flood Leach	None
HC 3	LX17-10 + LX17-02 Composite	Waste Rock	MEND	10.00	20.00	1.00	Plexiglas perforated disk & nylon mesh	Plexiglas	500	500	20-22 °C	Weekly	**26-Apr**	Thursday	Flood Leach	None
HC 4	LX17-03 + LX17-04 Composite	Waste Rock	MEND	10.00	20.00	1.00	Plexiglas perforated disk & nylon mesh	Plexiglas	500	500	20-22 °C	Weekly	**26-Apr**	Thursday	Flood Leach	None
HC 5	LX17-23 + LX17-01 Composite	Waste Rock	MEND	10.00	20.00	1.00	Plexiglas perforated disk & nylon mesh	Plexiglas	500	500	20-22 °C	Weekly	**26-Apr**	Thursday	Flood Leach	None
HC 6	LX17-17 + LX17-19 Composite	Waste Rock	MEND	10.00	20.00	1.00	Plexiglas perforated disk & nylon mesh	Plexiglas	500	500	20-22 °C	Weekly	**26-Apr**	Thursday	Flood Leach	None
HC 7	LX17-16	Waste Rock	MEND	10.00	20.00	1.00	Plexiglas perforated disk & nylon mesh	Plexiglas	500	500	20-22 °C	Weekly	**26-Apr**	Thursday	Flood Leach	None
HC 8	LX17-20 + LX17-21 Composite	Waste Rock	MEND	10.00	20.00	1.00	Plexiglas perforated disk & nylon mesh	Plexiglas	500	500	20-22 °C	Weekly	**26-Apr**	Thursday	Flood Leach	None

Appendix 4-5, Table 2: Kinetic Test Results - HC1

Mass	**1**																								
Date	**Cycle**	**Volume mL**		**pH**	**Cond.**	**Acidity**	**Acidity**	**Alkalinity**	**Sulphate**	**Chloride**	**Fluoride**	**Hardness**	**Al**	**Sb**	**As**	**Ba**	**Be**	**Bi**	**B**	**Cd**	**Ca**	**Cr**	**Co**	**Cu**	**Fe**
	No.	**Input**	**Output**			**(pH 4.5)**	**(pH 8.3)**					**$CaCO_3$**													
					umhos/cm	$mgCaCO_3/L$	$mgCaCO_3/L$	$mgCaCO_3/L$	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
26-Apr-18	0	500	325	7.08	67	#N/A	3.2	12.6	3	3	0.17	6.5	0.247	*<0.0001*	0.0121	0.00090	*<3.5E-06*	0.000008	0.008	0.000003	2.20	0.00011	0.000015	0.00054	0.040
3-May-18	1	500	470	7.75	74	#N/A	1.8	17.9	8	3	0.17	11.4	0.278	0.0004	0.0296	0.00119	*<3.5E-06*	0.000007	0.012	0.000003	3.86	0.00010	0.000013	0.00046	0.039
10-May-18	2	500	460	7.67	52	#N/A	2.6	16.6	5	1	0.17	7.9	0.310	0.0004	0.0352	0.00102	*<3.5E-06*	0.000009	0.011	0.000006	2.62	0.00013	0.000042	0.00037	0.046
17-May-18	3	500	450	7.71	46	#N/A	2.1	15.4	4	*<0.5*	0.16	5.8	0.179	0.0003	0.0398	0.00062	*<3.5E-06*	*<3.5E-06*	0.017	0.000016	1.92	0.00004	0.000014	0.00024	0.007
24-May-18	4	500	430	7.68	56	#N/A	3.4	18.4	5																
31-May-18	5	500	455	7.76	44	#N/A	2.3	17.8	3	*<0.5*	0.16	7.5	0.225	0.0004	0.0622	0.00106	*<3.5E-06*	0.000009	0.010	*<1.5E-06*	2.46	0.00006	0.000045	0.00042	0.045
7-Jun-18	6	500	500	7.77	41	#N/A	2.9	18.1	3																
14-Jun-18	7	500	455	7.68	29	#N/A	3.4	13.6	2	*<0.5*	0.08	6.2	0.161	0.0002	0.0460	0.00057	*<3.5E-06*	*<3.5E-06*	0.007	*<1.5E-06*	2.01	0.00004	0.000023	0.00096	0.014
21-Jun-18	8	500	445	7.64	26	#N/A	4.0	11.8	2																
28-Jun-18	9	500	430	7.61	24	#N/A	4.5	11.1	2	*<0.5*	0.07	4.8	0.191	*<0.0001*	0.0368	0.00088	*<3.5E-06*	0.000012	0.006	0.000019	1.53	0.00010	0.000069	0.00013	0.070
5-Jul-18	10	500	410	7.57	21	#N/A	4.7	9.4	2																
12-Jul-18	11	500	440	7.57	26	#N/A	1.4	10.6	3	*<0.5*	*<0.03*	5.89	0.101	*<0.0001*	0.0359	0.00070	*<3.5E-06*	*<3.5E-06*	0.007	*<1.5E-06*	1.95	0.00004	0.000049	0.00655	0.009
19-Jul-18	12	500	430	7.64	25	#N/A	1.3	13.4	3																
26-Jul-18	13	500	450	7.45	25	#N/A	2.2	11.5	4	*<0.5*	0.06	5.5	0.094	*<0.0001*	0.0373	0.00052	*<3.5E-06*	*<3.5E-06*	0.004	0.000003	1.75	*<0.000015*	0.000028	0.00023	0.010
2-Aug-18	14	500	435	7.61	24	#N/A	1.5	11.5	3																
9-Aug-18	15	500	420	7.57	22	#N/A	1.8	10.4	3	*<0.5*	0.06	4.9	0.101	*<0.0001*	0.0490	0.00051	*<3.5E-06*	*<3.5E-06*	0.005	*<1.5E-06*	1.54	0.00004	0.000021	0.00042	0.010
16-Aug-18	16	500	440	7.72	25	#N/A	3.0	12.9	2																
23-Aug-18	17	500	420	7.60	21	#N/A	3.7	11.3	3	*<0.5*	*<0.03*	5.31	0.092	*<0.0001*	0.0485	0.00046	*<3.5E-06*	*<3.5E-06*	0.008	*<1.5E-06*	1.68	0.00005	0.000027	0.00728	0.015
30-Aug-18	18	500	420	7.55	20	#N/A	2.5	10.8	3																
6-Sep-18	19	500	415	7.53	19	#N/A	3.6	10.3	2	*<0.5*	*<0.03*	4.7	0.110	*<0.0001*	0.0655	0.00064	*<3.5E-06*	*<3.5E-06*	0.007	0.000008	1.47	0.00005	0.000039	0.00030	0.016
13-Sep-18	20	500	415	7.35	17	#N/A	3.9	10.0	*<1*																
20-Sep-18	21	500	425	7.48	20	#N/A	2.5	9.6	2	*<0.5*	*<0.03*	4.3	0.064	*<0.0001*	0.0404	0.00042	0.000007	*<3.5E-06*	0.004	*<1.5E-06*	1.31	0.00004	0.000027	0.00042	0.017
27-Sep-18	22	500	415	7.48	21	#N/A	3.1	9.7	2																
4-Oct-18	23	500	415	7.37	20	#N/A	4.1	9.7	*<1*	*<0.5*	*<0.03*	4.4	0.073	*<0.0001*	0.0452	0.00057	*<3.5E-06*	*<3.5E-06*	0.004	*<1.5E-06*	1.34	0.00007	0.000026	0.00034	0.015
11-Oct-18	24	500	400	7.81	18	#N/A	3.0	8.7	*<1*																

Loads	**mg/kg**								mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
26-Apr-18	0			7.08					0.975	0.975	0.05525	2.1125	0.080275	0.0000325	0.0039325	0.0002925	1.1375E-06	0.0000026	0.0026	9.75E-07	0.715	3.575E-05	4.875E-06	0.0001755	0.013
3-May-18	1			7.75					3.76	1.41	0.0799	5.358	0.13066	0.000188	0.013912	0.0005593	1.645E-06	3.29E-06	0.00564	1.41E-06	1.8142	0.000047	6.11E-06	0.0002162	0.01833
10-May-18	2			7.67					2.3	0.46	0.0782	3.634	0.1426	0.000184	0.016192	0.0004692	0.00000161	4.14E-06	0.00506	2.76E-06	1.2052	0.0000598	1.932E-05	0.0001702	0.02116
17-May-18	3			7.71					1.8	0.225	0.072	2.61	0.08055	0.000135	0.01791	0.000279	1.575E-06	1.575E-06	0.00765	0.0000072	0.864	0.000018	0.0000063	0.000108	0.00315
24-May-18	4			7.68					2.15																
31-May-18	5			7.76					1.365	0.2275	0.0728	3.4125	0.102375	0.000182	0.028301	0.0004823	1.5925E-06	4.095E-06	0.00455	6.825E-07	1.1193	0.0000273	2.048E-05	0.0001911	0.020475
7-Jun-18	6			7.77					1.5																
14-Jun-18	7			7.68					0.91	0.2275	0.0364	2.821	0.073255	0.000091	0.02093	0.0002594	1.5925E-06	1.593E-06	0.003185	6.825E-07	0.91455	0.0000182	1.047E-05	0.0004368	0.00637
21-Jun-18	8			7.64					0.89																
28-Jun-18	9			7.61					0.86	0.215	0.0301	2.064	0.08213	0.000043	0.015824	0.0003784	1.505E-06	5.16E-06	0.00258	8.17E-06	0.6579	0.000043	2.967E-05	0.0000559	0.0301
5-Jul-18	10			7.57					0.82																
12-Jul-18	11			7.57					1.32	0.22	0.0132	2.5916	0.04444	0.000044	0.015796	0.000308	0.00000154	1.54E-06	0.00308	6.6E-07	0.858	0.0000176	2.156E-05	0.002882	0.00396
19-Jul-18	12			7.64					1.29																
26-Jul-18	13			7.45					1.8	0.225	0.027	2.475	0.0423	0.000045	0.016785	0.000234	1.575E-06	1.575E-06	0.0018	1.35E-06	0.7875	6.75E-06	0.0000126	0.0001035	0.0045
2-Aug-18	14			7.61					1.305																
9-Aug-18	15			7.57					1.26	0.21	0.0252	2.058	0.04242	0.000042	0.02058	0.0002142	0.00000147	1.47E-06	0.0021	6.3E-07	0.6468	0.0000168	8.82E-06	0.0001764	0.0042
16-Aug-18	16			7.72					0.88																
23-Aug-18	17			7.60					1.26	0.21	0.0126	2.2302	0.03864	0.000042	0.02037	0.0001932	0.00000147	1.47E-06	0.00336	6.3E-07	0.7056	0.000021	1.134E-05	0.0030576	0.0063
30-Aug-18	18			7.55					1.26																
6-Sep-18	19			7.53					0.83	0.2075	0.01245	1.9505	0.04565	0.0000415	0.0271825	0.0002656	1.4525E-06	1.453E-06	0.002905	3.32E-06	0.61005	2.075E-05	1.619E-05	0.0001245	0.00664
13-Sep-18	20			7.35					0.415																
20-Sep-18	21			7.48					0.85	0.2125	0.01275	1.8275	0.0272	0.0000425	0.01717	0.0001785	2.975E-06	1.488E-06	0.0017	6.375E-07	0.55675	0.000017	1.148E-05	0.0001785	0.007225
27-Sep-18	22			7.48					0.83																
4-Oct-18	23			7.37					0.415	0.2075	0.01245	1.826	0.030295	0.0000415	0.018758	0.0002366	1.4525E-06	1.453E-06	0.00166	6.225E-07	0.5561	2.905E-05	1.079E-05	0.0001411	0.006225
11-Oct-18	24			7.81					0.4																

Appendix 4-5, Table 2: Kinetic Test Results - HC1

Mass	**1**																								
Date	**Cycle**	**Volume mL**		**Pb**	**Li**	**Mg**	**Mn**	**Hg**	**Mo**	**Ni**	**P**	**K**	**Se**	**Si**	**Ag**	**Na**	**Sr**	**S**	**Tl**	**Sn**	**Ti**	**U**	**V**	**Zn**	**Zr**
	No.	**Input**	**Output**																						
				mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
26-Apr-18	0	500	325	0.00009	0.0046	0.247	0.00107	*<0.005*	0.00681	0.0002	0.018	5.40	0.00034	1.03	*<0.000025*	4.67	0.00435	1.1	0.000012	0.00030	0.00214	0.000013	0.00078	*<0.001*	*<0.001*
3-May-18	1	500	470	0.00009	0.0057	0.427	0.0017	*<0.005*	0.0133	0.0001	0.007	5.51	0.00054	1.48	*<0.000025*	6.35	0.00773	2.5	*<2.5E-06*	0.00014	0.00240	0.000160	0.00157	*<0.001*	*<0.001*
10-May-18	2	500	460	0.00011	0.0040	0.338	0.0014	*<0.005*	0.00926	0.0002	0.014	4.77	0.00036	1.53	*<0.000025*	4.61	0.00530	2.2	0.000016	0.00023	0.00299	0.000199	0.00193	*<0.001*	*<0.001*
17-May-18	3	500	450	0.00004	0.0035	0.251	0.0008	*<0.005*	0.00608	*<0.00005*	0.008	3.55	0.00040	1.35	*<0.000025*	4.22	0.00447	2.5	*<2.5E-06*	0.00010	0.00040	0.000341	0.00191	*<0.001*	*<0.001*
24-May-18	4	500	430																						
31-May-18	5	500	455	0.00012	0.0026	0.331	0.00100	*<0.005*	0.00221	0.0001	0.011	4.66	0.00025	2.00	*<0.000025*	2.92	0.00508	0.6	*<2.5E-06*	0.00004	0.00208	0.000668	0.00287	*<0.001*	*<0.001*
7-Jun-18	6	500	500																						
14-Jun-18	7	500	455	0.00005	0.0020	0.286	0.00088	*<0.005*	0.00125	*<0.00005*	*<0.0015*	3.32	0.00023	1.74	*<0.000025*	1.53	0.00411	0.9	*<2.5E-06*	0.00003	0.00074	0.000673	0.00226	*<0.001*	*<0.001*
21-Jun-18	8	500	445																						
28-Jun-18	9	500	430	0.00023	0.0018	0.247	0.00164	*<0.005*	0.00072	0.0002	*<0.0015*	3.03	0.00011	1.52	*<0.000025*	1.07	0.00331	1.0	*<2.5E-06*	0.00007	0.00289	0.000341	0.00196	*<0.001*	*<0.001*
5-Jul-18	10	500	410																						
12-Jul-18	11	500	440	*<0.000005*	0.0016	0.246	0.00115	*<0.005*	0.00057	*<0.00005*	*<0.0015*	2.70	0.00009	1.26	*<0.000025*	1.10	0.00350	0.7	*<2.5E-06*	0.00008	0.00049	0.000363	0.00199	*<0.001*	*<0.001*
19-Jul-18	12	500	430																						
26-Jul-18	13	500	450	0.00002	0.0017	0.278	0.00072	*<0.005*	0.00045	*<0.00005*	*<0.0015*	3.03	0.00009	1.75	*<0.000025*	1.02	0.00360	*<0.05*	*<2.5E-06*	0.00003	0.00040	0.000371	0.00250	*<0.001*	*<0.001*
2-Aug-18	14	500	435																						
9-Aug-18	15	500	420	0.00005	0.0017	0.248	0.00065	*<0.005*	0.00037	*<0.00005*	*<0.0015*	2.86	0.00010	2.02	*<0.000025*	0.87	0.00323	0.5	*<2.5E-06*	0.00004	0.00065	0.000235	0.00322	*<0.001*	*<0.001*
16-Aug-18	16	500	440																						
23-Aug-18	17	500	420	0.00004	0.0015	0.273	0.00074	*<0.005*	0.00162	*<0.00005*	*<0.0015*	3.04	0.00011	4.46	*<0.000025*	0.84	0.00359	*<0.05*	*<2.5E-06*	0.00037	0.00072	0.000236	0.00354	*<0.001*	*<0.001*
30-Aug-18	18	500	420																						
6-Sep-18	19	500	415	0.00005	0.0018	0.259	0.00068	*<0.005*	0.00030	*<0.00005*	*<0.0015*	2.91	0.00011	2.77	*<0.000025*	0.67	0.00317	*<0.05*	*<2.5E-06*	*<0.000005*	0.00085	0.000137	0.00466	*<0.001*	*<0.001*
13-Sep-18	20	500	415																						
20-Sep-18	21	500	425	0.00005	0.0014	0.242	0.00063	0.03	0.00027	*<0.00005*	*<0.0015*	2.34	0.00006	2.20	*<0.000025*	0.40	0.00297	3.2	*<2.5E-06*	0.00004	0.00071	0.000090	0.00286	*<0.001*	*<0.001*
27-Sep-18	22	500	415																						
4-Oct-18	23	500	415	0.00005	0.0017	0.245	0.00054	*<0.005*	0.00020	0.0002	*<0.0015*	2.40	0.00006	2.72	*<0.000025*	0.45	0.00277	0.9	*<2.5E-06*	0.00005	0.00083	0.000089	0.00348	*<0.001*	*<0.001*
11-Oct-18	24	500	400																						

Loads	**mg/kg**			mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
26-Apr-18	0			2.925E-05	0.001495	0.080275	0.0003478	0.001625	0.0022133	0.000065	0.00585	1.755	0.0001105	0.33475	8.125E-06	1.51775	0.0014138	0.3575	0.0000039	0.0000975	0.0006955	4.225E-06	0.0002535	0.000325	0.000325
3-May-18	1			0.0000423	0.002679	0.20069	0.000799	0.00235	0.006251	0.000047	0.00329	2.5897	0.0002538	0.6956	1.175E-05	2.9845	0.0036331	1.175	1.175E-06	0.0000658	0.001128	0.0000752	0.0007379	0.00047	0.00047
10-May-18	2			0.0000506	0.00184	0.15548	0.000644	0.0023	0.0042596	0.000092	0.00644	2.1942	0.0001656	0.7038	0.0000115	2.1206	0.002438	1.012	7.36E-06	0.0001058	0.0013754	9.154E-05	0.0008878	0.00046	0.00046
17-May-18	3			0.000018	0.001575	0.11295	0.00036	0.00225	0.002736	0.0000225	0.0036	1.5975	0.00018	0.6075	1.125E-05	1.899	0.0020115	1.125	1.125E-06	0.000045	0.00018	0.0001535	0.0008595	0.00045	0.00045
24-May-18	4																								
31-May-18	5			0.0000546	0.001183	0.150605	0.000455	0.002275	0.0010056	0.0000455	0.005005	2.1203	0.0001138	0.91	1.138E-05	1.3286	0.0023114	0.273	1.138E-06	0.0000182	0.0009464	0.0003039	0.0013059	0.000455	0.000455
7-Jun-18	6																								
14-Jun-18	7			2.275E-05	0.00091	0.13013	0.0004004	0.002275	0.0005688	2.275E-05	0.0006825	1.5106	0.0001047	0.7917	1.138E-05	0.69615	0.0018701	0.4095	1.138E-06	1.365E-05	0.0003367	0.0003062	0.0010283	0.000455	0.000455
21-Jun-18	8																								
28-Jun-18	9			0.0000989	0.000774	0.10621	0.0007052	0.00215	0.0003096	0.000086	0.000645	1.3029	0.0000473	0.6536	1.075E-05	0.4601	0.0014233	0.43	1.075E-06	0.0000301	0.0012427	0.0001466	0.0008428	0.00043	0.00043
5-Jul-18	10																								
12-Jul-18	11			0.0000022	0.000704	0.10824	0.000506	0.0022	0.0002508	0.000022	0.00066	1.188	0.0000396	0.5544	0.000011	0.484	0.00154	0.308	0.0000011	0.0000352	0.0002156	0.0001597	0.0008756	0.00044	0.00044
19-Jul-18	12																								
26-Jul-18	13			0.000009	0.000765	0.1251	0.000324	0.00225	0.0002025	0.0000225	0.000675	1.3635	0.0000405	0.7875	1.125E-05	0.459	0.00162	0.0225	1.125E-06	0.0000135	0.00018	0.000167	0.001125	0.00045	0.00045
2-Aug-18	14																								
9-Aug-18	15			0.000021	0.000714	0.10416	0.000273	0.0021	0.0001554	0.000021	0.00063	1.2012	0.000042	0.8484	0.0000105	0.3654	0.0013566	0.21	1.05E-06	0.0000168	0.000273	0.0000987	0.0013524	0.00042	0.00042
16-Aug-18	16																								
23-Aug-18	17			0.0000168	0.00063	0.11466	0.0003108	0.0021	0.0006804	0.000021	0.00063	1.2768	0.0000462	1.8732	0.0000105	0.3528	0.0015078	0.021	1.05E-06	0.0001554	0.0003024	9.912E-05	0.0014868	0.00042	0.00042
30-Aug-18	18																								
6-Sep-18	19			2.075E-05	0.000747	0.107485	0.0002822	0.002075	0.0001245	2.075E-05	0.0006225	1.20765	4.565E-05	1.14955	1.038E-05	0.27805	0.0013156	0.02075	1.038E-06	2.075E-06	0.0003528	5.686E-05	0.0019339	0.000415	0.000415
13-Sep-18	20																								
20-Sep-18	21			2.125E-05	0.000595	0.10285	0.0002678	0.01275	0.0001148	2.125E-05	0.0006375	0.9945	0.0000255	0.935	1.063E-05	0.17	0.0012623	1.36	1.063E-06	0.000017	0.0003018	3.825E-05	0.0012155	0.000425	0.000425
27-Sep-18	22																								
4-Oct-18	23			2.075E-05	0.0007055	0.101675	0.0002241	0.002075	0.000083	0.000083	0.0006225	0.996	0.0000249	1.1288	1.038E-05	0.18675	0.0011496	0.3735	1.038E-06	2.075E-05	0.0003445	3.694E-05	0.0014442	0.000415	0.000415
11-Oct-18	24																								

Appendix 4-5, Table 3: Kinetic Test Results - HC2

Mass	1																								
Date	**Cycle**	**Volume mL**		**pH**	**Cond.**	**Acidity**	**Acidity**	**Alkalinity**	**Sulphate**	**Chloride**	**Fluoride**	**Hardness**	**Al**	**Sb**	**As**	**Ba**	**Be**	**Bi**	**B**	**Cd**	**Ca**	**Cr**	**Co**	**Cu**	**Fe**
	No.	**Input**	**Output**			**(pH 4.5)**	**(pH 8.3)**					**$CaCO_3$**													
					umhos/cm	$mgCaCO_3/L$	$mgCaCO_3/L$	$mgCaCO_3/L$	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
26-Apr-18	0	500	315	7.43	358	#N/A	3.9	16.1	102	10	0.11	107	0.099	<0.0001	0.0594	0.00647	<3.5E-06	<3.5E-06	0.015	0.000005	36.9	0.00010	0.000275	0.00043	<0.0035
3-May-18	1	500	445	7.70	441	#N/A	2.7	25.0	154	9	0.13	179	0.098	0.0005	0.0543	0.0113	<3.5E-06	<3.5E-06	0.030	0.000019	62.0	<0.000015	0.000509	0.00044	<0.0035
10-May-18	2	500	445	7.74	292	#N/A	3.1	27.5	92	3	0.17	112	0.124	0.0006	0.0626	0.00680	<3.5E-06	<3.5E-06	0.027	0.000014	37.4	0.00004	0.000222	0.00026	<0.0035
17-May-18	3	500	445	7.86	177	#N/A	2.3	24.2	48	1	0.13	54.7	0.125	0.0004	0.0568	0.00393	<3.5E-06	<3.5E-06	0.023	0.000017	18.4	<0.000015	0.000092	0.00030	<0.0035
24-May-18	4	500	420	7.66	145	#N/A	4.0	22.1	41																
31-May-18	5	500	435	7.85	177	#N/A	2.7	24.6	47	<0.5	0.12	63.9	0.122	0.0004	0.0646	0.00376	<3.5E-06	<3.5E-06	0.015	0.000006	22.0	0.00003	0.000114	0.00966	0.009
7-Jun-18	6	500	495	7.84	161	#N/A	3.4	24.1	43																
14-Jun-18	7	500	445	7.76	168	#N/A	4.1	20.8	44	<0.5	0.08	62.9	0.103	0.0003	0.0474	0.00339	<3.5E-06	<3.5E-06	0.011	0.000007	21.3	<0.000015	0.000121	0.00032	<0.0035
21-Jun-18	8	500	425	7.76	177	#N/A	4.5	21.1	51																
28-Jun-18	9	500	430	7.71	165	#N/A	5.3	20.4	51	<0.5	0.06	62.0	0.095	0.0002	0.0370	0.00341	<3.5E-06	<3.5E-06	0.008	0.000031	21.2	0.00005	0.000120	<0.00001	<0.0035
5-Jul-18	10	500	415	7.68	147	#N/A	5.1	19.0	40																
12-Jul-18	11	500	435	7.74	153	#N/A	1.8	18.7	44	<0.5	<0.03	63.3	0.093	<0.0001	0.0337	0.00338	<3.5E-06	<3.5E-06	0.008	<0.0000015	21.3	<0.000015	0.000150	0.00302	<0.0035
19-Jul-18	12	500	430	7.68	150	#N/A	1.3	18.0	47																
26-Jul-18	13	500	435	7.61	140	#N/A	2.4	18.8	44	<0.5	<0.03	57.3	0.077	<0.0001	0.0238	0.00296	<3.5E-06	<3.5E-06	0.008	0.000003	19.4	<0.000015	0.000127	0.00021	<0.0035
2-Aug-18	14	500	430	7.73	134	#N/A	1.8	18.4	46																
9-Aug-18	15	500	420	7.64	125	#N/A	2.0	15.9	41	<0.5	<0.03	50.9	0.085	<0.0001	0.0241	0.00267	<3.5E-06	<3.5E-06	0.005	0.000008	17.4	<0.000015	0.000112	0.00039	<0.0035
16-Aug-18	16	500	440	7.63	115	#N/A	3.4	17.5	42																
23-Aug-18	17	500	430	7.57	112	#N/A	4.0	16.1	38	<0.5	<0.03	48.5	0.071	<0.0001	0.0211	0.00255	<3.5E-06	<3.5E-06	0.006	0.000006	16.9	<0.000015	0.000127	0.00027	<0.0035
30-Aug-18	18	500	430	7.64	100	#N/A	2.7	16.2	36																
6-Sep-18	19	500	415	7.61	95	#N/A	3.8	17.0	35	<0.5	<0.03	42.4	0.080	<0.0001	0.0229	0.00241	<3.5E-06	<3.5E-06	0.007	0.000006	14.7	0.00004	0.000094	0.00040	<0.0035
13-Sep-18	20	500	420	7.41	93	#N/A	4.1	14.9	33																
20-Sep-18	21	500	425	7.68	121	#N/A	2.6	16.1	35	<0.5	<0.03	44.6	0.062	<0.0001	0.0218	0.00218	0.000007	<3.5E-06	0.005	0.000008	15.5	0.00004	0.000110	0.00062	0.007
27-Sep-18	22	500	425	7.64	129	#N/A	3.8	15.5	37																
4-Oct-18	23	500	435	7.49	112	#N/A	4.0	15.1	30	<0.5	<0.03	40.5	0.062	<0.0001	0.0187	0.00215	<3.5E-06	<3.5E-06	0.005	0.000004	14.3	0.00004	0.000100	0.00042	<0.0035
11-Oct-18	24	500	405	7.59	109	#N/A	4.9	14.3	30																

Loads	**mg/kg**								mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
26-Apr-18	0			7.43					32.13	3.15	0.03465	33.705	0.031185	0.0000315	0.018711	0.0020381	1.103E-06	1.103E-06	0.004725	0.000001575	11.6235	0.0000315	0.000086625	0.0001355	0.0011025
3-May-18	1			7.70					68.53	4.005	0.05785	79.655	0.04361	0.0002225	0.0241635	0.0050285	1.558E-06	1.558E-06	0.01335	0.000008455	27.59	6.675E-06	0.000226505	0.0001958	0.0015575
10-May-18	2			7.74					40.94	1.335	0.07565	49.84	0.05518	0.000267	0.027857	0.003026	1.558E-06	1.558E-06	0.012015	0.00000623	16.643	0.0000178	0.00009879	0.0001157	0.0015575
17-May-18	3			7.86					21.36	0.445	0.05785	24.3415	0.055625	0.000178	0.025276	0.0017489	1.558E-06	1.558E-06	0.010235	0.000007565	8.188	6.675E-06	0.00004094	0.0001335	0.0015575
24-May-18	4			7.66					17.22																
31-May-18	5			7.85					20.445	0.2175	0.0522	27.7965	0.05307	0.000174	0.028101	0.0016356	1.523E-06	1.523E-06	0.006525	0.00000261	9.57	1.305E-05	0.00004959	0.0042021	0.003915
7-Jun-18	6			7.84					21.285																
14-Jun-18	7			7.76					19.58	0.2225	0.0356	27.9905	0.045835	0.0001335	0.021093	0.0015086	1.558E-06	1.558E-06	0.004895	0.000003115	9.4785	6.675E-06	0.000053845	0.0001424	0.0015575
21-Jun-18	8			7.76					21.675																
28-Jun-18	9			7.71					21.93	0.215	0.0258	26.66	0.04085	0.000086	0.01591	0.0014663	1.505E-06	1.505E-06	0.00344	0.00001333	9.116	0.0000215	0.0000516	0.0000043	0.001505
5-Jul-18	10			7.68					16.6																
12-Jul-18	11			7.74					19.14	0.2175	0.01305	27.5355	0.040455	0.0000435	0.0146595	0.0014703	1.523E-06	1.523E-06	0.00348	6.525E-07	9.2655	6.525E-06	0.00006525	0.0013137	0.0015225
19-Jul-18	12			7.68					20.21																
26-Jul-18	13			7.61					19.14	0.2175	0.01305	24.9255	0.033495	0.0000435	0.010353	0.0012876	1.523E-06	1.523E-06	0.00348	0.000001305	8.439	6.525E-06	0.000055245	9.135E-05	0.0015225
2-Aug-18	14			7.73					19.78																
9-Aug-18	15			7.64					17.22	0.21	0.0126	21.378	0.0357	0.000042	0.010122	0.0011214	1.47E-06	1.47E-06	0.0021	0.00000336	7.308	0.0000063	0.00004704	0.0001638	0.00147
16-Aug-18	16			7.63					18.48																
23-Aug-18	17			7.57					16.34	0.215	0.0129	20.855	0.03053	0.000043	0.009073	0.0010965	1.505E-06	1.505E-06	0.00258	0.00000258	7.267	6.45E-06	0.00005461	0.0001161	0.001505
30-Aug-18	18			7.64					15.48																
6-Sep-18	19			7.61					14.525	0.2075	0.01245	17.596	0.0332	0.0000415	0.0095035	0.0010002	1.453E-06	1.453E-06	0.002905	0.00000249	6.1005	0.0000166	0.00003901	0.000166	0.0014525
13-Sep-18	20			7.41					13.86																
20-Sep-18	21			7.68					14.875	0.2125	0.01275	18.955	0.02635	0.0000425	0.009265	0.0009265	2.975E-06	1.488E-06	0.002125	0.0000034	6.5875	0.000017	0.00004675	0.0002635	0.002975
27-Sep-18	22			7.64					15.725																
4-Oct-18	23			7.49					13.05	0.2175	0.01305	17.6175	0.02697	0.0000435	0.0081345	0.0009353	1.523E-06	1.523E-06	0.002175	0.00000174	6.2205	0.0000174	0.0000435	0.0001827	0.0015225
11-Oct-18	24			7.59					12.15																

Appendix 4-5, Table 3: Kinetic Test Results - HC2

Mass	1																									
Date	**Cycle**	**Volume mL**		**pH**	**Pb**	**Li**	**Mg**	**Mn**	**Hg**	**Mo**	**Ni**	**P**	**K**	**Se**	**Si**	**Ag**	**Na**	**Sr**	**S**	**Tl**	**Sn**	**Ti**	**U**	**V**	**Zn**	**Zr**
	No.	**Input**	**Output**																							
					mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
26-Apr-18	0	500	315	7.43	0.00002	0.0135	3.70	0.0337	0.03	0.00237	0.0061	0.011	11.7	0.00060	1.48	<0.000025	8.75	0.283	37.1	0.000034	0.00020	0.00008	0.00140	0.00051	<0.001	<0.001
3-May-18	1	500	445	7.70	0.00001	0.0177	5.90	0.0818	<0.005	0.0199	0.0055	0.003	12.0	0.00090	2.05	<0.000025	12.3	0.496	51.5	0.000038	0.00014	0.00009	0.00453	0.00090	<0.001	<0.001
10-May-18	2	500	445	7.74	0.00003	0.0140	4.41	0.0406	<0.005	0.0180	0.0017	0.007	10.6	0.00053	2.48	<0.000025	7.64	0.284	32.0	0.000032	0.00017	0.00037	0.00312	0.00114	<0.001	<0.001
17-May-18	3	500	445	7.86	0.00002	0.0087	2.12	0.0152	0.01	0.00838	0.0005	<0.0015	6.21	0.00030	1.88	<0.000025	3.94	0.155	15.6	0.000024	0.00018	0.00016	0.00194	0.00090	<0.001	<0.001
24-May-18	4	500	420	7.66																						
31-May-18	5	500	435	7.85	0.00006	0.0071	2.20	0.00895	<0.005	0.00531	0.0005	<0.0015	7.98	0.00024	2.49	<0.000025	2.22	0.154	17.9	0.000021	0.00009	0.00032	0.00164	0.00124	<0.001	<0.001
7-Jun-18	6	500	495	7.84																						
14-Jun-18	7	500	445	7.76	0.00002	0.0067	2.38	0.00560	<0.005	0.00304	0.0005	<0.0015	6.45	0.00036	2.13	<0.000025	1.28	0.141	18.4	0.000021	0.00004	0.00015	0.00201	0.00091	<0.001	<0.001
21-Jun-18	8	500	425	7.76																						
28-Jun-18	9	500	430	7.71	0.00004	0.0058	2.19	0.00487	<0.005	0.00185	0.0005	<0.0015	6.31	0.00015	2.07	<0.000025	0.82	0.140	19.7	0.000021	0.00004	0.00017	0.001636	0.00082	<0.001	<0.001
5-Jul-18	10	500	415	7.68																						
12-Jul-18	11	500	435	7.74	<0.000005	0.0053	2.46	0.00346	<0.005	0.00155	0.0004	<0.0015	4.91	0.00012	1.71	<0.000025	0.68	0.125	15.6	0.000019	0.00012	0.00016	0.00153	0.00081	<0.001	<0.001
19-Jul-18	12	500	430	7.68																						
26-Jul-18	13	500	435	7.61	0.00002	0.0046	2.12	0.00293	<0.005	0.00117	0.0003	<0.0015	4.86	0.00014	1.71	<0.000025	0.58	0.118	12.6	0.000021	0.00003	0.00017	0.00143	0.00066	<0.001	<0.001
2-Aug-18	14	500	430	7.73																						
9-Aug-18	15	500	420	7.64	0.00003	0.0042	1.82	0.00206	<0.005	0.00120	0.0003	<0.0015	4.59	0.00014	1.61	<0.000025	0.56	0.103	13.8	0.000019	0.00003	0.00022	0.000950	0.00069	<0.001	<0.001
16-Aug-18	16	500	440	7.63																						
23-Aug-18	17	500	430	7.57	0.00001	0.0033	1.51	0.00225	<0.005	0.00104	0.0003	<0.0015	4.28	0.00007	1.64	<0.000025	0.51	0.0989	14.1	0.000018	0.00004	0.00014	0.000857	0.00063	<0.001	<0.001
30-Aug-18	18	500	430	7.64																						
6-Sep-18	19	500	415	7.61	0.00003	0.0035	1.38	0.00187	<0.005	0.00090	0.0002	<0.0015	3.58	0.00006	1.61	<0.000025	0.46	0.0831	11.2	0.000019	<0.000005	0.00025	0.000771	0.00064	<0.001	<0.001
13-Sep-18	20	500	420	7.41																						
20-Sep-18	21	500	425	7.68	0.00003	0.0030	1.41	0.00169	0.04	0.00103	0.0003	<0.0015	3.71	0.00009	1.46	<0.000025	0.36	0.0918	12.6	0.000019	0.00004	0.00016	0.000760	0.00058	<0.001	<0.001
27-Sep-18	22	500	425	7.64																						
4-Oct-18	23	500	435	7.49	0.00003	0.0033	1.18	0.00158	<0.005	0.00070	0.0002	<0.0015	3.00	0.00005	1.44	<0.000025	0.35	0.0756	9.8	0.000015	0.00003	<0.000025	0.000679	0.00056	<0.001	<0.001
11-Oct-18	24	500	405	7.59																						

Loads	**mg/kg**				mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
26-Apr-18	0			7.43	0.0000063	0.0042525	1.1655	0.0106155	0.00945	0.0007466	0.0019215	0.003465	3.6855	0.000189	0.4662	7.875E-06	2.75625	0.089145	11.6865	0.00001071	0.000063	0.0000252	0.000441	0.0001607	0.000315	0.000315
3-May-18	1			7.70	4.45E-06	0.0078765	2.6255	0.036401	0.002225	0.0088555	0.0024475	0.001335	5.34	0.0004005	0.91225	1.113E-05	5.4735	0.22072	22.9175	0.00001691	0.0000623	4.005E-05	0.0020159	0.0004005	0.000445	0.000445
10-May-18	2			7.74	1.335E-05	0.00623	1.96245	0.018067	0.002225	0.00801	0.0007565	0.003115	4.717	0.0002359	1.1036	1.113E-05	3.3998	0.12638	14.24	0.00001424	7.565E-05	0.0001647	0.0013884	0.0005073	0.000445	0.000445
17-May-18	3			7.86	0.0000089	0.0038715	0.9434	0.006764	0.00445	0.0037291	0.0002225	0.0006675	2.76345	0.0001335	0.8366	1.113E-05	1.7533	0.068975	6.942	0.00001068	0.0000801	0.0000712	0.0008633	0.0004005	0.000445	0.000445
24-May-18	4			7.66																						
31-May-18	5			7.85	0.0000261	0.0030885	0.957	0.0038933	0.002175	0.0023099	0.0002175	0.0006525	3.4713	0.0001044	1.08315	1.088E-05	0.9657	0.06699	7.7865	0.000009135	3.915E-05	0.0001392	0.0007134	0.0005394	0.000435	0.000435
7-Jun-18	6			7.84																						
14-Jun-18	7			7.76	0.0000089	0.0029815	1.0591	0.002492	0.002225	0.0013528	0.0002225	0.0006675	2.87025	0.0001602	0.94785	1.113E-05	0.5696	0.062745	8.188	0.000009345	0.0000178	6.675E-05	0.0008945	0.000405	0.000445	0.000445
21-Jun-18	8			7.76																						
28-Jun-18	9			7.71	0.0000172	0.002494	0.9417	0.0020941	0.00215	0.0007955	0.000215	0.000645	2.7133	0.0000645	0.8901	1.075E-05	0.3526	0.0602	8.471	0.00000903	0.0000172	0.0000731	0.0007035	0.0003526	0.00043	0.00043
5-Jul-18	10			7.68																						
12-Jul-18	11			7.74	2.175E-06	0.0023055	1.0701	0.0015051	0.002175	0.0006743	0.000174	0.0006525	2.13585	0.0000522	0.74385	1.088E-05	0.2958	0.054375	6.786	0.000008265	0.0000522	0.0000696	0.0006656	0.0003524	0.000435	0.000435
19-Jul-18	12			7.68																						
26-Jul-18	13			7.61	0.0000087	0.002001	0.9222	0.0012746	0.002175	0.000509	0.0001305	0.0006525	2.1141	0.0000609	0.74385	1.088E-05	0.2523	0.05133	5.481	0.000009135	1.305E-05	7.395E-05	0.0006221	0.0002871	0.000435	0.000435
2-Aug-18	14			7.73																						
9-Aug-18	15			7.64	0.0000126	0.001764	0.7644	0.0008652	0.0021	0.000504	0.000126	0.00063	1.9278	0.0000588	0.6762	0.0000105	0.2352	0.04326	5.796	0.00000798	0.0000126	0.0000924	0.000399	0.0002898	0.00042	0.00042
16-Aug-18	16			7.63																						
23-Aug-18	17			7.57	0.0000043	0.001419	0.6493	0.0009675	0.00215	0.0004472	0.000129	0.000645	1.8404	0.0000301	0.7052	1.075E-05	0.2193	0.042527	6.063	0.00000774	0.0000172	0.0000602	0.0003685	0.0002709	0.00043	0.00043
30-Aug-18	18			7.64																						
6-Sep-18	19			7.61	1.245E-05	0.0014525	0.5727	0.0007761	0.002075	0.0003735	0.000083	0.0006225	1.4857	0.0000249	0.66815	1.038E-05	0.1909	0.0344865	4.648	0.000007885	2.075E-06	0.0001038	0.00032	0.0002656	0.000415	0.000415
13-Sep-18	20			7.41																						
20-Sep-18	21			7.68	1.275E-05	0.001275	0.59925	0.0007183	0.017	0.0004378	0.0001275	0.0006375	1.57675	3.825E-05	0.6205	1.063E-05	0.153	0.039015	5.355	0.000008075	0.000017	0.000068	0.000323	0.0002465	0.000425	0.000425
27-Sep-18	22			7.64																						
4-Oct-18	23			7.49	1.305E-05	0.0014355	0.5133	0.0006873	0.002175	0.0003045	0.000087	0.0006525	1.305	2.175E-05	0.6264	1.088E-05	0.15225	0.032886	4.263	0.000006525	1.305E-05	1.088E-05	0.0002954	0.0002436	0.000435	0.000435
11-Oct-18	24			7.59																						

Appendix 4-5, Table 4: Kinetic Test Results - HC3

Mass	**1**																								
Date	**Cycle**	**Volume mL**		**pH**	**Cond.**	**Acidity**	**Acidity**	**Alkalinity**	**Sulphate**	**Chloride**	**Fluoride**	**Hardness**	**Al**	**Sb**	**As**	**Ba**	**Be**	**Bi**	**B**	**Cd**	**Ca**	**Cr**	**Co**	**Cu**	**Fe**
	No.	**Input**	**Output**			**(pH 4.5)**	**(pH 8.3)**					**$CaCO_3$**													
					umhos/cm	$mgCaCO_3$/L	$mgCaCO_3$/L	$mgCaCO_3$/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
26-Apr-18	0	500	305	7.78	313	#N/A	3.8	26.4	67	9	0.25	51.7	0.196	*<0.0001*	0.0093	0.00340	*<0.0000035*	*<0.0000035*	0.015	*<0.0000015*	16.7	0.00012	0.000024	0.00070	0.007
3-May-18	1	500	465	8.05	254	#N/A	1.3	26.1	81	4	0.16	64.5	0.292	0.0003	0.0205	0.00371	*<0.0000035*	*<0.0000035*	0.024	*<0.0000015*	20.6	0.00005	0.000029	0.00025	0.016
10-May-18	2	500	465	7.76	215	#N/A	2.7	25.7	70	2	0.15	66.7	0.281	0.0004	0.0267	0.00294	*<0.0000035*	*<0.0000035*	0.018	*<0.0000015*	20.9	0.00004	0.000070	0.00026	0.008
17-May-18	3	500	455	8.01	203	#N/A	1.9	24.4	56	1	0.12	59.7	0.209	0.0003	0.0282	0.00270	*<0.0000035*	*<0.0000035*	0.021	0.000012	19.1	*<0.000015*	0.000056	0.00027	*<0.0035*
24-May-18	4	500	440	7.74	164	#N/A	3.3	24.7	45																
31-May-18	5	500	470	8.04	138	#N/A	2.1	24.1	36	*<0.5*	0.13	46.8	0.234	0.0002	0.0337	0.00153	*<0.0000035*	*<0.0000035*	0.010	*<0.0000015*	15.5	*<0.000015*	0.000078	0.00020	0.008
7-Jun-18	6	500	485	8.05	144	#N/A	2.7	27.0	40																
14-Jun-18	7	500	475	8.06	127	#N/A	2.8	24.6	33	1	0.13	45.2	0.214	0.0003	0.0392	0.00142	*<0.0000035*	*<0.0000035*	0.012	0.000003	15.0	*<0.000015*	0.000072	0.00028	*<0.0035*
21-Jun-18	8	500	435	8.04	122	#N/A	3.2	25.1	26																
28-Jun-18	9	500	445	8.02	113	#N/A	3.6	24.0	29	*<0.5*	0.07	45.0	0.227	*<0.0001*	0.0390	0.00143	*<0.0000035*	*<0.0000035*	0.008	0.000022	15.1	0.00003	0.000109	0.00020	0.016
5-Jul-18	10	500	405	7.99	99	#N/A	3.7	21.2	22																
12-Jul-18	11	500	435	8.10	116	#N/A	1.0	22.6	28	*<0.5*	*<0.03*	46.6	0.217	*<0.0001*	0.0391	0.00153	*<0.0000035*	*<0.0000035*	0.008	*<0.0000015*	15.9	*<0.000015*	0.000189	0.00263	*<0.0035*
19-Jul-18	12	500	435	8.00	98	#N/A	0.8	20.2	24																
26-Jul-18	13	500	445	7.69	102	#N/A	2.2	21.4	28	*<0.5*	*<0.03*	39.9	0.169	*<0.0001*	0.0263	0.00128	*<0.0000035*	*<0.0000035*	0.002	*<0.0000015*	13.7	*<0.000015*	0.000084	0.00018	*<0.0035*
2-Aug-18	14	500	435	8.03	102	#N/A	1.2	22.2	26																
9-Aug-18	15	500	415	7.93	83	#N/A	1.5	20.6	19	*<0.5*	*<0.03*	33.2	0.200	*<0.0001*	0.0286	0.00119	*<0.0000035*	*<0.0000035*	0.004	0.000006	11.7	*<0.000015*	0.000072	0.00042	0.008
16-Aug-18	16	500	440	8.00	82	#N/A	2.8	21.1	24																
23-Aug-18	17	500	430	7.94	84	#N/A	3.2	21.4	21	*<0.5*	*<0.03*	36.4	0.153	*<0.0001*	0.0262	0.00129	*<0.0000035*	*<0.0000035*	0.006	*<0.0000015*	12.7	*<0.000015*	0.000100	0.00035	0.007
30-Aug-18	18	500	425	7.95	81	#N/A	2.0	20.9	23																
6-Sep-18	19	500	415	7.96	76	#N/A	2.7	20.8	18	*<0.5*	*<0.03*	34.3	0.164	*<0.0001*	0.0260	0.00122	*<0.0000035*	*<0.0000035*	0.006	*<0.0000015*	12.2	*<0.000015*	0.000078	0.00026	0.007
13-Sep-18	20	500	420	7.63	89	#N/A	3.9	22.1	24																
20-Sep-18	21	500	425	7.92	118	#N/A	2.5	23.5	29	*<0.5*	*<0.03*	42.7	0.138	*<0.0001*	0.0334	0.00144	0.000008	*<0.0000035*	0.007	*<0.0000015*	15.2	0.00004	0.000102	0.00040	0.008
27-Sep-18	22	500	430	8.00	124	#N/A	2.8	23.2	29																
4-Oct-18	23	500	430	7.74	124	#N/A	3.9	26.2	29	*<0.5*	*<0.03*	46.6	0.152	*<0.0001*	0.0321	0.00151	*<0.0000035*	*<0.0000035*	0.005	*<0.0000015*	16.7	0.00004	0.000124	0.00028	*<0.0035*
11-Oct-18	24	500	405	7.70	115	#N/A	3.3	25.0	24																

Loads	**mg/kg**								mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
26-Apr-18	0			7.78					20.435	2.745	0.07625	15.7685	0.05978	0.0000305	0.0028365	0.001037	1.0675E-06	1.0675E-06	0.004575	4.575E-07	5.0935	0.0000366	7.32E-06	0.0002135	0.002135
3-May-18	1			8.05					37.665	1.86	0.0744	29.9925	0.13578	0.0001395	0.0095325	0.0017252	1.6275E-06	1.6275E-06	0.01116	6.975E-07	9.579	2.325E-05	1.349E-05	0.0001163	0.00744
10-May-18	2			7.76					32.55	0.93	0.06975	31.0155	0.130665	0.000186	0.0124155	0.0013671	1.6275E-06	1.6275E-06	0.00837	6.975E-07	9.7185	0.0000186	3.255E-05	0.0001209	0.00372
17-May-18	3			8.01					25.48	0.455	0.0546	27.1635	0.095095	0.0001365	0.012831	0.0012285	1.5925E-06	1.5925E-06	0.009555	0.00000546	8.6905	6.825E-06	2.548E-05	0.0001229	0.0015925
24-May-18	4			7.74					19.8																
31-May-18	5			8.04					16.92	0.235	0.0611	21.996	0.10998	0.000094	0.015839	0.0007191	0.000001645	0.000001645	0.0047	0.000000705	7.285	7.05E-06	3.666E-05	0.000094	0.00376
7-Jun-18	6			8.05					19.4																
14-Jun-18	7			8.06					15.675	0.475	0.06175	21.47	0.10165	0.0001425	0.01862	0.0006745	1.6625E-06	1.6625E-06	0.0057	0.000001425	7.125	7.125E-06	0.0000342	0.000133	0.0016625
21-Jun-18	8			8.04					11.31																
28-Jun-18	9			8.02					12.905	0.2225	0.03115	20.025	0.101015	0.0000445	0.017355	0.0006364	1.5575E-06	1.5575E-06	0.00356	0.00000979	6.7195	1.335E-05	4.851E-05	0.000089	0.00712
5-Jul-18	10			7.99					8.91																
12-Jul-18	11			8.10					12.18	0.2175	0.01305	20.271	0.094395	0.0000435	0.0170085	0.0006656	1.5225E-06	1.5225E-06	0.00348	6.525E-07	6.9165	6.525E-06	8.222E-05	0.0011441	0.0015225
19-Jul-18	12			8.00					10.44																
26-Jul-18	13			7.69					12.46	0.2225	0.01335	17.7555	0.075205	0.0000445	0.0117035	0.0005696	1.5575E-06	1.5575E-06	0.00089	6.675E-07	6.0965	6.675E-06	3.738E-05	0.0000801	0.0015575
2-Aug-18	14			8.03					11.31																
9-Aug-18	15			7.93					7.885	0.2075	0.01245	13.778	0.083	0.0000415	0.011869	0.0004939	1.4525E-06	1.4525E-06	0.00166	0.00000249	4.8555	6.225E-06	2.988E-05	0.0001743	0.00332
16-Aug-18	16			8.00					10.56																
23-Aug-18	17			7.94					9.03	0.215	0.0129	15.652	0.06579	0.000043	0.011266	0.0005547	0.000001505	0.000001505	0.00258	0.000000645	5.461	6.45E-06	0.000043	0.0001505	0.00301
30-Aug-18	18			7.95					9.775																
6-Sep-18	19			7.96					7.47	0.2075	0.01245	14.2345	0.06806	0.0000415	0.01079	0.0005063	1.4525E-06	1.4525E-06	0.00249	6.225E-07	5.063	6.225E-06	3.237E-05	0.0001079	0.002905
13-Sep-18	20			7.63					10.08																
20-Sep-18	21			7.92					12.325	0.2125	0.01275	18.1475	0.05865	0.0000425	0.014195	0.000612	0.0000034	1.4875E-06	0.002975	6.375E-07	6.46	0.000017	4.335E-05	0.00017	0.0034
27-Sep-18	22			8.00					12.47																
4-Oct-18	23			7.74					12.47	0.215	0.0129	20.038	0.06536	0.000043	0.013803	0.0006493	0.000001505	0.000001505	0.00215	0.000000645	7.181	0.0000172	5.332E-05	0.0001204	0.001505
11-Oct-18	24			7.70					9.72																

Appendix 4-5, Table 4: Kinetic Test Results - HC3

Mass	**1**																									
Date	**Cycle**	**Volume mL**		**pH**	**Pb**	**Li**	**Mg**	**Mn**	**Hg**	**Mo**	**Ni**	**P**	**K**	**Se**	**Si**	**Ag**	**Na**	**Sr**	**S**	**Tl**	**Sn**	**Ti**	**U**	**V**	**Zn**	**Zr**
	No.	**Input**	**Output**																							
					mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
26-Apr-18	0	500	305	7.78	0.00003	0.0070	2.45	0.00883	0.04	0.00100	0.0010	0.013	26.6	0.00041	1.00	<0.000025	10.6	0.0677	27.1	0.000053	0.00045	0.00032	0.000281	0.00049	<0.001	<0.001
3-May-18	1	500	465	8.05	0.00002	0.0075	3.17	0.0164	<0.005	0.00452	0.0004	<0.0015	20.8	0.00041	1.32	<0.000025	9.00	0.0884	27.4	0.000042	0.00022	0.00083	0.00113	0.00097	<0.001	<0.001
10-May-18	2	500	465	7.76	0.00002	0.0072	3.52	0.0127	<0.005	0.00233	0.0003	<0.0015	16.0	0.00025	1.41	<0.000025	5.08	0.0795	24.5	0.000045	0.00011	0.00056	0.00115	0.00098	<0.001	<0.001
17-May-18	3	500	455	8.01	<0.000005	0.0065	2.95	0.0128	0.02	0.00164	0.0002	<0.0015	12.1	0.00014	1.27	<0.000025	3.34	0.0751	21.2	0.000034	0.00016	0.00011	0.00126	0.00086	<0.001	<0.001
24-May-18	4	500	440	7.74																						
31-May-18	5	500	470	8.04	0.00001	0.0040	1.96	0.00992	0.01	0.00087	0.0003	<0.0015	7.85	0.00007	1.54	<0.000025	1.34	0.0451	13.1	0.000022	0.00004	0.00032	0.000565	0.00107	<0.001	<0.001
7-Jun-18	6	500	485	8.05																						
14-Jun-18	7	500	475	8.06	0.00002	0.0045	1.85	0.00918	<0.005	0.00072	0.0001	<0.0015	6.19	0.00008	1.46	<0.000025	0.94	0.0405	11.7	0.000022	0.00006	0.00010	0.000772	0.00119	<0.001	<0.001
21-Jun-18	8	500	435	8.04																						
28-Jun-18	9	500	445	8.02	0.00006	0.0037	1.73	0.0101	<0.005	0.00045	0.0002	<0.0015	6.02	0.00007	1.48	<0.000025	0.70	0.03854	11.5	0.000018	0.00006	0.00094	0.000583	0.00130	<0.001	<0.001
5-Jul-18	10	500	405	7.99																						
12-Jul-18	11	500	435	8.10	<0.000005	0.0036	1.69	0.00803	<0.005	0.00037	0.0001	<0.0015	4.43	0.00007	1.37	<0.000025	0.80	0.0350	9.3	0.000016	0.00008	0.00021	0.000711	0.00127	<0.001	<0.001
19-Jul-18	12	500	435	8.00																						
26-Jul-18	13	500	445	7.69	0.00001	0.0033	1.36	0.00802	<0.005	0.00029	<0.00005	<0.0015	4.17	0.00004	1.24	<0.000025	0.47	0.0313	7.6	0.000018	0.00002	0.00011	0.000690	0.00101	<0.001	<0.001
2-Aug-18	14	500	435	8.03																						
9-Aug-18	15	500	415	7.93	0.00004	0.0027	0.977	0.00610	0.02	0.00024	0.0001	<0.0015	3.34	<0.00002	1.25	<0.000025	0.41	0.0254	6.2	0.000015	0.00004	0.00050	0.000415	0.00108	<0.001	<0.001
16-Aug-18	16	500	440	8.00																						
23-Aug-18	17	500	430	7.94	0.00001	0.0025	1.14	0.00758	<0.005	0.00035	<0.00005	<0.0015	3.71	0.00006	1.29	<0.000025	0.48	0.0270	7.5	0.000014	0.00006	0.00030	0.000482	0.00097	<0.001	<0.001
30-Aug-18	18	500	425	7.95																						
6-Sep-18	19	500	415	7.96	0.00002	0.0025	0.954	0.00605	<0.005	0.00024	<0.00005	<0.0015	3.25	<0.00002	1.10	<0.000025	0.37	0.0245	6.5	0.000016	<0.000005	0.00033	0.000461	0.00098	<0.001	<0.001
13-Sep-18	20	500	420	7.63																						
20-Sep-18	21	500	425	7.92	0.00002	0.0029	1.17	0.00666	<0.005	0.00030	<0.00005	<0.0015	3.95	0.00010	1.36	<0.000025	0.33	0.0343	9.5	0.000017	0.00009	0.00025	0.000635	0.00107	<0.001	<0.001
27-Sep-18	22	500	430	8.00																						
4-Oct-18	23	500	430	7.74	0.00002	0.0036	1.18	0.00648	<0.005	0.00018	<0.00005	<0.0015	3.90	<0.00002	1.48	<0.000025	0.35	0.0342	8.5	0.000018	0.00004	0.00019	0.000726	0.00120	<0.001	<0.001
11-Oct-18	24	500	405	7.70																						

Loads	**mg/kg**				mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
26-Apr-18	0			7.78	9.15E-06	0.002135	0.74725	0.0026932	0.0122	0.000305	0.000305	0.003965	8.113	0.0001251	0.305	0.000007625	3.233	0.0206485	8.2655	1.617E-05	0.0001373	0.0000976	8.571E-05	0.0001495	0.000305	0.000305
3-May-18	1			8.05	0.0000093	0.0034875	1.47405	0.007626	0.002325	0.0021018	0.000186	0.0006975	9.672	0.0001907	0.6138	0.000011625	4.185	0.041106	12.741	1.953E-05	0.0001023	0.000386	0.0005255	0.0004511	0.000465	0.000465
10-May-18	2			7.76	0.0000093	0.003348	1.6368	0.0059055	0.002325	0.0010835	0.0001395	0.0006975	7.44	0.0001163	0.65565	0.000011625	2.3622	0.0369675	11.3925	2.093E-05	5.115E-05	0.0002604	0.0005348	0.0004557	0.000465	0.000465
17-May-18	3			8.01	2.275E-06	0.0029575	1.34225	0.005824	0.0091	0.0007462	0.000091	0.0006825	5.5055	0.0000637	0.57785	0.000011375	1.5197	0.0341705	9.646	1.547E-05	0.0000728	5.005E-05	0.0005733	0.0003913	0.000455	0.000455
24-May-18	4			7.74																						
31-May-18	5			8.04	0.0000047	0.00188	0.9212	0.0046624	0.0047	0.0004089	0.000141	0.000705	3.6895	0.0000329	0.7238	0.00001175	0.6298	0.021197	6.157	1.034E-05	0.0000188	0.0001504	0.0002656	0.0005029	0.00047	0.00047
7-Jun-18	6			8.05																						
14-Jun-18	7			8.06	0.0000095	0.0021375	0.87875	0.0043605	0.002375	0.000342	0.0000475	0.0007125	2.94025	0.000038	0.6935	0.000011875	0.4465	0.0192375	5.5575	1.045E-05	0.0000285	0.0000475	0.0003667	0.0005653	0.000475	0.000475
21-Jun-18	8			8.04																						
28-Jun-18	9			8.02	0.0000267	0.0016465	0.76985	0.0044945	0.002225	0.0002003	0.000089	0.0006675	2.6789	3.115E-05	0.6586	0.000011125	0.3115	0.0171503	5.1175	8.01E-06	0.0000267	0.0004183	0.0002594	0.0005785	0.000445	0.000445
5-Jul-18	10			7.99																						
12-Jul-18	11			8.10	2.175E-06	0.001566	0.73515	0.0034931	0.002175	0.000161	0.0000435	0.0006525	1.92705	3.045E-05	0.59595	0.000010875	0.348	0.015225	4.0455	6.96E-06	0.0000348	9.135E-05	0.0003093	0.0005525	0.000435	0.000435
19-Jul-18	12			8.00																						
26-Jul-18	13			7.69	4.45E-06	0.0014685	0.6052	0.0035689	0.002225	0.0001291	2.225E-05	0.0006675	1.85565	0.0000178	0.5518	0.000011125	0.20915	0.0139285	3.382	8.01E-06	0.0000089	4.895E-05	0.0003071	0.0004495	0.000445	0.000445
2-Aug-18	14			8.03																						
9-Aug-18	15			7.93	0.0000166	0.0011205	0.405455	0.0025315	0.0083	0.0000996	0.0000415	0.0006225	1.3861	0.0000083	0.51875	0.000010375	0.17015	0.010541	2.573	6.225E-06	0.0000166	0.0002075	0.0001722	0.0004482	0.000415	0.000415
16-Aug-18	16			8.00																						
23-Aug-18	17			7.94	0.0000043	0.001075	0.4902	0.0032594	0.00215	0.0001505	0.0000215	0.000645	1.5953	0.0000258	0.5547	0.00001075	0.2064	0.01161	3.225	6.02E-06	0.0000258	0.000129	0.0002073	0.0004171	0.00043	0.00043
30-Aug-18	18			7.95																						
6-Sep-18	19			7.96	0.0000083	0.0010375	0.39591	0.0025108	0.002075	0.0000996	2.075E-05	0.0006225	1.34875	0.0000083	0.4565	0.000010375	0.15355	0.0101675	2.6975	6.64E-06	2.075E-06	0.000137	0.0001913	0.0004067	0.000415	0.000415
13-Sep-18	20			7.63																						
20-Sep-18	21			7.92	0.0000085	0.0012325	0.49725	0.0028305	0.002125	0.0001275	2.125E-05	0.0006375	1.67875	0.0000425	0.578	0.000010625	0.14025	0.0145775	4.0375	7.225E-06	3.825E-05	0.0001063	0.0002699	0.0004548	0.000425	0.000425
27-Sep-18	22			8.00																						
4-Oct-18	23			7.74	0.0000086	0.001548	0.5074	0.0027864	0.00215	0.0000774	0.0000215	0.000645	1.677	0.0000086	0.6364	0.00001075	0.1505	0.014706	3.655	7.74E-06	0.0000172	0.0000817	0.0003122	0.000516	0.00043	0.00043
11-Oct-18	24			7.70																						

Appendix 4-5, Table 5: Kinetic Test Results - HC4

Mass	**1**																								
Date	**Cycle**	**Volume mL**		**pH**	**Cond.**	**Acidity**	**Acidity**	**Alkalinity**	**Sulphate**	**Chloride**	**Fluoride**	**Hardness**	**Al**	**Sb**	**As**	**Ba**	**Be**	**Bi**	**B**	**Cd**	**Ca**	**Cr**	**Co**	**Cu**	**Fe**
	No.	**Input**	**Output**			**(pH 4.5)**	**(pH 8.3)**					**$CaCO_3$**													
					umhos/cm	mg$CaCO_3$/L	mg$CaCO_3$/L	mg$CaCO_3$/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
26-Apr-18	0	500	305	7.50	494	#N/A	4.8	13.8	146	8	0.11	140	0.087	<0.0001	0.0289	0.00729	<3.5E-06	<0.0000035	0.015	0.000003	46.2	0.00007	0.000656	0.00059	<0.0035
3-May-18	1	500	440	7.72	530	#N/A	3.0	25.7	230	7	0.15	207	0.114	0.0005	0.0128	0.00969	<3.5E-06	<0.0000035	0.031	0.000011	66.9	<0.000015	0.000398	0.00039	<0.0035
10-May-18	2	500	460	7.59	338	#N/A	3.2	20.4	144	1	0.15	131	0.150	0.0005	0.0094	0.00466	<3.5E-06	<0.0000035	0.024	0.000007	42.0	0.00003	0.000164	0.00036	<0.0035
17-May-18	3	500	465	7.75	288	#N/A	2.6	20.8	104	1	0.15	97.7	0.126	0.0005	0.0096	0.00432	<3.5E-06	0.000007	0.027	0.000015	32.1	<0.000015	0.000140	0.00031	<0.0035
24-May-18	4	500	420	7.59	222	#N/A	3.8	19.7	78																
31-May-18	5	500	445	7.66	171	#N/A	2.7	16.5	56	<0.5	0.10	63.9	0.153	0.0003	0.0074	0.00183	<3.5E-06	0.000012	0.012	0.000007	22.1	<0.000015	0.000067	0.00036	0.007
7-Jun-18	6	500	495	7.72	184	#N/A	3.4	19.1	63																
14-Jun-18	7	500	460	7.65	144	#N/A	3.7	16.2	44	1	0.08	50.6	0.136	0.0003	0.0060	0.00146	<3.5E-06	0.000009	0.011	0.000008	17.8	<0.000015	0.000057	0.00028	<0.0035
21-Jun-18	8	500	430	7.63	126	#N/A	4.5	15.4	36																
28-Jun-18	9	500	430	7.62	127	#N/A	5.3	16.4	40	<0.5	0.07	46.6	0.134	0.0002	0.0055	0.00193	<3.5E-06	0.000016	0.008	0.000012	16.6	<0.000015	0.000070	<0.00001	0.014
5-Jul-18	10	500	415	7.60	129	#N/A	5.1	14.6	40																
12-Jul-18	11	500	440	7.61	144	#N/A	1.6	13.9	46	<0.5	0.06	57.7	0.128	<0.0001	0.0044	0.00159	<3.5E-06	0.000009	0.009	<1.5E-06	20.9	<0.000015	0.000090	0.00301	<0.0035
19-Jul-18	12	500	435	7.54	155	#N/A	1.6	13.4	54																
26-Jul-18	13	500	455	7.46	154	#N/A	2.2	14.7	59	<0.5	<0.03	64.9	0.089	<0.0001	0.0028	0.00183	<3.5E-06	0.000009	0.003	0.000011	23.8	<0.000015	0.000098	0.00033	<0.0035
2-Aug-18	14	500	445	7.55	135	#N/A	1.9	13.4	48																
9-Aug-18	15	500	415	7.62	141	#N/A	2.0	14.5	52	<0.5	<0.03	57.2	0.101	<0.0001	0.0031	0.00172	<3.5E-06	0.000009	0.006	0.000032	20.8	<0.000015	0.000108	0.00039	<0.0035
16-Aug-18	16	500	430	7.59	124	#N/A	3.5	13.3	50																
23-Aug-18	17	500	420	7.60	131	#N/A	4.0	14.8	50	<0.5	<0.03	58.0	0.075	<0.0001	0.0024	0.00180	<3.5E-06	<0.0000035	0.007	0.000011	21.3	<0.000015	0.000118	0.00035	<0.0035
30-Aug-18	18	500	420	7.51	121	#N/A	2.9	13.3	48																
6-Sep-18	19	500	415	7.52	123	#N/A	3.5	12.7	50	<0.5	<0.03	55.6	0.077	<0.0001	0.0023	0.00176	<3.5E-06	0.000007	0.006	0.000015	20.5	<0.000015	0.000116	0.00040	<0.0035
13-Sep-18	20	500	415	7.35	120	#N/A	4.3	13.2	47																
20-Sep-18	21	500	410	7.61	144	#N/A	2.6	14.4	46	<0.5	<0.03	51.6	0.069	<0.0001	0.0024	0.00162	0.000007	0.000008	0.006	0.000008	19.1	<0.000015	0.000117	0.00065	0.007
27-Sep-18	22	500	420	7.53	132	#N/A	3.9	11.7	41																
4-Oct-18	23	500	425	7.35	130	#N/A	3.7	12.7	44	<0.5	<0.03	47.2	0.064	<0.0001	0.0016	0.00135	<3.5E-06	0.000008	0.005	0.000010	17.6	<0.000015	0.000104	0.00031	<0.0035
11-Oct-18	24	500	405	7.59	121	#N/A	3.8	10.0	40																
Loads	**mg/kg**								mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
26-Apr-18	0			7.50					44.53	2.44	0.03355	42.7	0.026535	0.0000305	0.0088145	0.00222345	1.0675E-06	1.0675E-06	0.004575	9.15E-07	14.091	0.00002135	0.00020008	0.00017995	0.0010675
3-May-18	1			7.72					101.2	3.08	0.066	91.08	0.05016	0.00022	0.005632	0.0042636	0.00000154	0.00000154	0.01364	0.00000484	29.436	0.0000066	0.00017512	0.0001716	0.00154
10-May-18	2			7.59					66.24	0.46	0.069	60.26	0.069	0.00023	0.004324	0.0021436	0.00000161	0.00000161	0.01104	0.00000322	19.32	0.0000138	0.00007544	0.0001656	0.00161
17-May-18	3			7.75					48.36	0.465	0.06975	45.4305	0.05859	0.0002325	0.004464	0.0020088	1.6275E-06	0.000003255	0.012555	6.975E-06	14.9265	6.975E-06	0.0000651	0.00014415	0.0016275
24-May-18	4			7.59					32.76																
31-May-18	5			7.66					24.92	0.2225	0.0445	28.4355	0.068085	0.0001335	0.003293	0.00081435	1.5575E-06	0.00000534	0.00534	3.115E-06	9.8345	6.675E-06	2.9815E-05	0.0001602	0.003115
7-Jun-18	6			7.72					31.185																
14-Jun-18	7			7.65					20.24	0.46	0.0368	23.276	0.06256	0.000138	0.00276	0.0006716	0.00000161	0.00000414	0.00506	0.00000368	8.188	0.0000069	0.00002622	0.0001288	0.00161
21-Jun-18	8			7.63					15.48																
28-Jun-18	9			7.62					17.2	0.215	0.0301	20.038	0.05762	0.000086	0.002365	0.0008299	1.505E-06	0.00000688	0.00344	0.00000516	7.138	0.00000645	0.0000301	0.0000043	0.00602
5-Jul-18	10			7.60					16.6																
12-Jul-18	11			7.61					20.24	0.22	0.0264	25.388	0.05632	0.000044	0.001936	0.0006996	0.00000154	0.00000396	0.00396	0.00000066	9.196	0.0000066	0.0000396	0.0013244	0.00154
19-Jul-18	12			7.54					23.49																
26-Jul-18	13			7.46					26.845	0.2275	0.01365	29.5295	0.040495	0.0000455	0.001274	0.00083265	1.5925E-06	0.000004095	0.001365	5.005E-06	10.829	6.825E-06	0.00004459	0.00015015	0.0015925
2-Aug-18	14			7.55					21.36																
9-Aug-18	15			7.62					21.58	0.2075	0.01245	23.738	0.041915	0.0000415	0.0012865	0.0007138	1.4525E-06	0.000003735	0.00249	0.00001328	8.632	6.225E-06	0.00004482	0.00016185	0.0014525
16-Aug-18	16			7.59					21.5																
23-Aug-18	17			7.60					21	0.21	0.0126	24.36	0.0315	0.000042	0.001008	0.000756	0.00000147	0.00000147	0.00294	0.00000462	8.946	0.0000063	0.00004956	0.000147	0.00147
30-Aug-18	18			7.51					20.16																
6-Sep-18	19			7.52					20.75	0.2075	0.01245	23.074	0.031955	0.0000415	0.0009545	0.0007304	1.4525E-06	0.000002905	0.00249	6.225E-06	8.5075	6.225E-06	0.00004814	0.000166	0.0014525
13-Sep-18	20			7.35					19.505																
20-Sep-18	21			7.61					18.86	0.205	0.0123	21.156	0.02829	0.000041	0.000984	0.0006642	0.00000287	0.00000328	0.00246	0.00000328	7.831	0.00000615	0.00004797	0.0002665	0.00287
27-Sep-18	22			7.53					17.22																
4-Oct-18	23			7.35					18.7	0.2125	0.01275	20.06	0.0272	0.0000425	0.00068	0.00057375	1.4875E-06	0.0000034	0.002125	0.00000425	7.48	6.375E-06	0.0000442	0.00013175	0.0014875
11-Oct-18	24			7.59					16.2																

Appendix 4-5, Table 5: Kinetic Test Results - HC4

Mass	1																									
Date	**Cycle**	**Volume mL**		**pH**	**Pb**	**Li**	**Mg**	**Mn**	**Hg**	**Mo**	**Ni**	**P**	**K**	**Se**	**Si**	**Ag**	**Na**	**Sr**	**S**	**Tl**	**Sn**	**Ti**	**U**	**V**	**Zn**	**Zr**
	No.	**Input**	**Output**																							
					mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
26-Apr-18	0	500	305	7.50	0.00001	0.0170	6.01	0.0986	*<0.005*	0.00048	0.0132	*<0.0015*	25.3	0.00061	0.83	*<0.000025*	6.36	0.150	57.9	0.000035	0.00025	*<0.000025*	0.000486	0.00009	*<0.001*	*<0.001*
3-May-18	1	500	440	7.72	0.00002	0.0183	9.57	0.107	0.02	0.00898	0.0046	*<0.0015*	29.4	0.00105	1.50	*<0.000025*	9.68	0.221	81.3	0.000031	0.00009	*<0.000025*	0.00138	0.00021	*<0.001*	*<0.001*
10-May-18	2	500	460	7.59	0.00003	0.0114	6.29	0.0461	*<0.005*	0.00855	0.0011	*<0.0015*	18.3	0.00067	1.52	*<0.000025*	4.24	0.125	48.8	0.000024	0.00008	*<0.000025*	0.000711	0.00023	*<0.001*	*<0.001*
17-May-18	3	500	465	7.75	0.00005	0.0095	4.28	0.0379	*<0.005*	0.00637	0.0005	0.003	13.3	0.00049	1.35	*<0.000025*	2.82	0.0972	35.8	0.000028	0.00009	*<0.000025*	0.000786	0.00024	*<0.001*	*<0.001*
24-May-18	4	500	420	7.59																						
31-May-18	5	500	445	7.66	0.00007	0.0046	2.10	0.0196	0.02	0.00315	0.0002	*<0.0015*	7.83	0.00023	1.34	*<0.000025*	0.94	0.0489	21.5	0.000017	0.00008	0.00024	0.000305	0.00029	*<0.001*	*<0.001*
7-Jun-18	6	500	495	7.72																						
14-Jun-18	7	500	460	7.65	0.00008	0.0040	1.53	0.0164	*<0.005*	0.00217	0.0002	*<0.0015*	5.48	0.00021	1.31	*<0.000025*	0.69	0.0354	16.5	0.000016	0.00003	0.00024	0.000338	0.00030	*<0.001*	*<0.001*
21-Jun-18	8	500	430	7.63																						
28-Jun-18	9	500	430	7.62	0.00018	0.0034	1.27	0.0160	*<0.005*	0.00147	0.0002	*<0.0015*	4.89	0.00015	1.26	*<0.000025*	0.44	0.03087	15.3	0.000015	0.00006	0.00065	0.000247	0.00032	*<0.001*	*<0.001*
5-Jul-18	10	500	415	7.60																						
12-Jul-18	11	500	440	7.61	0.00003	0.0033	1.38	0.0180	0.01	0.00097	0.0002	*<0.0015*	4.03	0.00017	1.07	*<0.000025*	0.36	0.0320	15.6	0.000016	0.00007	0.00014	0.000309	0.00028	*<0.001*	*<0.001*
19-Jul-18	12	500	435	7.54																						
26-Jul-18	13	500	455	7.46	0.00006	0.0034	1.32	0.0215	*<0.005*	0.00075	0.0001	*<0.0015*	4.59	0.00014	1.18	*<0.000025*	0.48	0.0369	16.2	0.000019	0.00002	0.00008	0.000360	0.00023	*<0.001*	*<0.001*
2-Aug-18	14	500	445	7.55																						
9-Aug-18	15	500	415	7.62	0.00008	0.0034	1.27	0.02042	0.06	0.00071	0.0002	*<0.0015*	4.57	0.00014	1.23	*<0.000025*	0.50	0.0317	17.0	0.000020	0.00003	0.00018	0.000274	0.00027	*<0.001*	*<0.001*
16-Aug-18	16	500	430	7.59																						
23-Aug-18	17	500	420	7.60	0.00007	0.0029	1.15	0.0241	*<0.005*	0.00073	0.0002	*<0.0015*	4.48	0.00014	1.34	*<0.000025*	0.50	0.0311	18.6	0.000020	0.00009	0.00013	0.000258	0.00022	*<0.001*	*<0.001*
30-Aug-18	18	500	420	7.51																						
6-Sep-18	19	500	415	7.52	0.00007	0.0028	1.05	0.0216	*<0.005*	0.00050	0.0002	*<0.0015*	3.59	0.00009	1.03	*<0.000025*	0.45	0.0289	18.2	0.000019	*<0.000005*	0.00015	0.000231	0.00022	*<0.001*	*<0.001*
13-Sep-18	20	500	415	7.35																						
20-Sep-18	21	500	410	7.61	0.00009	0.0026	0.925	0.0221	*<0.005*	0.00048	0.0002	*<0.0015*	3.70	0.00013	1.18	*<0.000025*	0.29	0.0282	16.6	0.000021	0.00004	0.00013	0.000250	0.00020	*<0.001*	*<0.001*
27-Sep-18	22	500	420	7.53																						
4-Oct-18	23	500	425	7.35	0.00005	0.0027	0.775	0.0210	*<0.005*	0.00032	*<0.00005*	*<0.0015*	2.94	0.00008	0.94	*<0.000025*	0.27	0.0230	12.7	0.000022	0.00003	0.00006	0.000182	0.00019	*<0.001*	*<0.001*
11-Oct-18	24	500	405	7.59																						

Loads	**mg/kg**				mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
26-Apr-18	0			7.50	0.00000305	0.005185	1.83305	0.030073	0.001525	0.0001464	0.004026	0.0004575	7.7165	0.00018605	0.25315	7.625E-06	1.9398	0.04575	17.6595	1.0675E-05	0.00007625	7.625E-06	0.00014823	0.00002745	0.000305	0.000305
3-May-18	1			7.72	0.0000088	0.008052	4.2108	0.04708	0.0088	0.0039512	0.002024	0.00066	12.936	0.000462	0.66	0.000011	4.2592	0.09724	35.772	0.00001364	0.0000396	0.000011	0.0006072	0.0000924	0.00044	0.00044
10-May-18	2			7.59	0.0000138	0.005244	2.8934	0.021206	0.0023	0.003933	0.000506	0.00069	8.418	0.0003082	0.6992	0.0000115	1.9504	0.0575	22.448	0.00001104	0.0000368	0.0000115	0.00032706	0.0001058	0.00046	0.00046
17-May-18	3			7.75	0.00002325	0.0044175	1.9902	0.0176235	0.002325	0.00296205	0.0002325	0.001395	6.1845	0.00022785	0.62775	1.1625E-05	1.3113	0.045198	16.647	0.00001302	0.00004185	1.1625E-05	0.00036549	0.0001116	0.000465	0.000465
24-May-18	4			7.59																						
31-May-18	5			7.66	0.00003115	0.002047	0.9345	0.008722	0.0089	0.00140175	0.000089	0.0006675	3.48435	0.00010235	0.5963	1.1125E-05	0.4183	0.0217605	9.5675	7.565E-06	0.0000356	0.0001068	0.00013573	0.00012905	0.000445	0.000445
7-Jun-18	6			7.72																						
14-Jun-18	7			7.65	0.0000368	0.00184	0.7038	0.007544	0.0023	0.0009982	0.000092	0.00069	2.5208	0.0000966	0.6026	0.0000115	0.3174	0.016284	7.59	0.00000736	0.0000138	0.0001104	0.00015548	0.000138	0.00046	0.00046
21-Jun-18	8			7.63																						
28-Jun-18	9			7.62	0.0000774	0.001462	0.5461	0.00688	0.00215	0.0006321	0.000086	0.000645	2.1027	0.0000645	0.5418	0.00001075	0.1892	0.0132741	6.579	0.00000645	0.0000258	0.0002795	0.00010621	0.0001376	0.00043	0.00043
5-Jul-18	10			7.60																						
12-Jul-18	11			7.61	0.0000132	0.001452	0.6072	0.00792	0.0044	0.0004268	0.000088	0.00066	1.7732	0.0000748	0.4708	0.000011	0.1584	0.01408	6.864	0.00000704	0.0000308	0.0000616	0.00013596	0.0001232	0.00044	0.00044
19-Jul-18	12			7.54																						
26-Jul-18	13			7.46	0.0000273	0.001547	0.6006	0.0097825	0.002275	0.00034125	0.0000455	0.0006825	2.08845	0.0000637	0.5369	1.1375E-05	0.2184	0.0167895	7.371	8.645E-06	0.0000091	0.0000364	0.0001638	0.00010465	0.000455	0.000455
2-Aug-18	14			7.55																						
9-Aug-18	15			7.62	0.0000332	0.001411	0.52705	0.0084743	0.0249	0.00029465	0.000083	0.0006225	1.89655	0.0000581	0.51045	1.0375E-05	0.2075	0.0131555	7.055	0.0000083	0.00001245	0.0000747	0.00011371	0.00011205	0.000415	0.000415
16-Aug-18	16			7.59																						
23-Aug-18	17			7.60	0.0000294	0.001218	0.483	0.010122	0.0021	0.0003066	0.000084	0.00063	1.8816	0.0000588	0.5628	0.0000105	0.21	0.013062	7.812	0.0000084	0.0000378	0.0000546	0.00010836	0.0000924	0.00042	0.00042
30-Aug-18	18			7.51																						
6-Sep-18	19			7.52	0.00002905	0.001162	0.43575	0.008964	0.002075	0.0002075	0.000083	0.0006225	1.48985	0.00003735	0.42745	1.0375E-05	0.18675	0.0119935	7.553	7.885E-06	2.075E-06	0.00006225	9.5865E-05	0.0000913	0.000415	0.000415
13-Sep-18	20			7.35																						
20-Sep-18	21			7.61	0.0000369	0.001066	0.37925	0.009061	0.00205	0.0001968	0.000082	0.000615	1.517	0.0000533	0.4838	0.00001025	0.1189	0.011562	6.806	0.00000861	0.0000164	0.0000533	0.0001025	0.000082	0.00041	0.00041
27-Sep-18	22			7.53																						
4-Oct-18	23			7.35	0.00002125	0.0011475	0.329375	0.008925	0.002125	0.000136	0.00002125	0.0006375	1.2495	0.000034	0.3995	1.0625E-05	0.11475	0.009775	5.3975	0.00000935	0.00001275	0.0000255	0.00007735	0.00008075	0.000425	0.000425
11-Oct-18	24			7.59																						

Appendix 4-5, Table 6: Kinetic Test Results - HC5

Mass	1																									
Date	**Cycle**	**Volume mL**		**pH**	**Cond.**	**Acidity**	**Acidity**	**Alkalinity**	**Sulphate**	**Chloride**	**Fluoride**	**Hardness**	**Al**	**Sb**	**As**	**Ba**	**Be**	**Bi**	**B**	**Cd**	**Ca**	**Cr**	**Co**	**Cu**	**Fe**	**Pb**
	No.	**Input**	**Output**			**(pH 4.5)**	**(pH 8.3)**					**$CaCO_3$**														
					umhos/cm	$mgCaCO_3/L$	$mgCaCO_3/L$	$mgCaCO_3/L$	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
26-Apr-18	0	500	320	7.71	430	#N/A	4.2	22.2	121	9	0.14	134	0.087	*<0.0001*	0.0128	0.00855	0.000008	*<3.5E-06*	0.015	0.000015	46.5	0.00008	0.000280	0.00067	0.018	0.00031
3-May-18	1	500	470	7.78	344	#N/A	2.0	20.7	133	9	0.14	131	0.151	*<0.0001*	0.0156	0.00585	*<3.5E-06*	*<3.5E-06*	0.026	0.000008	45.6	*<0.000015*	0.000136	0.00028	*<0.0035*	0.00001
10-May-18	2	500	440	7.69	336	#N/A	2.9	22.9	129	5	0.19	133	0.154	*<0.0001*	0.0166	0.00642	*<3.5E-06*	*<3.5E-06*	0.024	0.000011	45.3	0.00003	0.000158	0.00023	*<0.0035*	0.00001
17-May-18	3	500	445	7.94	265	#N/A	2.1	21.2	93	2	0.14	86.8	0.148	*<0.0001*	0.0140	0.00398	*<3.5E-06*	*<3.5E-06*	0.017	0.000013	29.2	*<0.000015*	0.000067	0.00019	*<0.0035*	0.00002
24-May-18	4	500	425	7.70	214	#N/A	3.5	23.1	70																	
31-May-18	5	500	440	8.00	182	#N/A	2.1	23.4	52	*<0.5*	0.16	66.1	0.171	*<0.0001*	0.0173	0.00300	*<3.5E-06*	*<3.5E-06*	0.015	0.000004	23.1	*<0.000015*	0.000071	0.00023	*<0.0035*	0.00001
7-Jun-18	6	500	515	8.10	176	#N/A	2.4	24.1	53																	
14-Jun-18	7	500	445	8.14	125	#N/A	2.2	22.2	30	1	0.11	43.9	0.195	*<0.0001*	0.0166	0.00164	*<3.5E-06*	*<3.5E-06*	0.010	0.000006	15.4	*<0.000015*	0.000053	0.00026	*<0.0035*	0.00004
21-Jun-18	8	500	430	8.12	123	#N/A	2.7	22.6	31																	
28-Jun-18	9	500	423	8.00	127	#N/A	3.7	22.7	34	*<0.5*	0.17	48.2	0.188	*<0.0001*	0.0164	0.00202	*<3.5E-06*	*<3.5E-06*	0.009	0.000015	17.1	*<0.000015*	0.000079	0.00011	0.012	0.00013
5-Jul-18	10	500	415	8.07	130	#N/A	3.2	22.9	32																	
12-Jul-18	11	500	450	8.20	127	#N/A	1.0	21.6	33	*<0.5*	0.08	50.9	0.198	*<0.0001*	0.0165	0.00207	*<3.5E-06*	*<3.5E-06*	0.009	*<0.0000015*	18.2	*<0.000015*	0.000144	0.00422	*<0.0035*	*<0.000005*
19-Jul-18	12	500	445	8.14	123	#N/A	0.8	21.5	33																	
26-Jul-18	13	500	435	7.73	111	#N/A	2.2	23.4	29	*<0.5*	0.06	44.5	0.170	*<0.0001*	0.0125	0.00175	*<3.5E-06*	*<3.5E-06*	0.003	0.000004	15.9	*<0.000015*	0.000076	0.00030	*<0.0035*	0.00004
2-Aug-18	14	500	430	8.29	102	#N/A	1.0	21.4	27																	
9-Aug-18	15	500	420	8.11	102	#N/A	1.3	20.7	27	*<0.5*	*<0.03*	42.2	0.181	*<0.0001*	0.0121	0.00164	*<3.5E-06*	*<3.5E-06*	0.005	0.000003	15.2	*<0.000015*	0.000063	0.00040	*<0.0035*	0.00007
16-Aug-18	16	500	440	8.26	90	#N/A	2.0	21.5	26																	
23-Aug-18	17	500	435	8.13	87	#N/A	2.7	21.3	23	*<0.5*	*<0.03*	38.8	0.156	*<0.0001*	0.0108	0.00131	*<3.5E-06*	*<3.5E-06*	0.006	0.000005	14.1	*<0.000015*	0.000056	0.00050	*<0.0035*	0.00003
30-Aug-18	18	500	425	8.19	88	#N/A	1.3	22.8	25																	
6-Sep-18	19	500	415	8.16	88	#N/A	1.9	22.5	24	*<0.5*	*<0.03*	41.3	0.164	*<0.0001*	0.0123	0.00145	*<3.5E-06*	*<3.5E-06*	0.006	0.000003	14.9	*<0.000015*	0.000063	0.00038	*<0.0035*	0.00004
13-Sep-18	20	500	425	7.67	84	#N/A	3.7	22.4	21																	
20-Sep-18	21	500	415	8.10	95	#N/A	2.1	22.5	19	*<0.5*	*<0.03*	34.7	0.136	*<0.0001*	0.0126	0.00117	0.000007	*<3.5E-06*	0.005	0.000003	12.6	0.00018	0.000063	0.00060	0.011	0.00005
27-Sep-18	22	500	430	8.25	93	#N/A	2.2	19.7	18																	
4-Oct-18	23	500	430	7.73	99	#N/A	3.7	22.4	21	*<0.5*	*<0.03*	37.5	0.139	*<0.0001*	0.0108	0.00115	*<3.5E-06*	*<3.5E-06*	0.006	*<0.0000015*	13.7	0.00003	0.000060	0.00044	*<0.0035*	0.00005
11-Oct-18	24	500	400	7.90	93	#N/A	3.1	21.4	19																	

Loads	**mg/kg**								mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
26-Apr-18	0			7.71					38.72	2.88	0.0448	42.88	0.02784	0.000032	0.004096	0.002736	2.56E-06	1.12E-06	0.0048	0.0000048	14.88	0.0000256	0.0000896	0.0002144	0.00576	0.0000992
3-May-18	1			7.78					62.51	4.23	0.0658	61.57	0.07097	0.000047	0.007332	0.0027495	1.645E-06	1.645E-06	0.01222	0.00000376	21.432	7.05E-06	0.00006392	0.0001316	0.001645	0.0000047
10-May-18	2			7.69					56.76	2.2	0.0836	58.52	0.06776	0.000044	0.007304	0.0028248	1.54E-06	1.54E-06	0.01056	0.00000484	19.932	0.0000132	0.00006952	0.0001012	0.00154	0.0000044
17-May-18	3			7.94					41.385	0.89	0.0623	38.626	0.06586	0.0000445	0.00623	0.0017711	1.558E-06	1.558E-06	0.007565	0.000005785	12.994	6.675E-06	0.000029815	8.455E-05	0.0015575	0.0000089
24-May-18	4			7.70					29.75																	
31-May-18	5			8.00					22.88	0.22	0.0704	29.084	0.07524	0.000044	0.007612	0.00132	1.54E-06	1.54E-06	0.0066	0.00000176	10.164	0.0000066	0.00003124	0.0001012	0.00154	0.0000044
7-Jun-18	6			8.10					27.295																	
14-Jun-18	7			8.14					13.35	0.445	0.04895	19.5355	0.086775	0.0000445	0.007387	0.0007298	1.558E-06	1.558E-06	0.00445	0.00000267	6.853	6.675E-06	0.000023585	0.0001157	0.0015575	0.0000178
21-Jun-18	8			8.12					13.33																	
28-Jun-18	9			8.00					14.382	0.2115	0.07191	20.3886	0.079524	0.0000423	0.0069372	0.0008545	1.481E-06	1.481E-06	0.003807	0.000006345	7.2333	6.345E-06	0.000033417	4.653E-05	0.005076	5.499E-05
5-Jul-18	10			8.07					13.28																	
12-Jul-18	11			8.20					14.85	0.225	0.036	22.905	0.0891	0.000045	0.007425	0.0009315	1.575E-06	1.575E-06	0.00405	0.000000675	8.19	6.75E-06	0.0000648	0.001899	0.001575	2.25E-06
19-Jul-18	12			8.14					14.685																	
26-Jul-18	13			7.73					12.615	0.2175	0.0261	19.3575	0.07395	0.0000435	0.0054375	0.0007613	1.523E-06	1.523E-06	0.001305	0.00000174	6.9165	6.525E-06	0.00003306	0.0001305	0.0015225	0.0000174
2-Aug-18	14			8.29					11.61																	
9-Aug-18	15			8.11					11.34	0.21	0.0126	17.724	0.07602	0.000042	0.005082	0.0006888	1.47E-06	1.47E-06	0.0021	0.00000126	6.384	0.0000063	0.00002646	0.000168	0.00147	0.0000294
16-Aug-18	16			8.26					11.44																	
23-Aug-18	17			8.13					10.005	0.2175	0.01305	16.878	0.06786	0.0000435	0.004698	0.0005699	1.523E-06	1.523E-06	0.00261	0.000002175	6.1335	6.525E-06	0.00002436	0.0002175	0.0015225	1.305E-05
30-Aug-18	18			8.19					10.625																	
6-Sep-18	19			8.16					9.96	0.2075	0.01245	17.1395	0.06806	0.0000415	0.0051045	0.0006018	1.453E-06	1.453E-06	0.00249	0.000001245	6.1835	6.225E-06	0.000026145	0.0001577	0.0014525	0.0000166
13-Sep-18	20			7.67					8.925																	
20-Sep-18	21			8.10					7.885	0.2075	0.01245	14.4005	0.05644	0.0000415	0.005229	0.0004856	2.905E-06	1.453E-06	0.002075	0.000001245	5.229	0.0000747	0.000026145	0.000249	0.004565	2.075E-05
27-Sep-18	22			8.25					7.74																	
4-Oct-18	23			7.73					9.03	0.215	0.0129	16.125	0.05977	0.000043	0.004644	0.0004945	1.505E-06	1.505E-06	0.00258	0.000000645	5.891	0.0000129	0.0000258	0.0001892	0.001505	0.0000215
11-Oct-18	24			7.90					7.6																	

Appendix 4-5, Table 6: Kinetic Test Results - HC5

Mass	1																								
Date	**Cycle**	**Volume mL**		**pH**	**Li**	**Mg**	**Mn**	**Hg**	**Mo**	**Ni**	**P**	**K**	**Se**	**Si**	**Ag**	**Na**	**Sr**	**S**	**Tl**	**Sn**	**Ti**	**U**	**V**	**Zn**	**Zr**
	No.	**Input**	**Output**																						
					mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
26-Apr-18	0	500	320	7.71	0.0183	4.32	0.0635	<0.005	0.00195	0.0033	0.005	11.3	0.00095	1.16	<0.000025	9.14	0.169	46.7	0.000054	0.00016	0.00022	0.00105	0.00025	<0.001	<0.001
3-May-18	1	500	470	7.78	0.0143	4.17	0.0453	0.02	0.00626	0.0014	<0.0015	8.62	0.00123	1.28	<0.000025	9.50	0.184	46.8	0.000033	0.00015	<0.000025	0.00150	0.00046	<0.001	<0.001
10-May-18	2	500	440	7.69	0.0150	4.92	0.0376	<0.005	0.00697	0.0010	<0.0015	10.1	0.00105	1.67	<0.000025	9.08	0.183	47.5	0.000038	0.00007	0.00009	0.00172	0.00061	<0.001	<0.001
17-May-18	3	500	445	7.94	0.0093	3.38	0.0220	<0.005	0.00545	0.0004	<0.0015	6.34	0.00091	1.36	<0.000025	6.42	0.129	30.5	0.000024	0.00006	<0.000025	0.00146	0.00050	<0.001	<0.001
24-May-18	4	500	425	7.70																					
31-May-18	5	500	440	8.00	0.0070	2.02	0.0139	<0.005	0.00398	0.0003	<0.0015	6.11	0.00038	1.71	<0.000025	2.79	0.0819	20.4	0.000021	0.00002	0.00005	0.000802	0.00063	<0.001	<0.001
7-Jun-18	6	500	515	8.10																					
14-Jun-18	7	500	445	8.14	0.0054	1.29	0.0101	<0.005	0.00255	0.0002	<0.0015	4.21	0.00028	1.47	<0.000025	1.54	0.0504	11.7	0.000020	0.00003	0.00011	0.000518	0.00068	<0.001	<0.001
21-Jun-18	8	500	430	8.12																					
28-Jun-18	9	500	423	8.00	0.0055	1.31	0.0125	<0.005	0.00235	0.0002	<0.0015	4.77	0.00025	1.71	<0.000025	1.22	0.05321	13.6	0.000023	0.00005	0.00064	0.000566	0.00071	<0.001	<0.001
5-Jul-18	10	500	415	8.07																					
12-Jul-18	11	500	450	8.20	0.0052	1.34	0.0113	<0.005	0.00209	0.0002	<0.0015	3.70	0.00020	1.40	<0.000025	0.90	0.0506	11.1	0.000020	0.00007	0.00013	0.000706	0.00074	<0.001	<0.001
19-Jul-18	12	500	445	8.14																					
26-Jul-18	13	500	435	7.73	0.0055	1.18	0.0120	0.02	0.00221	<0.00005	<0.0015	4.01	0.00017	1.44	<0.000025	0.86	0.0461	8.2	0.000025	0.00002	0.00014	0.000609	0.00071	<0.001	<0.001
2-Aug-18	14	500	430	8.29																					
9-Aug-18	15	500	420	8.11	0.0044	1.01	0.00985	0.06	0.00218	0.0002	<0.0015	3.24	0.00012	1.30	<0.000025	0.76	0.0438	9.1	0.000019	0.00003	0.00020	0.000517	0.00071	<0.001	<0.001
16-Aug-18	16	500	440	8.26																					
23-Aug-18	17	500	435	8.13	0.0036	0.883	0.00923	<0.005	0.00215	0.0001	<0.0015	2.83	0.00013	1.58	<0.000025	0.69	0.0387	8.2	0.000017	0.00016	0.00012	0.000488	0.00067	<0.001	<0.001
30-Aug-18	18	500	425	8.19																					
6-Sep-18	19	500	415	8.16	0.0042	1.00	0.00938	<0.005	0.00232	0.0001	<0.0015	2.95	0.00014	1.32	<0.000025	0.68	0.0391	8.9	0.000020	<0.000005	0.00013	0.000512	0.00075	<0.001	<0.001
13-Sep-18	20	500	425	7.67																					
20-Sep-18	21	500	415	8.10	0.0038	0.811	0.00868	<0.005	0.00209	0.0001	<0.0015	2.50	0.00018	1.24	<0.000025	0.46	0.0344	6.3	0.000017	0.00009	0.00031	0.000404	0.00074	<0.001	<0.001
27-Sep-18	22	500	430	8.25																					
4-Oct-18	23	500	430	7.73	0.0040	0.794	0.00953	<0.005	0.00160	<0.00005	<0.0015	2.33	0.00009	1.25	<0.000025	0.44	0.0331	7.1	0.000017	0.00003	0.00017	0.000515	0.00067	<0.001	<0.001
11-Oct-18	24	500	400	7.90																					

Loads	**mg/kg**				mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
26-Apr-18	0			7.71	0.005856	1.3824	0.02032	0.0016	0.000624	0.001056	0.0016	3.616	0.000304	0.3712	0.000008	2.9248	0.05408	14.944	0.00001728	0.0000512	0.0000704	0.000336	0.00008	0.00032	0.00032
3-May-18	1			7.78	0.006721	1.9599	0.021291	0.0094	0.0029422	0.000658	0.000705	4.0514	0.0005781	0.6016	1.175E-05	4.465	0.08648	21.996	0.00001551	0.0000705	1.175E-05	0.000705	0.0002162	0.00047	0.00047
10-May-18	2			7.69	0.0066	2.1648	0.016544	0.0022	0.0030668	0.00044	0.00066	4.444	0.000462	0.7348	0.000011	3.9952	0.08052	20.9	0.00001672	0.0000308	0.0000396	0.0007568	0.0002684	0.00044	0.00044
17-May-18	3			7.94	0.0041385	1.5041	0.00979	0.002225	0.0024253	0.000178	0.0006675	2.8213	0.000405	0.6052	1.113E-05	2.8569	0.057405	13.5725	0.00001068	0.0000267	1.113E-05	0.0006497	0.0002225	0.000445	0.000445
24-May-18	4			7.70																					
31-May-18	5			8.00	0.00308	0.8888	0.006116	0.0022	0.0017512	0.000132	0.00066	2.6884	0.0001672	0.7524	0.000011	1.2276	0.036036	8.976	0.00000924	0.0000088	0.000022	0.00035288	0.0002772	0.00044	0.00044
7-Jun-18	6			8.10																					
14-Jun-18	7			8.14	0.002403	0.57405	0.0044945	0.002225	0.0011348	0.000089	0.0006675	1.87345	0.0001246	0.65415	1.113E-05	0.6853	0.022428	5.2065	0.0000089	1.335E-05	4.895E-05	0.00023051	0.0003026	0.000445	0.000445
21-Jun-18	8			8.12																					
28-Jun-18	9			8.00	0.0023265	0.55413	0.0052875	0.002115	0.0009941	0.0000846	0.0006345	2.01771	0.0001058	0.72333	1.058E-05	0.51606	0.0225078	5.7528	9.729E-06	2.115E-05	0.0002707	0.000239418	0.0003003	0.000423	0.000423
5-Jul-18	10			8.07																					
12-Jul-18	11			8.20	0.00234	0.603	0.005085	0.00225	0.0009405	0.00009	0.000675	1.665	0.00009	0.63	1.125E-05	0.405	0.02277	4.995	0.000009	0.0000315	0.0000585	0.0003177	0.000333	0.00045	0.00045
19-Jul-18	12			8.14																					
26-Jul-18	13			7.73	0.0023925	0.5133	0.00522	0.0087	0.0009614	2.175E-05	0.0006525	1.74435	7.395E-05	0.6264	1.088E-05	0.3741	0.0200535	3.567	1.0875E-05	0.0000087	0.0000609	0.000264915	0.0003089	0.000435	0.000435
2-Aug-18	14			8.29																					
9-Aug-18	15			8.11	0.001848	0.4242	0.004137	0.0252	0.0009156	0.000084	0.00063	1.3608	0.0000504	0.546	0.0000105	0.3192	0.018396	3.822	0.00000798	0.0000126	0.000084	0.00021714	0.0002982	0.00042	0.00042
16-Aug-18	16			8.26																					
23-Aug-18	17			8.13	0.001566	0.384105	0.0040151	0.002175	0.0009353	0.0000435	0.0006525	1.23105	5.655E-05	0.6873	1.088E-05	0.30015	0.0168345	3.567	7.395E-06	0.0000696	0.0000522	0.00021228	0.0002915	0.000435	0.000435
30-Aug-18	18			8.19																					
6-Sep-18	19			8.16	0.001743	0.415	0.0038927	0.002075	0.0009628	0.0000415	0.0006225	1.22425	0.0000581	0.5478	1.038E-05	0.2822	0.0162265	3.6935	0.0000083	2.075E-06	5.395E-05	0.00021248	0.0003113	0.000415	0.000415
13-Sep-18	20			7.67																					
20-Sep-18	21			8.10	0.001577	0.336565	0.0036022	0.002075	0.0008674	0.0000415	0.0006225	1.0375	0.0000747	0.5146	1.038E-05	0.1909	0.014276	2.6145	7.055E-06	3.735E-05	0.0001287	0.00016766	0.0003071	0.000415	0.000415
27-Sep-18	22			8.25																					
4-Oct-18	23			7.73	0.00172	0.34142	0.0040979	0.00215	0.000688	0.0000215	0.000645	1.0019	0.0000387	0.5375	1.075E-05	0.1892	0.014233	3.053	0.00000731	0.0000129	0.0000731	0.00022145	0.0002881	0.00043	0.00043
11-Oct-18	24			7.90																					

Appendix 4-5, Table 7: Kinetic Test Results - HC6

Mass	**1**																							
Date	**Cycle**	**Volume mL**		**pH**	**Cond.**	**Acidity**	**Acidity**	**Alkalinity**	**Sulphate**	**Chloride**	**Fluoride**	**Hardness**	**Al**	**Sb**	**As**	**Ba**	**Be**	**Bi**	**B**	**Cd**	**Ca**	**Cr**	**Co**	**Cu**
	No.	**Input**	**Output**			**(pH 4.5)**	**(pH 8.3)**					**$CaCO_3$**												
					umhos/cm	$mgCaCO_3/L$	$mgCaCO_3/L$	$mgCaCO_3/L$	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
26-Apr-18	0	500	345	7.60	606	#N/A	5.0	17.3	195	13	0.25	167	0.067	0.0003	0.0093	0.0113	*<0.0000035*	*<0.0000035*	0.018	0.000010	53.0	0.00010	0.000162	0.00096
3-May-18	1	500	465	7.57	355	#N/A	2.1	14.8	141	9	0.25	117	0.135	0.0008	0.0089	0.00577	*<0.0000035*	*<0.0000035*	0.019	0.000008	36.9	*<0.000015*	0.000037	0.00024
10-May-18	2	500	460	7.49	257	#N/A	3.1	15.6	95	2	0.26	95.3	0.164	0.0007	0.0089	0.00372	*<0.0000035*	*<0.0000035*	0.017	0.000009	29.9	0.00006	0.000028	0.00021
17-May-18	3	500	445	7.49	185	#N/A	2.5	12.9	64	1	0.20	56.9	0.097	0.0005	0.0062	0.00242	*<0.0000035*	*<0.0000035*	0.011	0.000012	18.1	*<0.000015*	0.000023	0.00142
24-May-18	4	500	430	7.49	146	#N/A	3.7	14.2	46															
31-May-18	5	500	450	7.59	120	#N/A	2.6	14.0	35	*<0.5*	0.19	38.2	0.152	0.0005	0.0070	0.00141	*<0.0000035*	*<0.0000035*	0.010	0.000006	12.5	*<0.000015*	0.000018	0.00020
7-Jun-18	6	500	500	7.58	128	#N/A	3.5	14.7	40															
14-Jun-18	7	500	445	7.55	82	#N/A	3.6	12.1	22	1	0.13	26.3	0.133	0.0004	0.0062	0.00087	*<0.0000035*	*<0.0000035*	0.009	0.000004	8.72	*<0.000015*	0.000006	0.00027
21-Jun-18	8	500	440	7.49	78	#N/A	4.2	11.1	22															
28-Jun-18	9	500	430	7.44	71	#N/A	5.1	10.9	21	*<0.5*	0.13	22.9	0.109	0.0003	0.0056	0.00085	*<0.0000035*	*<0.0000035*	0.007	0.000018	7.49	0.00004	0.000005	*<0.00001*
5-Jul-18	10	500	410	7.51	80	#N/A	4.9	11.5	20															
12-Jul-18	11	500	435	7.55	81	#N/A	1.6	11.5	22	*<0.5*	0.10	28.7	0.116	0.0004	0.0066	0.00099	*<0.0000035*	*<0.0000035*	0.009	*<0.0000015*	9.42	*<0.000015*	0.000026	0.00352
19-Jul-18	12	500	425	7.47	71	#N/A	1.3	11.1	20															
26-Jul-18	13	500	440	7.39	71	#N/A	2.1	11.3	22	*<0.5*	0.09	25.3	0.089	0.0003	0.0056	0.00080	*<0.0000035*	*<0.0000035*	0.003	0.000004	8.47	*<0.000015*	0.000010	0.00017
2-Aug-18	14	500	430	7.55	69	#N/A	1.7	11.1	21															
9-Aug-18	15	500	415	7.48	71	#N/A	2.0	10.8	22	*<0.5*	0.09	25.7	0.094	0.0004	0.0069	0.00083	*<0.0000035*	*<0.0000035*	0.006	0.000004	8.62	*<0.000015*	0.000010	0.00024
16-Aug-18	16	500	440	7.71	67	#N/A	3.2	12.7	19															
23-Aug-18	17	500	430	7.62	55	#N/A	3.7	10.6	18	*<0.5*	0.07	21.8	0.076	0.0003	0.0057	0.00070	*<0.0000035*	*<0.0000035*	0.005	0.000005	7.48	0.00003	0.000014	0.00024
30-Aug-18	18	500	425	7.44	56	#N/A	2.6	10.2	18															
6-Sep-18	19	500	420	7.49	64	#N/A	3.3	10.7	20	*<0.5*	0.07	26.8	0.071	0.0004	0.0070	0.00087	*<0.0000035*	*<0.0000035*	0.006	0.000005	9.17	*<0.000015*	0.000010	0.00047
13-Sep-18	20	500	420	7.36	62	#N/A	4.0	11.0	22															
20-Sep-18	21	500	430	7.54	72	#N/A	2.4	11.5	19	*<0.5*	0.06	24.1	0.070	0.0004	0.0084	0.00075	0.000008	*<0.0000035*	0.009	0.000006	8.21	*<0.000015*	0.000016	0.00053
27-Sep-18	22	500	425	7.42	76	#N/A	3.4	8.7	22															
4-Oct-18	23	500	420	7.28	73	#N/A	3.3	9.3	21	*<0.5*	*<0.03*	25.1	0.056	0.0003	0.0059	0.00081	*<0.0000035*	*<0.0000035*	0.006	*<0.0000015*	8.74	0.00004	0.000014	0.00029
11-Oct-18	24	500	410	7.61	73	#N/A	3.4	7.9	21															

Loads	**mg/kg**								mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
26-Apr-18	0			7.60					67.275	4.485	0.08625	57.615	0.023115	0.0001035	0.0032085	0.0038985	1.2075E-06	1.2075E-06	0.00621	0.00000345	18.285	0.0000345	0.00005589	0.0003312
3-May-18	1			7.57					65.565	4.185	0.11625	54.405	0.062775	0.000372	0.0041385	0.0026831	1.6275E-06	1.6275E-06	0.008835	0.00000372	17.1585	0.000006975	0.000017205	0.0001116
10-May-18	2			7.49					43.7	0.92	0.1196	43.838	0.07544	0.000322	0.004094	0.0017112	0.00000161	0.00000161	0.00782	0.00000414	13.754	0.0000276	0.00001288	0.0000966
17-May-18	3			7.49					28.48	0.445	0.089	25.3205	0.043165	0.0002225	0.002759	0.0010769	1.5575E-06	1.5575E-06	0.004895	0.00000534	8.0545	0.000006675	0.000010235	0.0006319
24-May-18	4			7.49					19.78															
31-May-18	5			7.59					15.75	0.225	0.0855	17.19	0.0684	0.000225	0.00315	0.0006345	0.000001575	0.000001575	0.0045	0.0000027	5.625	0.00000675	0.0000081	0.00009
7-Jun-18	6			7.58					20															
14-Jun-18	7			7.55					9.79	0.445	0.05785	11.7035	0.059185	0.000178	0.002759	0.0003872	1.5575E-06	1.5575E-06	0.004005	0.00000178	3.8804	0.000006675	0.00000267	0.0001202
21-Jun-18	8			7.49					9.68															
28-Jun-18	9			7.44					9.03	0.215	0.0559	9.847	0.04687	0.000129	0.002408	0.0003655	0.000001505	0.000001505	0.00301	0.00000774	3.2207	0.0000172	0.00000215	0.0000043
5-Jul-18	10			7.51					8.2															
12-Jul-18	11			7.55					9.57	0.2175	0.0435	12.4845	0.05046	0.000174	0.002871	0.0004307	1.5225E-06	1.5225E-06	0.003915	6.525E-07	4.0977	0.000006525	0.00001131	0.0015312
19-Jul-18	12			7.47					8.5															
26-Jul-18	13			7.39					9.68	0.22	0.0396	11.132	0.03916	0.000132	0.002464	0.000352	0.00000154	0.00000154	0.00132	0.00000176	3.7268	0.0000066	0.0000044	0.0000748
2-Aug-18	14			7.55					9.03															
9-Aug-18	15			7.48					9.13	0.2075	0.03735	10.6655	0.03901	0.000166	0.0028635	0.0003445	1.4525E-06	1.4525E-06	0.00249	0.00000166	3.5773	0.000006225	0.00000415	0.0000996
16-Aug-18	16			7.71					8.36															
23-Aug-18	17			7.62					7.74	0.215	0.0301	9.374	0.03268	0.000129	0.002451	0.000301	0.000001505	0.000001505	0.00215	0.00000215	3.2164	0.0000129	0.00000602	0.0001032
30-Aug-18	18			7.44					7.65															
6-Sep-18	19			7.49					8.4	0.21	0.0294	11.256	0.02982	0.000168	0.00294	0.0003654	0.00000147	0.00000147	0.00252	0.0000021	3.8514	0.0000063	0.0000042	0.0001974
13-Sep-18	20			7.36					9.24															
20-Sep-18	21			7.54					8.17	0.215	0.0258	10.363	0.0301	0.000172	0.003612	0.0003225	0.00000344	0.000001505	0.00387	0.00000258	3.5303	0.00000645	0.00000688	0.0002279
27-Sep-18	22			7.42					9.35															
4-Oct-18	23			7.28					8.82	0.21	0.0126	10.542	0.02352	0.000126	0.002478	0.0003402	0.00000147	0.00000147	0.00252	0.00000063	3.6708	0.0000168	0.00000588	0.0001218
11-Oct-18	24			7.61					8.61															

Appendix 4-5, Table 7: Kinetic Test Results - HC6

Mass	1																										
Date	**Cycle**	**Volume mL**		**pH**	**Fe**	**Pb**	**Li**	**Mg**	**Mn**	**Hg**	**Mo**	**Ni**	**P**	**K**	**Se**	**Si**	**Ag**	**Na**	**Sr**	**S**	**Tl**	**Sn**	**Ti**	**U**	**V**	**Zn**	**Zr**
	No.	**Input**	**Output**																								
					mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
26-Apr-18	0	500	345	7.60	<0.0035	0.00003	0.0266	8.46	0.163	0.03	0.00127	0.0085	0.003	33.6	0.00127	1.15	<0.000025	11.9	0.303	71.8	0.000033	0.00026	<0.000025	0.000586	0.00011	0.005	<0.001
3-May-18	1	500	465	7.57	<0.0035	<0.000005	0.0147	6.11	0.0721	0.01	0.00679	0.0007	<0.0015	19.3	0.00114	1.22	<0.000025	8.75	0.191	50.7	0.000017	0.00011	0.00006	0.000386	0.00024	<0.001	<0.001
10-May-18	2	500	460	7.49	0.010	0.00002	0.0117	5.03	0.0477	<0.005	0.00517	0.0004	<0.0015	14.8	0.00075	1.57	<0.000025	4.94	0.139	35.9	0.000020	0.00012	0.00050	0.000305	0.00036	0.003	<0.001
17-May-18	3	500	445	7.49	<0.0035	0.00015	0.0069	2.83	0.0281	<0.005	0.00355	0.0002	<0.0015	8.80	0.00044	1.08	<0.000025	2.89	0.0925	21.8	0.000014	0.00015	0.00005	0.000255	0.00022	0.002	<0.001
24-May-18	4	500	430	7.49																							
31-May-18	5	500	450	7.59	0.007	<0.000005	0.0043	1.71	0.0161	<0.005	0.00224	<0.00005	<0.0015	6.43	0.00024	1.42	<0.000025	1.49	0.0493	13.0	0.000006	0.00004	0.00026	0.000159	0.00037	<0.001	<0.001
7-Jun-18	6	500	500	7.58																							
14-Jun-18	7	500	445	7.55	<0.0035	0.00001	0.0036	1.11	0.0114	<0.005	0.00137	<0.00005	<0.0015	4.17	0.00014	1.12	<0.000025	0.90	0.0317	8.7	0.000005	0.00005	0.00019	0.000222	0.00037	<0.001	<0.001
21-Jun-18	8	500	440	7.49																							
28-Jun-18	9	500	430	7.44	0.017	0.00004	0.0030	1.01	0.0103	0.02	0.00098	<0.00005	<0.0015	3.64	0.00009	1.09	<0.000025	0.58	0.02684	8.0	0.000006	0.00005	0.00077	0.000151	0.00037	<0.001	<0.001
5-Jul-18	10	500	410	7.51																							
12-Jul-18	11	500	435	7.55	0.007	<0.000005	0.0032	1.26	0.0112	<0.005	0.00104	<0.00005	<0.0015	3.44	0.00009	1.12	<0.000025	0.55	0.0299	7.4	<0.0000025	0.00009	0.00059	0.000171	0.00043	<0.001	<0.001
19-Jul-18	12	500	425	7.47																							
26-Jul-18	13	500	440	7.39	<0.0035	<0.000005	0.0031	1.00	0.00962	<0.005	0.00066	<0.00005	<0.0015	3.34	0.00008	1.13	<0.000025	0.52	0.0271	6.0	0.000006	0.00004	0.00014	0.000198	0.00042	<0.001	<0.001
2-Aug-18	14	500	430	7.55																							
9-Aug-18	15	500	415	7.48	<0.0035	0.00003	0.0029	1.02	0.00900	0.05	0.00074	<0.00005	<0.0015	3.11	0.00006	1.12	<0.000025	0.56	0.0269	7.2	0.000007	0.00005	0.00032	0.000159	0.00045	<0.001	<0.001
16-Aug-18	16	500	440	7.71																							
23-Aug-18	17	500	430	7.62	<0.0035	<0.000005	0.0022	0.768	0.00929	<0.005	0.00043	<0.00005	<0.0015	2.40	<0.00002	1.14	<0.000025	0.40	0.0220	5.7	0.000005	<0.000005	0.00023	0.000135	0.00039	<0.001	<0.001
30-Aug-18	18	500	425	7.44																							
6-Sep-18	19	500	420	7.49	<0.0035	0.00002	0.0026	0.940	0.00960	<0.005	0.00051	<0.00005	<0.0015	2.72	0.00005	1.13	<0.000025	0.43	0.0268	8.1	0.000006	<0.000005	0.00014	0.000162	0.00041	0.003	<0.001
13-Sep-18	20	500	420	7.36																							
20-Sep-18	21	500	430	7.54	0.009	0.00002	0.0026	0.864	0.00936	<0.005	0.00071	<0.00005	<0.0015	2.42	0.00008	1.24	<0.000025	0.30	0.0239	6.8	0.000007	0.00005	0.00036	0.000165	0.00046	<0.001	<0.001
27-Sep-18	22	500	425	7.42																							
4-Oct-18	23	500	420	7.28	<0.0035	0.00001	0.0028	0.795	0.00965	<0.005	0.00026	<0.00005	<0.0015	1.99	0.00005	1.03	<0.000025	0.26	0.0234	7.1	0.000005	0.00004	0.00010	0.000138	0.00040	<0.001	<0.001
11-Oct-18	24	500	410	7.61																							

Loads	**mg/kg**				mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
26-Apr-18	0			7.60	0.0012075	1.035E-05	0.009177	2.9187	0.056235	0.01035	0.0004382	0.0029325	0.001035	11.592	0.0004382	0.39675	8.625E-06	4.1055	0.104535	24.771	0.000011385	0.0000897	8.625E-06	0.0002022	3.795E-05	0.001725	0.000345
3-May-18	1			7.57	0.0016275	2.325E-06	0.0068355	2.84115	0.0335265	0.00465	0.0031574	0.0003255	0.0006975	8.9745	0.0005301	0.5673	1.163E-05	4.06875	0.088815	23.576	0.000007905	5.115E-05	0.0000279	0.0001795	0.0001116	0.000465	0.000465
10-May-18	2			7.49	0.0046	0.0000092	0.005382	2.3138	0.021942	0.0023	0.0023782	0.000184	0.00069	6.808	0.000345	0.7222	0.0000115	2.2724	0.06394	16.514	0.0000092	0.0000552	0.00023	0.0001403	0.0001656	0.00138	0.00046
17-May-18	3			7.49	0.0015575	6.675E-05	0.0030705	1.25935	0.0125045	0.002225	0.0015798	0.000089	0.0006675	3.916	0.0001958	0.4806	1.113E-05	1.28605	0.0411625	9.701	0.00000623	6.675E-05	2.225E-05	0.0001135	0.0000979	0.00089	0.000445
24-May-18	4			7.49																							
31-May-18	5			7.59	0.00315	2.25E-06	0.001935	0.7695	0.007245	0.00225	0.001008	0.0000225	0.000675	2.8935	0.000108	0.639	1.125E-05	0.6705	0.022185	5.85	0.0000027	0.000018	0.000117	7.155E-05	0.0001665	0.00045	0.00045
7-Jun-18	6			7.58																							
14-Jun-18	7			7.55	0.0015575	4.45E-06	0.001602	0.49395	0.005073	0.002225	0.0006097	2.225E-05	0.0006675	1.85565	0.0000623	0.4984	1.113E-05	0.4005	0.0141065	3.8715	0.000002225	2.225E-05	8.455E-05	9.879E-05	0.0001647	0.000445	0.000445
21-Jun-18	8			7.49																							
28-Jun-18	9			7.44	0.00731	0.0000172	0.00129	0.4343	0.004429	0.0086	0.0004214	0.0000215	0.000645	1.5652	0.0000387	0.4687	1.075E-05	0.2494	0.0115412	3.44	0.00000258	0.0000215	0.0003311	6.493E-05	0.0001591	0.00043	0.00043
5-Jul-18	10			7.51																							
12-Jul-18	11			7.55	0.003045	2.175E-06	0.001392	0.5481	0.004872	0.002175	0.0004524	2.175E-05	0.0006525	1.4964	3.915E-05	0.4872	1.088E-05	0.23925	0.0130065	3.219	1.0875E-06	3.915E-05	0.0002567	7.439E-05	0.0001871	0.000435	0.000435
19-Jul-18	12			7.47																							
26-Jul-18	13			7.39	0.00154	0.0000022	0.001364	0.44	0.0042328	0.0022	0.0002904	0.000022	0.00066	1.4696	0.0000352	0.4972	0.000011	0.2288	0.011924	2.64	0.00000264	0.0000176	0.0000616	8.712E-05	0.0001848	0.00044	0.00044
2-Aug-18	14			7.55																							
9-Aug-18	15			7.48	0.0014525	1.245E-05	0.0012035	0.4233	0.003735	0.02075	0.0003071	2.075E-05	0.0006225	1.29065	0.0000249	0.4648	1.038E-05	0.2324	0.0111635	2.988	0.000002905	2.075E-05	0.0001328	6.599E-05	0.0001868	0.000415	0.000415
16-Aug-18	16			7.71																							
23-Aug-18	17			7.62	0.001505	2.15E-06	0.000946	0.33024	0.0039947	0.00215	0.0001849	0.0000215	0.000645	1.032	0.0000086	0.4902	1.075E-05	0.172	0.00946	2.451	0.00000215	2.15E-06	0.0000989	5.805E-05	0.0001677	0.00043	0.00043
30-Aug-18	18			7.44																							
6-Sep-18	19			7.49	0.00147	0.0000084	0.001092	0.3948	0.004032	0.0021	0.0002142	0.000021	0.00063	1.1424	0.000021	0.4746	0.0000105	0.1806	0.011256	3.402	0.00000252	0.0000021	0.0000588	6.804E-05	0.0001722	0.00126	0.00042
13-Sep-18	20			7.36																							
20-Sep-18	21			7.54	0.00387	0.0000086	0.001118	0.37152	0.0040248	0.00215	0.0003053	0.0000215	0.000645	1.0406	0.0000344	0.5332	1.075E-05	0.129	0.010277	2.924	0.00000301	0.0000215	0.0001548	7.095E-05	0.0001978	0.00043	0.00043
27-Sep-18	22			7.42																							
4-Oct-18	23			7.28	0.00147	0.0000042	0.001176	0.3339	0.004053	0.0021	0.0001092	0.000021	0.00063	0.8358	0.000021	0.4326	0.0000105	0.1092	0.009828	2.982	0.0000021	0.0000168	0.000042	5.796E-05	0.000168	0.00042	0.00042
11-Oct-18	24			7.61																							

Appendix 4-5, Table 8: Kinetic Test Results - HC7

Mass	**1**																									
Date	**Cycle**	**Volume mL**		**pH**	**Cond.**	**Acidity**	**Acidity**	**Alkalinity**	**Sulphate**	**Chloride**	**Fluoride**	**Hardness**	**Al**	**Sb**	**As**	**Ba**	**Be**	**Bi**	**B**	**Cd**	**Ca**	**Cr**	**Co**	**Cu**	**Fe**	**Pb**
	No.	**Input**	**Output**			**(pH 4.5)**	**(pH 8.3)**					**$CaCO_3$**														
					umhos/cm	$mgCaCO_3/L$	$mgCaCO_3/L$	$mgCaCO_3/L$	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
26-Apr-18	0	500	315	7.83	156	#N/A	3.0	23.8	6	18	0.12	25.8	0.052	0.0004	0.0175	0.00167	*<3.5E-06*	*<3.5E-06*	0.009	0.000003	8.99	0.00005	*<0.000002*	0.00061	*<0.0035*	*<0.000005*
3-May-18	1	500	450	8.45	141	#N/A	#N/A	26.4	11	18	0.14	29.3	0.194	0.0009	0.0413	0.00222	*<3.5E-06*	*<3.5E-06*	0.020	0.000010	9.98	0.00005	*<0.000002*	0.00050	*<0.0035*	*<0.000005*
10-May-18	2	500	435	7.85	114	#N/A	2.5	31.2	8	10	0.16	26.6	0.204	0.0010	0.0536	0.00170	*<3.5E-06*	*<3.5E-06*	0.018	0.000008	8.84	0.00007	0.000014	0.00050	*<0.0035*	*<0.000005*
17-May-18	3	500	460	8.46	77	#N/A	#N/A	25.5	4	3	0.09	19.8	0.206	0.0007	0.0463	0.00132	*<3.5E-06*	*<3.5E-06*	0.009	0.000005	6.81	0.00006	0.000014	0.00041	*<0.0035*	*<0.000005*
24-May-18	4	500	420	7.82	69	#N/A	3.0	26.9	4																	
31-May-18	5	500	450	8.43	66	#N/A	#N/A	27.7	3	1	0.07	22.1	0.211	0.0006	0.0635	0.00110	*<3.5E-06*	*<3.5E-06*	0.007	0.000003	7.73	0.00004	0.000016	0.00034	*<0.0035*	*<0.000005*
7-Jun-18	6	500	495	8.38	71	#N/A	#N/A	31.0	3																	
14-Jun-18	7	500	455	8.46	59	#N/A	#N/A	26.1	2	1	*<0.03*	22.1	0.216	0.0005	0.0604	0.00101	*<3.5E-06*	*<3.5E-06*	0.006	*<1.5E-06*	7.72	0.00004	0.000017	0.00045	*<0.0035*	*<0.000005*
21-Jun-18	8	500	445	8.36	58	#N/A	#N/A	25.9	2																	
28-Jun-18	9	500	445	8.28	55	#N/A	1.9	25.2	2	*<0.5*	*<0.03*	22.1	0.209	0.0003	0.0544	0.00108	*<3.5E-06*	*<3.5E-06*	0.005	0.000016	7.84	0.00005	0.000028	0.00023	0.013	0.00003
5-Jul-18	10	500	420	8.38	56	#N/A	#N/A	25.8	2																	
12-Jul-18	11	500	435	8.55	55	#N/A	#N/A	25.8	2	*<0.5*	*<0.03*	24.1	0.244	0.0002	0.0569	0.00110	*<3.5E-06*	*<3.5E-06*	0.005	*<1.5E-06*	8.72	0.00005	0.000059	0.00511	*<0.0035*	*<0.000005*
19-Jul-18	12	500	430	8.46	53	#N/A	#N/A	25.3	2																	
26-Jul-18	13	500	450	7.79	50	#N/A	2.3	25.9	3	*<0.5*	*<0.03*	22.2	0.204	0.0002	0.0362	0.00082	*<3.5E-06*	*<3.5E-06*	*<0.001*	*<1.5E-06*	7.96	0.00004	0.000024	0.00475	*<0.0035*	*<0.000005*
2-Aug-18	14	500	455	8.51	48	#N/A	#N/A	25.0	2																	
9-Aug-18	15	500	430	8.34	45	#N/A	#N/A	23.5	2	*<0.5*	*<0.03*	21.2	0.208	*<0.0001*	0.0343	0.00078	*<3.5E-06*	*<3.5E-06*	0.003	0.000003	7.67	0.00003	0.000021	0.00070	*<0.0035*	0.00003
16-Aug-18	16	500	440	8.49	44	#N/A	#N/A	25.4	2																	
23-Aug-18	17	500	440	8.39	42	#N/A	#N/A	24.4	2	*<0.5*	*<0.03*	21.3	0.189	0.0002	0.0296	0.00074	*<3.5E-06*	*<3.5E-06*	0.005	*<1.5E-06*	7.73	0.00003	0.000018	0.00071	*<0.0035*	*<0.000005*
30-Aug-18	18	500	425	8.36	40	#N/A	#N/A	23.3	3																	
6-Sep-18	19	500	425	8.34	39	#N/A	#N/A	23.2	2	*<0.5*	*<0.03*	21.4	0.202	*<0.0001*	0.0284	0.00074	*<3.5E-06*	*<3.5E-06*	0.004	*<1.5E-06*	7.86	0.00004	0.000016	0.00057	*<0.0035*	*<0.000005*
13-Sep-18	20	500	430	7.75	39	#N/A	3.2	23.2	*<1*																	
20-Sep-18	21	500	430	8.32	48	#N/A	#N/A	24.1	2	*<0.5*	*<0.03*	20.1	0.186	*<0.0001*	0.0280	0.00065	0.000009	*<3.5E-06*	0.005	0.000003	7.38	0.00004	0.000020	0.00081	0.007	0.00001
27-Sep-18	22	500	435	8.50	48	#N/A	#N/A	21.5	2																	
4-Oct-18	23	500	435	7.79	48	#N/A	3.5	24.1	*<1*	*<0.5*	*<0.03*	21.0	0.184	*<0.0001*	0.0234	0.00066	*<3.5E-06*	*<3.5E-06*	0.005	*<1.5E-06*	7.76	0.00004	0.000014	0.00051	*<0.0035*	*<0.000005*
11-Oct-18	24	500	415	8.02	42	#N/A	2.4	23.3	*<1*																	

Loads	**mg/kg**								mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
26-Apr-18	0			7.83					1.89	5.67	0.0378	8.127	0.01638	0.000126	0.0055125	0.0005261	1.103E-06	1.103E-06	0.002835	9.45E-07	2.83185	1.575E-05	6.3E-07	0.0001922	0.0011025	1.575E-06
3-May-18	1			8.45					4.95	8.1	0.063	13.185	0.0873	0.000405	0.018585	0.000999	1.575E-06	1.575E-06	0.009	0.0000045	4.491	0.0000225	0.0000009	0.000225	0.001575	2.25E-06
10-May-18	2			7.85					3.48	4.35	0.0696	11.571	0.08874	0.000435	0.023316	0.0007395	1.523E-06	1.523E-06	0.00783	3.48E-06	3.8454	3.045E-05	6.09E-06	0.0002175	0.0015225	2.175E-06
17-May-18	3			8.46					1.84	1.38	0.0414	9.108	0.09476	0.000322	0.021298	0.0006072	1.61E-06	1.61E-06	0.00414	0.0000023	3.1326	0.0000276	6.44E-06	0.0001886	0.00161	0.0000023
24-May-18	4			7.82					1.68																	
31-May-18	5			8.43					1.35	0.45	0.0315	9.945	0.09495	0.00027	0.028575	0.000495	1.575E-06	1.575E-06	0.00315	1.35E-06	3.4785	0.000018	0.0000072	0.000153	0.001575	2.25E-06
7-Jun-18	6			8.38					1.485																	
14-Jun-18	7			8.46					0.91	0.455	0.01365	10.0555	0.09828	0.0002275	0.027482	0.0004596	1.593E-06	1.593E-06	0.00273	6.825E-07	3.5126	0.0000182	7.735E-06	0.0002048	0.0015925	2.275E-06
21-Jun-18	8			8.36					0.89																	
28-Jun-18	9			8.28					0.89	0.2225	0.01335	9.8345	0.093005	0.0001335	0.024208	0.0004806	1.558E-06	1.558E-06	0.002225	7.12E-06	3.4888	2.225E-05	1.246E-05	0.0001024	0.005785	1.335E-05
5-Jul-18	10			8.38					0.84																	
12-Jul-18	11			8.55					0.87	0.2175	0.01305	10.4835	0.10614	0.000087	0.0247515	0.0004785	1.523E-06	1.523E-06	0.002175	6.525E-07	3.7932	2.175E-05	2.567E-05	0.0022229	0.0015225	2.175E-06
19-Jul-18	12			8.46					0.86																	
26-Jul-18	13			7.79					1.35	0.225	0.0135	9.99	0.0918	0.00009	0.01629	0.000369	1.575E-06	1.575E-06	0.00045	6.75E-07	3.582	0.000018	0.0000108	0.0021375	0.001575	2.25E-06
2-Aug-18	14			8.51					0.91																	
9-Aug-18	15			8.34					0.86	0.215	0.0129	9.116	0.08944	0.000043	0.014749	0.0003354	1.505E-06	1.505E-06	0.00129	1.29E-06	3.2981	0.0000129	9.03E-06	0.000301	0.001505	0.0000129
16-Aug-18	16			8.49					0.88																	
23-Aug-18	17			8.39					0.88	0.22	0.0132	9.372	0.08316	0.000088	0.013024	0.0003256	1.54E-06	1.54E-06	0.0022	6.6E-07	3.4012	0.0000132	7.92E-06	0.0003124	0.00154	0.0000022
30-Aug-18	18			8.36					1.275																	
6-Sep-18	19			8.34					0.85	0.2125	0.01275	9.095	0.08585	0.0000425	0.01207	0.0003145	1.488E-06	1.488E-06	0.0017	6.375E-07	3.3405	0.000017	0.0000068	0.0002423	0.0014875	2.125E-06
13-Sep-18	20			7.75					0.43																	
20-Sep-18	21			8.32					0.86	0.215	0.0129	8.643	0.07998	0.000043	0.01204	0.0002795	3.87E-06	1.505E-06	0.00215	1.29E-06	3.1734	0.0000172	0.0000086	0.0003483	0.00301	0.0000043
27-Sep-18	22			8.50					0.87																	
4-Oct-18	23			7.79					0.435	0.2175	0.01305	9.135	0.08004	0.0000435	0.010179	0.0002871	1.523E-06	1.523E-06	0.002175	6.525E-07	3.3756	0.0000174	6.09E-06	0.0002219	0.0015225	2.175E-06
11-Oct-18	24			8.02					0.415																	

Appendix 4-5, Table 8: Kinetic Test Results - HC7

Mass	1																								
Date	**Cycle**	**Volume mL**		**pH**	**Li**	**Mg**	**Mn**	**Hg**	**Mo**	**Ni**	**P**	**K**	**Se**	**Si**	**Ag**	**Na**	**Sr**	**S**	**Tl**	**Sn**	**Ti**	**U**	**V**	**Zn**	**Zr**
	No.	**Input**	**Output**																						
					mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
26-Apr-18	0	500	315	7.83	0.0042	0.814	0.00132	<0.005	0.00873	0.0002	0.015	6.51	0.00034	2.23	<0.000025	9.44	0.0931	2.3	0.000012	0.00029	<0.000025	0.000084	0.00160	<0.001	<0.001
3-May-18	1	500	450	8.45	0.0059	1.05	0.0023	0.02	0.0235	<0.00005	0.011	5.93	0.00042	2.03	<0.000025	11.9	0.118	3.3	0.000008	0.00017	0.00005	0.000756	0.00343	<0.001	<0.001
10-May-18	2	500	435	7.85	0.0060	1.10	0.0024	<0.005	0.0267	0.0001	0.008	5.62	0.00031	2.22	<0.000025	9.03	0.101	3.1	0.000020	0.00017	0.00051	0.00152	0.00395	<0.001	<0.001
17-May-18	3	500	460	8.46	0.0038	0.678	0.0023	<0.005	0.0127	<0.00005	0.008	2.83	0.00017	1.39	<0.000025	5.01	0.0714	2.5	0.000007	0.00009	0.00029	0.00287	0.00290	<0.001	<0.001
24-May-18	4	500	420	7.82																					
31-May-18	5	500	450	8.43	0.0028	0.669	0.00251	<0.005	0.00414	<0.00005	0.004	2.68	0.00013	1.90	<0.000025	2.37	0.0633	0.8	<2.5E-06	0.00004	0.00014	0.00532	0.00327	<0.001	<0.001
7-Jun-18	6	500	495	8.38																					
14-Jun-18	7	500	455	8.46	0.0028	0.69	0.0030	<0.005	0.00203	<0.00005	0.008	1.85	0.00017	1.64	<0.000025	1.49	0.0585	1.0	0.000005	0.00006	0.00024	0.006590	0.00304	<0.001	<0.001
21-Jun-18	8	500	445	8.36																					
28-Jun-18	9	500	445	8.28	0.0025	0.619	0.00405	<0.005	0.00127	<0.00005	0.003	1.85	0.00007	1.66	<0.000025	1.13	0.05381	1.0	0.000005	0.00005	0.00109	0.005236	0.00310	<0.001	<0.001
5-Jul-18	10	500	420	8.38																					
12-Jul-18	11	500	435	8.55	0.0024	0.559	0.00397	<0.005	0.00099	<0.00005	<0.0015	1.47	0.00005	1.59	<0.000025	0.75	0.0518	0.3	<2.5E-06	0.00008	0.00053	0.00435	0.00347	<0.001	<0.001
19-Jul-18	12	500	430	8.46																					
26-Jul-18	13	500	450	7.79	0.0023	0.556	0.00336	<0.005	0.00066	<0.00005	<0.0015	1.15	0.00005	1.52	<0.000025	0.66	0.0490	<0.05	0.000005	0.00004	0.00018	0.00319	0.00263	<0.001	<0.001
2-Aug-18	14	500	455	8.51																					
9-Aug-18	15	500	430	8.34	0.0020	0.499	0.00338	0.05	0.00064	<0.00005	<0.0015	1.11	0.00007	1.40	<0.000025	0.65	0.0436	0.5	<2.5E-06	0.00003	0.00032	0.002259	0.00282	<0.001	<0.001
16-Aug-18	16	500	440	8.49																					
23-Aug-18	17	500	440	8.39	0.0016	0.471	0.00377	<0.005	0.00054	<0.00005	<0.0015	0.938	0.00005	1.45	<0.000025	0.57	0.0417	<0.05	<2.5E-06	<0.000005	0.00031	0.00190	0.00246	<0.001	<0.001
30-Aug-18	18	500	425	8.36																					
6-Sep-18	19	500	425	8.34	0.0018	0.424	0.00346	<0.005	0.00050	<0.00005	<0.0015	0.846	0.00005	1.32	<0.000025	0.52	0.0377	<0.05	<2.5E-06	0.00008	0.00025	0.001468	0.00248	<0.001	<0.001
13-Sep-18	20	500	430	7.75																					
20-Sep-18	21	500	430	8.32	0.0016	0.396	0.00311	<0.005	0.00047	<0.00005	<0.0015	0.722	0.00006	1.40	<0.000025	0.37	0.0382	0.9	<2.5E-06	0.00007	0.00023	0.00124	0.00215	<0.001	<0.001
27-Sep-18	22	500	435	8.50																					
4-Oct-18	23	500	435	7.79	0.0018	0.380	0.00364	<0.005	0.00029	<0.00005	<0.0015	0.692	<0.00002	1.32	<0.000025	0.38	0.0342	0.9	<2.5E-06	0.00003	0.00010	0.00118	0.00214	<0.001	<0.001
11-Oct-18	24	500	415	8.02																					

Loads	**mg/kg**				mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
26-Apr-18	0			7.83	0.001323	0.25641	0.0004158	0.001575	0.00275	0.000063	0.004725	2.05065	0.0001071	0.70245	7.875E-06	2.9736	0.0293265	0.7245	3.78E-06	9.135E-05	7.875E-06	2.646E-05	0.000504	0.000315	0.000315
3-May-18	1			8.45	0.002655	0.4725	0.001035	0.009	0.010575	0.0000225	0.00495	2.6685	0.000189	0.9135	1.125E-05	5.355	0.0531	1.485	0.0000036	0.0000765	0.0000225	0.0003402	0.0015435	0.00045	0.00045
10-May-18	2			7.85	0.00261	0.4785	0.001044	0.002175	0.0116145	0.0000435	0.00348	2.4447	0.0001349	0.9657	1.088E-05	3.92805	0.043935	1.3485	0.0000087	7.395E-05	0.0002219	0.0006612	0.0017183	0.000435	0.000435
17-May-18	3			8.46	0.001748	0.31188	0.001058	0.0023	0.005842	0.000023	0.00368	1.3018	0.0000782	0.6394	0.0000115	2.3046	0.032844	1.15	3.22E-06	0.0000414	0.0001334	0.0013202	0.001334	0.00046	0.00046
24-May-18	4			7.82																					
31-May-18	5			8.43	0.00126	0.30105	0.0011295	0.00225	0.001863	0.0000225	0.0018	1.206	0.0000585	0.855	1.125E-05	1.0665	0.028485	0.36	1.125E-06	0.000018	0.000063	0.002394	0.0014715	0.00045	0.00045
7-Jun-18	6			8.38																					
14-Jun-18	7			8.46	0.001274	0.31395	0.0013468	0.002275	0.0009237	2.275E-05	0.00364	0.84175	7.735E-05	0.7462	1.138E-05	0.67795	0.0266175	0.455	2.275E-06	0.0000273	0.0001092	0.0029985	0.0013832	0.000455	0.000455
21-Jun-18	8			8.36																					
28-Jun-18	9			8.28	0.0011125	0.275455	0.0018023	0.002225	0.0005652	2.225E-05	0.001335	0.82325	3.115E-05	0.7387	1.113E-05	0.50285	0.0239455	0.445	2.225E-06	2.225E-05	0.0004851	0.00233	0.0013795	0.000445	0.000445
5-Jul-18	10			8.38																					
12-Jul-18	11			8.55	0.001044	0.243165	0.001727	0.002175	0.0004307	2.175E-05	0.0006525	0.63945	2.175E-05	0.69165	1.088E-05	0.32625	0.022533	0.1305	1.088E-06	0.0000348	0.0002306	0.0018923	0.0015095	0.000435	0.000435
19-Jul-18	12			8.46																					
26-Jul-18	13			7.79	0.001035	0.2502	0.001512	0.00225	0.000297	0.0000225	0.000675	0.5175	0.0000225	0.684	1.125E-05	0.297	0.02205	0.0225	2.25E-06	0.000018	0.000081	0.0014355	0.0011835	0.00045	0.00045
2-Aug-18	14			8.51																					
9-Aug-18	15			8.34	0.00086	0.21457	0.0014534	0.0215	0.0002752	0.0000215	0.000645	0.4773	0.0000301	0.602	1.075E-05	0.2795	0.018748	0.215	1.075E-06	0.0000129	0.0001376	0.0009714	0.0012126	0.00043	0.00043
16-Aug-18	16			8.49																					
23-Aug-18	17			8.39	0.000704	0.20724	0.0016588	0.0022	0.0002376	0.000022	0.00066	0.41272	0.000022	0.638	0.000011	0.2508	0.018348	0.022	0.0000011	0.0000022	0.0001364	0.000836	0.0010824	0.00044	0.00044
30-Aug-18	18			8.36																					
6-Sep-18	19			8.34	0.000765	0.1802	0.0014705	0.002125	0.0002125	2.125E-05	0.0006375	0.35955	2.125E-05	0.561	1.063E-05	0.221	0.0160225	0.02125	1.063E-06	0.000034	0.0001063	0.0006239	0.001054	0.000425	0.000425
13-Sep-18	20			7.75																					
20-Sep-18	21			8.32	0.000688	0.17028	0.0013373	0.00215	0.0002021	0.0000215	0.000645	0.31046	0.0000258	0.602	1.075E-05	0.1591	0.016426	0.387	1.075E-06	0.0000301	0.0000989	0.0005332	0.0009245	0.00043	0.00043
27-Sep-18	22			8.50																					
4-Oct-18	23			7.79	0.000783	0.1653	0.0015834	0.002175	0.0001262	2.175E-05	0.0006525	0.30102	0.0000087	0.5742	1.088E-05	0.1653	0.014877	0.3915	1.088E-06	1.305E-05	0.0000435	0.0005133	0.0009309	0.000435	0.000435
11-Oct-18	24			8.02																					

Appendix 4-5, Table 9: Kinetic Test Results - HC8

Mass	**1**																								
Date	**Cycle**	**Volume mL**		**pH**	**Cond.**	**Acidity**	**Acidity**	**Alkalinity**	**Sulphate**	**Chloride**	**Fluoride**	**Hardness**	**Al**	**Sb**	**As**	**Ba**	**Be**	**Bi**	**B**	**Cd**	**Ca**	**Cr**	**Co**	**Cu**	**Fe**
	No.	**Input**	**Output**			**(pH 4.5)**	**(pH 8.3)**					**$CaCO_3$**													
					umhos/cm	$mgCaCO_3/L$	$mgCaCO_3/L$	$mgCaCO_3/L$	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
26-Apr-18	0	500	330	7.94	153	#N/A	2.8	29.2	16	6	0.20	13.1	0.353	0.0006	0.112	0.00086	<3.5E-06	<3.5E-06	0.010	<0.0000015	4.36	0.00006	<0.000002	0.00022	<0.0035
3-May-18	1	500	470	8.42	146	#N/A	#N/A	32.9	29	5	0.20	20.1	0.495	0.0025	0.131	0.00259	0.000007	0.000021	0.015	0.000008	6.36	0.00020	0.000015	0.00039	0.075
10-May-18	2	500	445	7.86	138	#N/A	2.4	31.4	31	1	0.16	23.7	0.321	0.0019	0.109	0.00165	<3.5E-06	<3.5E-06	0.012	<0.0000015	7.17	0.00007	0.000012	0.00021	0.009
17-May-18	3	500	435	8.48	90	#N/A	#N/A	23.5	16	<0.5	0.10	18.1	0.331	0.0011	0.0901	0.00095	<3.5E-06	<3.5E-06	0.007	0.000003	5.78	0.00003	0.000015	0.00038	0.009
24-May-18	4	500	415	7.80	99	#N/A	3.2	24.6	18																
31-May-18	5	500	445	8.30	95	#N/A	#N/A	26.6	15	<0.5	0.09	23.6	0.312	0.0013	0.107	0.00149	<3.5E-06	<3.5E-06	0.009	<0.0000015	7.38	0.00005	0.000023	0.00034	0.027
7-Jun-18	6	500	495	8.15	78	#N/A	2.2	25.7	11																
14-Jun-18	7	500	445	8.23	72	#N/A	1.8	22.1	9	<0.5	<0.03	21.5	0.283	0.0008	0.0853	0.00082	<3.5E-06	<3.5E-06	0.007	<0.0000015	6.88	<0.000015	0.000010	0.00019	<0.0035
21-Jun-18	8	500	430	8.22	69	#N/A	2.2	21.3	9																
28-Jun-18	9	500	430	7.95	69	#N/A	3.6	19.7	12	<0.5	<0.03	21.7	0.276	0.0005	0.0581	0.00104	<3.5E-06	<3.5E-06	0.005	0.000008	6.98	0.00008	0.000014	<0.00001	0.031
5-Jul-18	10	500	405	8.08	90	#N/A	3.4	22.1	16																
12-Jul-18	11	500	420	8.15	79	#N/A	1.0	20.3	12	<0.5	<0.03	27.3	0.269	0.0004	0.0625	0.00106	<3.5E-06	<3.5E-06	0.006	<0.0000015	9.06	0.00004	0.000033	0.0108	0.008
19-Jul-18	12	500	430	8.01	93	#N/A	1.0	22.3	20																
26-Jul-18	13	500	425	7.70	87	#N/A	2.2	22.3	20	<0.5	<0.03	31.7	0.219	0.0004	0.0480	0.00116	<3.5E-06	<3.5E-06	<0.001	<0.0000015	10.6	<0.000015	0.000015	0.00024	<0.0035
2-Aug-18	14	500	435	7.99	73	#N/A	1.2	18.7	15																
9-Aug-18	15	500	410	7.96	100	#N/A	1.9	21.2	25	<0.5	<0.03	38.7	0.207	0.0004	0.0512	0.00128	<3.5E-06	<3.5E-06	0.005	<0.0000015	13.2	<0.000015	0.000018	0.00027	<0.0035
16-Aug-18	16	500	425	8.08	59	#N/A	2.4	17.8	13																
23-Aug-18	17	500	425	7.90	60	#N/A	3.2	16.4	13	<0.5	<0.03	25.4	0.197	0.0002	0.0290	0.00084	<3.5E-06	<3.5E-06	0.004	0.000003	8.84	0.00003	0.000023	0.00047	0.008
30-Aug-18	18	500	430	7.85	58	#N/A	2.1	15.4	14																
6-Sep-18	19	500	410	7.87	67	#N/A	2.6	15.6	20	<0.5	<0.03	29.2	0.183	0.0003	0.0280	0.00096	<3.5E-06	<3.5E-06	0.004	0.000005	10.4	<0.000015	0.000012	0.00024	<0.0035
13-Sep-18	20	500	420	7.55	69	#N/A	3.6	16.2	20																
20-Sep-18	21	500	420	7.85	82	#N/A	2.1	16.1	20	<0.5	<0.03	28.8	0.168	0.0002	0.0265	0.00096	0.000009	<3.5E-06	0.005	0.000003	10.2	0.00004	0.000021	0.00056	0.012
27-Sep-18	22	500	435	7.81	88	#N/A	2.8	14.1	24																
4-Oct-18	23	500	415	7.85	141	#N/A	5.8	17.5	44	<0.5	<0.03	50.5	0.156	0.0003	0.0277	0.00140	<3.5E-06	<3.5E-06	0.005	<0.0000015	18.9	0.00004	0.000020	0.00041	<0.0035
11-Oct-18	24	500	395	7.80	115	#N/A	3.1	15.5	33																

Loads	**mg/kg**								mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
26-Apr-18	0			7.94					5.28	1.98	0.066	4.323	0.11649	0.000198	0.03696	0.0002838	1.155E-06	1.155E-06	0.0033	0.000000495	1.4388	0.0000198	0.00000066	0.0000726	0.001155
3-May-18	1			8.42					13.63	2.35	0.094	9.447	0.23265	0.001175	0.06157	0.0012173	3.29E-06	9.87E-06	0.00705	0.00000376	2.9892	0.000094	0.00000705	0.0001833	0.03525
10-May-18	2			7.86					13.795	0.445	0.0712	10.5465	0.142845	0.0008455	0.048505	0.0007343	1.558E-06	1.558E-06	0.00534	6.675E-07	3.19065	3.115E-05	0.00000534	9.345E-05	0.004005
17-May-18	3			8.48					6.96	0.2175	0.0435	7.8735	0.143985	0.0004785	0.0391935	0.0004133	1.523E-06	1.523E-06	0.003045	0.000001305	2.5143	1.305E-05	0.000006525	0.0001653	0.003915
24-May-18	4			7.80					7.47																
31-May-18	5			8.30					6.675	0.2225	0.04005	10.502	0.13884	0.0005785	0.047615	0.0006631	1.558E-06	1.558E-06	0.004005	6.675E-07	3.2841	2.225E-05	0.000010235	0.0001513	0.012015
7-Jun-18	6			8.15					5.445																
14-Jun-18	7			8.23					4.005	0.2225	0.01335	9.5675	0.125935	0.000356	0.0379585	0.0003649	1.558E-06	1.558E-06	0.003115	6.675E-07	3.0616	6.675E-06	0.00000445	8.455E-05	0.0015575
21-Jun-18	8			8.22					3.87																
28-Jun-18	9			7.95					5.16	0.215	0.0129	9.331	0.11868	0.000215	0.024983	0.0004472	1.505E-06	1.505E-06	0.00215	0.00000344	3.0014	0.0000344	0.00000602	0.0000043	0.01333
5-Jul-18	10			8.08					6.48																
12-Jul-18	11			8.15					5.04	0.21	0.0126	11.466	0.11298	0.000168	0.02625	0.0004452	1.47E-06	1.47E-06	0.00252	0.00000063	3.8052	0.0000168	0.00001386	0.004536	0.00336
19-Jul-18	12			8.01					8.6																
26-Jul-18	13			7.70					8.5	0.2125	0.01275	13.4725	0.093075	0.00017	0.0204	0.000493	1.488E-06	1.488E-06	0.000425	6.375E-07	4.505	6.375E-06	0.000006375	0.000102	0.0014875
2-Aug-18	14			7.99					6.525																
9-Aug-18	15			7.96					10.25	0.205	0.0123	15.867	0.08487	0.000164	0.020992	0.0005248	1.435E-06	1.435E-06	0.00205	0.000000615	5.412	6.15E-06	0.00000738	0.0001107	0.001435
16-Aug-18	16			8.08					5.525																
23-Aug-18	17			7.90					5.525	0.2125	0.01275	10.795	0.083725	0.000085	0.012325	0.000357	1.488E-06	1.488E-06	0.0017	0.000001275	3.757	1.275E-05	0.000009775	0.0001998	0.0034
30-Aug-18	18			7.85					6.02																
6-Sep-18	19			7.87					8.2	0.205	0.0123	11.972	0.07503	0.000123	0.01148	0.0003936	1.435E-06	1.435E-06	0.00164	0.00000205	4.264	6.15E-06	0.00000492	0.0000984	0.001435
13-Sep-18	20			7.55					8.4																
20-Sep-18	21			7.85					8.4	0.21	0.0126	12.096	0.07056	0.000084	0.01113	0.0004032	3.78E-06	1.47E-06	0.0021	0.00000126	4.284	0.0000168	0.00000882	0.0002352	0.00504
27-Sep-18	22			7.81					10.44																
4-Oct-18	23			7.85					18.26	0.2075	0.01245	20.9575	0.06474	0.0001245	0.0114955	0.000581	1.453E-06	1.453E-06	0.002075	6.225E-07	7.8435	0.0000166	0.0000083	0.0001702	0.0014525
11-Oct-18	24			7.80					13.035																

Appendix 4-5, Table 9: Kinetic Test Results - H(

Mass	1																									
Date	**Cycle**	**Volume mL**		**pH**	**Pb**	**Li**	**Mg**	**Mn**	**Hg**	**Mo**	**Ni**	**P**	**K**	**Se**	**Si**	**Ag**	**Na**	**Sr**	**S**	**Tl**	**Sn**	**Ti**	**U**	**V**	**Zn**	**Zr**
	No.	**Input**	**Output**																							
					mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
26-Apr-18	0	500	330	7.94	<0.000005	0.0041	0.540	0.00107	0.03	0.00262	0.0005	0.014	20.2	0.00030	1.43	<0.000025	6.96	0.00992	6.9	0.000006	0.00016	0.00019	0.000043	0.00187	<0.001	<0.001
3-May-18	1	500	470	8.42	0.00017	0.0068	1.03	0.0060	0.06	0.0100	0.0003	0.006	20.3	0.00037	1.72	<0.000025	7.76	0.0171	10.1	0.000011	0.00009	0.00573	0.000575	0.00235	<0.001	<0.001
10-May-18	2	500	445	7.86	0.00003	0.0067	1.40	0.0062	<0.005	0.00974	0.0002	<0.0015	18.9	0.00033	1.59	<0.000025	5.49	0.0192	9.9	0.000007	0.00007	0.00061	0.00126	0.00216	<0.001	<0.001
17-May-18	3	500	435	8.48	0.00004	0.0044	0.900	0.0042	<0.005	0.00404	<0.00005	<0.0015	10.1	0.00022	1.17	<0.000025	2.35	0.0130	5.8	0.000006	0.00005	0.00048	0.000712	0.00172	<0.001	<0.001
24-May-18	4	500	415	7.80																						
31-May-18	5	500	445	8.30	0.00010	0.0048	1.26	0.00640	<0.005	0.00208	0.0001	<0.0015	10.4	0.00020	1.75	<0.000025	1.50	0.0145	5.2	0.000005	0.00002	0.00165	0.00137	0.00233	<0.001	<0.001
7-Jun-18	6	500	495	8.15																						
14-Jun-18	7	500	445	8.23	0.00002	0.0037	1.06	0.00570	<0.005	0.00109	<0.00005	<0.0015	6.19	0.00022	1.50	<0.000025	0.88	0.0111	4.2	0.000005	0.00003	0.00029	0.00163	0.00210	<0.001	<0.001
21-Jun-18	8	500	430	8.22																						
28-Jun-18	9	500	430	7.95	0.00013	0.0033	1.04	0.00506	<0.005	0.00072	0.0001	<0.0015	5.49	0.00017	1.28	<0.000025	0.59	0.01043	4.9	0.000005	0.00004	0.00156	0.001338	0.00167	<0.001	<0.001
5-Jul-18	10	500	405	8.08																						
12-Jul-18	11	500	420	8.15	0.00023	0.0035	1.13	0.00467	<0.005	0.00054	<0.00005	<0.0015	4.37	0.00013	1.26	<0.000025	0.38	0.0117	4.4	<0.0000025	0.00054	0.00063	0.00179	0.00183	0.005	<0.001
19-Jul-18	12	500	430	8.01																						
26-Jul-18	13	500	425	7.70	0.00006	0.0039	1.26	0.00384	<0.005	0.00053	<0.00005	<0.0015	5.09	0.00018	1.44	<0.000025	0.51	0.0146	5.5	0.000007	0.00007	0.00028	0.00218	0.00162	<0.001	<0.001
2-Aug-18	14	500	435	7.99																						
9-Aug-18	15	500	410	7.96	0.00005	0.0042	1.40	0.00317	0.06	0.00065	0.0001	<0.0015	4.97	0.00014	1.49	<0.000025	0.56	0.0170	8.6	0.000007	0.00002	0.00031	0.001848	0.00181	<0.001	<0.001
16-Aug-18	16	500	425	8.08																						
23-Aug-18	17	500	425	7.90	0.00003	0.0023	0.797	0.00195	<0.005	0.00041	0.0001	<0.0015	3.13	0.00009	1.10	<0.000025	0.36	0.00994	5.5	0.000005	<0.000005	0.00065	0.000827	0.00108	<0.001	<0.001
30-Aug-18	18	500	430	7.85																						
6-Sep-18	19	500	410	7.87	0.00004	0.0024	0.785	0.00192	0.02	0.00046	<0.00005	<0.0015	2.98	0.00007	1.01	<0.000025	0.41	0.0116	7.0	0.000006	<0.000005	0.00027	0.000890	0.00102	<0.001	<0.001
13-Sep-18	20	500	420	7.55																						
20-Sep-18	21	500	420	7.85	0.00005	0.0023	0.802	0.00261	<0.005	0.00047	<0.00005	<0.0015	2.98	0.00010	1.04	<0.000025	0.27	0.0120	6.6	0.000008	0.00008	0.00029	0.000742	0.00085	<0.001	<0.001
27-Sep-18	22	500	435	7.81																						
4-Oct-18	23	500	415	7.85	0.00002	0.0029	0.820	0.00245	<0.005	0.00033	<0.00005	<0.0015	2.84	0.00007	1.08	<0.000025	0.30	0.0207	12.6	0.000006	0.00004	0.00022	0.000987	0.00098	<0.001	<0.001
11-Oct-18	24	500	395	7.80																						

Loads	**mg/kg**				mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
26-Apr-18	0			7.94	1.65E-06	0.001353	0.1782	0.0003531	0.0099	0.0008646	0.000165	0.00462	6.666	0.000099	0.4719	8.25E-06	2.2968	0.0032736	2.277	0.00000198	0.0000528	0.0000627	0.00001419	0.0006171	0.00033	0.00033
3-May-18	1			8.42	0.0000799	0.003196	0.4841	0.00282	0.0282	0.0047	0.000141	0.00282	9.541	0.0001739	0.8084	1.175E-05	3.6472	0.008037	4.747	0.00000517	0.0000423	0.0026931	0.00027025	0.0011045	0.00047	0.00047
10-May-18	2			7.86	1.335E-05	0.0029815	0.623	0.002759	0.002225	0.0043343	0.000089	0.0006675	8.4105	0.0001469	0.70755	1.113E-05	2.44305	0.008544	4.4055	0.000003115	3.115E-05	0.0002715	0.0005607	0.0009612	0.000445	0.000445
17-May-18	3			8.48	0.0000174	0.001914	0.3915	0.001827	0.002175	0.0017574	2.175E-05	0.0006525	4.3935	0.0000957	0.50895	1.088E-05	1.02225	0.005655	2.523	0.00000261	2.175E-05	0.0002088	0.00030972	0.0007482	0.000435	0.000435
24-May-18	4			7.80																						
31-May-18	5			8.30	0.0000445	0.002136	0.5607	0.002848	0.002225	0.0009256	0.0000445	0.0006675	4.628	0.000089	0.77875	1.113E-05	0.6675	0.0064525	2.314	0.000002225	0.0000089	0.0007343	0.00060965	0.0010369	0.000445	0.000445
7-Jun-18	6			8.15																						
14-Jun-18	7			8.23	0.0000089	0.0016465	0.4717	0.0025365	0.002225	0.0004851	2.225E-05	0.0006675	2.75455	0.0000979	0.6675	1.113E-05	0.3916	0.0049395	1.869	0.000002225	1.335E-05	0.0001291	0.00072535	0.0009345	0.000445	0.000445
21-Jun-18	8			8.22																						
28-Jun-18	9			7.95	0.0000559	0.001419	0.4472	0.0021758	0.00215	0.0003096	0.000043	0.000645	2.3607	0.0000731	0.5504	1.075E-05	0.2537	0.0044849	2.107	0.00000215	0.0000172	0.0006708	0.00057534	0.0007181	0.00043	0.00043
5-Jul-18	10			8.08																						
12-Jul-18	11			8.15	0.0000966	0.00147	0.4746	0.0019614	0.0021	0.0002268	0.000021	0.00063	1.8354	0.0000546	0.5292	0.0000105	0.1596	0.004914	1.848	0.00000105	0.0002268	0.0002646	0.0007518	0.0007686	0.0021	0.00042
19-Jul-18	12			8.01																						
26-Jul-18	13			7.70	0.0000255	0.0016575	0.5355	0.001632	0.002125	0.0002253	2.125E-05	0.0006375	2.16325	0.0000765	0.612	1.063E-05	0.21675	0.006205	2.3375	0.000002975	2.975E-05	0.000119	0.0009265	0.0006885	0.000425	0.000425
2-Aug-18	14			7.99																						
9-Aug-18	15			7.96	0.0000205	0.001722	0.574	0.0012997	0.0246	0.0002665	0.000041	0.000615	2.0377	0.0000574	0.6109	1.025E-05	0.2296	0.00697	3.526	0.00000287	0.0000082	0.0001271	0.00075768	0.0007421	0.00041	0.00041
16-Aug-18	16			8.08																						
23-Aug-18	17			7.90	1.275E-05	0.0009775	0.338725	0.0008288	0.002125	0.0001743	0.0000425	0.0006375	1.33025	3.825E-05	0.4675	1.063E-05	0.153	0.0042245	2.3375	0.000002125	2.125E-06	0.0002763	0.000351475	0.000459	0.000425	0.000425
30-Aug-18	18			7.85																						
6-Sep-18	19			7.87	0.0000164	0.000984	0.32185	0.0007872	0.0082	0.0001886	0.0000205	0.000615	1.2218	0.0000287	0.4141	1.025E-05	0.1681	0.004756	2.87	0.00000246	2.05E-06	0.0001107	0.0003649	0.0004182	0.00041	0.00041
13-Sep-18	20			7.55																						
20-Sep-18	21			7.85	0.000021	0.000966	0.33684	0.0010962	0.0021	0.0001974	0.000021	0.00063	1.2516	0.000042	0.4368	0.0000105	0.1134	0.00504	2.772	0.00000336	0.0000336	0.0001218	0.00031164	0.000357	0.00042	0.00042
27-Sep-18	22			7.81																						
4-Oct-18	23			7.85	0.0000083	0.0012035	0.3403	0.0010168	0.002075	0.000137	2.075E-05	0.0006225	1.1786	2.905E-05	0.4482	1.038E-05	0.1245	0.0085905	5.229	0.00000249	0.0000166	0.0000913	0.000409605	0.0004067	0.000415	0.000415
11-Oct-18	24			7.80																						

Appendix 4-6: Shake Flask Extraction Results

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Appendix 4-6: Shake Flask Extraction Results - Overburden

Parameters	Units	CCME WQG		LX-BDT-01	LX-BDT-02	LX-BDT-03	LX-BDT-04	LX-BDT-05
		Short Term	Long Term	L2178440-1	L2178440-2	L2178440-3	L2178440-4	L2178440-5
Physical Tests (Soil)								
Moisture	%	-	-	<0.25	<0.25	<0.25	<0.25	<0.25
Leachable Anions & Nutrients (Soil)								
Alkalinity, Total (as $CaCO_3$)	mg/L	-	-	<2.0	<2.0	<2.0	<2.0	<2.0
Conductivity	µS/cm	-	-	12.6	15.7	89.1	36.7	19.5
pH	pH	6.5-9	-	5.27	5.15	4.88	4.54	5.83
Sulfate (SO4)	mg/L	-	-	2.24	1.23	10.1	1.42	2.08
Leachable Metals (Soil)								
Aluminum (Al)-Leachable	mg/L	-	0.1	***0.108***	***0.683***	***1.51***	***1.26***	***0.483***
Antimony (Sb)-Leachable	mg/L	-	-	<0.00010	<0.00010	0.00015	<0.00010	<0.00010
Arsenic (As)-Leachable	mg/L	-	0.005	0.0012	0.0012	***0.315***	0.0038	***0.0084***
Barium (Ba)-Leachable	mg/L	-	-	0.0044	0.0040	0.0271	0.0066	0.0097
Beryllium (Be)-Leachable	mg/L	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Bismuth (Bi)-Leachable	mg/L	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Boron (B)-Leachable	mg/L	29	1.5	<0.010	<0.010	0.015	<0.010	<0.010
Cadmium (Cd)-Leachable	mg/L	0.001	0.00009	<0.000050	<0.000050	***0.000217***	0.000075	<0.000050
Calcium (Ca)-Leachable	mg/L	-	-	0.87	0.59	8.78	1.03	1.18
Chromium (Cr)-Leachable	mg/L	-	0.001	<0.00050	0.00088	***0.00118***	***0.00126***	0.00064
Cobalt (Co)-Leachable	mg/L	-	-	0.00084	0.00042	0.00761	0.00054	0.00101
Copper (Cu)-Leachable	mg/L	-	0.002	<0.0010	<0.0010	***0.0085***	0.0014	***0.0033***
Iron (Fe)-Leachable	mg/L	-	0.3	<0.030	0.194	***0.425***	***0.490***	0.262
Lead (Pb)-Leachable	mg/L	-	0.001	<0.00010	0.00013	0.00090	***0.00129***	0.00012
Lithium (Li)-Leachable	mg/L	-	-	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Magnesium (Mg)-Leachable	mg/L	-	-	0.237	0.345	1.44	0.556	0.471
Manganese (Mn)-Leachable	mg/L	-	-	0.107	0.0446	0.131	0.0681	0.106
Mercury (Hg)-Leachable	mg/L	-	0.000026	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Molybdenum (Mo)-Leachable	mg/L	-	0.073	<0.00010	<0.00010	0.00023	<0.00010	<0.00010
Nickel (Ni)-Leachable	mg/L	-	0.025	0.00098	0.00118	***0.0360***	0.00151	0.00179
Phosphorus (P)-Leachable	mg/L	-	-	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)-Leachable	mg/L	-	-	0.286	0.551	2.92	1.72	0.793
Selenium (Se)-Leachable	mg/L	-	0.001	<0.00050	0.00068	0.00079	***0.00101***	0.00085
Silicon (Si)-Leachable	mg/L	-	-	3.44	1.37	1.52	0.752	1.71
Silver (Ag)-Leachable	mg/L	-	0.00025	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Sodium (Na)-Leachable	mg/L	-	-	0.258	0.629	2.65	1.24	0.757
Strontium (Sr)-Leachable	mg/L	-	-	0.00454	0.00563	0.0403	0.00885	0.0105
Thallium (Tl)-Leachable	mg/L	-	0.0008	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Tin (Sn)-Leachable	mg/L	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Titanium (Ti)-Leachable	mg/L	-	-	<0.010	<0.010	0.016	0.027	0.011
Uranium (U)-Leachable	mg/L	0.033	0.015	0.000020	0.000087	0.000101	0.000073	0.000103
Vanadium (V)-Leachable	mg/L	-	-	<0.0010	<0.0010	0.0038	0.0023	<0.0010
Zinc (Zn)-Leachable	mg/L	0.037	0.007	<0.010	<0.010	***0.045***	***0.012***	<0.010

Notes:
Aluminum guideline is based on pH > 6.5
Hardness dependent guidelines (Cu, Pb, Ni) are based on a hardness of 10 mg/L
Grey shading indicates values above the short-term CCME water quality guideline
Bold italic text indicates values above the long-term CCME water quality guideline

Appendix E.3

Beaver Dam Project – Geochemical Source Term Predictions for Waste Rock, Low-Grade Ore, Tailings, and Overburden

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Beaver Dam Project Geochemical Source Term Predictions for Waste Rock, Low-Grade Ore, Tailings and Overburden

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Project No. A458-3

20 December 2018

LORAX ENVIRONMENTAL

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1. Introduction

1. Introduction

The Beaver Dam project is a proposed gold mine owned by Atlantic Mining Nova Scotia Corporation (AMNS) who is preparing a revised Environmental Impact Statement (EIS) that will be submitted to the Canadian Environmental Assessment Agency (CEAA) and Nova Scotia Environment (NSE) as part of the project's regulatory requirements. Lorax Environmental Services Ltd. (Lorax) was retained by AMNS to develop geochemical source terms as input for the site-wide water quality model that is being developed in support of the EIS.

The drainage chemistry from the various Beaver Dam facilities discussed herein is influenced by a variety of geochemical and physical factors. The overarching controls that will govern the water quality associated with any facility that contains exposed mine materials, include:

- Mineralogy and geochemistry of the exposed material;
- Grain size distribution;
- Water-rock ratio;
- Depositional environment (*e.g.*, saturated versus unsaturated conditions); and
- Temperature.

The prediction of both the major and trace elemental geochemistry of contact water from waste rock dumps, stockpiles, pit walls and the Tailings Management Facility (TMF) was conducted using a combination of kinetic test results as well as site monitoring and analogue data. Table 1-1 provides an overview of all facilities for which geochemical source terms were produced as well as the approach taken for their derivation. Where predictions relied on upscaling of kinetic test results, a number of calibrated work stages were implemented. The following sections discuss the background and rationale for the various considerations built into the geochemical source term model.

Table 1-1:
Overview of Source Term Locations and Modelling Approach Used

Mine Component	Storage Location	Contaminant Source	Approach
Process water	TMF	Mill; CN-detox	Touquoy monitoring data
Porewater/seepage	TMF	Mill; Tailings	Touquoy saturated columns
Pit Walls	Open pit	Waste rock	Upscaling of kinetic tests & Touquoy monitoring data
Waste Rock Dumps	Surface	Waste rock	Upscaling of kinetic tests
Low-Grade Ore SP	Surface	Ore	Upscaling of kinetic tests
Till SP	Surface	Till/Overburden	Shake Flask Extraction tests

Notes: TMF = Tailings Management Facility; CN = cyanide; SP = stockpile.

2. Upscaling Approach (Waste Rock/Ore)

2. Upscaling Approach (Waste Rock/Ore)

A flow chart of the work stages comprising the scale-up of kinetic tests results is given in Figure 2-1. Each of these work stages is described in detail below. Note that this approach was chosen only for the derivation of the waste rock dump and low-grade ore stockpile source term predictions. While the pit wall runoff source term predictions also employed scaling factors, these were empirically derived for each species via inverse modelling of Touquoy pit sump monitoring data. Note that source terms relating to the TMF (process and porewater) do not rely on the upscaling approach presented in this chapter and are discussed in detail in Section 3.1.

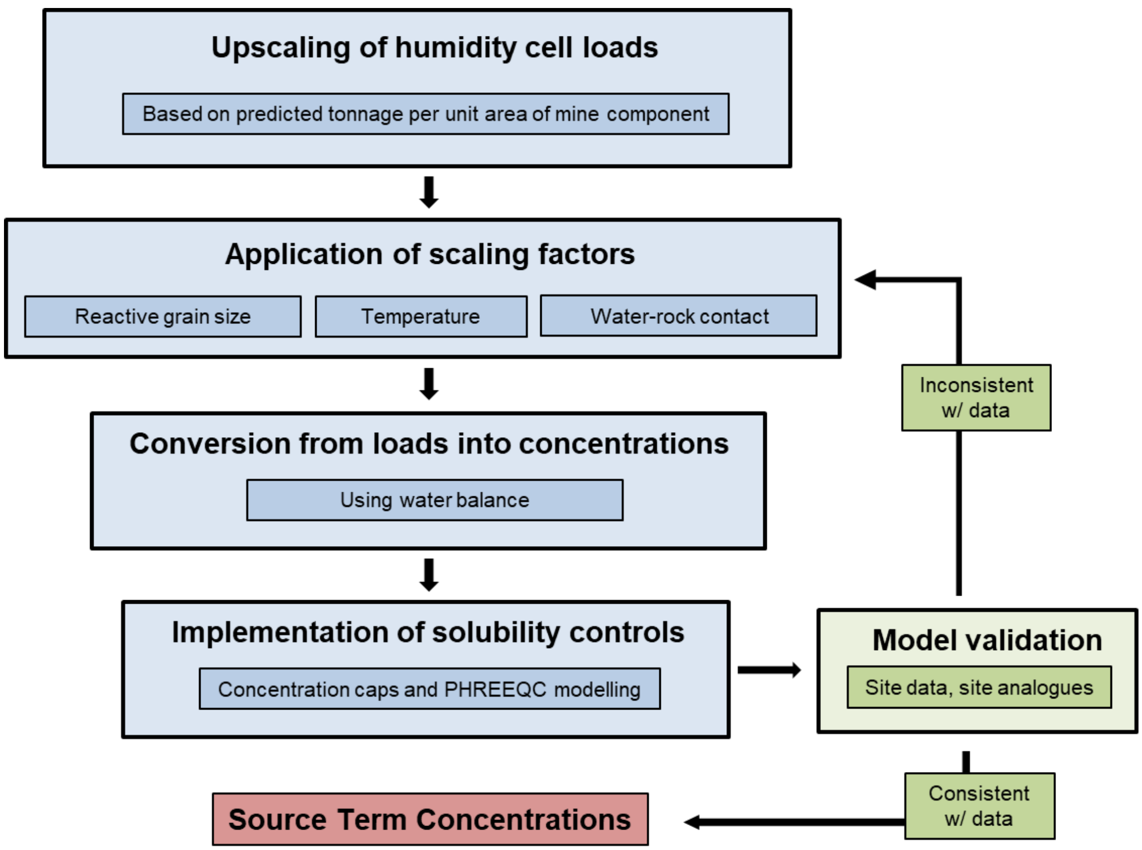

Figure 2-1: Work stages involved in the scaling of geochemical source terms.

2.1 Derivation of Humidity Cell Loading Rates

Aqueous geochemical signatures produced by water in contact with mine wastes are predominately controlled by the mineralogical make-up of the materials as well as mining-related processes (*e.g.*, processing, blasting, *etc*.), with sulphide mineral oxidation and carbonate mineral dissolution generally dictating pH. Trace elemental leaching signatures are typically governed by the sulphide mineral reactivity, abundance and type, although other phases can be relevant (*e.g.,* oxide minerals). Based on these considerations, humidity cell tests used for the calculation of loading rates were selected to encompass representative lithological and mineralogical variables.

Loading rates are herein defined as the mass of a solute released per kg of rock material over one week of humidity cell testing (mg/kg/wk). Scenarios modelled (base and upper case) and humidity cells used for the Beaver Dam source term predictions are outlined in Table 2-1. Multiple sets of input loading rates were derived from the eight humidity cells representing the four major waste rock types to be stored and exposed on site. For source terms related specifically to Beaver Dam waste rock, all eight humidity cells were proportioned based on their sulphide sulphur contents in relation to the Beaver Dam waste rock static test database (Table 2-2). Importantly, due to the lack of more detailed information pertaining the relative proportions of the four major geologic units, the loading rates and source term model units were grouped into *argillite* (**AR** = Argillite w/ <5% Greywacke interbeds and **AG** = Argillite w/ 5- 49% Greywacke interbeds) and *greywacke* (**GW** = Greywacke w/ < 20% Argillite interbeds and **GA** = Greywacke w/ 20-50% Argillite interbeds**)** waste rock to better link the model input with the mine schedule provided from site. Identical loading rates were applied to model two mine phases, namely post-closure (PC) and end of mining (EOM).

To calculate loading rates emanating from the Touquoy pit walls which will contribute to the geochemical balance within the Beaver Dam TMF located in the Touquoy open pit, historic Touquoy humidity cells (Golder, 2007) were proportioned using the same approach as that applied to the Beaver Dam humidity cells (Table 2-2).

No designated ore humidity cells were initiated with Beaver Dam specific material for the kinetic test program. For the derivation of input loading rates to be used for the low-grade ore stockpile geochemical source terms, the “marginal ore” humidity cell (06-085) reported in Golder (2007) was used. This approach is considered defensible as the two pits mine ore from the same geologic formation, and static test results shows that ore generally has similar sulphide sulphur content (0.54 wt.% at Touquoy versus 0.40 wt.% at Beaver Dam).

No kinetic testing was initiated on till samples from either the Beaver Dam or Touquoy sites. Geochemical characterization of till is limited to five static test samples, which were analyzed for ABA parameters, water soluble metals by shake flask extractions (SFE) and total metal content after aqua-regia digestion. Source term predictions for till stockpile and wall rock runoff are developed from these SFE results.

None of the Beaver Dam or Touquoy PAG humidity cells had turned acidic during their laboratory runtime such that assumptions had to be made with respect to the long-term (PC) drainage chemistry of Beaver Dam PAG rock. Using a humidity cell from another gold mine (Brucejack Mine) that had produced neutral as well as acidic drainage an "acid factor" (AF) was calculated for each species that relates the neutral and acidic water chemistry as follows:

$$AF_i = C_{Ai}/C_{Ni} \qquad (1)$$

where C_{Ai} is the concentrations of species i under acidic conditions and C_{Ni} is the concentrations of species i under neutral conditions.

Table 2-1:
Laboratory Tests and Scenarios Used for the Beaver Dam Source Term Model

Facility	Laboratory test used	Phase	Scenario	Cycles Used
Waste Dumps	Beaver Dam HC 1 through HC 8	Operational (End of Mine)	Base Case	median of cycles 3-10
			Upper Case	90th percentile of cycles 3-10
		Long-Term (Post-Closure)	Base Case	median of cycles 3-10
			Upper Case	90th percentile of cycles 3-10
Beaver Dam Pit Walls	Beaver Dam HC 1 through HC 8	Operational (End of Mine)	Base Case	median of cycles 3-10
			Upper Case	90th percentile of cycles 3-10
		Long-Term (Post-Closure)	Base Case	median of cycles 3-10
			Upper Case	90th percentile of cycles 3-10
Touquoy Pit Walls	Touquoy Waste Rock HCs (06-017, 06-012, 06-006, 06-049, 06-079, 06-039, 06-068)	Operational (End of Mine)	Base Case	median of cycles 3-10
			Upper Case	90th percentile of cycles 3-10
		Long-Term (Post-Closure)	Base Case	median of cycles 3-10
			Upper Case	90th percentile of cycles 3-10
Low-Grade Ore Stockpile	Touquoy Marginal Ore HC (06-085)	Operational (End of Mine)	Base Case	median of cycles 3-10
			Upper Case	90th percentile of cycles 3-10
		Long-Term (Post-Closure)	Base Case	median of cycles 3-10
			Upper Case	90th percentile of cycles 3-10
Till Stockpile	Beaver Dam Till SFE	Operational & Long-Term	Base Case	median of SFE results
			Upper Case	90th percentile of SFE results

Notes: HC = Humidity Cell; SFE = Shake Flask Extraction test

**Table 2-2:
Laboratory Tests Used To Represent Waste Rock Units and Weighting Based on Sulphide Content**

Mine	Rock Unit	Test ID	Sulphide-S %	% Rank of Sulphide Content	% Weight
Beaver Dam	Argillite	HC1	0.02	15%	28%
		HC2	0.25	46%	23%
		HC3	0.18	40%	16%
		HC4	0.76	86%	34%
	Greywacke	HC5	0.19	67%	28%
		HC6	0.39	90%	11%
		HC7	0.03	32%	49%
		HC8	0.35	88%	12%
Touquoy	Argillite	06-017	0.03	0%	8%
		06-012	0.08	16%	33%
		06-006	0.18	65%	28%
		06-049	0.22	71%	13%
		06-079	0.51	92%	18%
	Greywacke	06-039	0.49	96%	33%
		06-068	0.08	37%	67%

It should be noted that this approach is considered preliminary where geochemical source term model outputs will be updated for the PC scenario once acidic drainage from at least one of the Beaver Dam humidity cells is observed.

Neutral and acidic loading rates that were used as model input for both the EOM and PC mine phases are summarized in Table 2-3 and Table 2-4, respectively.

Table 2-3:
Loading Rates Used as Input for Neutral Drainage in Beaver Dam Source Term Model (EOM and PC)

		Beaver Dam				**Touquoy**			
		ARG		**GW**		**ARG**		**GW**	
Parameter	Unit	Median	90th PCTL	Median	90th PCTL	Median	90th PCTL	Median	90th PCTL
Sulphate	mg/kg/wk	14	19	5.9	12	2.7	4.4	3.3	5.3
Al	mg/kg/wk	0.056	0.075	0.086	0.096	0.064	0.078	0.099	0.15
Ag	mg/kg/wk	0.000011	0.000011	0.000011	0.000011	0.000014	0.000014	0.000015	0.000015
As	mg/kg/wk	0.012	0.017	0.016	0.021	0.036	0.062	0.22	0.29
Ca	mg/kg/wk	6.3	7.5	4.5	6.0	4.6	6.3	7.2	9.5
Cd	mg/kg/wk	0.0000029	0.0000073	0.0000013	0.0000041	0.000027	0.000028	0.000029	0.000030
Co	mg/kg/wk	0.000037	0.000046	0.000014	0.000025	0.000035	0.000054	0.000023	0.000041
Cr	mg/kg/wk	0.000011	0.000016	0.000013	0.000017	0.00014	0.00014	0.00015	0.00015
Cu	mg/kg/wk	0.00014	0.0010	0.00019	0.00078	0.00014	0.00023	0.000086	0.00022
Fe	mg/kg/wk	0.0031	0.0079	0.0018	0.0044	0.0046	0.013	0.0049	0.0050
Hg	mg/kg/wk	0.0000026	0.0000070	0.0000022	0.000013	0.000045	0.000047	0.000049	0.000050
Mn	mg/kg/wk	0.0040	0.0058	0.0029	0.0040	0.019	0.023	0.016	0.022
Mo	mg/kg/wk	0.00044	0.0016	0.00056	0.0021	0.000055	0.00023	0.00025	0.00038
Ni	mg/kg/wk	0.000082	0.00012	0.000040	0.000059	0.00032	0.00033	0.00034	0.00035
Pb	mg/kg/wk	0.000019	0.000039	0.0000095	0.000024	0.000025	0.00015	0.000014	0.000046
Sb	mg/kg/wk	0.000044	0.00015	0.000094	0.00023	0.0025	0.0037	0.16	0.23
Se	mg/kg/wk	0.000055	0.00012	0.000050	0.00012	0.00045	0.00047	0.00049	0.00050
Tl	mg/kg/wk	0.0000061	0.0000075	0.0000039	0.0000047	0.000045	0.000047	0.000049	0.000050
U	mg/kg/wk	0.00029	0.00040	0.00097	0.0016	0.000050	0.000093	0.00075	0.00095
Zn	mg/kg/wk	0.00044	0.00046	0.00044	0.00059	0.00064	0.0014	0.00079	0.0013

Notes: ARG = Argillite-rich material; GW = greywacke-rich material

Table 2-4:
Loading Rates Scaled to Estimate Acidic Conditions Used as Input for the Beaver Dam Source Term Model (PC only)

		Beaver Dam				**Touquoy**			
		AR		**GW**		**ARG**		**GW**	
Parameter	Unit	Median	90th PCTL	Median	90th PCTL	Median	90th PCTL	Median	90th PCTL
Sulphate	mg/kg/wk	16	23	7.0	14	3.2	5.3	3.9	6.3
Al	mg/kg/wk	1.5	2.0	2.3	2.6	1.7	2.1	2.7	3.9
Ag	mg/kg/wk	0.000054	0.000056	0.000054	0.000055	0.000066	0.000069	0.000071	0.000073
As	mg/kg/wk	0.075	0.11	0.098	0.13	0.23	0.39	1.4	1.8
Ca	mg/kg/wk	7.9	9.4	5.6	7.5	5.7	7.9	9.0	12
Cd	mg/kg/wk	0.000018	0.000045	0.0000082	0.000026	0.00017	0.00018	0.00018	0.00018
Co	mg/kg/wk	0.000095	0.00012	0.000036	0.000065	0.000092	0.00014	0.000061	0.00011
Cr	mg/kg/wk	0.000010	0.000016	0.000013	0.000017	0.00013	0.00014	0.00014	0.00015
Cu	mg/kg/wk	0.0024	0.017	0.0033	0.013	0.0024	0.0039	0.0015	0.0037
Fe	mg/kg/wk	0.074	0.19	0.042	0.11	0.11	0.32	0.12	0.12
Hg	mg/kg/wk	0.0000025	0.0000068	0.0000022	0.000013	0.000044	0.000046	0.000048	0.000049
Mn	mg/kg/wk	0.0064	0.0092	0.0046	0.0063	0.030	0.036	0.026	0.035
Mo	mg/kg/wk	0.00011	0.00041	0.00014	0.00053	0.000014	0.000057	0.000064	0.000096
Ni	mg/kg/wk	0.00022	0.00033	0.00011	0.00016	0.00085	0.00088	0.00092	0.00093
Pb	mg/kg/wk	0.000031	0.000062	0.000015	0.000039	0.000040	0.00024	0.000023	0.000073
Sb	mg/kg/wk	0.000022	0.000074	0.000045	0.00011	0.0012	0.0018	0.079	0.11
Se	mg/kg/wk	0.000049	0.00010	0.000045	0.00011	0.00040	0.00042	0.00044	0.00044
Tl	mg/kg/wk	0.0000037	0.0000045	0.0000024	0.0000028	0.000027	0.000028	0.000029	0.000030
U	mg/kg/wk	0.0035	0.0049	0.012	0.019	0.00061	0.0011	0.0090	0.012
Zn	mg/kg/wk	0.0040	0.0041	0.0040	0.0053	0.0058	0.012	0.0071	0.011

Notes: ARG = Argillite-rich material; GW = greywacke-rich material

2.2 Scaling of Geochemical Loads

One of the most critical steps in the development of geochemical source terms is the scaling of geochemical loads from small-scale laboratory experiments to mine-site dimensions. In theory, if the entire modelled facility was contacted by water under conditions similar to those seen in humidity cell experiments, the upscaled maximum leachable load ML (in mg) would be written as:

$$ML_i = r_i * m * t \qquad (2)$$

where r_i is the geochemical loading rate for species i; m is the mass (in kg) of the material contained in a facility of interest; and t (in wk) is the time interval of interest.

Through empirical and theoretical studies (*e.g.,* Malmström *et al.*, 2000; Kempton, 2012; Andrina *et al.*, 2012; Sapsford *et al.*, 2009; Kirchner & Mattson, 2015; Bornhorst & Logsdon, 2016), it is now well-established that this approach will strongly overestimate the geochemical load that is expected to drain from mine facilities due to the marked differences between laboratory and field conditions. To account for these differences, “scaling factors” are applied in the development of geochemical source terms that are based on humidity cell data. These scaling factors are implemented into the source term prediction model simply by multiplication with the maximum leachable load calculated above according to

$$SL_i = ML_i * SF_a * SF_b * \ldots * SF_x \qquad (3)$$

where SL_i is the scaled load for species i (in mg) and SF is the scaling factor for a given property to be scaled (a, b, x). Critical parameters that justify the implementation of scaling factors for the Beaver Dam Mine include particle size, water-rock ratio (contact water) and temperature. Each of these variables is discussed in turn below. As noted previously, the implementation of individual scaling factors only applies to the source term model for the Beaver Dam waste dump and low-grade ore stockpile. Pit wall runoff predictions were generated using an adjusted upscaling approach based on bulk scaling factors that were calculated via inverse modelling of Touquoy open pit sump monitoring data in relation to the exposed pit wall (Section 3.2.4).

2.2.1 **Particle Size**

Before representative material is placed into laboratory kinetic test cells, rock samples are crushed to a nominal grain size of <1/4” to allow for better comparability of reaction rates between different cells containing different geological materials. The particle size distribution of the mine rock stockpiles and other facilities influences the degree of water-rock interaction by controlling the exposed surface area; surface area increases exponentially as the particle size decreases. Therefore, the relatively largest surface area per mass is associated with the finest particles which may comprise a relatively small quantity of the waste rock dump. Strömberg and Banwart (1999) observed a large difference in weathering rates between fine particles and larger waste rock at the Aitik mine in northern Sweden. Particles with diameters smaller than 25 mm were shown to account for 80% of the sulphide and silicate weathering. The same study determined the <25 mm fraction to be only about 27% of the total waste rock mass. Similar conclusions have been drawn in other studies that have examined the effect of particle size on geochemical release rates (*e.g.*, Fines *et al.* 2003; Frostad *et al.*, 2005; and Neuner *et al.*, 2009).

In consideration of the above for the Beaver Dam mine, it can be assumed that only a fraction of material contained in the modelled mine components is reactive. Observations made on site suggest that the argillite end-member is generally more fissile and friable than greywacke waste rock. As such, particle size scaling factors of 10% and 20% were assigned to greywacke and argillite, respectively (Table 2-5).

2.2.2 **Water-Rock Ratio**

Laboratory experiments are conducted using high water-rock ratios (0.5:1) that allow for the flushing of virtually all material surfaces placed into the reactor cell. The hydrogeology of unsaturated waste dumps has been subject to much research and most studies suggest that only a portion of the rock mass contained in these facilities is contacted by infiltrating water. In one study, for example, a small-scale waste rock dump was disassembled one year after its construction and the distribution of moisture contents within the dump indicated that the development of preferential flow paths is an important process (Marcoline *et al.,* 2006). Under low-flow conditions, water is retained and will travel along the fine fractions within the waste dumps (matrix flow), whereas heavy rainfalls may flush relatively higher proportions of the coarser grain sizes (Andrina *et al.*, 2009, Neuner *et al.*, 2009). The larger the mine storage facility for a given infiltration rate, the more rock material will be physically shielded from water contact as preferential flow paths develop and water is diverted along higher permeability layers. Furthermore, low water-rock ratios within a mine rock or tailings facility are more likely to result in the development of geochemical equilibrium conditions (Morin, 2013). Therefore, after a certain mass of rock material has been flushed, further physical contact may not necessarily lead to an increase in concentrations as kinetic or thermodynamic limitations are reached (*e.g.*, Kirchner & Mattson, 2015).

The relationship between cover placement and the reduction of geochemical loads in response to decreased water and oxygen ingress is not straightforward. As a first approximation, it is herein assumed that the reduction in infiltration in the covered PC scenario for waste rock and ore leads to an equivalent reduction in water contact and resulting loading rates. The contact water scaling factors chosen for the Beaver Dam source term model are summarized in Table 2-5.

Table 2-5:
Scaling Factors Employed in the Beaver Dam Upscaling Model for Waste Rock Dumps and the Low-Grade Ore Stockpiles

Scaling Factor	Facility	EOM	PC
Contact Water Factor	Waste Rock Dump	25%	12%
	LG Ore SP	40%	19%
Temperature Factor	Waste Rock Dump	50%	100%
	LG Ore SP	50%	100%
Particle Size	Waste Rock Dump	10% - 20%	10% - 20%
	LG Ore SP	15%	15%

Notes: EOM = End of mining; PC = Post-closure; The particle size scaling factor in the waste rock dump was set to 10% for greywacke-rich rock and 20% for argillite-rich rock

2.2.3 Temperature

Kinetic experiments used for the source term model were conducted at SGS laboratories at a temperature of 22˚C and it is well known that the rate of many geochemical reactions leading to the release of acidity and dissolved metals is temperature-dependent (*e.g.*, Nicholson *et al.*, 1988; SRK, 2006). For Beaver Dam ore, mine rock, and tailings, the oxidation of pyrite can be considered the main mechanism driving contaminant leaching. Dockrey and Mattson (2016) compared sulphate release rates produced by kinetic tests under room (22°C) and fridge (4°C) temperatures and found a 31% reduction in oxidation rate over this temperature change.

Due to the climatic conditions at the Beaver Dam site, a temperature scaling factor of 50% was modelled for the EOM scenario to account for slowing of sulphide oxidation rates in response to cold temperatures. In the post-closure scenario, it was conservatively assumed that the heat produced from the accelerated sulphide oxidation rates under partly acidic conditions would roughly offset the cold ambient temperatures affecting the outer layers of the waste rock dump and temporary stockpile. Therefore, the temperature scaling factor was set to 100% for this scenario (Table 2-5), conservatively assuming that the bulk of the waste dump will have average temperatures equivalent those maintained in the laboratory.

2.3 Conversion of Loads into Concentrations

Average monthly drainage and runoff concentrations were calculated by dividing the scaled geochemical loads (in mg/month) by the volume of water predicted to infiltrate into the facility of interest. These assumed infiltration values were provided by Stantec (pers., comm., 2018) and are summarized in Table 2-6 for the different facilities. Note that the pit wall hydrology is based on runoff rates. The percent runoff is provided in Table 2-6, while the surface area of pit walls at EOM and in PC are described in detail in Section 3.2.4.

Table 2-6:
Overview of Contact Water for the Beaver Dam Mine Facilities Modelled by Upscaling of Kinetic Tests

Facility Name	Scenario	Infiltration	Runoff	Footprint	Contact water
		% MAP	*% MAP*	*m^2*	*L*
Waste Dumps	EOM	90%	-	330,000	445,500,000
	PC	42.5%			210,375,000
Pit Walls	EOM/PC	-	85%	N/A	N/A
Low-Grade Ore SP	EOM	90%	-	25,000	33,750,000
	PC	42.5%			15,937,500

Notes: MAP = Mean annual precipitation = 1350 mm; EOM = End of mining; PC = Post-closure;
For all facilities except pit walls, only annual infiltration was considered for source term model;
For waste dumps, only the larger of the two facilities was modelled and is presented here in this table.

2.4 Model Validation and Capping

As a final step, the model output was compared to water quality results from other data sources, namely field-scale kinetic testing and site analogues (Touquoy). These data sources are highly valuable in re-assessing solubility limits and provide an opportunity to validate and adjust scaling factors used for the geochemical source term model.

During the scaling exercise it was noted that several species commonly fall below the detection limit in humidity cell leachates and/or the site analogue databases and are therefore not expected to be a concern due to their low solubility, at least under neutral conditions. To mitigate unrealistic scaling effects, an upper concentration limit was imposed for these species if the model output showed exceedances of a cap value. Table 2-7 provides an overview of the caps implemented. In most cases, the maximum concentration observed in any of the field reference data (Touquoy field bins and monitoring data), was used as the solubility cap for the upper case scenario. For several species (Ag, Hg, Tl, P, V, Zn), this maximum observed value equalled the analytical detection limit. For the base case model, half of the maximum observed field value was chosen as the solubility cap. With the exception of As and Hg which are not expected to be significantly more soluble under oxic, mildly acidic conditions, no caps were applied to the post-closure scenario to maintain conservatism.

Due to the relatively well-constrained mineralogical fate in mining environments, Fe and sulphate caps were derived using the geochemical speciation code PHREEQC, which contains an extensive thermodynamic database (Parkhurst and Appelo, 1999). Fe was solubility capped by the equilibration with hydrous ferric oxide (HFO) while sulphate was allowed to precipitate as gypsum in both the base and upper case models. The resulting concentration limits imposed by this exercise are provided in Table 2-7.

Table 2-7:
Mineral Phases Considered in the Application of the PHREEQC Speciation Model

		EOM		PC		Source
Parameter	**Unit**	**Base Case**	**Upper Case**	**Base Case**	**Upper Case**	
SO^4	mg/L	979	1396	979	1396	PHREEQC-Gypsum
Al	mg/L	0.030	0.059	0.24	8.8	Field and HC Data
As	mg/L	0.087	0.13	0.55	0.83	Field and HC Data
Cd	mg/L	0.000018	0.000036	-	-	Field and HC Data
Ca	mg/L	-	-	623	852	PHREEQC-Fe(OH)3
Cu	mg/L	0.0010	0.0020	-	-	Field and HC Data
Fe	mg/L	0.025	0.050	0.12	0.44	Field and HC Data
Hg	mg/L	0.0000065	0.000013	0.0000064	0.000013	Field and HC Data
Ag	mg/L	0.000050	0.00010	-	-	Field and HC Data
Tl	mg/L	0.000050	0.00010	-	-	Field and HC Data
Zn	mg/L	0.0025	0.0050	-	-	Field and HC Data

Notes: EOM = End of mining; PC = Post-closure.

3. Source Term Locations and Results

3. Source Term Locations and Results

3.1 Tailings Management Facility (TMF)

Once operations at the currently operating Touquoy mine cease, the final Touquoy open pit will serve as the TMF for Beaver Dam tailings. This allows for safe containment of the tailings under fully saturated conditions while minimizing the mine footprint. Potential contaminant sources associated with the Beaver Dam TMF include (i) those contained in the tailings process water (supernatant) as well as (ii) those associated with post-depositional processes, including the dissolution of metal-bearing tailings phases in submerged tailings materials.

At the time of source term development, no Beaver Dam metallurgical tailings samples were available for the ML/ARD assessment. Touquoy and Beaver Dam pits mine ore from the same geologic formation with similar sulphur content. This, along with the fact that Beaver Dam ore processing and cyanide detoxification will occur in the Touquoy mill and will follow the same general approach, led to the conclusion that the extensive kinetic test and TMF monitoring database from the Touquoy project is an excellent site analogue to model Beaver Dam TMF related water chemistry. The following sections describe the derivation of the two source terms produced for the Beaver Dam TMF.

3.1.1 **Tailings Supernatant (End of Mining)**

3.1.1.1 Model Concept and Assumptions

Ore processing at the Beaver Dam TMF will involve grinding, cyanidation and tailings slurry treatment with SO_2/air for CN detoxification. Within the cyanidation circuit, solution pH will be maintained at pH>10.5 (Devuyst *et al.,* 1989). Upon SO_2/air treatment, pH will decrease to values between 8<pH<9 prior to final discharge to the TMF. A portion of the trace metal inventory may be removed from solution via precipitation as metal hydroxide phases. These secondary phases that form within the mill circuit represent a potential source of labile metals following deposition in the TMF. Cyanide degradation products (*e.g.*, cyanate) hydrolyze to form ammonia, which can be expected to sustain elevated concentrations in the TMF during the operational period.

Tailings supernatant represents the process water that is discharged to the TMF as part of the tailings slurry. While tailings are being discharged during operations phase, it can be assumed that the supernatant chemistry will dominate the aqueous chemistry in the tailings pond and pore water.

Water quality monitoring data were available for various sampling locations within the Touquoy TMF and from operational tailings supernatant. The monitoring stations chosen to derive the Beaver Dam source terms include the "Tailings Discharge" and the "Decant Well" stations. The slurry collected at Tailings Discharge is left to settle before the supernatant is decanted and submitted for geochemical analysis. Figure 3-1 plots the temporal geochemical trends for selected species in these two monitoring stations and shows that increasing trends of As and sulphate are observed. This trend, amongst other explanations, may be attributed to the recycling of TMF pond water and the associated accumulation of geochemical loads. It is expected that the combined effects of in-pond attenuation mechanisms and recycling of TMF pond water will eventually produce a relatively consistent end-of-pipe tailings supernatant chemistry.

To maintain model conservatism and in consideration of potentially accumulating chemical loads resulting from TMF pond water recycling, the Beaver Dam TMF source term to be applied to the process water and pore water during operations was calculated as follows:

The higher value of either the:

1. Maximum concentrations at the Decant Well monitoring station (December 2017 to September 2018) plus 20%;
2. The 90th percentile concentration of the Tailings Discharge monitoring station (January to September 2018) plus 20%.

20% were added to each of the potential data sources to maintain conservatism and account for the potential for accumulating loads that can be expected in the TMF over time.

Cyanide and ammonia may volatilize and/or oxidize to nitrite and nitrate when exposed to the atmosphere in the TMF pond. It is assumed that the tailings pore water will be sufficiently shielded from atmospheric (oxic) conditions to inhibit this reaction path. Thus, relatively high values of nitrate and nitrite observed in the Decant Well monitoring station are not expected to be present in the TMF pore water during operations and at the end of mining. As a result of this consideration, nitrate and nitrite values from the saturated column data that were also used for the PC TMF pore water source term (Section 3.1.2) were adopted (Table 3-1).

3.1.1.2 Model Results

The operational process water source terms used for input into the site-wide water quality model are presented in Table 3-1. For most species, these predictions represent the 90th percentile concentrations observed at the Tailings Discharge station which are generally higher than the maximum Decant Well monitoring data.

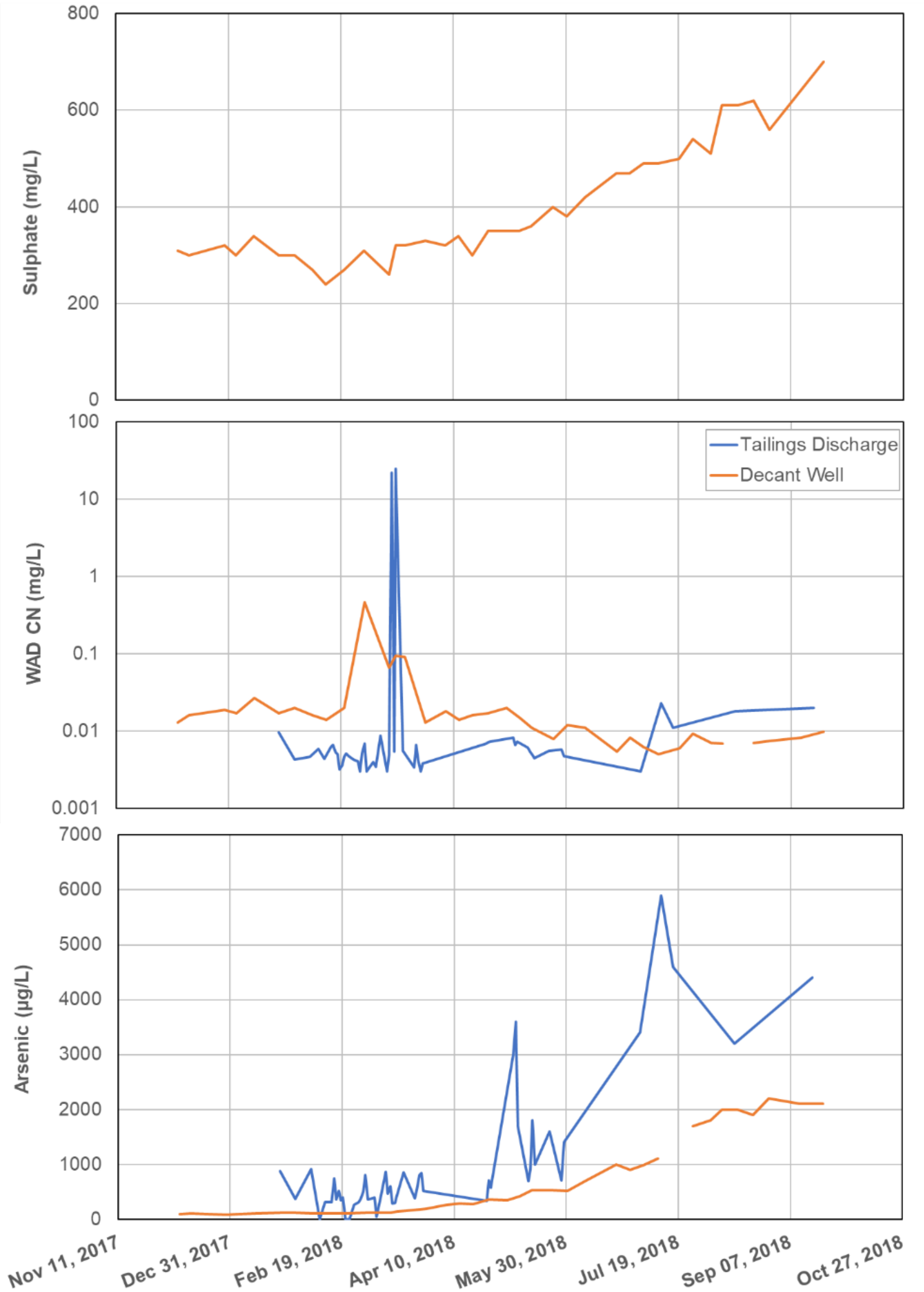

Figure 3-1: Touquoy monitoring data for selected species at the stations used for the Beaver Dam supernatant/process water source terms.

Table 3-1:
Geochemical Source Term Concentrations Associated with the Beaver Dam TMF Pore Water

		Process/ Pore Water	Pore Water Only
		EOM	PC
Sulphate	mg/L	840	897
Al	mg/L	0.51	0.047
Ag	mg/L	0.00010	0.000010
As	mg/L	3.9	3.1
Ca	mg/L	180	87
Cd	mg/L	0.000030	0.000020
Co	mg/L	0.29	0.026
Cr	mg/L	0.0011	0.00020
Cu	mg/L	0.16	0.0094
Fe	mg/L	0.31	0.033
Hg	mg/L	0.000013	0.0000050
Mn	mg/L	0.31	0.37
Mo	mg/L	0.031	0.060
Ni	mg/L	0.052	0.0069
Pb	mg/L	0.00085	0.000025
Sb	mg/L	0.014	0.0060
Se	mg/L	0.0027	0.00019
Tl	mg/L	0.00010	0.000015
U	mg/L	0.0051	0.0020
Zn	mg/L	0.0079	0.0096
WAD CN	mg/L	0.56	0.005
Total CN	mg/L	1.6	0.087
Nitrate (as N)	mg/L	0.053	0.053
Nitrite (as N)	mg/L	0.11	0.11
Ammonia	mg/L	34	34

Notes: EOM = End of mining; PC = Post-closure.

3.1.2 **Tailings Porewater**

3.1.2.1 Model Concept and Assumptions

Following cessation of the tailing discharge, post-depositional processes will become increasingly important over time in the saturated tailings. Depending on the mineralogy of the tailings materials and the aqueous regime, these post-depositional processes may attenuate or release contaminants within the TMF pore water. The basis for the potential release relates to the chemical instability of solid phases in the saturated portions of the TMF in the long-term in response to contrasting redox conditions in the mill (basic pH, oxidizing redox potentials) and TMF environments (circum-neutral pH, low redox potential). In this regard, both redox- and pH-dependent mechanisms can promote the dissolution of tailings phases. It can also be expected that various attenuation mechanisms will take place within the saturated pore spaces and as the water exits the TMF along groundwater pathways. For example, the gradual decay of residual cyanide species and ammonia is expected in inactive tailings ponds due to these species being unstable under atmospheric conditions (Devuyst *et al.,* 1989).

To assess the long-term geochemical behaviour of tailings under fully-saturated conditions, two saturated columns, each constructed with around 5 kg of run-of-mine (ROM) Touquoy tailings, were initiated in the Lorax laboratory in April 2018. While the development of reducing conditions depends on various factors, such as the pyrite oxidation rate and the presence of organic substrate, it is herein assumed that suboxic conditions are attained within six months of the experiment start-up. Continued kinetic testing will shed light on the validity of this assumption.

Serving as a proxy for the Beaver Dam tailings, the Touquoy saturated column leachate results were used directly for the derivation of the Beaver Dam pore water source terms. To maintain conservatism and to account for any uncertainties associated with the saturated column test conditions, the maximum leachate concentrations of the last four sampling cycles (June – September 2018) represent the predicted the long-term (post-closure) pore water concentrations.

3.1.2.2 Model Results

The final source term concentrations predicted for the long-term Beaver Dam TMF pore water are presented in Table 3-1.

3.2 Waste Rock, Low-Grade Ore, and Till

3.2.1 Waste Rock Dump

3.2.1.1 Model Concept and Assumptions

Waste rock dumps are heterogeneous in texture, exhibiting a wide range of particle sizes. Along with the geochemical and mineralogical composition of the rock, grain size presents a critical control on the chemistry of stockpile drainage as this variable drives water retention properties, oxygen fluxes, temperature gradients, and the exposure of particle surfaces. Under high-flow conditions (*e.g.*, after high rainfall events), a relatively larger portion of water moves through preferential flow paths, while low-flow conditions favour slower matrix flow in contact with finer particles (Andrina *et al.*, 2009, Neuner *et al.*, 2009). All of these factors are considered in the source term model for the Beaver Dam waste dump and are detailed in Section 2 (Upscaling Approach).

Note that due to the limited information available with regards to the lithological proportions across the two waste dumps, only the larger waste dump was modelled. The larger waste rock dump is composed of 37.6 Mt of waste material of which 34% represent argillite-rich rock (assumed to be AR and AG) while the remaining 66% are greywacke (assumed to be GW and GA). The model results should conservatively be applied to both waste dumps in the site-wide water quality model.

The geochemical characterization program revealed that an estimated 35-40% of the Beaver Dam waste rock to be generated will be potentially acid-generating (PAG). While sufficient neutralization potential is contained in these rocks to initially buffer the waste rock seepage at circum-neutral pH, it is likely that, owing to the depletion of NP in the PAG material, the pH is expected to decrease in the long-term to mildly acidic conditions. Refer to Section 3.3 for a more detailed discussion of pH modelling. This reduced pH will have a direct effect on mineral solubility, and hence drainage chemistry, when comparing the end of mine and the post-closure scenarios.

3.2.1.2 Model Results

Geochemical source terms for the Beaver Dam waste rock dump are given in Table 3-2.

Table 3-2:
Geochemical Source Term Concentrations for Beaver Dam Waste Rock Stockpiles

		EOM		PC	
		Base Case	**Upper Case**	**Base Case**	**Upper Case**
Sulphate	mg/L	444	701	977	1396
Al	mg/L	0.030	0.059	0.24	8.8
Ag	mg/L	0.000050	0.00010	0.0027	0.0028
As	mg/L	0.087	0.13	0.55	0.83
Ca	mg/L	275	366	622	852
Cd	mg/L	0.000018	0.000036	0.00069	0.0018
Co	mg/L	0.0011	0.0016	0.0042	0.0058
Cr	mg/L	0.00053	0.00074	0.0011	0.0015
Cu	mg/L	0.0010	0.0020	0.11	0.69
Fe	mg/L	0.025	0.050	0.12	0.44
Hg	mg/L	0.0000065	0.000013	0.0000064	0.000013
Mn	mg/L	0.16	0.22	0.40	0.56
Mo	mg/L	0.022	0.083	0.031	0.11
Ni	mg/L	0.0028	0.0041	0.010	0.015
Pb	mg/L	0.00065	0.0014	0.0017	0.0037
Sb	mg/L	0.0031	0.0087	0.0050	0.014
Se	mg/L	0.0024	0.0053	0.0045	0.010
Tl	mg/L	0.000050	0.00010	0.00037	0.00044
U	mg/L	0.028	0.043	0.27	0.41
Zn	mg/L	0.0025	0.0050	0.18	0.21

Notes: EOM = End of mining; PC = Post-closure.

3.2.2 Low-Grade Ore Stockpile

3.2.2.1 Model Concept and Assumptions

By definition, the low-grade ore stockpile is a temporary site feature that is expected to be processed at the end of mining. Nevertheless, to account for the possibility that fluctuating gold prices will affect the mine plan rendering the low-grade or stockpile unprofitable, an EOM and a PC scenario was modelled. The ore tonnage assumed for the source term model was set at 349 kt which represents the maximum amount of low-grade ore stored on site during operations.

Conceptual assumptions around the low-grade ore stockpile, including the percentage of PAG materials, are identical to those made for the waste rock dumps with the upscaling approach described in Section 2 used as the basis for the development of geochemical source term predictions from this facility.

3.2.2.2 Model Results

Geochemical source terms for the low-grade ore stockpile are given in Table 3-3.

Table 3-3:
Geochemical Source Term Concentrations for the Low-Grade Ore Stockpile

		EOM		PC	
		Base Case	**Upper Case**	**Base Case**	**Upper Case**
Sulphate	mg/L	168	260	362	559
Al	mg/L	0.030	0.059	0.24	8.8
Ag	mg/L	0.000050	0.00010	0.0016	0.0018
As	mg/L	0.087	0.13	0.55	0.83
Ca	mg/L	73	122	100	163
Cd	mg/L	0.000018	0.000036	0.0040	0.0044
Co	mg/L	0.00071	0.0015	0.0023	0.0049
Cr	mg/L	0.0032	0.0035	0.0064	0.0070
Cu	mg/L	0.0010	0.0020	0.018	0.044
Fe	mg/L	0.025	0.050	0.12	0.44
Hg	mg/L	0.0000065	0.000013	0.0000064	0.000013
Mn	mg/L	0.49	0.80	1.2	2.0
Mo	mg/L	0.00059	0.0025	0.00083	0.0034
Ni	mg/L	0.0077	0.0087	0.026	0.029
Pb	mg/L	0.00021	0.00024	0.00053	0.00058
Sb	mg/L	0.041	0.051	0.066	0.081
Se	mg/L	0.011	0.012	0.021	0.023
Tl	mg/L	0.000050	0.00010	0.0018	0.0020
U	mg/L	0.00084	0.0022	0.0092	0.024
Zn	mg/L	0.0025	0.0050	0.082	0.13

Notes: EOM = End of mining; PC = Post-closure.

3.2.3 **Till Stockpile**

3.2.3.1 Model Concept and Assumptions

Overburden will be stripped from the mine pit and stockpiled to the south and east of the mine pit. Overburden is typically 2 to 20 m thick and consists of stony till derived from local bedrock sources. A total of 2.6 Mt of overburden is expected to be produced.

Geochemical characterization of overburden is limited to five test pit samples. These samples were analyzed for total metals, SFE, and ABA parameters. The ABA results showed that till has a relatively low sulphide content (0.02 wt.% to 0.08 wt.%) and is deplete in carbonate minerals (<0.05 wt.% inorganic-C). The low sulphide content and lack of carbonate mineralization is consistent with highly weathered surficial material. The residual sulphide mineralization in the test pit samples are likely refractory. That is, the presence of these trace sulphides in shallow test pit samples shows that they are resistant to weathering.

The rinse pH of the five till samples is mildly acidic, ranging from 5.0 to 6.1. This pH range is similar to surface water in the vicinity of the Beaver Dam Pit which has historically been affected by acid rain. This is illustrated by monitoring of the Killag River which shows pH ranging from 4.59 pH to 6.0 pH (median 5.37 pH) at monitoring station SW1 adjacent to the Beaver Dam Pit. Considering the lack of carbonates or reactive sulphide minerals, the runoff pH from excavated till is expected to remain similar to mildly acidic meteoric water.

Source term concentrations for the till stockpile are predicted using SFE concentrations. This is considered appropriate since surficial till lacks reactive sulphides, and the primary source of metal leaching from this material will be from rinsing of soluble oxides. Considered a geochemical outlier sample, one sample (LX-BDT-03) was excluded from source term calculations. Significant metal leaching from till is considered unlikely owing to the highly weathered nature of this material. The median SFE concentration of the remaining four samples is applied to the base case scenario, while the maximum SFE concentration is applied to the upper case scenario.

3.2.3.2 Model Results

Source terms for the till stockpile are presented in Table 3-4. Note that the same source terms are applied to the EOM and PC scenarios.

Table 3-4:
Geochemical Source Term Concentrations for the Till Stockpile

		EOM/PC	
		Base Case	**Upper Case**
Sulphate	mg/L	1.8	2.2
Al	mg/L	0.58	1.3
Ag	mg/L	0.000025	0.000025
As	mg/L	0.0025	0.0084
Ca	mg/L	0.95	1.2
Cd	mg/L	0.000025	0.000075
Co	mg/L	0.00069	0.0010
Cr	mg/L	0.00076	0.0013
Cu	mg/L	0.00095	0.0033
Fe	mg/L	0.23	0.49
Hg	mg/L	0.000025	0.000025
Mn	mg/L	0.087	0.11
Mo	mg/L	0.000050	0.000050
Ni	mg/L	0.0014	0.0018
Pb	mg/L	0.00013	0.0013
Sb	mg/L	0.000050	0.000050
Se	mg/L	0.00077	0.0010
Tl	mg/L	0.000050	0.000050
U	mg/L	0.000080	0.00010
Zn	mg/L	0.0050	0.012

Notes: EOM = End of mining; PC = Post-closure.

3.2.4 **Pit Walls**

3.2.4.1 Model Concept and Assumptions

Pit dewatering at the Beaver Dam open pit will occur during operations since the natural groundwater table is above the mining elevations. Runoff (via direct precipitation and snow melt) that comes into contact with the freshly exposed pit walls will also contribute to the water and loading balance within the open pit during operations. Generally, blasting practices will lead to the development of a blast-influenced (fracture) zone within the pit walls, a portion of which can be expected to fail and collapse onto underlying pit benches over time. Rinsing of pit wall surfaces and mine rock material that accumulates on the pit benches will release weathering products, in particular those related to sulphide oxidation.

Source terms for pit wall runoff are developed for each geologic unit exposed on the pit wall. The geologic units considered in source term calculations are argillite (AR and AG units), greywacke (GW and GA units) and till. The till wall rock exposures on both the Beaver Dam and Touquoy pit are calculated using SFE data, applying the same approach as that described for the till stockpile described in the previous section. Drainage chemistry from the argillite and greywacke are calculated by scaling humidity cell loading rates which is described in Section 3.2.4.3 below. In the post closure scenario, a portion of the pit wall rock is expected to become acid-generating. The calculation of source term concentrations is described in 3.2.4.4.

3.2.4.2 Pit Wall Area and Geology

The surface area of rock units exposed in the Beaver Dam Pit and Touquoy pit walls are listed in Table 3-5. This table shows estimates of wall rock exposures in the Beaver Dam pit at EOM and in PC when the mine pit is fully flooded to the spillway elevation (125 masl). A portion of the Beaver Dam pit wall rock is not defined in the geologic block model. This ‘undefined’ unit is assumed to be 50% argillite and 50% greywacke for the purpose of source term calculation. At the Touquoy pit, estimates are only available for existing wall rock exposures. In source term calculations it is assumed that the relative proportions of argillite, greywacke and till are unchanged between current, EOM and PC scenarios in the Touquoy pit.

Table 3-5:
Pit Wall Rock Exposed in Touquoy Pit Currently, and in Beaver Dam Pit at EOM and PC

Wall rock Lithology		TQ	BD	BD*
	Units	Existing	EOM	PC
Argillite	m^2	169,551	78,189	205
Greywacke	m^2	181,444	204,861	10,570
Till	m^2	25,585	21,238	20,659
Undefined	m^2	-	88,378	6,957
Total	m^2	376,580	392,665	38,390

Notes: EOM = End of mining; PC = Post-closure; wall rock present above spillway elevation

3.2.4.3 Scaling Factor Calibration

Monitoring data from the Touquoy pit provides an opportunity to develop calibrated wall rock scaling factors. Calibrated scaling factors remove uncertainty regarding applicability of literature scaling values that may not reflect site-specific conditions. Furthermore, the approach allows for the development of parameter specific scaling factors which reflect the geochemical behaviour of individual elements. For these reasons calibrated scaling factors are preferred over literature values when adequate field data is available. Scaling factors are only calibrated for AR and GW pit wall rock exposures. Runoff from till wall rock exposures is assigned the same source term as the till stockpile, as described in section 3.2.3.

Calibrated scaling factors are the quotient of Touquoy waste rock HC loading rates and estimated loading rates from the existing Touquoy pit. Loading from the Touquoy pit is calculated by multiplying the median concentration observed in the pit sump between Aug. 31, 2017 and May 18, 2018 by the average annual runoff volume estimated using the water balance assumptions outlined in section 2.3. The Touquoy pit loading rate is calculated as:

$$OPr_i = V*C_i*A_{tot}^{-1} \qquad (4)$$

Where V is the estimated annual runoff volume, C_i is the median concentration of parameter i, A_{tot} is the wall rock exposure area of bedrock (GW and AR), and OPr_i is the estimated loading rate from the Touquoy Pit per unit area of wall rock.

Humidity cell test results are averaged based on the relative exposure of AR and GW on the pit wall during the calibration time period and corrected for differences in grain size between the two rock units. The grain size correction is introduced because the more competent GW unit is expected to produce coarser grained talus on pit wall slopes compared to the less competent AR unit. The particle size distribution used in HC tests is manipulated to conform with test specifications and does not reflect the expected difference in particle size distribution between these two rock units. The HC loading rates used in the calibration are calculated as follows:

$$HCr_i = HC_{ar}*PS_{ar}*A_{ar}/A_{tot} + HC_{gw}*PS_{gw}*A_{gw}/A_{tot} \quad (5)$$

Where HC_{ar} and HC_{gw} are the median loading rates of AR and GW humidity cells (Table 2-3), PS is the particle size correction of (0.2 for PS_{ar} and 0.1 for PS_{gw}), A_{ar} is the surface area of AR wall rock exposures and A_{gw} is the surface area of GW wall rock exposures (Table 3-5), and HCr_i is the loading rate of parameter i used to calculate calibrated scaling factors. The calibrated scaling factor are calculated from HCr_i and OPr_i as follows:

$$SF_i = OPr_i / HCr_i \quad (6)$$

Where SF_i is the calibrated scaling factor for parameter i. The above equation is used to calculate the element specific scaling factors used in wall rock source term prediction which are presented in Table 3-6.

Table 3-6:
Calibrated Scaling Factors for Touquoy and Beaver Dam Pit Walls

Parameter	Unit	Calibrated Scaling Factor (SF_i)
Sulphate	kg/m^2	5,372
Al	kg/m^2	27
Ag	kg/m^2	415
As	kg/m^2	55
Ca	kg/m^2	1,720
Cd	kg/m^2	39
Co	kg/m^2	7,082
Cr	kg/m^2	415
Cu	kg/m^2	961
Fe	kg/m^2	620
Hg	kg/m^2	133
Mn	kg/m^2	1,272
Mo	kg/m^2	5,819
Ni	kg/m^2	6,048
Pb	kg/m^2	1,351
Sb	kg/m^2	6.4
Se	kg/m^2	125
Tl	kg/m^2	125
U	kg/m^2	3,548
Zn	kg/m^2	417

3.2.4.4 Concentration Calculation

Pit lake source term concentrations are calculated by applying the parameter specific scaling factor to humidity cell loading rates and scaling them by the size, composition and runoff volume of pit wall rock:

$$ST_i = HCr_i * SF_i * A_{tot} * V^{-1} \quad (7)$$

Where ST_i is the source term concentration for parameter i. This calculation is used to produce source term concentrations for runoff from GW and AR wall rock exposure in the EOM and PC scenarios.

A portion of the wall rock exposures in the Touquoy and Beaver Dam Pits will be composed of potentially acid generating material. Acidification of pit wall PAG exposures may not result in acidic pH values being observed in the pit sump or pit lake if sufficient alkalinity is provided by groundwater seepage or runoff from neutral pH wall rock exposures. However, development of acidic zones of wall rock will result in the acceleration of metal leaching rates.

During mine life, pit wall rock exposures are expected to remain at a neutral pH, hence, neutral pH loading rates are used to calculate HCr_i at the end of mine life (Table 2-3). In the PC scenario it is assumed that all PAG exposures have become acid generating, and an acidic loading rate is assigned to them. The percent of wall rock that will become acid generating is estimated based on the ABA databases for waste rock at the Touquoy Mine and Beaver Dam Mine. Touquoy ABA results indicate that 26% of argillite and 1% of greywacke will become acid generating, while Beaver Dam ABA results indicate that 62% argillite and 26% greywacke are PAG and are predicted to become acidic. Acidic loading rates shown in Table 2-4 are applied to the estimated proportion of acidic wall rock exposures in the PC model scenario.

3.2.4.5 Model Results

Pit wall source terms used for input into the site-wide water quality model for the Beaver Dam and Touquoy pit walls are presented in Table 3-8 and Table 3-9, respectively.

Table 3-7:
Geochemical Source Term Concentrations for Beaver Dam Pit Wall Runoff

		EOM		PC	
		Base Case	**Upper Case**	**Base Case**	**Upper Case**
Sulphate	mg/L	418	662	178	296
Al	mg/L	0.047	0.085	0.39	0.77
Ag	mg/L	0.000035	0.000039	0.000053	0.000055
As	mg/L	0.0062	0.0088	0.0095	0.016
Ca	mg/L	74	92	35	44
Cd	mg/L	0.0000020	0.0000058	0.000014	0.000043
Co	mg/L	0.0015	0.0021	0.0013	0.0019
Cr	mg/L	0.000080	0.00012	0.00043	0.00070
Cu	mg/L	0.00100	0.0021	0.0051	0.039
Fe	mg/L	0.024	0.047	0.18	0.38
Hg	mg/L	0.0000039	0.000012	0.000015	0.000019
Mn	mg/L	0.040	0.055	0.065	0.083
Mo	mg/L	0.023	0.086	0.0077	0.029
Ni	mg/L	0.0030	0.0044	0.0028	0.0040
Pb	mg/L	0.00016	0.00041	0.00014	0.00087
Sb	mg/L	0.0000062	0.000013	0.000028	0.000031
Se	mg/L	0.000093	0.00017	0.00043	0.00059
Tl	mg/L	0.0000077	0.0000087	0.000029	0.000029
U	mg/L	0.018	0.028	0.041	0.063
Zn	mg/L	0.0017	0.0024	0.0053	0.0096

Table 3-8:
Geochemical Source Term Concentrations for Touquoy Pit Wall Runoff

		EOM		PC	
		Base Case	**Upper Case**	**Base Case**	**Upper Case**
Sulphate	mg/L	136	222	140	229
Al	mg/L	0.057	0.10	0.058	0.10
Ag	mg/L	0.000043	0.000054	0.000044	0.000066
As	mg/L	0.049	0.069	0.067	0.099
Ca	mg/L	83	112	86	116
Cd	mg/L	0.000011	0.000015	0.000019	0.000023
Co	mg/L	0.0020	0.0031	0.0026	0.0041
Cr	mg/L	0.00056	0.00061	0.00055	0.00060
Cu	mg/L	0.00077	0.0018	0.00082	0.0016
Fe	mg/L	0.037	0.057	0.040	0.059
Hg	mg/L	0.000056	0.000058	0.000056	0.000057
Mn	mg/L	0.21	0.26	0.23	0.28
Mo	mg/L	0.0063	0.014	0.0059	0.013
Ni	mg/L	0.017	0.018	0.022	0.023
Pb	mg/L	0.00026	0.0014	0.00029	0.0016
Sb	mg/L	0.0033	0.0047	0.0032	0.0047
Se	mg/L	0.00056	0.00059	0.00055	0.00058
Tl	mg/L	0.000054	0.000055	0.000050	0.000052
U	mg/L	0.0091	0.012	0.013	0.019
Zn	mg/L	0.0025	0.0047	0.0026	0.0043

3.3 Prediction of pH

The pH of mine drainage is governed by a sensitive and complex acid-base balance which, in turn, is controlled by rock storage regime, solute speciation, water-rock ratios and the availability and type of acid-generating and acid-buffering solid phases. The upscaling approach described in this document focusses primarily on the relationship of metal release in a laboratory-scale versus mine-scale environment. Due to the uncertainties related to the prediction of pH through geochemical modelling and upscaling of humidity cell tests, it was decided to provide a range of pH values based on the knowledge gained from the Beaver Dam static and kinetic test programs as well as regional water quality data. It can be said with some certainty that the during the EOM scenario all mine facilities will yield circum-neutral conditions due to the neutralization potential afforded by the waste rock, tailings and ore. During post-closure 35-40% of waste rock materials are estimated to become depleted in neutralization minerals before acid-generating sulphides are exhausted and are therefore PAG. There is no direct evidence from the Beaver Dam or Touquoy site of the pH range that will be produced from waste rock after carbonate mineral depletion. A survey of standing water in 50 slate quarries in the Meguma Fm. throughout Nova Scotia found an average pH of 3.78 (Manchester, 1986). Furthermore, Kereks *et al.,* (1984) found mean pH of 3.6 and 4.0 in two lakes north of Halifax. These results are consistent with ARD being buffered by hydrous ferric oxide (HFO) at approximately pH 3.5 (Blowes *et al.*, 2003). Given the relatively low overall sulphide contents in Beaver Dam rock, it can reasonably be expected that the pH in the PAG materials will be buffered at a similar range as in these other Meguma Formation sites with pH between 3.6 and 4.0.

Since only 35-40% of the materials stored in the pit walls, waste dumps and ore stockpile are PAG and will release drainage with acidic pH values, the confluence of acidic with alkaline contact water from NAG waste materials would yield a mix pH of 4 to 5 (*i.e.,* buffered by Al-hydroxide) which is considered an adequate estimate for long-term drainage from Beaver Dam waste rock and ore. A pH of 5 could therefore reasonably be expected as the best estimate for the base case scenario, while a pH of 4 to 4.5 is predicted for the more conservative upper case scenario. The considerably lower PAG percentage in Touquoy waste rock, as evidenced by the pre-mine geochemical characterization (Golder, 2007) as well as operational monitoring data, suggests that net neutral conditions will be maintained in Touquoy pit in the long-term.

Due to the fact that tailings materials will be fully saturated shortly after deposition which inhibits oxygen ingress and sulphide oxidation, neutral conditions will be maintained in the tailings pore water in the long-term. The fine grain size of tailings, as well as the additions of lime along with the intimate mixing of particles during ore processing lead to the liberation of neutralizing phases which will ensure that neutral or slightly alkaline conditions will be maintained should tailings be exposed to the atmosphere.

Surficial overburden is composed of till and is relatively weathered compared to the competent underlying bedrock. Geochemical characterization results show that till has a relatively low sulphide content (0.02 wt.% to 0.08 wt.%) and is deplete in carbonate minerals (<0.05 wt.% inorganic-C). The rinse pH of the five till samples is mildly acidic, similar to background surface water, ranging from 4.54 pH to 5.83 pH. These results show that till is at an advanced weathering state, lacking carbonate mineralization and containing minimal sulphide content. Long term runoff from the till is expected to remain within the current range, with no further acidification of runoff pH expected.

4. Recommended Future Work

4. Recommended Future Work

Geochemical source term predictions heavily rely on theoretical constraints, representative geochemical testwork, and the availability of site analogue data. While kinetic test data is available for Beaver Dam waste rock, the test duration used for the development of source terms is relatively short (<20 weeks) presenting uncertainties with respect to the long-term behaviour of these materials. This absence of any acidic leachate data makes the prediction of post-closure drainage from waste rock and the low-grade ore stockpile particularly difficult. To close this and other identified information gaps and to increase the confidence of the source term predictions for future model runs, the following recommendations are made:

- Initiation of a waste rock humidity cell that is immediately acid-generating (*e.g.,* from weathered core) and/or the acid-leaching of a representative currently running humidity cell sample to deplete pH-neutralizing mineral phases. This will allow a more accurate prediction of long-term drainage chemistry within Beaver Dam PAG rock.
- Continued operation of Beaver Dam PAG humidity cells to assess the long-term effect of metal leaching behaviour in site-specific materials.
- Generation and geochemical testing of Beaver Dam specific tailings sample to better constrain its geochemical comparability to Touquoy tailings. Potentially, saturated column testing may be required if sample proves to be geochemically different from Touquoy material.
- Collection of additional till samples to better understand and asses this material's geochemical variability.
- Tracking and reporting of Touquoy waste rock dump tonnage, footprint, and lithological proportions along with continued waste rock drainage monitoring to allow for better calibration of model and scaling factors which can be applied to the Beaver Dam waste rock dumps in future model iterations.

5. Closure

5. Closure

This Lorax report was prepared and reviewed by the undersigned.

Yours sincerely,
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Appendix F.1

Assessment of Potential Open Pit Groundwater Inflows – Beaver Dam Gold Project

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ASSESSMENT OF POTENTIAL OPEN PIT GROUNDWATER INFLOWS
BEAVER DAM GOLDPROJECT
NOVA SCOTIA

Report prepared for:

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Report No: 1501_R01

April 2015

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1 INTRODUCTION

Atlantic Gold Corporation is assessing the feasibility of developing an open pit gold mine at their Beaver Dam Project in Nova Scotia, Canada, and are currently preparing documentation for a Bankable Feasibility Study. The proposed open put has dimensions 690 m by 360 m at the crest, and has a maximum depth of 200 m.

This report provides an assessment of potential groundwater inflows to the proposed open pit at the Beaver Dam Project. The assessment is based on previous hydrogeological investigations by Jacques, Whitford and Associates Limited, and the results of recent hydraulic conductivity testing by Stantec Consulting Ltd.

Recommendations for monitoring of groundwater during mining and the periodic assessment of these data are included.

2 PROJECT SETTING

2.1 Location and Topography

The Beaver Dam Project is located in central Nova Scotia about 85 km NE of Halifax and about 25 km from the North Atlantic Ocean. Beaver Dam is about 20 km NE of Atlantic Gold's Touquoy Gold Project (Figure 1)

The project site lies in an area of relatively low local topographic relief at an elevation of around 140 m, with scattered drumlins to 160 m elevation. Regional surface water drainage is predominantly to the south east along several poorly drained stream channels and shallow lakes, and there are several low-lying boggy areas across the site.

Vegetation coverage in and around the project site consists of spruce, fir, and some hardwood. Logging has been conducted in the area, and there has recently been clear felling of timber in the immediate vicinity of the project site.

The proposed open pit adjacent to Cameron Flowage, a stillwater area on the Killag River and a remnant of past logging operations (JWA, 1986a). Cameron Flowage is around 1.2 km long by up to 120 m wide (Figure 2). All surface water generated within the drainage catchment that includes the proposed open pit flows into Cameron Flowage.

There is a shallow sediment settling dam located in the eastern part of the proposed open pit (Figure 2). This dam was used to trap sediment generated by the dewatering of the Seabright underground operations in the mid-1980s before discharging to Cameron Flowage.

2.2 Prior Mining History and Dewatering

The following discussion is mostly adapted from Schofield (2015).

Gold was discovered at Beaver Dam in 1868, with first production recorded in 1871.

Intermittent attempts to develop a mine in the area occurred until 1949, with the property changing ownership several times. Some of these attempts focused on the Austen Shaft which was collared in 1902 and developed initially to a depth of 30 m with crosscuts 19 m north and 12 m south at a depth of 22 m. The southern crosscut was extended to a length of 90 m in 1927, and an incline was sunk to 61 m in 1936 from the southern crosscut.

The Austen Shaft and associated underground workings are within the perimeter of the proposed Beaver Dam open pit.

In 1985 the leases were acquired by Seabright Resources Inc who subsequently conducted a number of exploration programs which delineated an auriferous zone between 20 m and 30 m wide over a strike length of 700 m and depth 600 m. Between 1986 and 1988 Seabright conducted exploration from a new underground development that reached a maximum depth of 105 m and spanned 400 m of strike. All of the Seabright workings are within the perimeter of the proposed open pit, and they are not connected with any of the developments from the Austen Shaft.

No records of rates of long-term mine dewatering during the previous phases of mining and underground exploration have been discovered. There are notations that the Austen Shaft was dewatered on at least six occasions – 1928, 1934, 1954-57, 1965, and twice by Seabright in the late 1980s.

Jacques, Whitford and Associates Limited conducted a hydrogeological investigation at Beaver Dam in 1986 prior to Seabright's underground exploration program (JWA, 1986b). This work included a pumping test to dewater the Austen Shaft and associated workings. The results of this testing program are discussed in Section 3.1.

2.3 Rainfall, Evaporation, and Temperature

Precipitation data are available from the Middle Musquodoboit weather station, 33 km west of the Beaver Dam project site (CRA, 2005).

Precipitation occurs as rain, and during the cooler winter months as snow. Average annual precipitation (including snow as equivalent rainfall) is around 1,400 mm, and this is evenly distributed throughout the year with average monthly precipitation of between 100 mm and 140 mm. Lake evaporation data presented in CRA (2005) indicates evaporation rates are negligible from November to April, and range between

40 mm/month and 110 mm/month from May to October. Annual lake evaporation is around 500 mm, which is about 40% of the annual precipitation.

Average monthly temperatures range between -6°C in January and 18°C in July.

2.4 Geology and Hydrogeology

The Beaver Dam gold deposit is within the Meguma Group, which is a sequence of Cambro-Ordovician sandstones and mudstones that form the southern half of the province of Nova Scotia. The Meguma Group is divided into two stratigraphic units: the basal Goldenville Formation and overlying Halifax Formation. The dominant lithologies are greywacke in the Goldenville Formation and argillite in the Halifax Formation. The Goldenville Formation is at least 5,600 m thick, and the average thickness of the Halifax Formation is 4,400 m.

The Meguma Group sedimentary sequence was uplifted and deformed into a series of tightly folded sub-parallel northeast trending anticlines and synclines during the Arcadian Orogeny. This sequence has been metamorphosed to between greenschist and amphibolite (staurolite) facies, and intruded by granites and minor mafic intrusives.

The Meguma Group sequence, and predominantly the Goldenville Formation, is host to most of the gold mineralisation that has been exploited in Nova Scotia since 1860.

The Beaver Dam Project is within the argillite dominated Moose River Member of the Goldenville Formation (Figure 3). This member also hosts the Touquoy deposit to the SW and Fifteen Mile Stream deposit to the NE (Figure 1).

The Moose River Member is folded into three sub-parallel anticlines at Beaver Dam, and the gold deposit is associated with the southern overturned limb of the central anticline which dips to the north at between 75° and 90°. The sequence at Beaver Dam is sinistrally offset by two northwest trending faults: the Mud Lake Fault and the Cameron Flowage Fault. The Mud Lake Fault is described from drill cores as a 2 m to 3 m zone of gouge within a 10 m to 20 m wide brecciated zone.

The Meguma Group sequence at Beaver Dam is covered by glacial till deposits of varying thickness and occasional shallow peat bogs. The range of grain size of the till materials is large, being from clay to boulder. Regionally the sheet of till deposits has a mean thickness of about 3 m, but locally it can be up to 20 m thick (eg, at drumlin deposits). At Beaver Dam the till sheet is about 5 m thick, and there is evidence of a sediment-filled gully up to 25 m deep which intersects the trace of the Mud Lake Fault.

Groundwater occurs at shallow depths at the Beaver Dam site, and Cameron Flowage is probably an area of groundwater discharge. The bedrock sequence forms a fractured rock aquifer system, and this overlain by a thin aquifer in the till. The degree of hydraulic connection amongst the smaller bedrock fracture systems is probably poor to moderate, and the main zones that are capable of storing and transmitting relatively large amounts of groundwater would be the larger scale faults.

The volume of groundwater stored in the bedrock aquifer is probably small, and this reflects the relatively small primary porosity of these rocks. Some of the larger bedrock structures may be hydraulically connected to surface water bodies which may become sources of aquifer recharge under a mine dewatering scenario.

Descriptions of drilling conditions through the Mud Lake Fault in JWA (1986b) indicate boreholes were quite unstable in this section, and groundwater flows were “low”. The latter comment appears to refer to the groundwater yielding capability of boreholes for the purpose of supplying water for drilling rigs. One borehole, BD-86-47, is noted to be a flowing artesian borehole with measured flow rate of 0.1 L/sec. BD-86-47 is located slightly north of the south east end of Cameron Flowage, and has a total depth of 500 m.

3 PREVIOUS HYDROGEOLOGICAL INVESTIGATIONS

Jacques, Whitford and Associates conducted a hydrogeological investigation at the Beaver Dam site in 1986 prior to the exploration work by Seabright Resources Inc (JWA, 1986b). The objectives of the investigation were to predict the rates of groundwater inflow to the proposed underground exploration development, and the quality of water flowing into the underground. The scope of the investigation included a pumping test to dewater the Austen Shaft, and several single borehole packer tests using some of the diamond core holes. The results of this work are discussed in Sections 3.1 and 3.2.

In 2014, Stantec Consulting Ltd conducted packer testing of one diamond core hole at the Beaver Dam site. The objective of this investigation was to determine the hydraulic conductivity of various parts of the bedrock sequence at Beaver Dam including the Mud Lake Fault. Results of this work are discussed in Section 3.3.

3.1 Austen Shaft Dewatering 1986

This test involved pumping from the Austen Shaft, and monitoring water levels in the shaft during pumping and recovery (JWA, 1986b). The maximum pumping water level that could be achieved during testing was around 22 m. This depth is equivalent to the depths of the crosscuts that were developed off the shaft in 1902.

The first pumping test commenced at 1:35pm on 18 June 1986. The static water level (SWL) in the shaft prior to pumping was noted to be 3.86 m below the datum for the test, which presumably was close to ground level. The pumping rate during the test was

2,275 kL/day (26.3 L/sec), and all of the available drawdown was exhausted after 16 hours of pumping.

A graph of drawdown versus time from this pumping test is presented in Figure 4. There are three linear segments in this drawdown-time graph, with the rate of drawdown tending to decrease at longer times during the test. The linear trends of drawdown versus time indicate that, in this instance. there is a linear relationship between water level and water storage volume in each of the three vertical intervals of the shaft and its associated developments. This also indicates that the rate of pumping during the test was much greater than the rate of groundwater seepage into the shaft and underground developments.

The total volume of water pumped from the Austen Shaft and associated developments in the June 1986 test was 1,520 kL.

A second group of pumping tests was conducted in July 1986. In one of these test pumping occurred until the available drawdown was exhausted, and the pumping rate was then reduced to maintain a steady water level. The final pumping rate of 2.9 L/sec (249 kL/day) was maintained for a period of 5½ hours. Note that this pumping rate can be interpreted as the maximum rate of groundwater seepage into all of the underground voids of the Austen Shaft and associated underground developments which extend to a depth of 61 m.

3.2 Packer Testing 1986

Jacques, Whitford and Associates selected nine existing diamond core holes for conducting single borehole packer injection tests to determine values of formation hydraulic conductivity. Boreholes for testing were selected on the basis of their inclination (near-vertical holes preferred), and the lithology and structure intersected (Mud Lake Fault, ore zones, the anticline axis, greywacke, argillite, and quartzite). Initially sixteen boreholes were selected a possible candidates for testing, however only nine were suitable. Packer test were conducted in 56 intervals within these boreholes. The locations of the boreholes used for packer testing are indicated on Figure 5, and listed in Table 1.

A “straddle” packer consisting of a 4.5 m length of perforated pipe with 1 m long inflatable packers at either end was used in this testing program. The packer assembly was run in and out of the hole on a wireline. Nitrogen gas was used to inflate the packers, and water was injected into the packed-off interval through a high-pressure hose.

Table 1 lists the intervals in each borehole that were tested, the lithology and structure in these intervals, and the values of hydraulic conductivity calculated from the test data by JWA (1986b). All boreholes listed in Table 1 are inclined with dip angles between -60° and -70° at the collars, and the depth intervals are the depths within the borehole, ie these are not vertical depth intervals.

The range of hydraulic conductivity values determined by the 1986 testing program is 3.7×10^{10} m/sec and 1.9×10^{-6} m/sec. The mean of the set of values is 2.5×10^{-7} m/sec, and the geometric mean (approximate median)[1] value is 4.8×10^{-8} m/sec.

Five of the 1986 packer tested intervals intersected to Mud Lake Fault. Hydraulic conductivity determined from this group of tests ranges between 1.2×10^{-9} m/sec and 1.9×10^{-6} m/sec, and the mean and geometric mean values are 3.7×10^{-7} m/sec and 1.5×10^{-8} m/sec, respectively.

All of the values of hydraulic conductivity determined from the 1986 packer testing program are relatively small, and are not unusual given the geological and structural settings.

3.3 Packer Testing 2014

Stantec Consulting Ltd conducted five packer tests in diamond cored borehole BD14-188 in December 2014 (Stantec, 2015). The location of BD14-188 is indicated on Figure 5.

BD14-188 was selected for packer testing so that the tested intervals included the hanging wall sequence, the Mud Lake Fault, and the foot wall sequence. Five intervals were tested, with test interval lengths ranging between 8 m and 64 m. Results are listed in Table 1.

Stantec note that one of the tested intervals in the hanging wall and both tested intervals in the footwall did not accept any of the injected water. The values of hydraulic conductivity inferred from these three tests are indicated by the “<” character in Table 1.

Hydraulic conductivity calculated from the two successful packer tests conducted in December 2014 are within the range of hydraulic conductivities calculated from the 1986 testing program. The value of K determined by the test of the Mud Lake Fault is 1.0×10^{-8} m/sec, which is again within the range of values determined for this structure in the 1986 testing.

[1] The geometric mean value of several hydraulic conductivity results based on similar tests is generally taken to be the best representative large-scale estimate of this parameter for subsequent use in groundwater flow rate calculations.

Stantec note that the intersection of the Mud Lake Fault in BD14-188 had a significantly higher rock mass quality than was anticipated on the basis of cores from adjacent boreholes. The implication is that parts of the Mud Lake Fault have larger hydraulic conductivities than the value determined from this packer test.

The geometric mean value of all of the hydraulic conductivity results from the 1986 and 2014 testing programs is 4.5 x 10^{-8} m/sec.

4 ESTIMATES OF OPEN PIT GROUNDWATER INFLOW RATES

As groundwater occurs at shallow depths across the Beaver Dam site, groundwater seepage into the proposed open pit will be one issue that will need to be managed basically from the start of mining.

Groundwater can be expected to seep into an open pit developed at the Beaver Dam site through the surficial glacial till deposits, and though fractures and structures in the bedrock. As dewatering progresses and groundwater levels in the vicinity of the open pit are lowered, some surface water bodies which are presently groundwater discharge areas may become areas of groundwater recharge. The main effect of this recharge will be to maintain some of the seepage into the open pit.

4.1 Seepage from Till

Atlantic Gold's Touquoy Project, 20 km SW of Beaver Dam, has similar geological and hydrogeological settings to Beaver Dam, with a thin sheet of surficial glacial till overlying folded and fractured argillite and greywacke. The estimated average groundwater inflow rate into an open pit at Touquoy from the till is 450 kL/day (5.2 L/sec) (Peter Clifton & Associates, 2006). Given the proposed open pits at Touquoy and Beaver Dam have similar crest perimeter lengths, this estimate of groundwater inflow rate from the till can also be applied to the Beaver Dam site.

Some spatial variation in the rates of groundwater inflow from the till must be expected around the crest of the pit. There are likely to be sections of the wall where seepage rates are negligible and other sections where the seepage is noticeable. Some seasonal variation in seepage rates from the till is also expected. The recommended approach for managing groundwater seepage from the till is discussed in Section 5.

4.2 Seepage from Bedrock

The results of extensive packer testing of the bedrock at Beaver Dam did not identified any large-scale permeable units from which large rates of groundwater seepage into an open pit could be expected. The geometric mean (approximate median) value of the entire set of hydraulic conductivity values determined from these tests is 4.5×10^{-8} m/sec. This is a relatively small value of this parameter, however this is consistent with the lithology of the sequence at Beaver Dam apparent from diamond cores.

Some caution is needed when using the results of packer tests conducted in diamond core holes. Packer tests in core holes may underestimate the actual hydraulic conductivity of the tested interval due to blinding, or blocking, of permeable fractures by fine grained drill cuttings or viscous drilling fluid. It is not possible to quantify the magnitude of these effects, and they may not necessarily be a significant factor. The set of hydraulic conductivity results from the tests at Beaver Dam appears reasonable given the lithology and the type of aquifer (fractured bedrock).

One uncertainty is the role of the Mud Lake Fault in groundwater seepage into the proposed Beaver Dam open pit. All of the packer tests which have been conducted in the Mud Lake Fault produced hydraulic conductivity estimates which are not significantly different from the remainder of the tests. However, the Mud Lake Fault is described as a 2 m to 3 m zone of gouge within a 10 m to 20 m wide brecciated zone, and is noted to be associated with borehole instability issues during drilling. The Mud Lake Fault is only known from cores, and it was not intersected by any of the underground developments associated with the Austen Shaft and the Seabright workings.

If the actual hydraulic conductivity of the Mud Lake Fault is larger than indicated by the results of the packer tests, groundwater inflow rates to an open pit at Beaver Dam will be influenced more by the small hydraulic conductivities of the greywacke and argillite sequence. Recommendations for managing groundwater pressures in the Mud Lake Fault are included in Section 5.

Figure 6 is a graph of hydraulic conductivity versus depth based on the results of the packer tests. Only the results of the testing in 1986 have been included in this graph. While there is generally weak correlation between hydraulic conductivity and depth apparent in Figure 6, there is a tendency for the smaller values of K to occur at greater depths. This is an expected trend, and can be explained by slight dilation of fractures at shallower depths.

An estimate of the rate of groundwater inflow through the bedrock to an open pit at Beaver Dam can be made using a model which assumes that all of the flow enters the pit through the north and south walls (ie, the longer walls in the pit – see Figure 2). For a pit wall 800 m long and 100 m deep, and assuming a bulk formation hydraulic conductivity of 4.5×10^{-8} m/sec (the geometric mean of the packer test results) and hydraulic gradient of 1 (a conservative assumption), the estimated rate of groundwater seepage is 311 kL/day. The estimated groundwater seepage rate into the 100 m deep pit from both the north and south walls would thus be 622 kL/day (7.2 L/sec). In deeper sections of the pit, groundwater inflows are expected to be smaller than these values due to the lower formation hydraulic conductivities that tend to occur with increasing depth at Beaver Dam.

It is recommended that a range of groundwater seepage rates from bedrock at Beaver Dam of between 100 kL/day (1.2 L/sec) and 1,000 kL/day (12 L/sec) be used for planning purposes.

5 RECOMMENDATIONS FOR MANAGING GROUNDWATER SEEPAGE

From a mine dewatering perspective there are two groundwater seepage issues at the proposed Beaver Dam open pit that require attention:

- Seepage from the glacial till deposits into the open pit (eg seepage that migrates along the till/bedrock contact)
- Seepage from the bedrock sequence into the open pit and the associated groundwater pressures in the pit walls – this is an important issue that can influence open pit wall stability

The above issues follow from the hydrogeological setting of the site, and different approaches are required to control inflows and seepage from these sources.

5.1 Seepage from Till

The glacial till at Beaver is a sheet of poorly sorted sediment with a fine grained matrix averaging 5 m thick. There is evidence of a sediment-filled gully up to 25 m deep which intersects the trace of the Mud Lake Fault.

Rates of seepage from the till exposed around the perimeter of the open pit will vary, and will primarily be related to the proportion of fine grained matrix material. Larger rates of seepage can be expected where the till is relatively coarse and contains a small proportion of fines.

Seepage rates from the till to the open pit will also vary by small amounts seasonally due to normal seasonal changes in the level of the water table. Seepage rates from the till are expected to be greatest following the spring thaw and during the early summer months.

Where the till consists of relatively coarse grained gravels with a small proportion of fines there is the potential for larger groundwater inflows to occur. Whether these inflow rates are sustained will depend on the lateral extent of the gravel deposits, and the degree of interconnection between the gravels and surface water bodies. This may require further investigation if the risk is considered significant.

The estimated rate of groundwater seepage from the till into an open pit at Beaver Dam 450 kL/day. This is considered to be an average value, with seasonal variations superimposed.

Although the total rate of groundwater seepage from the till into the open pit is not expected to be large, if left unmanaged this could result in erosion, slumping of the till, and possibly water flowing over the crest of the pit. It is recommended that this seepage be intercepted and diverted before it reaches the open pit. This can be achieved with an open drain at the base of the till which is dug a short distance into the top of the bedrock, and one or more sumps at low points in the drain to collect the seepage and pump it from the pit. Because the expect flow rates are relatively small, the cross section area of the drain can safely be of order 1 m^2 and still provide sufficient carrying capacity. The drain may need to be lined where it crosses major structures to prevent recharge occurring to the bedrock groundwater system as this may cause problems for pit wall stability.

Where thicker accumulations of till occur drains and sumps will need to be positioned deeper within the open pit to intercept any seepage.

Figure 7 presents a conceptual design of a drain at the base of the till in an open pit at Beaver Dam. The distance between the edge of the drain and the inner pit crest (ie, bedrock crest) is about 30 m. This is also the recommended length of sub-horizontal drain holes in the pit walls (see Section 5.2).

5.2 Seepage from Bedrock

The ambient water table at Beaver Dam is close to the land surface and the bedrock sequence is saturated. Groundwater will therefore flow into an open pit at Beaver Dam, and dewatering will be required to maintain dry working conditions. Lowering of groundwater pressures in the pit walls will also be required for wall stability purposes, and dewatering of the bedrock sequence exposed in the walls will be important from this perspective. Dewatering facilities will also be needed in the pit to remove surface water that collects after rainfall.

Seepage through the bedrock sequence at Beaver Dam will largely be controlled by geological structures, and will vary around the pit due to variations in the density of joints and fractures, and the occurrence of major faults.

Managing groundwater pressures in the pit walls at Beaver Dam will require groundwater levels to be monitored in piezometers behind the walls, and groundwater pressures in the walls to be dissipated by means of sub-horizontal drain holes. It is recommended that drain holes be located to intersect permeable structures 20 m to 30 m back from the walls. If possible, drain holes should be selectively located in areas where seepage is an obvious issue rather than placing them at regular spacing on every bench of the pit. A greater density of drains may be required to control groundwater pressures within and near the Mud Lake Fault.

Figure 7 presents a conceptual design of pit wall drainage by means of sub-horizontal drain holes. Drains should be about 30 m long, and can be drilled with a blast hole rig. Flows from drains will generally diminish over time, and drains on the higher benches may eventually cease flowing as the mine is developed. Discharge from drains should be directed to a sump either through a series of pipes or channels. Collaring of drain holes may be necessary if large and persistent flow rates are encountered, however in most cases flows are expected to be no greater than a trickle and should diminish over time.

Monitoring of groundwater levels will require piezometers to be constructed at the pit crest, and progressively on some benches as the open pit is developed. Piezometers can be vertical boreholes drilled to a depth of 40 m to 50 m, possibly with a blast hole drilling rig, and cased with 32 mm or 40 mm PVC pipe which has been slotted from 10 m below surface. The annulus outside the slotted casing should be packed with graded sand (~2 mm grain size) to about 3 m above the top of the slots. Slots can be cut with a hacksaw, or machine slotted casing can be used if this is available.

Piezometers located at the pit crest will require the glacial till sequence to be collared to below the till/bedrock contact so that groundwater in the till cannot seep into the borehole. These piezometers should also include annular bentonite clay seals of height about 1 m on top of the sand pack. It may be necessary to modify the design of these piezometers during construction to ensure that the bentonite seal is a few metres below the till/bedrock contact.

All piezometers should be finished with steel surface casing about 0.7 m above ground level, and these casings should be painted bright orange or green so that they are clearly visible. Piezometers should be surveyed to determine locations and reference elevations for measuring water levels against.

For planning purposes, allowance should be made for piezometers at the pit crest to be around 200 m apart, ie there will be nine or ten piezometers around the crest of the proposed Beaver Dam open pit. Transects of piezometers every 50 m vertically down the pit wall should be constructed at every second crest piezometer.

Data from the piezometers will provide profiles of the phreatic surface which will be important for assessing pit wall stability. If access to piezometers over the longer term is uncertain, consideration should be given to equipping these facilities with pressure transducers that connect to logging units at the crest of the pit.

6 REMAINING HYDROGEOLOGICAL ISSUES

Hydrogeological issues at Beaver Dam that may need to be considered are:

- Quality and quantity of any groundwater that may need to be discharged off site, ie in excess of what can be utilised for ore processing
- Groundwater and surface water monitoring programs that may need to be established under statutory requirement for mining operations in Nova Scotia

A possible issue that may need to be considered given the setting is the effect of freezing temperatures on groundwater seepage close to the pit walls. The expansion of water that occurs at temperatures below 4°C and when ice is formed has the potential to cause slight dilation of the rock mass and joints. This process may lead to exfoliation at the pit walls. Whether this will be a significant process in an open pit at Beaver Dam is unclear. Avoiding this condition would require that the wall rocks be completely dewatered, especially close to the face of the pit.

Peter Clifton & Associates

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Table 1: Beaver Dam Project Packer Testing Results

Borehole	From	To	Lithology / Structure	K (m/sec)
BD85-005	15.2	19.8	Argillite	5.2×10^{-7}
	19.8	24.4	Argillite	9.0×10^{-8}
	24.4	29	Argillite	1.8×10^{-7}
	50.3	54.9	Greywacke	1.4×10^{-6}
BD85-007	15.2	19.8	Argillite	4.7×10^{-8}
	19.8	24.4	Argillite, Quartzite	1.1×10^{-8}
	24.4	29	Quartzite	8.4×10^{-7}
	56.4	61	Greywacke / Fault	2.0×10^{-9}
	65.5	70.1	Greywacke	5.4×10^{-7}
	88.4	93	Argillite	3.0×10^{-8}
BD85-013	21.6	26.2	Greywacke	2.0×10^{-8}
	25.9	30.5	Greywacke, Quartzite	2.4×10^{-8}
	81.7	86.3	Greywacke, Argillite	5.8×10^{-8}
	86	90.6	Argillite	4.1×10^{-8}
	90.2	94.8	Argillite	2.8×10^{-8}
	94.5	99.1	Argillite	2.5×10^{-8}
	98.8	103.4	Argillite	4.3×10^{-8}
BD85-016	10.6	15.2	Greywacke, Quartzite	8.0×10^{-7}
	15.2	19.8	Quartzite	1.6×10^{-6}
	19.8	24.4	Quartzite	4.9×10^{-8}
	76.2	80.8	Greywacke, Argillite	2.5×10^{-7}
	80.8	85.3	Greywacke, Argillite	3.0×10^{-7}
	85.3	89.9		3.9×10^{-7}
BD85-029	13.7	18.3	Argillite	4.7×10^{-7}
	24.1	28.7	Greywacke	9.9×10^{-8}
	33.5	38.1	Greywacke	9.4×10^{-7}
	39.6	44.2	Greywacke	9.0×10^{-8}
	102.1	106.7	Greywacke, Argillite	4.9×10^{-8}
	106.7	111.3	Greywacke	1.6×10^{-8}
BD85-043	19.8	24.4	Quartzite	8.3×10^{-9}
	24.4	29	Greywacke, Argillite	2.6×10^{-8}

continued…

Table 1 (cont): Beaver Dam Project Packer Testing Results

Borehole	From	To	Lithology / Structure	K (m/sec)
BD85-043 (cont)	47.2	51.8	Greywacke	1.0×10^{-6}
	51.8	56.4	Greywacke	2.3×10^{-7}
	62.5	67.1	Greywacke	2.7×10^{-9}
	67.1	71.6	Greywacke	3.4×10^{-9}
	117.3	121.9	Greywacke	1.0×10^{-9}
	121.9	126.5	Greywacke	7.6×10^{-10}
	126.5	131.1	Greywacke	2.6×10^{-9}
	131.1	135.6	Greywacke, Argillite	1.6×10^{-9}
	135.6	140.2	Argillite	5.5×10^{-10}
	140.2	144.8	Argillite	3.7×10^{-10}
BD85-082	15.2	19.8	Greywacke	3.6×10^{-8}
	19.8	24.4	Greywacke	1.1×10^{-6}
	24.4	29	Quartzite / Fault	1.9×10^{-6}
	30.5	35.1	Greywacke	8.0×10^{-7}
	41.1	45.7	Quartzite	6.1×10^{-7}
	45.7	50.3	Quartzite	4.6×10^{-7}
BD85-083	39.6	44.2	Greywacke / Fault	1.5×10^{-8}
	48.8	53.3	Greywacke / Fault	1.0×10^{-8}
	57.9	62.5	Greywacke / Fault	1.2×10^{-9}
	71.6	76.2	Argillite	7.1×10^{-9}
	80.8	85.3	Greywacke, Argillite	2.7×10^{-8}
BD85-090	19.8	24.4	Quartzite	3.1×10^{-8}
	24.4	29	Greywacke	3.0×10^{-8}
	29	33.5	Greywacke, Quartzite	2.4×10^{-8}
	33.5	38.1	Greywacke, Quartzite	8.1×10^{-8}
BD14-188	12	23	Hanging wall	$<1.0 \times 10^{-8}$
	33	50	Hanging wall	5.0×10^{-9}
	117	125	Fault	1.0×10^{-8}
	147	160	Foot wall	$<2.0 \times 10^{-9}$
	147	210	Foot wall	$<4.0 \times 10^{-10}$

Notes: "K" is hydraulic conductivity
Boreholes with prefix "BD-85" tested in 1986 (JWA, 1986b)
Borehole BD14-188 tested in 2015 (Stantec, 2015)