Baffinland Iron Mines Corporation

PHASE 1 WASTE ROCK MANAGEMENT PLAN

BAF-PH1-830-P16-0029

Rev 2

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ACKNOWLEDGEMENTS

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1 PURPOSE

The Phase 1 Waste Rock Management Plan (WRMP) provides a waste rock deposition plan for the estimated 640 Mt of waste rock and 32 Mt of overburden from mining Deposit No. 1. Specifically, the Plan details the management of potential acid generating (PAG) and non-acid generating (Non-AG) waste rock at Baffinland's Waste Rock Facility (WRF). As additional geological, geotechnical and geochemical data is collected, the waste rock management plan will be updated based on the application of best management practices. Note that the existing, approved, Life of Mine (LOM) waste rock management plan is still in effect.

2 SCOPE

This Plan describes the waste rock deposition strategy for the Deposit No. 1 WRF. The Plan accommodates operational constraints, addresses the occurrence of acid rock drainage (ARD) from the WRF, and plans for the chemical stability of future PAG waste rock deposition. Closure considerations are included as well as environmental monitoring and reporting.

3 DEFINITIONS

Acid rock drainage (ARD): outflow of acidic water from acid generating minerals with reduced pH.

Non-acid generating (Non -AG): rock that does not have the potential to produce any acid or acidic water.

Potentially acid generating (PAG): rock containing minerals which potentially can produce acid or acidic water, with a total sulphur content greater than 0.2 wt% as S.

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4 RESPONSIBILITIES

4.1 Mine Manager

The Mine Manager or designate is responsible for implementing the Plan within their department and area of operation. They must ensure that their personnel understand the contents of this Plan and follow its requirements. They are responsible for auditing the WRMP program and ensuring implementation of corrective actions in the event of identified non-compliances, non-conformances, and/or issues of concern.

4.2 Mine Operations Superintendent

The Mine Operations Superintendent is responsible for the following:

- The health and safety of all persons while managing and directing activities associated with the equipment operating and labour tasks within the WRF and vicinity.
- Ensuring all activities are executed as per the plan set in place by the Technical Services Superintendent.
- Ensuring all supervisors and operators receive the proper training and understand the plan to be executed.

4.3 Technical Services Superintendent

The Technical Services Superintendent is responsible for the following:

- The health and safety of all persons while managing and directing activities associated with the technical services related to placement of waste rock and WRF stability monitoring.
- Ensuring all engineers, geologists, technicians and surveyors are properly trained and understand this Plan
- Designate responsible persons for implementing the Plan within their department and area of expertise
- Responsible for implementing an inspection program to ensure that the Plan is being fully implemented.

4.4 Mine Development Supervisor

The Mine Development Supervisor, in conjunction with the Load and Haul Supervisor, is responsible for the following:

- The health and safety of all persons while managing and directing activities associated with the hauling and placement of waste rock
- Ensuring all workers and operators are trained and understand this Plan
- Inspections of the WRF and reporting of all non-conformances
- In the event that a push unit is not available to direct the dumping activities, the supervisor shall ensure the placement of used tires to indicate the dumping limits of waste material

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4.5 Haul Truck Operator

Haul truck operators are responsible for the safe operation of their haul truck as outlined in the Haul Truck Operation Procedure (BAF-PH1-340-PRO-0006) and the following responsibilities:

- Carry out all pre-operation and shut down inspections as specified in Baffinland policies
- Observe all speed limits and adjust driving for the conditions during bad weather
- Follow closely all directional signs when operating in the waste rock stockpile
- Reporting all spills and/ or non-conformance to their supervisor
- Contacting their supervisor if uncertain about any of the tasks

4.6 Push Unit Operator

Operators are responsible for the safe operation of their equipment as outlined in the Loader Operation Procedure (BAF-PH1-300-PRO-0010) and Dozer Operation Procedure (BAF-PH1-300-PRO-0011) and the following responsibilities:

- Reading and understanding the Working Near Slopes: Pit Walls, Dumps, and Stockpiles Procedure (BAF-PH1-340-PRO-0033)
- Carry out all pre-operation and shut down inspections as per Baffinland policy
- Maintain safe conditions for haul truck dumping at the edges of the stockpile lift and at the dumping location
- Give clear communication and signals to the haul truck operator
- Ensuring material is dumped and/or pushed in such a way as to minimize material segregation and respects designated lift height
- Reporting all spills and/ or non-conformances to their supervisor
- Contacting their supervisor if uncertain about any of the tasks

4.7 Mine Engineer

Mine Engineers are responsible for the following responsibilities:

- Reading and understanding the Working Near Slopes: Pit Walls, Dumps, and Stockpiles Procedure (BAF-PH1-340-PRO-0033)
- Short and Long Term Scheduling of placement PAG and Non-AG materials on the WRF
- Scheduling Non-AG and PAG lifts sequence
- Design ultimate WRF for existing footprint
- Ensuring WRF slopes are maintained according to original design
- Frequent WRF visits and monitoring

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4.8 Mine Geologist

Mine Geologists are responsible for the following responsibilities:

- Reading and understanding the Working Near Slopes: Pit Walls, Dumps, and Stockpiles Procedure (BAF-PH1-340-PRO-0033)
- Classifying and delineating in-pit waste, PAG and Non-AG based upon the WRF QAQC Program
- Monitoring PAG and Non-AG placement on the WRF daily to ensure PAG materials are properly separated and deposited in the correction location
- Collecting samples of PAG and Non-AG to ensure proper placement of materials
- WRF temperature monitoring by retrieving data from thermistors

4.9 Mine Surveyor

Mine Surveyors are responsible for the following responsibilities:

- Reading and understanding the Working Near Slopes: Pit Walls, Dumps, and Stockpiles Procedure (BAF-PH1-340-PRO-0033)
- Survey pick up of WRF construction development as required
- Monitoring of lift thickness to meet design requirements
- Survey and stake out areas to differentiate between PAG and Non-AG deposit locations

4.10 Environment Department

The Environmental Department will be responsible for:

- Regular inspections of the WRF ditches and WRF pond
- Monitoring and sampling of the WRF Pond Final Discharge Point (FDP) during discharge as per Baffinland's Type A Water Licence and MDMER.
- All required reporting to external regulators

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5 REGULATORY REQUIREMENTS

All mining operations are carried out under the Mines Act and the requirements will be reflected in Baffinland procedures, which must be followed.

The Mary River Operation is permitted under Nunavut Impact Review Board Project Certificate #005 and Nunavut Water Board Type A Water License, 2AM-MRY1325. The specific environmental requirement related to the WRF is for run-off to be collected in a downstream pond with capacity sized to reduce suspended solids in the discharge to meet discharge requirements of <30 mg/L (maximum concentration of any grab sample) and 15 mg/L maximum average concentration.

In addition, the discharge from the pond is established as a monitoring and discharge point under the Metal and Diamond Mining Effluent Regulations (MDMER) SOR/2002-222.

All monitoring and reporting of runoff water quality will be carried out by the Environmental Department including annual reporting to the appropriate Regulatory Agencies.

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6 WASTE ROCK CHARACTERIZATION

One of the primary strategies of the waste rock deposition plan for mitigating the occurrence of ARD from the WRF is the appropriate management of PAG waste rock. Effective management of the PAG waste rock requires that the waste rock geochemistry and mechanisms driving ARD production be understood.

Results of the December 2018 geochemical investigation suggested that dissolution of soluble sulphate minerals within the waste rock may also be a contributing to the acidic drainage observed at the WRF. A detailed review of the available waste rock geochemistry was undertaken and the PAG classification criteria reviewed. The waste rock geochemistry and PAG classification review were supported by results of the previously carried out geochemical sampling, as well as the 2019 geochemical investigation, and are discussed in the following sections and Appendix A.

6.1 Deposit Geology

Deposit No.1 occurs at the nose of a syncline plunging steeply to the north-east (Aker Kvaerner, 2008). The iron formation occupies the nose and two limbs of this feature with a ~1,300 m long northern portion and a ~700 m long southern portion. The footwall to the iron formation mainly consists of gneiss with minor schist, psammitic gneiss (psammite) and amphibolite. The hanging wall is primarily composed of schist and volcanic tuff with lesser amphibolite and metasediment.

The hanging wall primarily encompasses chlorite–actinolite schist and garnetiferous amphibolites. Metavolcanic tuff is also a significant lithology identified in the hanging wall. The footwall mainly consists of quartz-feldspar-mica gneiss with lesser meta-sediment (greywacke) and quartz-mica schist. Microcline and albite are the predominant feldspars within the gneiss and biotite is generally more abundant than muscovite.

The iron ore deposits at the Mary River project represent high-grade examples of Algoma-type iron formation and are composed of hematite, magnetite and mixed hematite-magnetite-specular hematite varieties of ore (Aker Kvaerner, 2008). The iron deposits consist of a number of lensoidal bodies that vary in their proportions of the main iron oxide minerals and impurity content of sulphur and silica in the ore. The massive hematite ore is the highest grade ore and also has the fewest impurities, which may indicate it was derived from relatively pure magnetite or that chert, quartzite and sulphides were leached and oxidized during alteration of the iron formation.

Intense deformation and lack of outcrop limit the ability to subdivide by lithology on the basis of future mined tonnages.

The existence of the ridge north of Deposit No. 1 and outcrop appearing along the ridge support existing evidence from geotechnical drilling of the geotechnical stability of the area and make it a suitable location

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to start construction of the waste rock stockpile. Ongoing geotechnical drilling to complement existing data will be used to optimize the stockpile design.

6.2 Geochemical Sampling Program

The 2019 geochemistry program was intended to further advance review of the waste rock geochemistry, specifically with respect to the presence of soluble sulphate minerals, and to support a review of the PAG classification criteria. The 2019 geochemistry program included:

- Drilling investigation to collect waste rock samples at locations throughout the WRF with a focus on areas in the vicinity of observed poor runoff water quality, and;
- Samples of drill cuttings from the boreholes used for blasting ("blastholes") in the open pit to expand the geochemical database for samples with total sulphur slightly above and below 0.2 wt% as S to assess the presence of soluble sulphate minerals in material with low total sulphur that would have implications for the current waste rock segregation criteria

Geochemical analysis was carried out on all collected samples and the detailed results provided as Appendix A. The main conclusions from the 2019 geochemistry program and historic geochemistry results review are summarized as follows:

- The geochemical results suggest that the overall existing waste rock pile design and placement, as presented in the December 2018 WRMP (Golder, 2018b), remains valid to reduce potential for ARD and ML, provided the Non-AG material does not contain stored acidity. In addition, ensuring that PAG material is covered with a lift of Non-AG material, to maintain the PAG waste rock below the permafrost active layer, to limit release of stored acidity from the PAG material
- The geochemistry of the current WRF may be localized within the current area of Deposit 1. Stored acidity, particularly within material currently classified as Non-AG waste rock, appears to be primarily within the current Deposit 1 area and the potential appears to decrease based on available historical data.
- The presence of significant enough quantities of soluble sulphate to produce ARD and ML are predominately constrained to material with a total sulphur content greater than 0.20 wt% as S, and therefore, this material is already identified by the current PAG classification method.
- 7% of the 2019 geochemical samples with less than 0.20 wt% as S total sulphur had acidic pH values (<6) in either the paste pH from ABA or final pH from SFE.

To reduce the amount of low sulphur waste rock with stored acidity classified as Non-AG under the current criterion that may have some potential to release acidity, paste pH testing will be implemented as part of the current waste rock segregation practices for samples that have less than 0.20 wt% as S. The updated PAG and Non-AG classification criteria are provided in

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Table 1 below:

TABLE 1 PAG CLASSIFICATION

Acid Generation Potential	Criteria
PAG	Total sulphur > 0.20 wt% as S
PAG	Total sulphur < 0.20 wt% as S and paste pH <6
Non-AG	Total sulphur < 0.20 wt% as S and paste pH >6

Select blasthole samples of both PAG and Non-AG material will be submitted for ABA and SFE testing on an ongoing basis. The purpose of this additional testing is to develop a comprehensive geochemical database for the WRF and allow for the potential refinement of waste rock segregation practices, if required in the future, and increase the level of confidence in the data set.

7 THERMAL ASSESSMENT

A thermal assessment was undertaken to characterize the freezing patterns of deposited waste rock and assess the WRF thermal performance. A thermal model was run to assess the time for waste rock placed during summer and the subsequent winter to freeze back. The main conclusions from the thermal assessment are as follows:

- Review of data obtained from the site thermistors indicate that the WRF is almost entirely frozen, with exception of a 2 - 3m thick active zone subject to seasonal freeze and thaw cycles.
- Temperatures within the WRF are affected not only by air temperature, but also potentially by air flow, air convection and by internal heat generation connected to airflow through the WRF and variation in the geochemical behavior of the waste rock. Progressive increase in air temperatures slowly impacts ground temperature, while airflow and/or internal heat generation lead to sudden, localized and temporary variations in temperatures.
- Results from thermal models suggest that between 5 m and 7 m of waste rock could be placed in summer and the entire thickness of material would freeze during the following winter, assuming the summer placed material was not covered over during the winter. However, depending on the existence of heat sources within the WRF, a 7 m thick waste rock summer deposition could cause the development of a thawed zone in portions of waste rock previously deposited. Limiting the thickness of summer placed waste rock to 5 m would reduce the risk of creating a thawed zone at depth within the WRF.

- Winter deposition will delay freezing of the underlying material deposited during the summer. The models predict that a 5 m thick lift of waste rock deposited in summer, covered by a 5 m thick layer of waste rock in winter, would freeze prior to the following summer in most scenarios. However, heat exchange between summer deposition layers and waste rock deeper in the WRF could cause the development of a thawed zone in the interior of the WRF. Delaying winter deposition or reducing the thickness of summer deposition would decrease freezing times and reduce the extent of thawed portions within the WRF.
- If no internal heat source is present, the models indicate that the entire waste rock layer deposited in summer would freeze within a year, with or without additional deposition of waste rock in winter, and the extent of the thawed zone in the interior of the pile would be very limited.

Updates to the thermal model will be carried out, as appropriate, to incorporate improved understanding of the WRF gained by the ongoing review of the WRF instrumentation data and as required to inform the waste rock deposition.

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8 WRF DEVELOPMENT STRATEGY

The primary objectives for the WRF development are the safety of personnel/environment and long-term physical and chemical stability. Thin lift deposition of waste rock is expected to create a more homogenous stockpile and reduce segregation that may create preferential air and water flow paths throughout the stockpile (i.e. reduce flow channelization and potential for oxygen supply to PAG materials). Waste rock placement locations and lift thickness also focus on the continuous development and raising of permafrost within the WRF. It is expected that permafrost aggradation will provide an effective barrier to acid-forming reactions as absence of oxygen and water supply limits potential for sulphide oxidation and ARD transport.

The WRF development considers winter (October through May) and summer (June through September) deposition. The conceptual waste rock deposition plans are based off projected quantities of waste rock, and were used as input into the water balance and water quality models (Appendix A). The actual waste rock deposition locations are expected to vary, and will follow the development strategy presented below.

The WRF deposition strategy and guidelines below are developed from Golder's assessment of the geochemistry analysis and their various thermal, water quality and water balance models, presented in Appendix A.

8.1 WRF Design Criteria

The following design criteria have been developed with consideration to the criteria established under the LOM WRMP (Baffinland, 2014):

- Runoff and seepage from the WRF will be collected at the WRF Pond. Collected flows will be treated to comply with requirements of the Type A Water License 2AM-MRY1325 and MDMER;
- The stockpile will be constructed in lifts from the bottom up with lift and bench characteristics appropriate for the geotechnical conditions and waste handling equipment. These characteristics will be approved by the Mine Manager;
- The WRF will be developed in a manner conducive to permafrost aggradation, following the development strategy discussed here. At closure, the WRF active layer will consist of Non-AG material.
- The following conditions define the WRF geometry (Baffinland, 2014):
  - Overall external side slopes will be 2H:1V. Exterior slopes will be benched with inter bench slopes of 1.5H:1V;
  - Minimum crest width will be 25 m; and,
  - The perimeter of the WRF will be a minimum of 31 m from any water body.

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8.2 Deposition Strategy and Guidelines

The following WRF design guidelines will develop over time as the results of the ongoing studies and field piles become available:

- **Footprint expansion:** The first lift of the WRF on native ground shall be Non-AG waste rock. Waste rock placement over native ground shall be carried out in the winter to the extent practicable. As a minimum, the lift should be allowed to freeze prior to layering activities. Maintaining a frozen base and perimeter is expected to reduce potential for seepage.
- **Stockpile expansion construction:** Waste rock placed over an area of new WRF expansion shall be carried out in a manner conducive to aggrading permafrost, to limit potential for further development of ARD.
- **Material separation:** PAG and Non-AG waste rock placement locations at the WRF shall be documented. Non-AG material that may be intermixed with PAG shall be classified as, and follow the waste rock deposition strategies for, PAG material.
- **Stockpile exterior face:** PAG waste rock shall be placed 4.0 m (minimum) interior from the ultimate stockpile or an interior or temporary face. The final or temporary outer face of the stockpile shall be Non-AG waste rock. This criterion has been established to maintain the PAG materials interior from the permafrost active zone which has been measured up to 2.9 m in thickness. A larger 4.0 m buffer has been recommended until more data points are available to define the permafrost active zone (current site measurements are limited to 1 season).
- **Lift thickness:** Waste rock placement to target a maximum thickness of 5.0 m. This lift thickness has been established to reduce potential for waste rock segregation during placement while remaining operationally feasible with the available equipment. Reducing segregation of deposited waste rock is expected to reduce the potential for development of preferential air flow paths that can delivery oxygen to PAG waste rock.
  - The maximum recommended lift thickness has been increased from 3.0 m to 5.0 m, provided the material does not segregate. Baffinland will regularly inspect the waste rock lift advancement for signs of material segregation. If segregation of the waste rock particles occurs during spreading the lift thickness shall be reduced or placement methods modified to reduce occurrence of segregation.
- **Successive lift placement:** Placement of successive waste rock lifts shall give consideration to the waste rock and environmental conditions as described below. These placement strategies may be revised as the thermal performance of the WRF becomes better understood.

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- When the waste rock temperature at the time of placement is <0°C successive lifts may be continuously placed over a given footprint.
- When the waste rock temperature is above 0°C and the air temperature below 0°C, the surface of the waste rock shall be kept clear of snow for the length of time required to promote permafrost aggradation prior to placement of the subsequent lift.
- When the waste rock temperature is greater than 0°C only a single lift is to be placed at a given location and shall be limited to a maximum thickness of 5.0 m.
- Winter waste rock placement shall defer covering over summer placed material to the extent possible. When required and to the extent practical, waste rock placed during winter shall cover over the earliest placed waste rock from the preceding summer.

- **Capping winter PAG placement before summer:** To the extent practicable, PAG waste rock placed during winter shall be covered with a 3.0 m thick (minimum) layer of Non-AG waste rock prior to summer (thickness increased from the previous 2.5 m based on the thermistor results). The intention of this criteria is to maintain the permafrost active zone within the Non-AG waste rock during the summer months (i.e. maintain the PAG waste rock in a frozen state).

It is noted that, in the near-term until the WRF footprint can be sufficiently expanded, waste rock deposition following the above guidelines may not always be possible. Baffinland will document and keep record of deviations from the above waste rock deposition strategies, understanding that deviation from the above guidelines may temporarily or permanently influence the chemical stability of the WRF, and will need to be evaluated and possibly mitigated prior to, or as part of the ultimate WRF closure.

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9 WRF WATER MANAGEMENT

In compliance with Baffinland's Type A Water Licence, runoff from the WRF and surrounding disturbed area are collected in a network of ditches and directed towards the WRF Pond. Dewatering from Deposit 1 is also directed to the WRF and collected at the WRF Pond at times when the WRF Pond can accommodate the flow or pumped directly to the WTP. Clean, non contact water from upstream of the WRF will be diverted around the WRF by diversion berms. In addition, as part of the Snow Management Plan (BAF-PH1-830-P16-0023), clean snow is stockpiled in designated areas outside of the WRF Pond catchment area to limit clean melt water from reporting into the WRF pond.

Baffinland executed construction of the WRF Phase 1 ditch, expanding the WRF Pond catchment to the approximate design area of 358,000 m^2. Ditches were excavated through the native overburden and lined with rip rap where required to reduce potential for erosion. The Phase 2 ditch expansion, which increases the WRF Pond catchment area to approximately 585,000 m^2, is expected to be constructed prior to spring freshet 2021 and following completion of the WRF Pond expansion to the 65,000 m^3 capacity. Further phased drainage management berms and ponds will be designed as mining progresses and additional WRF expansions are required for capacity and/or adherence to the WRF development strategy.

Error! Reference source not found. shows that the initial footprint of the waste rock storage area is partially in the western watershed of the two watersheds that drain the area to the north of the open pit and which drain into Camp Lake. WRF Pond effluent reports to the Mary River watershed.

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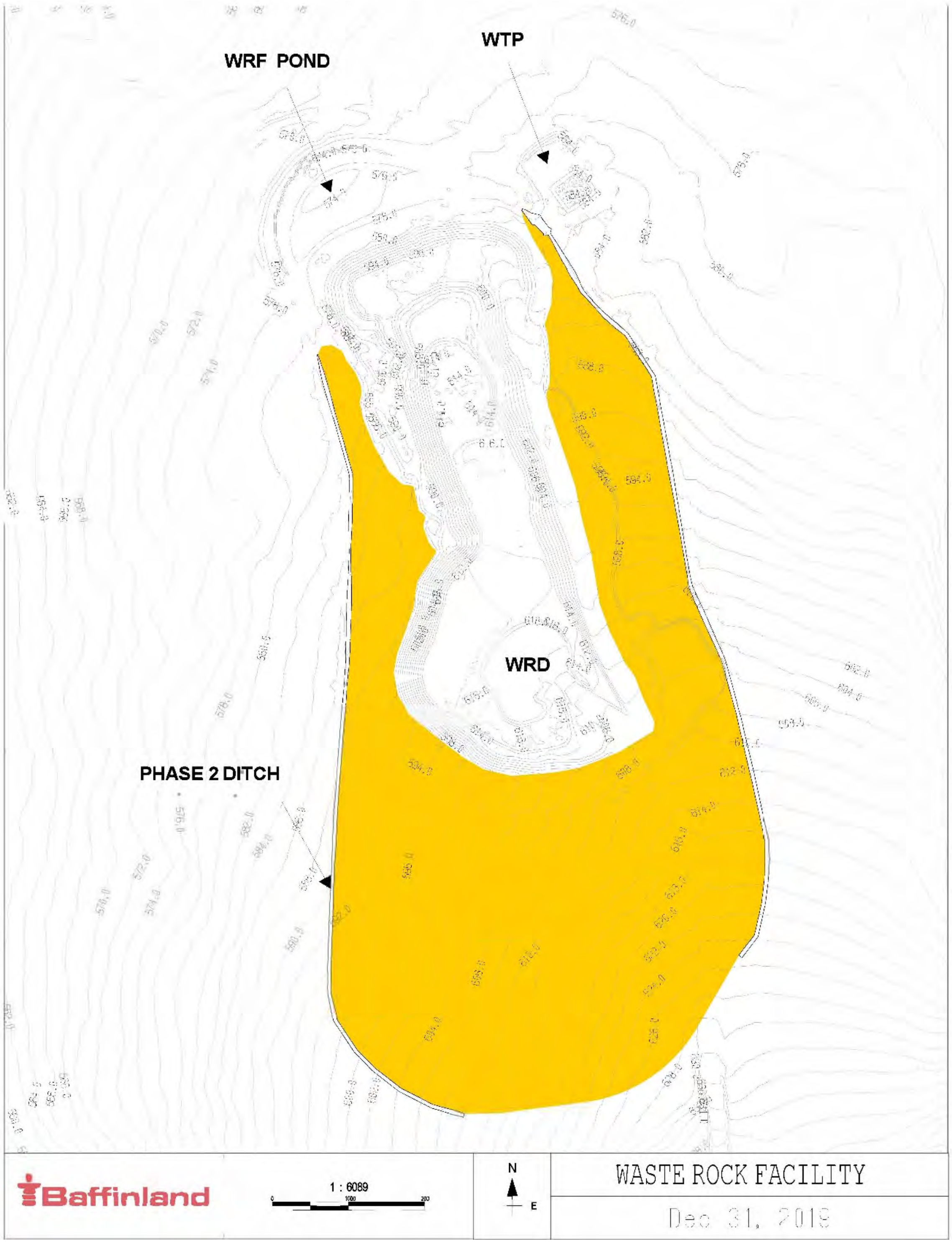

FIGURE 1 WRF DESIGN FOOTPRINT

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9.1 Environmental Performance Indicators

Discharge from the WRF shall not exceed the below effluent quality limits of Part F, Item 24 in the Type A Water Licence site-specific limits shown in Table 2, as well as criteria listed under Schedule 4 of MDMER. In addition, Environmental Effects Monitoring or biological monitoring will be carried out as required by MDMER. Baffinland has implemented an Aquatic Effects Monitoring Plan (AEMP) to monitor environmental effects of effluent discharge to the receiving environment at Mary River. Results of the discharge monitoring, EEM and the AEMP can trigger additional adaptive management actions such as further treatment of pond effluent, if required.

TABLE 2 DISCHARGE PERFORMANCE INDICATORS AND THRESHOLDS

Indicator	Units	Maximum Concentration of Any Grab Sample
pH	-	6.0 < pH < 9.5
Arsenic	mg/L	0.5
Copper	mg/L	0.30
Lead	mg/L	0.20
Nickel	mg/L	0.50
Zinc	mg/L	0.5
TSS	mg/L	15
Oil and Grease	-	No visible sheen
Toxicity	-	Non-Acutely Toxic

9.2 WRF Runoff Water Treatment Alternatives

9.2.1 Water Treatment Systems

Temporary treatment systems can be used to alter water chemistry with various mixing and dosing components. Treatment systems could be established alongside the WRF Pond berm, or in a facility. Suction and recirculation hose is installed with floats, ensuring the lines do not damage the liner or disturb any settled solids.

A water treatment plant (WTP) facility established in close proximity to the WRF Pond was constructed to treat surface runoff collected at the WRF Pond. A transfer pump conveys water from the WRF pond through approximately 330 metres (m) of layflat hose to the WTP. The WTP consists of physical-chemical treatment for pH adjustment, chemical precipitation and removal of solids by physical barrier. The water treatment processes include coagulation, pH adjustment and precipitation, flocculation and filtration. The WTP effluent is then discharged to the receiving environment of Mary River tributary.

A detailed design of the WTP was carried out by McCue Engineering Contractors. The WTP was constructed in 2018 and has a design treatment rate of 280 m^3/hr capacity, consisting of two 140 m^3/hr treatment trains. For each train, the water flow rate and pH in Reactor tanks 1 and 2 is continuously monitored. Ferric sulfate and polymer is added based on flow rate, while the lime dosage is based on pH in the reactor tank 1. The chemical dose rate is adjusted by the plant operator in the PLC to meet the targets. The WTP operating manual and treatment process are provided in Appendix B.

Temporary treatment systems established alongside the WRF Pond have the components required for mixing and dosing the chemistry placed on top of the berm and connected using flexible tank hose. A typical potential arrangement for a pond-side mixing and dosing system is shown in Figure 2.

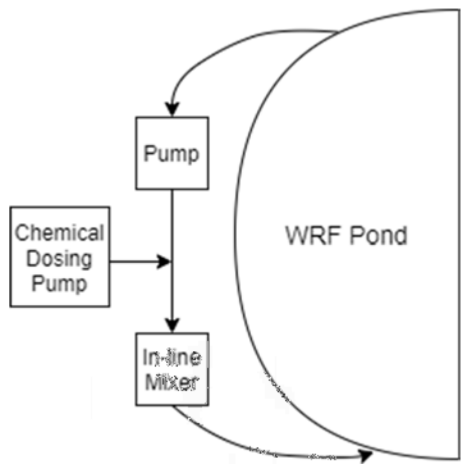

FIGURE 2 LAYOUT OF POND-SIDE MIXING/DOSING SYSTEM

During discharge, it may be necessary to arrange equipment on the discharge end of the pump to provide pH adjustment or final solids removal before the water enters the receiving environment. A typical discharge arrangement is shown in Figure 3.

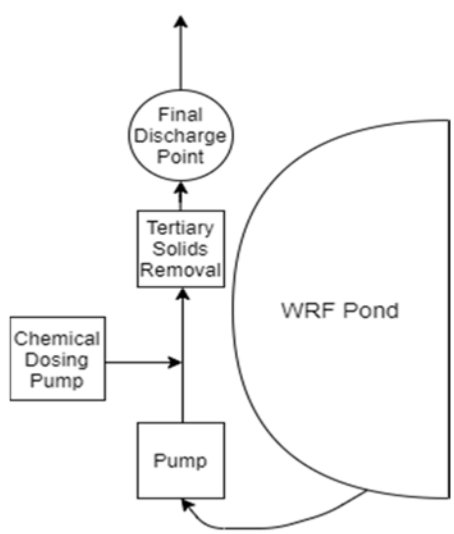

FIGURE 3 TYPICAL POND-SIDE DISCHARGE TREATMENT LAYOUT

9.2.2 pH Adjustment Alternatives

To adjust the pH of the pond, a basic chemical would be dosed under constant mixing, until samples confirmed that the pH of the pond had increased sufficiently to be compliant with applicable guidelines, including acute toxicity testing. Monitoring would then be necessary during discharge to ensure that further runoff does not drop the pH below MDMER and Water Licence discharge criteria. Chemicals that could be used to raise the pH include:

- Sodium Bicarbonate, $NaHCO_3$ (Baking soda)
- Sodium Hydroxide, NaOH (Caustic soda)
- Calcium Hydroxide, $Ca(OH)_2$ (Hydrated lime)
- Magnesium Hydroxide, $Mg(OH)_2$
- Calcium Carbonate, $CaCO_3$ (Limestone)
- Sodium Carbonate, Na_2CO_3 (Soda ash)
- Other coagulation chemicals identified by subject-matter experts

To ensure adequate mixing, the pond will need to be mixed during dosing. This can be achieved using pumps and hoses placed on the top of the berm, drawing suction from one side of the pond and discharging to the opposite end in a recirculation set up. Doing this provides complete mixing for chemical dosing, and ensures that any samples taken will be representative of the overall pond water quality.

The pH adjustment chemicals noted above are available as both solids and liquids, in a variety of different shipping containers. If a liquid chemical is selected, the chemical can be dosed directly in-line through the mixing pumps, using a small dosing pump and an in-line mixer. Solid chemicals will need to be prepared as a solution first, to allow them to be injected in a similar manner.

An estimate of chemical requirements should be completed beforehand to provide a target dosage for the volume of water in the pond. This is most effectively done through bench-scale titration of samples of the pond water, with the proposed chemistry being used for treatment.

As the actual dose approaches the theoretical dose, care should be taken to avoid overdosing and surpassing the upper pH limit. It is important to take into consideration the reaction time of the specific chemistry being used when evaluating performance and measuring pond water quality. Adequate time should be given for the reactions to run to completion, before pond samples are taken.

9.2.3 Metals Precipitation

Monitoring of the Waste Rock Pond and inflow into the pond have shown elevated levels of Nickel. If, during discharge, the water impounded in the Waste Rock Pond is found to have metals concentrations over the limits, further treatment will be required.

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Precipitation is a reliable method of removing metal species from a water body. To precipitate metals, the pH of the water must be adjusted to the point that the target metals become insoluble in water, and form a precipitate (see Section 8.2.2). This precipitate is then allowed to settle to the bottom of the pond as a solid, which later may need to be removed and disposed of as a sludge depending on accumulation rates. Figure 4 below shows a typical solubility chart for metal hydroxides and sulphides, showing the relationship between solubility and pH of the solution. Figure 4 displays a pH of approximately 8 is optimal to precipitate out Nickel concentrations in Waste Rock Sedimentation Pond waters.

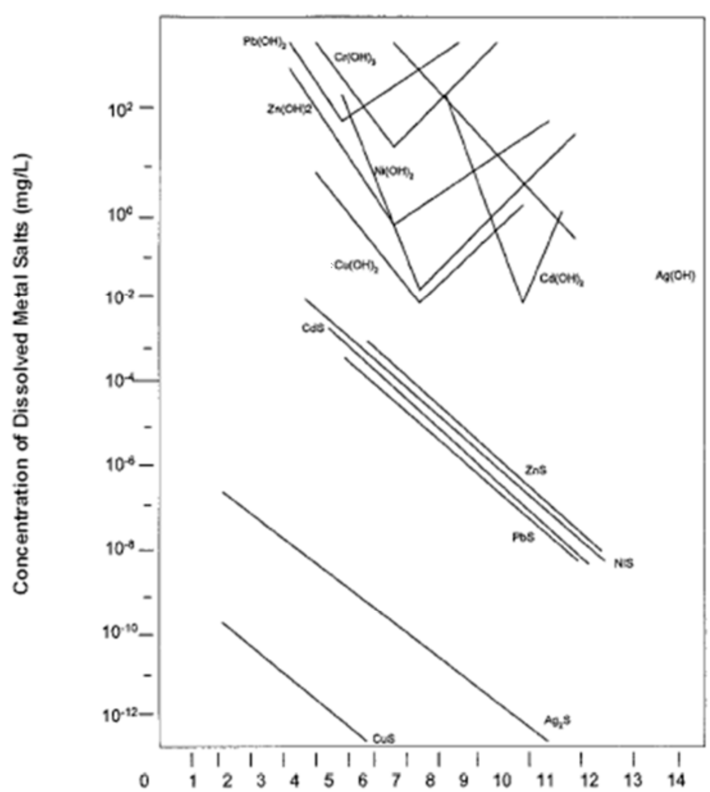

Figure 2-2. Solubility of metal hydroxides and sulfides as a function of pH (*x*-axis) (source: EPA 625/8-80-003).

FIGURE 4 SOLUBILITY OF METAL HYDROXIDES AND SULPHIDES

Once the water has been pH adjusted, the pond would be allowed to settle for a period of time. This gives time for the reactions to take place, and for precipitates to form and settle out to the bottom of the pond. Once analysis shows that metals concentrations are within applicable discharge guidelines, further pH adjustment may be necessary prior to discharge to ensure compliance with MDMER and Water Licence

Regulations. This pH adjustment should be done in-line if possible, to prevent any precipitated metals in the pond from going back into solution.

Chemicals that could be used to decrease pH to meet regulatory requirements during discharge include:

- Sulphuric acid, H_2SO_4
- Hydrochloric acid, HCl
- Nitric acid, HNO_3
- Phosphoric acid, H_3PO_4
- Other coagulation chemicals identified by subject-matter experts

9.2.4 Solids Removal

At present, solids concentration in the pond is variable, likely due to the depth of the pond and solids characteristics. If solids concentrations are elevated prior to discharge, it may be necessary to utilize a coagulant to assist with settling. Using a coagulant, in conjunction with the chemistry noted above, will cause the solids in the water to bind together, forming heavier particles that sink more readily. This will create more sludge, but will result in clearer water.

As with the other chemicals, the coagulant must be added and mixed into the pond, but may be added in-line during mixing. The coagulant chemical addition should follow the pH chemical addition program, if required. A theoretical dose should be established through bench scale testing first for target dosing. An effective dose of coagulant will yield a clear supernatant and form a layer of thick solids, which is not easily disturbed. The lighter the solids layer, the more affected by wind it will be, and the greater the possibility the solids will go back into suspension.

Chemicals that may be used for coagulation of solids in the pond include:

- Ferric Chloride, $FeCl_3$
- Ferrous Sulphate, $FeSO_4$
- Aluminium Chloride $AlCl_3$
- Polyaluminium Chloride (PAC)
- Aluminium Sulphate $Al(SO_4)_3$
- Other coagulation chemicals identified by subject-matter experts

As with the pH adjustment chemicals, these chemicals are available as both solids and liquids, which have different handling and dosing requirements. Liquid chemistry can be dosed directly in-line, while solid products must be made-down into a solution prior to dosing.

9.2.5 Solids Polishing

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If solids concentrations in the pond continue to be elevated beyond discharge criteria, a further polishing step will be required to meet discharge criteria. Solids concentrations in the pond could be elevated due to ineffective settling, or environmental conditions such as wind, precipitation, or additional runoff.

A polishing filter is a physical barrier designed to capture and retain solids in a stream of water. These systems are typically installed in-line, and would be initially arranged to recirculate into the runoff pond. Once the effluent from the filtration system has been tested and shown to be compliant, the filters can be connected to the discharge line. It is important to note that filtration systems require monitoring and periodic cleaning to perform optimally. This should be done in accordance with the manufacturer's instructions.

Technologies that could be employed to provide tertiary solids removal include:

- Microfiltration (MF)
- Ultrafiltration (UF)
- Nanofiltration (NF)
- Cartridge filter
- Disk filter
- Sand filter
- Filter bags
- Other solids removal methods identified by subject-matter experts

9.2.6 Sludge Management

The use of in-pond treatment techniques will generate a certain amount of sludge, which will settle to the bottom of the pond and accumulate over time. Sludge levels in the pond should be inventoried on a yearly basis as the sludge may require removal and disposal. This can be done by taking sludge depth measurements at different points throughout the pond, then calculating a total volume of sludge based on pond geometry.

When sludge needs to be removed, care should be taken to ensure it can be removed and stored without damaging the pond or the causing harm to the environment. Sludge is typically removed by first draining the pond, and a pump dredge system or other method removes the solids. A dewatering process may then be employed to reduce sludge volume and make storage and disposal easier. This can be passive, using a gravity drain system, or active, using a centrifuge or other similar piece of technology. Dewatered sludge could be stored in a landfill, encapsulated in the Waste Rock Stockpile or backhauled, depending on its composition.

9.2.6.1 High Density Sludge (HDS) Process- Inline Treatment option

As an alternative to in-pond treatment, the HDS Process uses a series of tanks, chemical dosing systems, mixing systems and clarifiers to achieve the same metals removal. The HDS process uses the same

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principles of treatment discussed above, while allowing treatment to occur outside the pond. This reduces the impact of adverse weather on effluent quality, and can eliminate some of the risk posed by influent runoff changing pond conditions following treatment. The process also makes more efficient use of the chemistry, through improved mixing and sludge recycling.

WRF pond water is first collected and pumped into a mixing chamber, where it is mixed with one of the neutralizing chemicals noted above to achieve the target pH, creating sludge. From there, the mixture is fed to a main reaction tank, where it is subjected to aggressive aeration and mixing to maximize the effectiveness of the chemistry. It is then fed into a flocculation tank, where a flocculent is added to aid in settling. Finally, the water is fed into a clarifier unit, where the solids are separated and collected as a sludge, and the final clarified effluent overflows from this unit into either an above ground tank or a lined pond. The treated effluent can then be sampled for compliance and discharged. A portion of the sludge collected in the clarifier is recycled to the front of the system to improve performance, and any additional sludge can be pumped off the bottom of the clarifier, dewatered and disposed of.

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10 MONITORING

Continuous monitoring at the WRF includes geochemistry sampling, water quality monitoring of the WRF pile seepage and discharge effluent, thermistor data collection and water volume tracking. This monitoring data is used in the various models that inform the WRF design criteria and the WRF deposition strategy and guidelines. Results from the current iterations of the models are found in Appendix A.

10.1 WRF QAQC PROGRAM

The WRF QAQC program is intended to mitigate the risk of ARD at the WRF due to the deposition of both PAG and Non-AG waste at the WRF. Waste rock deposition is monitored through ongoing continuous material classification and data collection of:

- In-Pit Material
- WRF Foundation Preparation and Tracking
- WRF Material Placement Tracking
- WRF Thermal Assessment
- WRF Instrumentation Monitoring

Details on the WRF QAQC program is found in Appendix C.

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11 WRF CLOSURE

At closure the principal objectives are the safety of the public and maintaining the physical and chemical stability of the permanent structures to ensure that there is no long-term safety or environmental impact.

Baffinland will ensure that at closure the exterior of the final stockpile consists of an active layer of Non-AG material up to 50 m thick such that the interior of the WRF remains frozen year-round in the long term. If required, additional Non-AG material may be sourced from the open pit through modifications to the mine plan to ensure that sufficient coverage is applied to the WRF. The final thickness of this layer will be determined through experience gained during operation of the facility, data gathered through instrumentation at the site, thermal modeling and allowances for climate change. Baffinland's Interim Closure and Reclamation Plan (BAF-PH1-830-P16-0012) can be referenced for details on the closure plan and criteria for the WRF.

11.1 Climate Change Considerations

Studies of waste rock in permafrost demonstrate that permafrost forms an effective long-term barrier to water and oxygen, thereby preventing significant oxidation of sulphidic waste rock located below the surficial active zone. The surficial "active" zone, which will be subject to seasonal freeze-thaw, will not reach the 50 m thickness of Non-AG material in the long-term (within 200 years) under the influence of current climate change criteria (IPCC, 2007).

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12 REFERENCES

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BAF-PH1-300-PRO-0011 r1 - Loader Operation Procedure

BAF-PH1-300-PRO-0011 r2 - Dozer Operation Procedure

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BAF-PH1-830-P16-0012 r4 - Interim Closure and Reclamation Plan

BAF-PH1-830-P16-0023 r3 - Snow Management Plan

Intergovernmental Panel on Climate Change (IPCC), 2007.

Metal and Diamond Mining Effluent Regulation, 2002. SOR/2002-222. Schedule 5, Part I

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APPENDIX A WASTE ROCK MANAGEMENT PLAN

GOLDER

REPORT

Waste Rock Management Plan

For 2020 through 2021

Submitted to:

Baffinland Iron Mines

Submitted by:

Golder Associates Ltd.

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December 31, 2019

Distribution List

Baffinland Iron Mines – electronic copy

Golder Associates – electronic copy

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1.0 INTRODUCTION

Baffinland Iron Mines Corporation's (Baffinland) Mary River Project is an operational iron mine on Baffin Island in Nunavut, Canada. An estimated 640 Mt of waste rock and 32 Mt of overburden will require management from mining Deposit No. 1 (Baffinland, 2014). Baffinland has retained Golder Associates Ltd. (Golder) to assist with developing an updated waste rock management plan (WRMP) for deposition of potential acid generating (PAG) and non-acid generating (Non-AG) waste rock at their Waste Rock Facility (WRF). An updated WRMP is required to accommodate current operational constraints, address the occurrence of acid rock drainage (ARD) from the WRF, and improve the chemical stability of future PAG waste rock deposition.

This WRMP provides a waste rock deposition plan for January 2020 through September 2021. Review of the waste rock geochemistry, results of the 2019 instrumentation program, the WRF thermal, water balance and water quality modelling are also discussed.

2.0 DEPOSIT GEOLOGY

Deposit No.1 occurs at the nose of a syncline plunging steeply to the north-east (Aker Kvaerner, 2008). The iron formation occupies the nose and two limbs of this feature with a ~1,300 m long northern portion and a ~700 m long southern portion. The footwall to the iron formation mainly consists of gneiss with minor schist, psammitic gneiss (psammite) and amphibolite. The hanging wall is primarily composed of schist and volcanic tuff with lesser amphibolite and metasediment.

The hanging wall primarily encompasses chlorite–actinolite schist and garnetiferous amphibolites. Metavolcanic tuff is also a significant lithology identified in the hanging wall. The footwall mainly consists of quartz-feldspar-mica gneiss with lesser meta-sediment (greywacke) and quartz-mica schist. Microcline and albite are the predominant feldspars within the gneiss and biotite is generally more abundant than muscovite.

The iron ore deposits at the Mary River project represent high-grade examples of Algoma-type iron formation and are composed of hematite, magnetite and mixed hematite-magnetite-specular hematite varieties of ore (Aker Kvaerner, 2008). The iron deposits consist of a number of lensoidal bodies that vary in their proportions of the main iron oxide minerals and impurity content of sulphur and silica in the ore. The massive hematite ore is the highest grade ore and also has the fewest impurities, which may indicate it was derived from relatively pure magnetite or that chert, quartzite and sulphides were leached and oxidized during alteration of the iron formation.

Intense deformation and lack of outcrop limit the ability to subdivide by lithology on the basis of future mined tonnages.

3.0 REGULATORY REQUIREMENTS

All mining operations at Baffinland are carried out under applicable regulations and the requirements will be reflected in Baffinland procedures.

The Mary River Operation is permitted under Nunavut Impact Review Board Project Certificate #005 and Nunavut Water Board Type A Water Licence, 2AM-MRY1325. The specific environmental requirements related to the WRF is for runoff to be collected in a downstream pond with capacity sized to reduce suspended solids in the discharge to meet discharge requirements of <30 mg/L (maximum concentration of any grab sample) and 15 mg/L maximum average concentration, as well as the effluent quality discharge limits set out in Part F, Item 24 in Type A Water License 2AM-MR1325.

In addition, discharge from the runoff collection pond is established as a monitoring and discharge point under the Metal and Diamond Mining Effluent Regulations (MDMER) SOR/2002-222.

4.0 WASTE ROCK CHARACTERIZATION AND GEOCHEMISTRY REVIEW

One of the primary strategies of the waste rock deposition plan for mitigating the occurrence of ARD from the WRF is the appropriate management of PAG waste rock. Effective management of the PAG waste rock requires that the waste rock geochemistry and mechanisms driving ARD production be understood.

PAG waste rock is currently defined as that material with a total sulphur content greater than 0.2 wt% as S. Results of the December 2018 geochemical investigation suggested that dissolution of soluble sulphate minerals within the waste rock may be a contributing to the acidic drainage observed at the WRF (Golder, 2019a). A detailed review of the available waste rock geochemistry was undertaken and the PAG classification criteria reviewed. The waste rock geochemistry and PAG classification review were supported by results of the previously carried out geochemical sampling, as well as the 2019 geochemical investigation, and are discussed in the following sections.

4.1 2019 Geochemistry Program Results and Discussion

The 2019 geochemistry program was intended to further advance review of the waste rock geochemistry, specifically with respect to the presence of soluble sulphate minerals, and to support a review of the PAG classification criteria. The 2019 geochemistry program included:

- Drilling investigation to collect waste rock samples at locations throughout the WRF with a focus on areas in the vicinity of observed poor runoff water quality, and;
- Samples of drill cuttings from the boreholes used for blasting ("blastholes") in the open pit to expand the geochemical database for samples with total sulphur slightly above and below 0.2 wt% as S to assess the presence of soluble sulphate minerals in material with low total sulphur that would have implications for the current waste rock segregation criteria

Geochemical analysis was carried out on all collected samples and the detailed results provided as Appendix A1. The main conclusions from the 2019 geochemistry program and historic geochemistry results review are summarized as follows:

- The geochemical results suggest that the overall existing waste rock pile design and placement, as presented in the December 2018 WRMP (Golder, 2018b), remains valid to reduce potential for ARD and ML, provided the Non-AG material does not contain stored acidity. In addition, ensuring that PAG material is covered with a lift of Non-AG material, to maintain the PAG waste rock below the permafrost active layer, would be beneficial to limit release of stored acidity from the PAG material
- The geochemistry of the current WRF may be localized within the current area of Deposit 1. Stored acidity, particularly within material currently classified as Non-AG waste rock, appears to be primarily within the current Deposit 1 area and the potential appears to decrease based on available historical data and the current mining plan through 2021.
- The presence of significant enough quantities of soluble sulphate to produced ARD and ML are predominately constrained to material with a total sulphur content greater than 0.20 wt% as S, and therefore, this material is already identified by the current PAG classification method.

- 7% of the 2019 geochemical samples with less than 0.20 wt% as S total sulphur had acidic pH values (<6) in either the paste pH from ABA or final pH from SFE.

To reduce the amount of low sulphur waste rock with stored acidity classified as Non-AG under the current criterion that may have some potential to release acidity, it is recommended that paste pH testing be implemented as part of the current waste rock segregation practices for samples that have less than 0.20 wt% as S. The proposed updated PAG and Non-AG classification criteria are provided in Table 1 below:

Table 1: Proposed PAG Classification

Acid Generation Potential	Criteria
Potentially Acid Generating (PAG)	Total sulphur > 0.20 wt% as S
Potentially Acid Generating (PAG)	Total sulphur < 0.20 wt% as S and paste pH <6
Non-Potentially Acid Generating (Non-AG)	Total sulphur < 0.20 wt% as S and paste pH >6

When applied to the current dataset, the addition of paste pH to the PAG classification criteria would reduce the amount of low sulphur, Non-AG waste rock with potential to release stored acidity to less than 2% of the samples tested (1 of 55 samples).

In addition to altering the PAG classification criteria, it is also recommended that supplemental blasthole samples of both PAG and Non-AG material be submitted for ABA and SFE testing on an ongoing basis opposed to the current practices of ABA analysis of PAG samples only. The supplemental samples should be representative of the material mined, including a representative range of sulphide content. A frequency of 10 samples per month (five of each PAG and Non-AG) is recommended through 2020 with the results and sample frequency reviewed on a six-month basis. The purpose of this additional testing is to develop a comprehensive geochemical database for the WRF and allow for the potential refinement of waste rock segregation practices, if required in the future, and increase the level of confidence in the data set. Baffinland has initiated inclusion of paste pH as part of waste rock characterization process and will fully implement the updated classification scheme in early 2020.

5.0 THERMAL ASSESSMENT

A thermal assessment was undertaken to characterize the freezing patterns of deposited waste rock and assess the WRF thermal performance. Transient two-dimensional (2D) thermal modelling was carried out using the finite element software TEMP/W of GeoStudio 2019 (Version 10.0), developed by GEO-SLOPE international Ltd.

Results of the WRF instrumentation data and thermal model review are summarized in the following sections. Refer to Appendix A2 for further details on the thermal model and instrumentation results to date, including a discussion on the model limitations.

5.1 Instrumentation Program

A field program was undertaken from December 2018 to February 2019 to characterize the waste rock deposited at the WRF and to assess the WRF's thermal performance. Instrumentation installed as part of this program are summarized below and their location presented in Figure 1.

- Vertical thermistor strings at BH1, BH2, and BH3, with sensors located within the WRF and underlying overburden;

- Vertical oxygen sensor strings installed at BH1 and BH2, with sensors located within the WRF fill;
- Vertical thermistor strings installed at T1 and T2 to monitor the WRF Pond liner south anchor trench (T2) and WRF Pond Berm foundation performance (T1);
- Horizontal thermistor strings at T3, T4, and T5, extending 40 m interior from the WRF edge and buried approximately 1.5 m below the stockpile crest at the time of installation;
- A barometer installed at BH1; and,
- A vibrating wire piezometer installed at the base of the WRF at BH1 and BH2.

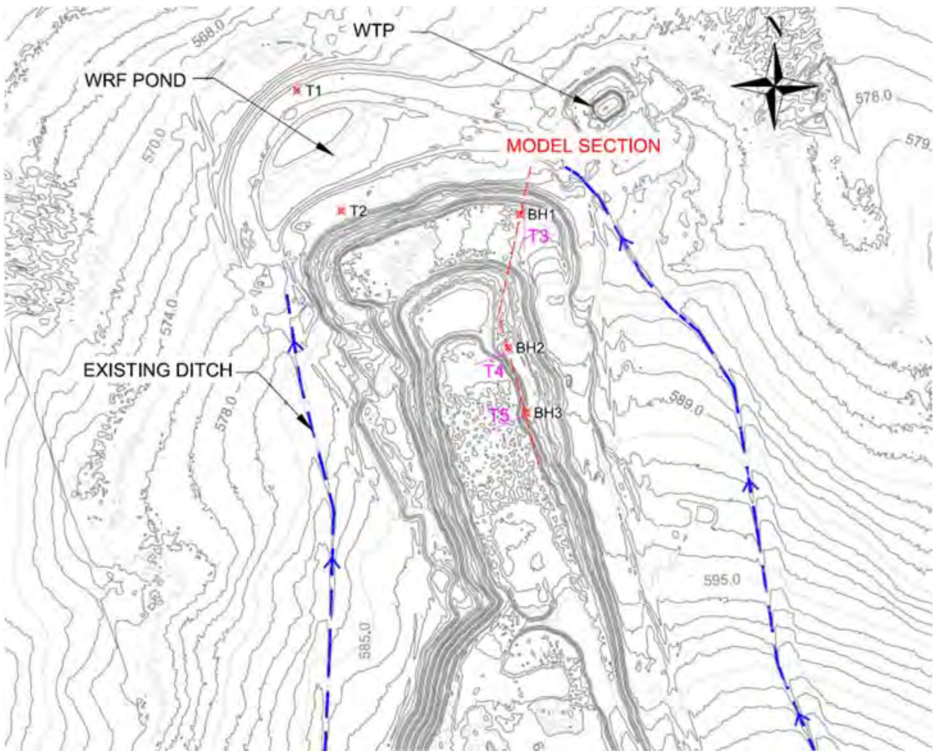

Figure 1 - Instrumentation and thermal model alignment location

The combined data from the installed sensors supports review of the WRF thermal performance.

All instruments are functional with the exception of the oxygen sensors at BH2 (damaged in August 2019) and 8 of the 26 thermistor nodes at BH2 (damaged September 2019). An attempt will be made to restore the damaged instrumentation during summer 2020. Baffinland will continue to maintain the installed instrumentation to the extent practical. At this time the installed instrumentation is considered sufficient for the current need. The instrumentation requirements will be reviewed regularly based on the results of site observations and measurements.

Thermistor readings have captured several instances of abrupt and localized variations in temperature. These events are discussed in Appendix A2. Abrupt and localized temperature changes cannot be associated solely with heat transfer through conduction (i.e. by direct particle contact) but could be at least partially produced by air flow within the pile associated with barometric pumping, temperature-driven air convection, and/or geochemical processes. Additional thermal and seepage water quality monitoring is required to further evaluate potential causes of these temperature variations.

5.2 Thermal Model Calibration

Calibration models were run for the period between March 15, 2019 and September 11, 2019, with temperature profiles predicted along boreholes BH1, BH2 and BH3 and horizontal thermistor T3. The purpose of the calibration models was to validate the model input parameters until the predicted temperature profiles generally agreed with the temperature profiles provided by the thermistors.

To improve model calibration at BH2 and BH3, internal heat generation was included by adding a heat flux boundary (30 kJ/day) to waste rock parcels adjacent to the BH2 and BH3 thermistor strings at depths where the existence of PAG waste rock was identified (Golder, 2019b). Inclusion of the 30 kJ/day heat flux boundary improved model calibration to the measured temperatures at BH2 and BH3. Refer to Appendix A2 for further discussion on the model calibration and comparison of measured vs. modelled temperature profiles.

5.3 Thermal Model Results

The thermal model was run to assess the time for waste rock placed during summer and the subsequent winter to freeze back. The detailed model results are discussed under Appendix A2, and the main conclusions summarized below:

- Review of data obtained from the site thermistors indicate that the WRF is almost entirely frozen, with exception of a 2 - 3m thick active zone subject to seasonal freeze and thaw cycles.
- Temperatures within the WRF are affected not only by air temperature, but also potentially by air flow, air convection and by internal heat generation connected to airflow through the WRF and variation in the geochemical behavior of the waste rock. Progressive increase in air temperatures slowly impacts ground temperature, while airflow and/or internal heat generation lead to sudden, localized and temporary variations in temperatures.
- Results from thermal models suggest that between 5 m and 7 m of waste rock could be placed in summer and the entire thickness of material would freeze during the following winter, assuming the summer placed material was not covered over during the winter. However, depending on the existence of heat sources within the WRF, a 7 m thick waste rock summer deposition could cause the development of a thawed zone in portions of waste rock previously deposited. Limiting the thickness of summer placed waste rock to 5 m would reduce the risk of creating a thawed zone at depth within the WRF.
- Winter deposition will delay freezing of the underlying material deposited during the summer. The models predict that a 5 m thick lift of waste rock deposited in summer, covered by a 5 m thick layer of waste rock in winter, would freeze prior to the following summer in most scenarios. However, heat exchange between summer deposition layers and waste rock deeper in the WRF could cause the development of a thawed zone in the interior of the WRF. Delaying winter deposition or reducing the thickness of summer deposition would decrease freezing times and reduce the extent of thawed portions within the WRF.
- If no internal heat source is present, the models indicate that the entire waste rock layer deposited in summer would freeze within a year, with or without additional deposition of waste rock in winter, and the extent of the thawed zone in the interior of the pile would be very limited.

Updates to the thermal model will be carried out, as appropriate, to incorporate improved understanding of the WRF gained by the ongoing review of the WRF instrumentation data and as required to inform the waste rock deposition.

6.0 WATER BALANCE

A water balance for the WRF was developed in support of the water quality model (Section 7.0). The water balance was developed using the computer software package GoldSim (version 12.1.3). GoldSim is a graphical, object-oriented mathematical code where all input components and functions are defined by the user and are built as individual objects or elements linked together by mathematical expressions.

The water balance considers the climatic conditions and WRF catchment areas to estimate the flows reporting the WRF Pond, on a daily basis, generated over the following surfaces:

- Natural ground;
- Unclassified waste rock (existing placed waste rock where survey is not available to differentiate PAG and non-PAG materials);
- Non-PAG waste rock;
- PAG waste rock; and,
- Direct precipitation to the WRF Pond.

Since the focus of this report is the WRF, and accurate record of the inflow to the WRF Pond from the Deposit 1 sump were not available, these flows were excluded from the water balance. It is assumed that flow from the Deposit 1 sump will be managed by Baffinland such that the WRF Pond remains operated within the design parameters.

The historic climate data available from the on-site climate station was insufficient to carry out a frequency analysis and assess various climatic return periods. A long-term data record was constructed for the period of 1923 – 2019 using the nearby regional climate stations at Pond Inlet. This long-term climate data set was used as input into the water balance.

6.1 Water Balance Results and Recommendations

Calibration of the water balance could not be carried out because the untracked inflow to the WRF Pond from the Deposit 1 sump did not allow for accurate determination of the actual runoff generated over the WRF footprint. The water balance input parameters were therefore selected based on professional judgement and experience.

The primary output from the water balance is the volume of runoff generated over each of the aforementioned surface types with time. The surface flows were calculated based on the conceptual waste rock deposition plans presented in Appendix C and corresponding to the waste rock tonnages presented under Section 10.2.

Refer to Appendix A3 for sample results from the water balance.

The following recommendations are provided to allow for calibration of the water balance:

- Improve monitoring of the WRF water management system;
  - Install a pressure transducer in the WRF Pond to provide a reliable and complete record of water level measurements;

  - Install a staff gauge and develop a rating curve at the east and west ditches;
  - Additional consideration of snowfall and snowpack within the WRF Pond catchment.
- Include protocols for the collection, processing and quality assurance of the data collected in the WRF Construction Quality Control Plan, and,
- Continue collection of climate data at the Mary River station.

It is recommended that the water balance be updated following collection of additional site data following the recommendations above.

7.0 WATER QUALITY MODEL

A water quality model was constructed using the geochemical mixing and speciation model PHREEQC (USGS 2015) to predict average yearly water quality concentrations of the WRF runoff for 2020 and 2021. The purpose of the model was to assess the potential impact of the waste rock pile design on runoff water quality. The WRF Pond water quality was not predicted as part of the current model due to the lack of available data for other water inputs to the pond. Closure conditions were also not evaluated as part of the current model. Water quantity inputs were assigned for defined catchment areas, based on the water balance model. Water quality inputs to the model were based on observed site water quality from WRF runoff in 2019 to represent water interaction with PAG and Non-AG waste rock within the active layer. Three climate scenarios were modelled for each year including; average, 100-year wet and 100-year dry. The water quality model assumes that flow from the WRF only occurs via direct runoff or as shallow interflow within the waste rock active layer. Water that infiltrates the WRF will become frozen due to permafrost aggradation and no seepage occurs. The model was calibrated to the observed water quality trends within the WRF runoff with the primary focus on predicting average yearly nickel concentrations as nickel was identified as the primary parameter of concern. The calibration predicted nickel concentrations (0.60 mg/L) were slightly higher than MDMER criteria (0.5 mg/L) and within the range of average nickel concentrations observed within the WRF east drainage ditch and runoff locations (0.11 – 1.39 mg/L).

The water quality model was used to predict runoff concentrations for 2019-2020 and 2020-2021 based on the current mine plan and water balance (Section 6.0). The detailed results are provided in Appendix A4. The water quality model predicts mildly acidic pH values (5.3 – 5.4) and concentrations of nickel (0.48 – 0.77 mg/L) above the MDMER criteria (0.5 mg/L) (Table 2). Actual nickel concentrations may vary from the predicted concentrations as the model is intended to predict peak concentrations within the WRF runoff. Although the model results are compared to MDMER, the results are not representative of discharge to the receiving environment or FDP regulated under MDMER at the WRF.

The low pH and high nickel concentrations can be attributed to the consistent contribution of PAG runoff between all climate scenarios and years and the assumption that exposure of PAG waste rock at surface (within the active layer) will continue to produce low pH and high metal leachate. Encapsulation of at least 50% of the exposed PAG waste rock with Non-AG prior to the spring freshet, to remove PAG material from the active layer, may assist with limiting low pH and high metal runoff from the WRF.

Although not explicitly predicted in the model, ongoing water treatment is considered to be required through 2021 or until water quality monitoring at the WRF Pond is compliant with MDMER Schedule 4 water quality criteria. The need for treatment may be re-evaluated should conditions improve relative to current observations and predictions.

8.0 WRF WATER MANAGEMENT

The following section discusses the current WRF water management practices and related construction activities carried out since the March 2019 WRMP (Golder, 2019a).

8.1 Runoff Management and Water Treatment

In compliance with Baffinland's Type A Water License, runoff from the WRF and surrounding disturbed area are collected in a network of ditches and directed towards the WRF Pond. Dewatering from Deposit 1 is also discharged into the WRF Pond at times when the WRF Pond can accommodate the flow (current practice) or pumped directly to the WTP (future operational revision). Clean, non-contact water from upstream of the WRF is diverted around the WRF by diversion berms. In addition, as part of Baffinland's snow management plan, clean snow is stockpiled in designated areas outside of the WRF Pond catchment to limit clean melt water from reporting into the WRF Pond.

Baffinland continues to maintain and operate a water treatment plant to treat surface runoff collected at the WRF Pond. Detailed design of the WTP was carried out by McCue Engineering Contractors. A summary of the McCue Engineering Contractors WTP operating manual and treatment process is provided in Golder, 2018b. All monitoring and reporting of runoff water quality is carried out by Baffinland's Environmental Department, including annual reporting to the appropriate Regulatory Agencies.

All water collected at the WRF Pond is passed through the WTP prior to discharge to the receiving environment. Sampling of the water chemistry is completed on a regular basis while the WTP is running to verify that the output complies with the Water License and MDMER. The current WRF runoff management areas captured by Phase 1 and Phase 2 ditch expansions are provided as Figure 2.

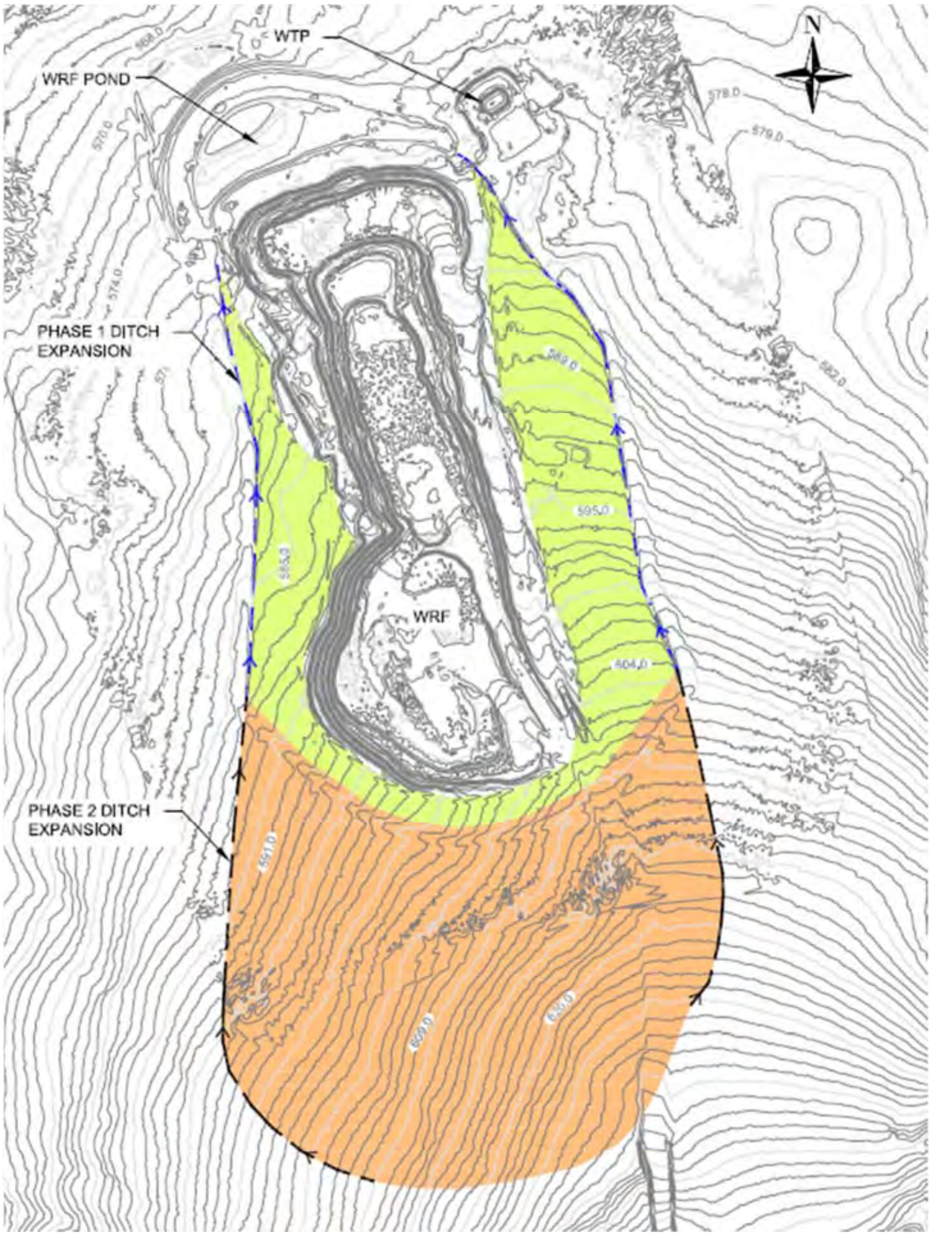

Figure 2 - WRF Water Management

Baffinland executed construction of the WRF Phase 1 ditch expansion as presented in the March 2019 WRMP (Golder, 2019a), expanding the WRF Pond catchment to the approximate design area of 358,000 m^2 (Golder, 2018a).

The Phase 2 ditch expansion (Golder, 2019a), which increases the WRF Pond catchment area to approximately 585,000 m^2, is expected to be constructed prior to spring freshet 2021 and following completion of the WRF Pond expansion to the 65,000 m^3 capacity.

Further phased drainage management berms and ponds will be designed as mining progresses and additional WRF expansions are required for capacity and/or adherence to the WRF development strategy.

8.2 Environmental Performance Indicators and Thresholds

Discharge from the WTP and/or WRF shall not exceed the effluent quality limits set-out in Part F, Item 24 in Type A Water License 2AM-MRY1325 and site-specific indicators shown in Table 2 below. In addition, Environmental Effects Monitoring will be carried out as required by MDMER.

Table 2: Discharge Performance Indicators and Thresholds

Indicator	Units	Maximum Concentration of Any Grab Sample
pH		6.0 < pH < 9.5
Arsenic	mg/L	0.5
Copper	mg/L	0.30
Lead	mg/L	0.20
Nickel	mg/L	0.50
Zinc	mg/L	0.5
TSS	mg/L	15
Oil and Grease		No visible sheen
Toxicity		Non-Acutely Toxic

Any contaminants of potential concern identified from on-going testing will be measured to provide temporal data on effluent quality that could potentially affect the receiving water quality.

Baffinland has implemented an Aquatic Effects Monitoring Plan (AEMP) to monitor environmental effects of effluent discharge to the receiving environment at Mary River. Results of the AEMP can trigger additional adaptive management actions such as further treatment of the WRF Pond effluent, if required.

8.3 WRF Pond Repair and Expansion

As discussed under the December 2018 WRMP (Golder, 2018b) and March 2019 WRMP (Golder, 2019a), seepage from the WRF Pond has been observed. Baffinland continues to maintain the seepage collection sump downstream of the WRF Pond, pumping the collected flows back to the WRF Pond as required. Golder inspected the WRF Pond condition in August 2018 and recommended that, due to the observed deteriorating condition of the liner subgrade, the liner subgrade be exposed/repaired, and the existing liner replaced.

Baffinland commenced remediation of the existing WRF Pond liner in September 2019. The existing liner was removed and the pond subgrade repaired. Installation of the replacement liner was carried out from September

2019 through December 2019. Completion of the repair work restored the WRF Pond capacity of 9,000 m^3 (Hatch 2017).

Construction of the WRF Pond expansion (Golder, 2018a) earthworks commenced in July 2019. Installation of the expanded liner was carried out concurrent with replacement of the existing liner. Once the expansion construction is complete, the WRF Pond capacity will be increased from the current 9,000 m^3 to 65,000 m^3, corresponding to the Phase 2 catchment area of 585,000 m^2.

The WRF Pond expansion is expected to be completed in January 2020. Further phased drainage management berms and ponds will be designed as mining progresses. All phases of the runoff management system will be designed in compliance with the conditions of the Type A Water License and local regulation.

9.0 WRF CONSTRUCTION QUALITY CONTROL (CQC)

A construction quality control plan was developed and implemented by Baffinland, and is provided as Appendix B.

10.0 WRF DEVELOPMENT STRATEGY

The primary objectives for the WRF development are the safety of personnel/environment and long-term physical and chemical stability. Thin lift deposition of waste rock is expected to create a more homogenous stockpile and reduce segregation that may create preferential air and water flow paths throughout the stockpile (i.e. reduce flow channelization and potential for oxygen supply to PAG materials). Waste rock placement locations and lift thickness also focus on the continuous development and raising of permafrost within the WRF. It is expected that permafrost aggradation will provide an effective barrier to acid-forming reactions as absence of oxygen and water supply limits potential for sulphide oxidation and ARD transport.

The following WRF development strategies were presented in the December 2018 WRMP (Golder, 2018b) and remain applicable. Updates to the waste rock deposition guidelines are identified in *italic* text.

- **Footprint expansion:** The first lift of the WRF on native ground shall be Non-AG waste rock. Waste rock placement over native ground shall be carried out in the winter to the extent practicable. As a minimum, the lift should be allowed to freeze prior to layering activities. Maintaining a frozen base and perimeter is expected to reduce potential for seepage.
- **Stockpile expansion construction:** Waste rock placed over an area of new WRF expansion shall be carried out in a manner conducive to aggrading permafrost, to limit potential for further development of ARD.
- **Material separation:** PAG and Non-AG waste rock placement locations at the WRF shall be documented. Non-AG material that may be intermixed with PAG shall be classified as, and follow the waste rock deposition strategies for, PAG material.
- **Stockpile exterior face:** *PAG waste rock shall be placed 4.0 m (minimum) interior from the ultimate stockpile or an interior or temporary face*. The final or temporary outer face of the stockpile shall be Non-AG waste rock*. This criterion has been established to maintain the PAG materials interior from the permafrost active zone which has been measured up to 2.9 m in thickness*. A larger 4.0 m buffer has been recommended until more data points are available to define the permafrost active zone (current site measurements are limited to 1 season). Thickness of the outer Non-AG layer at closure is discussed in Section 10.3 below.

- **Lift thickness:** *Waste rock placement to target a maximum thickness of 5.0 m*. This lift thickness has been established to reduce potential for waste rock segregation during placement while remaining operationally feasible with the available equipment. Reducing segregation of deposited waste rock is expected to reduce the potential for development of preferential air flow paths that can delivery oxygen to PAG waste rock.
  - *The maximum recommended lift thickness has been increased from 3.0 m to 5.0 m, provided the material does not segregate, and is considered appropriate providing that Baffinland regularly inspect the waste rock lift advancement for signs of material segregation. If segregation of the waste rock particles occurs during spreading the lift thickness shall be reduced or placement methods modified to reduce occurrence of segregation.*
- **Successive lift placement:** Placement of successive waste rock lifts shall give consideration to the waste rock and environmental conditions as described below. These placement strategies may be revised as the thermal performance of the WRF becomes better understood.
  - When the waste rock temperature at the time of placement is <0^{o}C successive lifts may be continuously placed over a given footprint.
  - When the waste rock temperature is above 0^{o}C and the air temperature below 0^{o}C, the surface of the waste rock shall be kept clear of snow for the length of time required to promote permafrost aggradation prior to placement of the subsequent lift.
  - When the waste rock temperature is greater than 0^{o}C only a single lift is to be placed at a given location *and shall be limited to a maximum thickness of 5.0 m*.
    - As discussed under Appendix A2, freeze back of summer placed waste rock is dependent primarily on the timing of summer waste rock placement, timing of covering over the following winter, and the waste rock lift thickness. The thermal model results presented under Section 5.0 and Appendix A2 are intended to inform the waste rock deposition but do not cover all waste rock placement scenarios. Baffinland intends on adjusting waste rock layer thickness and timing of placement such that summer placed waste rock freezes by the following winter. Additional thermal modelling will be carried out during operations, as required, to verify that the planned waste rock deposition will achieve this objective.
  - *Winter waste rock placement shall defer covering over summer placed material to the extent possible. When required and to the extent practical, waste rock placed during winter shall cover over the earliest placed waste rock from the preceding summer.*
- **Capping winter PAG placement before summer:** To the extent practicable, PAG waste rock placed during winter shall be covered with a *3.0 m* thick (minimum) layer of Non-AG waste rock prior to summer *(thickness increased from the previous 2.5 m based on the thermistor results).* The intention of this criteria is to maintain the permafrost active zone within the Non-AG waste rock during the summer months (i.e. maintain the PAG waste rock in a frozen state).

It is noted that, in the near-term until the WRF footprint can be sufficiently expanded, waste rock deposition following the above guidelines may not always be possible. Baffinland will document and keep record of deviations from the above waste rock deposition strategies, understanding that deviation from the above guidelines may temporarily or permanently influence the chemical stability of the WRF, and will need to be evaluated and possibly mitigated prior to, or as part of, the ultimate WRF closure.

10.1 WRF Design Criteria

The following design criteria have been developed with consideration to the criteria established under the LOM WRMP (Baffinland, 2014) and remain unchanged from the March 2019 WRMP (Golder, 2019a):

- Runoff and seepage from the WRF will be collected at the WRF Pond. Collected flows will be treated to comply with requirements of the Type A Water License 2AM-MRY1325 and MDMER;
- The stockpile will be constructed in lifts from the bottom up with lift and bench characteristics appropriate for the geotechnical conditions and waste handling equipment. These characteristics will be approved by the Mine Manager;
- The WRF will be developed in a manner conducive to permafrost aggradation, following the development strategy discussed under Section 10.0. At closure, the WRF active layer will consist of non-AG material.
- The following conditions define the WRF geometry (Baffinland, 2014):
  - Overall external side slopes will be 2H:1V. Exterior slopes will be benched with inter bench slopes of 1.5H:1V;
  - Minimum crest width will be 25 m; and,
  - The perimeter of the WRF will be a minimum of 31 m from any water body.

10.2 Waste Rock Volumes and Deposition Plan

The WRF development considers winter (October through May) and summer (June through Summer) deposition. These periods have been defined based on climatic records from the Mary River meteorological station (Golder, 2018b). The projected quantities of waste rock to be stored at the WRF during each deposition period based on the mine plan provided by Baffinland are summarized in Table 3. A swell factor of 1.3 and Non-AG and PAG densities of 2.85 t/m^3 and 3.6 t/m^3, respectively, have been applied to convert waste rock tonnages to volumes. The total waste rock tonnage for disposal at the WRF from January 2020 through September 2021 is estimated to be 4,617,660 m^3. These values are may change as the mining plan may be revised to reflect operational requirements.

Table 3: Summary of waste rock volumes by deposition season

Period	Non-AG (m^3)	PAG (m^3)	Total Waste Rock (m^3)
January 2020 through May 2020	897,509	123,504	1,021,013
June 2020 through September 2020	353,255	100,766	454,021
October 2020 through May 2021	1,570,685	359,967	1,930,653
June 2021 through September 2021	1,055,008	156,966	1,211,974

Period	Non-AG (m^3)	PAG (m^3)	Total Waste Rock (m^3)
Total	**3,876,457**	**741,204**	**4,617,660**

Conceptual waste rock deposition plans were prepared for each season presented in Table 3, and are presented in Appendix C. The conceptual waste rock deposition plans were used as input into the water balance (Section 6.0) and water quality (Section 7.0) models. The actual waste rock deposition locations are expected to vary, and will be determined by Baffinland based on operational requirements, following the development strategies presented under Section 10.0.

10.3 WRF Closure

At closure the principal objectives are the safety of the public and maintaining the physical and chemical stability of the permanent structures to ensure that there is no long-term safety or environmental impact.

Baffinland will ensure that at closure the exterior of the final stockpile consists of an active layer of non-AG material up to 50 m thick such that the interior of the WRF remains frozen year-round in the long term. If required, additional Non-AG material may be sourced from the open pit through modifications to the mine plan to ensure that sufficient coverage is applied to the WRF. The final thickness of this layer will be determined through experience gained during operation of the facility, data gathered through instrumentation at the site, thermal modeling and allowances for climate change.

When monitoring shows that runoff meets water quality objectives for closure the runoff management ponds will be decommissioned and runoff will be discharged directly to the environment.

11.0 DISCUSSION AND RECOMMENDATIONS

It is acknowledged that, while Baffinland has undertaken recent actions to address the occurrence of ARD and ML at the WRF, treatment of the WRF runoff remains a requirement. The WRF development strategies discussed under Section 10.0 are expected to require implementation over a duration of time prior to improvement of the WRF Pond water quality. In recent years, the ability to expand the WRF footprint has been constrained by the WRF Pond capacity. With expansion of the WRF Pond scheduled for completion in January 2020, Baffinland can now focus on expansion of the WRF footprint and encapsulation of the existing stockpile following the development strategies discussed under Section 10.0. It is noted that the existing WRF consists of approximately 1.3% of the total expected tonnage of waste rock to be deposited over the life of mine and will be fully encapsulated prior to closure. The lessons learned from the early stages of the WRF development will be applied going forward to reduce potential for further ARD and ML development as the WRF expands.

It is Baffinland's intent to construct the WRF in a manner that results in freeze back of summer placed waste rock by the following winter. Additional expansions of the WRF will be required to allow for optimal waste rock placement for short-term permafrost aggradation. It is recommended, that planning of subsequent WRF and water management expansions should be advanced to provide increased flexibility for waste rock deposition.

While it is desirable to achieve freeze back of waste rock within 1 year following placement, it is not a strict requirement to achieve geochemical stability. As noted under Appendix A1, the results of humidity cell testing indicates that sulphide oxidation and onset of strong acidic conditions may be delayed under the proper conditions

(AMEC, 2017). More importantly, PAG waste rock placed during winter should be covered with a 3.0 m thick (minimum) layer of Non-AG waste rock prior to summer. The Non-AG cover will reduce runoff from PAG waste rock which, as noted in Section 7.0, is the primary contributor of low pH and elevated metal loadings runoff from the WRF.

Ongoing thermal and water quality performance evaluation of the WRF will continue in order to confirm the long-term waste rock deposition strategy and improve the understanding of the WRF thermal performance. The installation of additional instrumentation will be considered as the WRF expands to verify the WRF performance. A longer-term review of the waste rock deposition, integrated with construction of the life of mine water management structures, expansion of the WRF ditch network, and the life of mine waste rock production schedule is recommended to be able to continue to develop and refine the WRF management strategy.

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Signature Page

We trust that the information provided in this report meets your present needs. Should you have any questions or require clarification, please do not hesitate to contact the undersigned.

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APPENDIX A

Supporting Technical Memoranda

APPENDIX A1

Geochemisty Memorandum

TECHNICAL MEMORANDUM

DATE December 31, 2019 **Project No.** 1790951

TO Baffinland Iron Mines

CC

FROM Ken De Vos and Dan LaPorte **EMAIL Dan_Laporte@golder.com**

2019 GEOCHEMISTRY WASTE ROCK INVESTIGATION RESULTS – BAFFINLAND IRON MINES MARY RIVER PROJECT

1.0 INTRODUCTION

Baffinland Iron Mines Corporation's (Baffinland) Mary River Project (the Site) is an operational iron mine on Baffin Island in Nunavut, Canada. Baffinland has retained Golder Associates Ltd. (Golder) to assist with developing an updated Waste Rock Management Plan (WRMP) for deposition of Potential Acid Generating (PAG) and Non-AG waste rock at their Waste Rock Facility (WRF). An updated WRMP is required to address the occurrence of Acid Rock Drainage (ARD) from the WRF and improve the chemical stability of future waste rock deposition.

In December 2018, drilling within the WRF and subsequent geochemical analysis was conducted as part of updating the WRMP. The geochemical results from the waste rock characterization suggested that dissolution of soluble sulphate minerals within the PAG waste rock material may be a key source of the acidic drainage currently observed from the WRF. Further investigation, with an emphasis on Non-AG waste rock, has been completed as part of the WRMP update to further assess presence and potential implications of soluble sulphate minerals within the WRF. This technical memorandum presents the geochemical results of 69 samples collected from the Site in June and July 2019.

2.0 BACKGROUND

Geochemical characterization to assess the potential for metal leaching and acid rock drainage in waste rock has been conducted in stages since 2006 at the Site. Previous geochemical characterization reports are summarized in Table 1.

Table 1: Previous Geochemical Reports

Document	Date	Relevant Appended Reports
Life-of-Mine Waste Rock Management Plan (AMEC, 2012)	30-04-2014	*Appendix 3: Waste Rock Geological and Geochemical Characterization Program (2012 – 2014) [*January 2012*]
2016 Review of Mine Rock Humidity Cell Program (AMEC, 2016)	24-03-2016	-

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Document	Date	Relevant Appended Reports
2017 Review of Mine Rock Humidity Cell Program (AMEC, 2017b)	15-03-2017	-
Phase 1 Waste Rock Management Plan (AMEC, 2014)	15-11-2017	*Appendix A: Mary River Deposit 1,5-Year Pit ML/ARD Characterization Rev 1 – Issued for Phase 1, WRMP [*April 2014*]
Ongoing Humidity Cell Testing – Review and Recommendations For Path Forward (Golder, 2018)	08-05-2018	-

AMEC (2012) conducted a geochemical characterization program on 377 samples of waste rock material with the waste classified as either hanging wall (HW), footwall (FW), hanging wall schist (HWS) or footwall schist (FWS). Static testing included ABA, NAG, elemental analysis and short-term leach testing. The static testing results noted that waste rock generally has low neutralization potential (NP) with carbonate representing approximately 30% of the overall NP. Sulphur is primarily in the form of sulphide and the deposit typically had low acid potential (AP). Samples classified as potentially acid generating (NP/AP ratio less than 2) typically had sulphide content greater than 0.5%. It was observed that sulphide content was typically greater in the HWS and FWS which are located in closer proximity to the ore zones. Kinetic testing was being completed on 27 waste rock samples including 10 samples from 2008 and an additional 17 samples initiated in 2011. The most recent kinetic tests included 9 standard humidity cell tests and 8 humidity cells with NP depleted samples to assess mineral reaction rates and acid buffering capacity in the absence of carbonate NP.

In 2014, AMEC completed a geochemical characterization for the revised 5-year mine plan (AMEC, 2014). This involved re-evaluating available geochemical data in relation to the 5-year mine plan and recommended guidance for development of waste rock management planning. The revised mine plan was projected to produce approximately 2.5 million tonnes of waste rock predominantly from HWS and FWS. Sample results reviewed in the AMEC (2014) plan included all HWS and FWS samples within 150 m of the 5-year pit outline. It was noted that there were no samples in the current geochemical database from within the actual 5-year pit envelope since there was no exploration drilling occurring in this area at the time. Analysis of the extracted results noted a lower proportion of PAG waste rock in the vicinity of the 5-year pit compared to the life of mine pit. The waste rock above the base of the planned 5-year pit (570 masl) typically had less than 0.5% total Sulphur, less than 0.3% sulphide and higher NPR values.

Guidance on PAG waste rock management was also detailed in AMEC (2014) which indicated that a total Sulphur cut-off of >0.2% was the most appropriate approach to prevent PAG waste rock being identified as Non-AG. Using the Sulphur cut-off, opposed to NPR <2, was considered conservative in that it would result in greater in life of mine projected PAG quantities while still correctly classifying material as PAG or Non-AG.

Humidity Cell Testing (HCT) annual updates have been presented in several technical memorandums (AMEC, 2016; AMEC, 2017; and Golder, 2018). Humidity cell tests are long-term kinetic tests in which leachate from subsequent wetting and drying cycles on samples of waste rock is collected and analyzed to evaluate potential for geochemical weathering and resulting drainage quality. Ten HCTs were run for 53 weeks in 2008 and 2009.

Nineteen were initiated in 2011 and 2014, including 9 standard humidity cells, 2 standard humidity cells with mineralized waste, and 8 carbonate depleted humidity cells. These HCTs were run between 170 and 356 weeks.

Humidity cells initiated in 2011 and 2014 mostly exhibited pH between 5.5 and 7, though 3 had slowly declining pH to minimums of 4.5 and 5 after about 2 years. Metal and sulphate release were found to be low, though concentrations of Cd, Co, Cu, Ni, Pb and Zn were highest in HCTs with pH less than 5. Most PAG HCTs presented weakly acidic leaching (e.g., 6 > pH > 4.5) within 20 to 30 weeks of initiation suggesting that PAG material could produce weakly acidic runoff within the first of year of placement if stored within the active zone. However, the onset of moderate to strongly acidic conditions (e.g., pH < 4.5) was estimated by AMEC (2017a) to take at least 20 years.

Observed metals that produced elevated concentrations in the HCTs were consistent with the observed elevated metals in the WRF runoff water quality at Site between 2017 and 2019, however the concentrations are not in agreement with concentrations of some metals (e.g., Nickel) being higher in the WRF runoff compared to the HCT results. In addition, the WRF runoff has elevated sulphate and iron that has not been observed in the HCT data. Due to the inconsistencies, the remaining active HCTs were terminated and a field-based approach has been developed as detailed in the following sections.

3.0 2019 GEOCHEMISTRY INVESTIGATION

The 2019 geochemistry program was intended to further advance review of the waste rock geochemistry, specifically with respect to the presence of soluble sulphate minerals, and to support a review of the PAG classification criteria. The 2019 geochemistry program included:

- Drilling investigation to collect waste rock samples at locations throughout the WRF with a focus on areas in the vicinity of observed poor runoff water quality, and;
- Samples of drill cuttings from the boreholes used for blasting (“blastholes”) in the open pit to expand the geochemical database for samples with total sulphur slightly above and below 0.2 wt% as S to assess the presence of sulphate minerals in material with low total sulphur that would have implications for the current waste rock segregation criteria.

3.1 WRF Drilling Investigation

Drilling and test pitting was completed at five (5) locations on the WRF in June and July 2019 to further develop the geochemical understanding of the current WRF with respect to soluble sulphate presence. Boreholes were drilled using a drill rig using 200 mm (8”) diameter bits and were drilled through the entire thickness of the WRF at each location. The test pit was excavated using a track mounted excavator. The four boreholes (P1, P2, P3, P5) and one test pit (P4) were located adjacent to areas where low pH and/or high metal concentrations (specifically copper, iron, nickel, and zinc) were observed in the 2018 runoff water quality data. Boreholes P1, P2, P3 and P5 were drilled to 30 m, 30 m, 16 m and 28 m deep, respectively and yielded 6, 10, 3 and 6 samples, respectively. Test pit P4 was excavated to 4.5 m depth with 4 samples were collected. The 29 samples collected from the WRF investigation were submitted for geochemical analyses, including acid base accounting (ABA; modified Sobek), bulk metals analysis and shake flask extraction (SFE). The boreholes and the test pit were logged by a Baffinland geologist. Sample descriptions and locations are presented in Table 1 and Figure 1, respectively.

3.2 Blasthole Investigation

In addition to the drilling and test pitting investigation, blasthole samples from the standard production blasthole sampling program in Deposit 1 were also collected for geochemical analysis. The blasthole investigation focused on samples with total sulphur contents <0.25% to determine if these low sulphur samples contained soluble sulphate minerals that would release acidity and would have implications for the current waste rock segregation criteria. Samples were selected based on a review of the blasthole database information provided by Baffinland which included bulk metals and total sulphur content results from the on-site lab for samples collected during production between January and May 2019. The number of samples selected from each lithology was based on the percentage of each lithology that was classified as waste rock within the blasthole database. A total of 40 samples were selected and are presented in Table 2.

3.3 Lab Analysis

All samples were sent to SGS Canada Inc. in Lakefield, Ontario for analysis. Samples collected from the WRF boreholes, WRF test pit and blastholes underwent testing to determine bulk chemical characteristics, acid generation potential, short term acidity and metal leaching potential which included the following:

- Elemental analysis (aqua regia digest with ICP-MS finish) to quantify the solid phase composition of waste rock samples;
- Acid base accounting (ABA – paste pH, sulphur species, (including total sulphur, sulphate sulphur, and sulphide sulphur), bulk NP, total carbon and carbonate) to inventory the AP and NP present in each sample, and;
- Shake Flask Extraction (SFE) leach test performed according to the method described in Price (1997) and MEND (2009) and is used to assess short-term metal leaching potential.

The following sub-sections outline the details of the testing methods.

3.3.1 Elemental Analysis

Bulk metals analyses were conducted on all samples to quantify the elemental composition of the materials. Bulk metal analysis determines the concentrations of major and trace elements by a multi-acid leach followed by an inductively coupled plasma (ICP) analysis finish to determine the concentrations of the following: silver, aluminum, arsenic, barium, beryllium, bismuth, calcium, cadmium, cobalt, chromium, copper, iron, mercury, potassium, lithium, magnesium, manganese, molybdenum, sodium, nickel, phosphorus, lead, antimony, selenium, tin, strontium, titanium, thallium, uranium, vanadium, yttrium and zinc.

The results of the bulk metal analyses provide a basis for comparison between samples of rock and typical crustal abundances (Price, 1997). Comparison to typical crustal abundances is completed as part of a screening tool to identify materials and site-specific parameters that may require further review with respect to environmental significance. It should be noted, however, that high concentrations in the solid-phase does not necessarily identify materials that will be of environmental significance. Furthermore, some parameters are anticipated to be elevated within and near an ore body (e.g., iron concentrations).

3.3.2 Potential for Acid Generation

3.3.2.1 Acid-Base Accounting

Acid-base accounting was performed to evaluate the acid generation potential. As part of ABA, the bulk quantities of acid generating minerals (e.g., sulphide minerals) and acid neutralizing minerals (e.g., carbonate minerals) are measured to assess whether the materials tested will have sufficient capacity to neutralize acidity or if the materials have the potential to generate acidity. The methodology performed on the samples is a modified Sobek method (Sobek et al., 1978) that includes analysis for paste pH, sulphur species, acid potential (AP), neutralization potential (NP) and carbon species (total carbon, carbonate content and organic carbon content).

Acid Potential (AP)

The acid potential (AP) represents the bulk amount of acidity that can be produced. The AP is based on sulphur content and determined by calculating the amount of acid that could be produced if all sulphur is converted to sulphuric acid (H_2SO_4). It is used as a predictive tool to determine the total amount of acid that could be generated through oxidation reactions during weathering, however, in reality under natural conditions, not all sulphur will necessarily oxidize to produce acid due to limiting factors such as oxygen availability or mineral availability within the rock. The AP for the data is calculated from the total sulphur content opposed to sulphide-sulphur since it is known at Baffinland that total sulphur concentrations also include reactive forms of sulphate. It should be noted that although the dissolution of sulphate minerals can contribute some AP in the short-term, sulphate minerals do not generally contribute to the long-term acid generation potential of a material. Therefore, calculation of AP using the total sulphur content is considered a conservative estimate.

Neutralization Potential (NP) and Carbonate Neutralization Potential (CO_3-NP)

The neutralization potential (NP) represents the bulk amount of acidity that the sample can potentially consume or neutralize. The “bulk” NP is determined by acidifying the sample with sulphuric acid. Following the acidification of the sample, the amount of acid that is consumed during the test period is determined by a reverse titration. Negative NP values indicate that samples that contain stored acidity in the form of soluble phases that contribute acidity upon dissolution.

The carbonate neutralization potential (CO_3-NP) is a calculated value that represents the bulk amount of acidity that the sample can potentially consume through the dissolution of carbonate minerals. The CO_3-NP is calculated from the carbonate content (wt % as CO_3).

The NP and CO_3-NP are typically compared for the purpose of evaluating the mineralogical source of NP in a sample. The difference between the NP and CO_3-NP is that the NP represents the ‘bulk’ neutralization potential, whereas CO_3-NP is solely based on the carbonate content of a sample. Thus, in addition to the consumption of acid by readily soluble carbonate minerals, the ‘bulk’ NP incorporates the consumption of acid by less soluble, slower reacting, aluminosilicate, silicate and/or other minerals. If the NP is approximately equal to the CO_3-NP, the NP is likely attributable to the dissolution of carbonate minerals. In cases where the NP is significantly greater than CO_3-NP, the NP could be overestimated due to the partial dissolution of the less soluble, non-carbonate minerals. The rate of aluminosilicate or silicate mineral dissolution may be too slow to provide effective neutralizing capacity depending on the ambient field conditions. However, aluminosilicate and silicates can be the predominant neutralizing mineral phases under low-pH conditions or where water-rock interaction times are very long.

3.3.3 Short-Term Leach Tests

Short-term leach tests are commonly used as a qualitative screening tool to identify elements of potential environmental concern and to assist with the selection of samples for additional testing if required. The results of short-term leach tests do not directly translate to the expected environmental behaviour of materials due to:

- relatively small sample size and volume;
- the short duration of the test that may not be sufficient to account for representative water-rock interaction times and mineral reaction rates (i.e., sulphide oxidation);
- the enhanced dissolution of some mineral phases due to lab imposed conditions (i.e., pH, redox, agitation), and;
- ambient conditions that differ from laboratory conditions.

Although there are limitations with the testing, it is a useful indication of the soluble metals that can be readily leached from the test materials; as such, it is intended to be used as a screening tool to identify metals of potential concern.

Shake flash extraction (SFE) leach testing was completed to measure the concentrations of constituents in the sample leachate that are readily soluble in water. The SFE leach method is described in Price (1997) and MEND (2009). Samples are mixed with DI water at a 3:1 liquid to solid ratio in an extraction vessel. The vessel is shaken immediately and an initial pH is recorded. The slurry is then shaken for twenty-four hours, after which a final pH is measured and the supernatant is extracted for analysis including the following parameters:

- alkalinity, acidity, conductivity, sulphate, chloride, silver, aluminum, arsenic, barium, boron, beryllium, bismuth, calcium, cadmium, cobalt, chromium, copper, iron, mercury, potassium, lithium, magnesium, manganese, molybdenum, sodium, nickel, lead, antimony, selenium, tin, strontium, titanium, thallium, uranium, vanadium, tungsten, yttrium and zinc.

Comparisons to Regulatory Criteria

Metal concentrations and pH values in the leachate were compared to the Metal and Diamonds Mining Effluent Regulations Schedule 4 (MDMER, 2018) for purposes of determining parameters that may need to be further evaluated as part of an overall site water quality prediction. Although the SFE results are compared to regulatory criteria, it is important to note that these regulatory criteria do not apply to short-term leach test results and therefore should not be interpreted within a regulatory context. Rather, these comparisons are conducted herein to qualitatively identify parameters that are leachable from test materials at concentrations that may require further evaluation in the context of the ambient environment or conditions under which the materials will be stored or exposed.

4.0 GEOCHEMICAL RESULTS

A description of the results and tabulated summaries are presented in the relevant sections below. The Laboratory certificates are presented in Attachment A. It is important to note that the results discussion below is based on the current understanding of the waste rock geochemistry and management plan.

4.1 Elemental Analysis

Elemental analysis was completed on all samples and are compared to the average crustal abundances as presented in Price (1997) for the purpose of identifying parameters that may require further evaluation within a site-specific context (see Table 3 for full dataset). Parameters with one or more analytical result greater than five times the average crustal concentration are: silver, arsenic, bismuth, chromium, iron, lithium, molybdenum and selenium. Elevated elemental analytical results were found in a range of lithologies. These parameters of interest are common to many ore deposit types and often found elevated at mine sites. These parameters were included in the assessment completed as part of the life of mine waste rock management plan (BIM 2014).

4.2 Acid Base Accounting

Acid base accounting was performed on all samples. The ABA results samples are summarized in Table 4 and plotted in Figures 2 through 7. The results are discussed below.

Paste pH

The paste pH values ranged between 5.42 to 9.26 with 3 blast hole samples having a pH below 6 (one magnetite, one magnetite / chlorite schist and one hematite / chlorite schist). No discernable trends were observed between lithologies or in comparison to sulphur species.

Sulphur Species

The concentrations of total sulphur, sulphide-sulphur and sulphate-sulphur were analysed as part of the ABA analyses. Total sulphur ranged from 0.03 to 0.39 wt% as S, sulphide-sulphur ranged from 0.02 to 0.27 wt% as S and sulphate-sulphur ranged from 0.03 to 0.18 wt% as S.

Plots of total sulphur content versus sulphide-sulphur content and sulphate-sulphur based on sample location (drillhole or blasthole) and lithology are presented in Figures 2 to 5. The reference lines on the plots indicate a 1:1 ratio of the plotted parameters. Where a result falls on the reference line the total sulphur content of the sample (x axis) is dominated by the form of sulphur plotted on the y axis, thus in Figures 2 and 3 if the result falls on the line all sulphur is in sulphide form, whereas in Figures 4 and 5 if the result falls on the line all sulphur is in sulphate form.

In all figures, the majority of the data falls to the right of the 1:1 line indicating that the total sulphur content contains both sulphide and sulphate forms. In Figures 4 and 5, 9 blasthole samples plot along the reference line suggest all sulphur in these samples is in the sulphate form. The blasthole and WRF drilling/test pit samples show slightly different trends in Figure 4 with the blasthole data exhibiting a slightly higher representation of sulphate in the samples.

Acid Production Potential (AP)

The AP (described in section 2.3.2) ranges from 1.1 to 12.1 tonnes $CaCO_3$ /1000 tonnes within the dataset, with the highest values tending to be from chlorite schist lithologies. Low acid potential is found in a wide range of lithologies with no discernable trends.

Neutralization Potential (NP)

The NP (described in section 2.3.2) values range between 1.8 and 68.6 tonnes $CaCO_3$/1000 tonnes. The Carbonate neutralization potential (CO_3-NP) value ranges from 0.9 to 66 tonnes $CaCO_3$/1000 tonnes with 12 samples having higher CO_3-NP than NP values, likely as a result of iron carbonates that are known to exist within the deposit. Higher NP and the range of carbonate NP are not distinctly related to certain lithologies, while the lowest NP values were found in samples with BIF or hematite / partial hematite lithology. On average, 39% of NP within the samples analysed is carbonate based NP (excluding the 12 samples with higher CO_3-NP values).

Waste Rock Classification

Current waste rock classification at the Site is based on a total sulphur content cut-off of 0.2% wt as S as described in Table 2 below:

Table 2: Acid Generation Potential Classification at Baffinland

Acid Generation Potential	Criteria
Potentially Acid Generating (PAG)	Total sulphur > 0.20 wt% as S
Non-Potentially Acid Generating (Non-AG)	Total sulphur < 0.20 wt% as S

Based on the existing criteria, 14 samples have total sulphur greater than >0.20 wt% as S and are classified as PAG including 7 WRF samples and 7 blasthole samples. The remaining 55 samples have total sulphur less than the 0.20 wt% as S criterion and are therefore considered Non-AG.

An evaluation of the acid generation potential was also conducted using the ABA results and are presented in Figures 6 and 7. Acid generation potential can be interpreted according to the ratio of NP to AP, referred to as the neutralization potential ratio (NPR), according to the guidelines recommended by MEND (2009) and presented in Table 3 below:

Table 3: Acid Generation Potential Criteria (MEND, 2009)

Acid Generation Potential	Criteria	Comments
Potentially Acid Generating (PAG)	NPR < 1	Potentially acid generating unless sulphide minerals are non-reactive.
Uncertain	1 ≤ NPR ≤ 2	Possibly acid generating if NP is insufficiently reactive or is depleted at a rate faster than sulphides.
Non-potentially Acid Generating (Non-AG)	NPR > 2	Not expected to generate acidity.

Using bulk NP in the NPR calculation accounts for less reactive silicate minerals as well as the more reactive carbonate minerals. CO_3-NP can be used in the NPR calculations (CO_3-NPR = CO_3-NP / AP) to account for buffering capacity from carbonate minerals only and ignores the neutralizing capacity of the more slowly reacting minerals. At Deposit 1, there is limited carbonate minerals that contribute to the neutralizing capacity. As such, the CO_3-NPR is not discussed.

Thirty-eight samples had NPR values greater than 2 and are classified as non-potentially acid generating (Non-AG). 21 samples had NPR values between 1 and 2 and are classified as “uncertain” (i.e., having unknown acid generation potential). 10 samples had NPR values less than 1 and are therefore classified as potentially acid generating (PAG). 17 samples including; 13 samples classified as uncertain and four of the samples classified as PAG based on NPR values, would be considered Non-AG based on the current waste rock segregation criteria.

The PAG samples tended to be from chlorite schist/BIF lithologies, whereas uncertain and non-AG samples are found in a wide range of lithologies including chlorite schist lithologies, with no discernable trends.

4.3 Shake Flask Extraction

SFE testing was performed on all 69 samples (see Table 5 for full dataset). For comparison, select SFE results were plotted against sulphate-sulphur content in Figures 8 and 9. The results of the SFE were compared to MDMER criteria. It is important to note that MDMER criteria do not directly apply to the results of short-term leach tests; however, the comparison is completed to qualitatively identify parameters that leach from test materials at concentrations that may require further evaluation within the overall site context. The results for key parameters are summarized as follows:

- pH values ranged from 4.92 to 9.43. In general, the SFE results show a trend toward lower pH values with increasing sulphate-sulphur content with the exception of the chlorite schist samples (Figure 8).
- Sulphate concentrations ranged from 5 to 1,700 mg/L. In general, sulphate concentrations in the SFE results show an increasing trend with increasing solid-phase sulphate-sulphur as observed in the ABA results (Figure 9).
- Arsenic (As) concentrations ranged from <0.0002 to 0.0018 mg/L. No samples were greater than the MDMER criteria of 0.5 mg/L.
- Copper (Cu) concentrations ranged from <0.0002 to 0.0042 mg/L. No samples were greater than the MDMER criteria of 0.3 mg/L.
- Nickel (Ni) concentrations ranged from <0.0001 to 0.841 mg/L. One chlorite schist / BIF sample (P1-9-12) had a nickel concentration greater than the MDMER criteria of 0.5 mg/L. Nickel concentrations are generally highest in samples with pH values less than 6.
- Lead (Pb) concentrations ranged from <0.00001 to 0.0491 mg/L. No samples were greater than the MDMER criteria of 0.2 mg/L.
- Zinc (Zn) concentrations ranged from <0.002 to 0.024 mg/L. No samples were greater than the MDMER criteria of 0.5 mg/L.

3 samples classified as Non-AG and 3 samples classified as PAG (based on current segregation criteria) had final pH values below 6. Samples with higher levels of total sulphur (>0.25 wt%) tended to have lower pH, higher Ni and higher Cd in SFE when compared to samples with lower sulphur content. Nickel concentrations show a general increase in concentrations in SFE results with decreasing pH values. No clear trends were noted for other SFE metal concentrations. The single sample exceeding the MDMER criteria for nickel would be classified and segregated as PAG using the current classification scheme. None of the 69 samples tested had concentrations greater than the MDMER criteria for arsenic, copper, lead or zinc.

5.0 COMPARISON WITH HISTORICAL GEOCHEMICAL DATA

The geochemical results from previous investigations were provided by Baffinland, which included all results presented in previous reports discussed in Section 2.0. As noted in previous investigations (e.g., AMEC, 2014) the geochemical characteristics of the waste rock within the current mining area was previously inferred due to the lack of samples with the 5-year pit area because the area is located at a higher elevation than the majority of exploration boreholes. However, the waste rock from the current operations represents only 13% of the total planned WRF volume (8.5 Mt deposited; 640 Mt planned). Comparison of the historical dataset with the data presented in this report and Golder (2019) can be used to understand the geochemical differences between the current waste rock stored in the WRF and the future waste rock material to be deposited within the WRF.

A plot of total sulphur and NPR values for all samples collected since 2010 is presented in Figure 10. Added to the figure is dashed lines for total sulphur of 0.2 wt% as S and NPR of 2. As shown, only 65 samples (3.8% of samples) fall within the bottom left corner representing less than 0.2 wt% as S total sulphur and NPR less than 2. Eighteen of the samples were collected during the 2018 (Golder, 2019) and 2019 drilling and blasthole sampling programs which represents 20% of the samples collected during these programs (89 samples in total). This is significantly higher than the percentage of samples within the historical database (2.9%; 47 of 1,594 samples).

A similar trend is noted in comparison of paste pH and SFE pH with total sulphur (Figure 11 and Figure 12, respectively). Dashed lines on the figures represent a total sulphur of 0.2 wt% as S and a paste/SFE pH of 6. The results show a greater number of samples within the 2018/2019 results fall within the lower left quadrant for either paste pH or SFE pH (two samples plot below in both figures) compared to the historical dataset. A difference in the 2018/2019 dataset compared to the historical dataset is noted with samples typically having lower pH values throughout the dataset and a higher number of samples also plotting within the lower right PAG quadrant (>0.2% total sulphur and pH <6) suggesting some stored acidity within the PAG material. Based on the PAG/Non-AG classification, 85% of samples in the historical dataset would be considered Non-AG compared to only 58% of samples from the 2018 and 2019 dataset.

To further assess the noted trends spatially, historical geochemical data presented in AMEC (2014) and the 2019 blasthole data were compared with respect to the mine plan through 2021 in Figures 13 to 15. Figure 13 presents elevations of the selected geochemical samples in relation to the current Deposit 1 mining area outline. The figure shows that most of the samples from AMEC (2014) are from areas outside or below the current Deposit 1 mining area however, some samples are from within the 2021 expansion. Figure 14 presents PAG/Non-AG classification (based on current cut-off criteria) and percent sulphate from the ABA results. The results show that there is typically less sulphate in samples from AMEC (2014) compared to the 2019 data. In addition, Figure 15 shows that none of the Non-AG samples from AMEC (2014) had paste or SFE pH values less than 6 and the 2019 samples with pH values less than 6 appear to be concentrated to one area of Deposit 1.

The comparison with the historical dataset suggests that the potential for soluble sulphates within Non-AG material is limited with only a few samples within the current geochemical database (2 from historical and 4 from the current data) falling within the total sulphur content below 0.20 wt% as S and paste/SFE pH values less than 6 criteria. All the historical dataset is from areas outside the current Deposit 1 mining area with some samples from within the planned 2021 expansion. The differences in the geochemical results between the 2019 blasthole data and the historical suggests that Non-AG material with stored acidity may be limited to the current area of Deposit 1.

6.0 SUMMARY AND CONCLUSIONS

Baffinland currently segregates waste rock material as PAG and Non-AG using a total sulphur cut-off of 0.20 wt% as S. Recent geochemical analysis of waste rock samples from the WRF indicated the presence of soluble sulphates within PAG waste rock that may be contributing to the observed poor runoff water quality (Golder, 2019). As a due-diligence measure, the current geochemical analysis has been completed to develop a database to assess soluble sulphate content in the WRF that may result in ARD within the waste rock classified as Non-AG.

A geochemical investigation was completed in 2019 with the sampling consisting of the collection of 29 borehole samples from four boreholes and one test pit from the WRF and 40 blasthole samples from the standard production blasthole sampling program. The purpose of the sampling was to better characterize the waste material in the WRF in the vicinity of poor runoff water quality and to assess the presence and effect of soluble sulphate minerals in waste rock classified as Non-AG. All samples were sent for static geochemical analysis, including elemental analysis (by ICP-MS), acid-base accounting (ABA) and shake flask extraction (SFE).

A total of 7 samples including; 4 samples classified as Non-AG and 3 samples classified as PAG (based on current segregation criteria) had either paste or SFE pH values below 6 suggesting some stored acidity within these samples. In terms of metal leaching potential, samples with higher levels of total sulphur (>0.25 wt%) tended to have lower pH, higher Ni and higher Cd in SFE when compared to samples with lower sulphur content. Nickel concentrations show a general increase in concentrations with decreasing pH values in SFE results while other parameters had no discernable trends.

The geochemical results suggest that the overall existing waste rock pile design and placement, as presented in the previous WRMPs (including use of thin lifts to promote freezing and placement of Non-AG material around the edges of the pile), remains valid to reduce potential for acid generation and metal leaching, provided the Non-AG material does not contain stored acidity. In addition, ensuring that PAG material is covered with a lift of Non-AG material, to maintain the PAG waste rock below the permafrost active layer, to limit release of stored acidity from the PAG material.

The current WRF represents a small portion of the life of mine WRF (1.3%) and will be fully encapsulated within the centre of the final WRF pile. A comparison between the historical geochemical dataset and the blasthole data collected from this investigation was completed to understand the potential extent of material within Deposit 1 that would be characterized as Non-AG based on current practices (total sulphur <0.2 wt% as S) and has paste or SFE pH less than 6 that suggests stored acidity. The review suggests that stored acidity, particularly within Non-AG waste rock, appears to be primarily within the current area of Deposit 1. Ongoing testing, as part of the current and recommended Site segregation practices, should be reviewed on an ongoing basis to confirm these observations as the mining area of Deposit 1 expands.

The results of this investigation indicate that the current waste rock segregation criteria requires minor modification (as identified below) in order to better identify Non-AG rock that does not contain stored acidity.

Current PAG Classification

Based on the results from the 69 samples tested, the current waste rock segregation criteria results in some samples being improperly classified and being placed as Non-AG material. The presence of soluble sulphates at significant enough quantities to produce low pH and elevated metal concentrations appears to be predominantly constrained to waste rock with greater than 0.20 wt% as S total sulphur content, thus is already captured by the current PAG classification method. However, of the low sulphur (less than 0.20 wt% as S total sulphur) samples, four out of these 55 samples had slightly acidic pH values (<6) in either the paste pH from ABA or final pH from SFE. These samples represent 7% of the samples that were classified as Non-AG using the current PAG classification method.

Proposed PAG Classification

To reduce the amount of low sulphur rock classified as Non-AG that may have some potential to release acidity it is recommended that paste pH testing be implemented as part of the current segregation practices at site for samples that have less than 0.20 wt% as S. The proposed updated classification of PAG vs. Non-AG is provided in the Table 4 below:

Table 4: Proposed PAG Classification

Acid Generation Potential	Criteria
Potentially Acid Generating (PAG)	Total sulphur > 0.20 wt% as S
Potentially Acid Generating (PAG)	Total sulphur < 0.20 wt% as S and paste pH <6
Non-Potentially Acid Generating (Non-AG)	Total sulphur < 0.20 wt% as S and paste pH >6

Paste pH provides a relatively easy and quick way to predict if a material will yield acidic pH (and potential elevated metals) when exposed to water. When applied to the current dataset, the addition of paste pH to the classification criteria would reduce the amount of low sulphur, Non-AG waste rock with potential to release stored acidity to less than 2% of the samples tested (1 of 55 samples).

In addition to altering the PAG classification criteria, it is also recommended that select blasthole samples of both PAG and Non-AG material are submitted for ABA and SFE testing on an ongoing basis. A frequency of 10 samples per month (5 of each PAG and Non-AG) is recommended through 2020 with the results and sample frequency reviewed on a six-month basis. The purpose of this additional testing is to develop a comprehensive geochemical database for the WRF, allow for the potential refinement of waste rock segregation practices (if required in the future), and support future updates to the Waste Rock Management Plan.

7.0 CLOSURE

We trust that this technical memorandum meets your current needs. Should you have any comments or questions this document, please do not hesitate to contact the undersigned.

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Tables

Table 1
WRF Drilling and Test Pitting Sample Information

Borehole/Test Pit	Depth (m)	Lithology Description	ABA Classification[1]
P1	0 – 3	CHLORITE SCHIST/BIF	Non-PAG
P1	3 – 6	CHLORITE SCHIST	PAG
P1	6 – 9	CHLORITE SCHIST/BIF	PAG
P1	9 – 12	CHLORITE SCHIST/BIF	PAG
P1	12 – 15	CHLORITE SCHIST/BIF	PAG
P1	30	TILL/CHLORITE SCHIST	Non-PAG
P2	0 – 3	CHLORITE SCHIST/BIF	Non-PAG
P2	3 – 6	CHLORITE SCHIST/BIF	Non-PAG
P2	6 – 9	CHLORITE SCHIST/BIF	Non-PAG
P2	9 – 12	CHLORITE SCHIST/BIF	Non-PAG
P2	12 – 15	CHLORITE SCHIST/BIF	Non-PAG
P2	15 – 18	BIF	Non-PAG
P2	18 – 21	BIF	Non-PAG
P2	21 – 24	BIF	Non-PAG
P2	24 – 27	BIF	Non-PAG
P2	27 – 30	CHLORITE SCHIST/BIF	Non-PAG
P3	0 – 3	CHLORITE SCHIST	Non-PAG
P3	3 – 8	CHLORITE SCHIST/BIF	Non-PAG
P3	8 – 16	CHLORITE SCHIST/BIF	Non-PAG
P4	0 – 1	CHLORITE SCHIST/BIF	PAG
P4	1 – 2	CHLORITE SCHIST/BIF	Non-PAG
P4	2 – 4	CHLORITE SCHIST/BIF	Non-PAG
P4	4 – 4.5	CHLORITE SCHIST/BIF/TILL	PAG
P5	0 – 8.5	CHLORITE SCHIST/BIF	PAG
P5	8.5 – 16	CHLORITE SCHIST/BIF	Non-PAG
P5	16 – 19	CHLORITE SCHIST/BIF	Non-PAG
P5	19 – 22	CHLORITE SCHIST/BIF	Non-PAG
P5	22 – 25	CHLORITE SCHIST/BIF	Non-PAG
P5	25 – 28	CHLORITE SCHIST/BIF	Non-PAG

Notes:

[1] Based on total sulphur content. Material considered PAG if S-total ≥ 0.20 wt% and Non-PAG if S-total < 0.20 wt%.

Table 2
Blasthole Database Sample Information

Blasthole	Open Pit Bench	Lithology Description	ABA Classification[1]
2309	590	CHLORITE SCHIST	Non-PAG
2005	590	CHLORITE SCHIST	Non-PAG
1509	590	CHLORITE SCHIST	PAG
2006	580	CHLORITE SCHIST	Non-PAG
2509	580	CHLORITE SCHIST	PAG
1401	590	CHLORITE SCHIST	Non-PAG
1411	590	CHLORITE SCHIST	Non-PAG
1302	590	CHLORITE SCHIST	PAG
1411	590	CHLORITE SCHIST	PAG
1503	600	CHLORITE SCHIST	Non-PAG
1802	590	CHLORITE SCHIST	Non-PAG
1100	590	CHLORITE SCHIST	Non-PAG
1313	590	CHLORITE SCHIST	Non-PAG
1301	590	CHLORITE SCHIST	PAG
1109	590	CHLORITE SCHIST/HEMATITE	Non-PAG
974	600	CHLORITE SCHIST/HEMATITE	Non-PAG
1819	590	CHLORITE SCHIST/LIM	Non-PAG
1301	590	CHLORITE SCHIST/MAGNETITE	Non-PAG
1317	590	CHLORITE SCHIST/MAGNETITE	Non-PAG
1609	590	CHLORITE SCHIST/MAGNETITE	Non-PAG
1306	590	HEMATITE	Non-PAG
1605	590	HEMATITE	Non-PAG
215	580	HEMATITE	Non-PAG
1706	590	HEMATITE/CHLORITE SCHIST	Non-PAG
1102	590	HEMATITE/CHLORITE SCHIST	Non-PAG
1502	590	HEMATITE/MAG	Non-PAG
1403	590	MAGNETITE	Non-PAG
1512	590	MAGNETITE	Non-PAG
2005	590	MAGNETITE/CHLORITE SCHIST	Non-PAG
1410	600	MAGNETITE/CHLORITE SCHIST	Non-PAG
1611	600	MAGNETITE/CHLORITE SCHIST	PAG
1609	600	MAGNETITE/CHLORITE SCHIST	Non-PAG
2004	660	SILICIFIED GRANITE	Non-PAG
2112	660	SILICIFIED GRANITE	Non-PAG
1705	660	SILICIFIED GRANITE	Non-PAG
1212	660	TILL/GNEISS	Non-PAG
1110	660	TILL/GNEISS	Non-PAG
1505	660	TILL/GNEISS	Non-PAG
1405	590	Unclassified	PAG
1104	590	Unclassified	Non-PAG

Notes:
[1] Based on total sulphur content. Material considered PAG if S-total ≥ 0.20 wt% and Non-PAG if S-total < 0.20 wt%.

Table 3
Bulk Metal Results

Sample ID	Sample Type	Lithology	Ag	Al	As	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Li	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Se	Sn	Sr	Ti	Tl	U	V	Y	Zn
			μg/g	μg/g	μg/g	μg/g	μg/g	μg/g	μg/g	μg/g	μg/g	μg/g	μg/g	μg/g	μg/g	%	μg/g	μg/g	μg/g	μg/g	μg/g	μg/g	μg/g	μg/g	μg/g	μg/g	μg/g	μg/g	μg/g	μg/g	μg/g	μg/g	μg/g	μg/g
		Average Crustal Abundance >	0.075	82300	1.8	425	3	0.0085	41500	3	25	102	60	56300	0.085	20850	20	23300	950	1.2	23550	84	1050	14	0.2	0.05	2.3	370	5650	0.85	2.7	120	33	70
R804546	Blasthole	HEMATITE/CHLORITE SCHIST	0.26	35000	5.6	3.5	0.4	0.52	770	0.08	74	108	68	290000	< 0.05	52	13	27000	2209	2	19	135	38	8	< 0.8	1	1.2	2	256	0.04	1.9	48	2.9	61
S684739	Blasthole	HEMATITE/CHLORITE SCHIST	0.05	1600	1	2.6	0.2	0.37	60	< 0.02	2.9	7.7	7.4	520000	< 0.05	34	< 2	320	299	0.6	12	8.6	100	1.4	< 0.8	< 0.7	< 0.5	0.35	83	< 0.02	0.13	10	0.8	3.3
S077563	Blasthole	MAGNETITE/CHLORITE SCHIST	0.06	16000	1.2	1.2	1.1	0.83	3600	0.16	7	14	19	540000	< 0.05	39	6	17000	771	3.1	21	44	2200	4.2	< 0.8	1	0.7	5.7	127	< 0.02	1.5	26	6.4	13
S077365	Blasthole	MAGNETITE/CHLORITE SCHIST	0.14	19000	6.4	1.9	0.58	0.17	3600	0.06	8.5	21	17	510000	< 0.05	28	< 2	16000	719	1.9	14	36	2300	7.7	< 0.8	< 0.7	0.8	2.5	281	0.02	2.1	33	4.2	19
S077566	Blasthole	MAGNETITE/CHLORITE SCHIST	0.04	15000	1	2.8	1.6	0.41	4400	0.08	11	29	39	520000	< 0.05	73	9	20000	683	5.8	40	52	1900	5	< 0.8	< 0.7	0.6	19	92	< 0.02	1.6	40	5	27
R804556	Blasthole	MAGNETITE/CHLORITE SCHIST	0.04	27000	4	0.67	0.26	0.13	55	0.03	25	261	8.5	340000	< 0.05	41	8	24000	1445	1.9	12	95	42	2.1	< 0.8	< 0.7	< 0.5	1	174	< 0.02	1	107	1.7	48
R804914	Blasthole	HEMATITE	0.03	3400	1.4	6.2	0.79	< 0.09	86	< 0.02	7.8	17	8.6	490000	0.07	39	< 2	1700	302	1.5	13	27	61	1.7	< 0.8	< 0.7	< 0.5	0.29	167	0.03	0.49	14	1.8	8.8
R804543	Blasthole	HEMATITE	0.19	61000	13	8.3	1.2	1.3	140	0.03	50	248	38	240000	< 0.05	520	44	43000	1094	11	23	142	170	7.9	< 0.8	1.9	1.7	1.4	357	0.05	2.8	74	1.6	107
R804554	Blasthole	HEMATITE	0.12	24000	5.7	5.4	0.61	0.55	140	0.02	30	87	21	340000	< 0.05	520	83	10000	1183	6.3	26	84	70	5.2	< 0.8	< 0.7	1.2	1.9	263	0.06	1.4	36	1.6	50
S076986	Blasthole	HEMATITE/MAG	0.04	4300	0.9	8.6	0.65	0.11	37	< 0.02	12	16	6.4	460000	< 0.05	37	4	3000	385	0.4	14	33	30	0.77	< 0.8	< 0.7	< 0.5	0.45	93	< 0.02	0.57	9	2.4	16
S077304	Blasthole	MAGNETITE	0.02	4800	1	1.2	0.61	0.25	26	< 0.02	7.3	12	2.7	550000	< 0.05	55	4	2400	263	1.4	16	27	31	1.8	< 0.8	< 0.7	< 0.5	0.13	174	< 0.02	0.36	13	1.3	9.4
S684626	Blasthole	MAGNETITE	0.04	12000	2.4	3	0.32	0.21	1300	0.03	15	43	28	550000	< 0.05	92	3	10000	936	4.5	27	37	880	1.5	< 0.8	< 0.7	0.6	2.6	99	< 0.02	0.54	33	2.3	21
R804213	Blasthole	Unclassified	0.03	19000	0.8	1.1	0.74	0.22	29	< 0.02	16	16	14	550000	< 0.05	56	10	18000	484	4.5	49	58	43	1.6	< 0.8	< 0.7	< 0.5	0.06	72	< 0.02	1.2	24	2.6	18
S684745	Blasthole	Unclassified	0.02	3100	0.7	1.9	0.4	0.22	21	< 0.02	6	8	5.1	500000	< 0.05	41	< 2	2200	290	0.4	8.6	19	44	0.67	< 0.8	< 0.7	< 0.5	0.11	75	< 0.02	0.3	7	0.9	7.4
S076762	Blasthole	CHLORITE SCHIST/HEMATITE	0.27	30000	35	5.6	0.62	1	70	0.02	31	52	52	230000	< 0.05	100	25	16000	1236	6.5	19	102	34	6.3	< 0.8	1.8	0.7	1.6	203	0.04	2.6	54	1.2	78
S074992	Blasthole	CHLORITE SCHIST/HEMATITE	0.12	28000	12	3.7	1.3	0.19	44	< 0.02	39	425	41	310000	< 0.05	47	5	28000	527	4.7	8.6	233	170	5.8	< 0.8	< 0.7	0.9	0.97	461	0.05	2.5	68	3	55
R805632	Blasthole	CHLORITE SCHIST/MAGNETITE	0.07	28000	0.5	122	4.2	0.15	240	0.08	31	83	6.3	500000	< 0.05	7000	13	32000	975	0.2	290	124	150	13	< 0.8	< 0.7	1	1	871	0.27	12	57	4	43
S076968	Blasthole	CHLORITE SCHIST/MAGNETITE	0.21	28000	56	1.7	0.36	0.87	49	< 0.02	15	81	56	440000	< 0.05	51	< 2	23000	1440	7.3	11	37	100	6	< 0.8	1	1.3	0.36	251	0.02	2.1	58	1.3	49
S684417	Blasthole	CHLORITE SCHIST/MAGNETITE	0.21	47000	36	4.1	0.54	0.73	62	0.02	16	43	42	310000	< 0.05	45	4	39000	927	55	7.7	63	68	5.9	< 0.8	0.8	1.1	0.87	278	0.06	2.2	60	1	84
S075744	Blasthole	CHLORITE SCHIST	0.14	49000	3.2	220	1.9	0.83	83	0.03	37	78	55	140000	< 0.05	9800	28	29000	528	31	150	117	47	10	< 0.8	0.8	2.5	3.6	1900	0.31	3.3	116	0.4	54
R807291	Blasthole	CHLORITE SCHIST	0.13	40000	3	1.2	0.73	0.19	1800	0.02	23	616	35	270000	< 0.05	63	7	51000	716	3.3	27	136	920	6.1	< 0.8	< 0.7	0.7	1.2	305	0.03	2.4	121	3.7	51
S684606	Blasthole	CHLORITE SCHIST	0.12	75000	1.7	533	3.1	0.94	240	0.11	101	82	16	160000	< 0.05	4200	33	62000	945	5.4	86	253	370	8.2	< 0.8	0.7	1.5	2.8	506	0.29	3.9	88	6	90
R807797	Blasthole	CHLORITE SCHIST	0.17	45000	10	2.8	0.63	0.53	42	< 0.02	12	73	25	230000	< 0.05	150	7	34000	331	2.7	16	38	49	4.9	< 0.8	1.2	0.9	0.24	206	0.03	2	64	1.8	66
S076760	Blasthole	CHLORITE SCHIST	0.34	61000	6.5	6.9	2.4	1.7	240	< 0.02	97	44	46	220000	< 0.05	600	97	59000	317	4.7	40	343	87	8.3	< 0.8	0.9	1.6	1.5	516	0.18	2.1	54	2.1	91
S075727	Blasthole	CHLORITE SCHIST	0.05	22000	2.4	4.6	1.4	0.16	56	< 0.02	29	222	10	510000	< 0.05	24	10	22000	570	1.5	12	117	97	2.7	< 0.8	< 0.7	0.7	0.7	351	0.03	1.4	55	6.8	33
R807731	Blasthole	CHLORITE SCHIST	0.16	34000	5	17	1.8	0.44	100	0.02	33	27	34	230000	< 0.05	430	23	25000	576	2.9	47	76	140	5	< 0.8	0.8	0.7	0.79	118	0.09	2	41	3	54
S684530	Blasthole	CHLORITE SCHIST	0.03	49000	1.8	3.3	1	0.2	1800	0.08	29	431	18	230000	< 0.05	180	22	55000	913	2	45	109	970	2.2	< 0.8	< 0.7	< 0.5	8.5	149	< 0.02	1.6	164	5.3	38
R805578	Blasthole	CHLORITE SCHIST	0.14	70000	33	39	1.9	1.9	430	< 0.02	58	104	46	210000	0.06	2000	261	47000	734	15	54	139	300	4.1	< 0.8	1.2	1.4	3.9	554	0.09	3.4	96	2.9	102
S075667	Blasthole	CHLORITE SCHIST	0.2	68000	6.3	5.4	1.4	1	52	< 0.02	60	564	33	220000	< 0.05	96	21	57000	878	1.1	9.5	306	77	5.8	< 0.8	< 0.7	< 0.5	1.2	372	0.02	2.8	134	3.4	173
R805460	Blasthole	CHLORITE SCHIST	0.07	37000	2.2	142	1.3	0.53	930	0.04	19	77	30	100000	< 0.05	9500	12	35000	1250	1.6	210	68	450	11	< 0.8	< 0.7	1.6	4.3	1642	0.35	1.8	68	1.2	34
S075663	Blasthole	CHLORITE SCHIST	0.06	35000	3.8	30	0.87	0.59	220	< 0.02	34	85	38	110000	< 0.05	2400	17	30000	1064	3.1	37	105	120	3.3	< 0.8	< 0.7	1.1	1.6	459	0.1	1.8	56	2.5	35
S684571	Blasthole	CHLORITE SCHIST	0.03	58000	23	2.3	2.1	0.12	23	< 0.02	34	394	45	320000	< 0.05	35	< 2	60000	891	1.7	6.2	108	110	2.1	< 0.8	< 0.7	0.6	0.63	480	< 0.02	2.6	231	6.9	111
S684603	Blasthole	CHLORITE SCHIST	0.05	31000	1.6	51	0.79	0.14	770	0.04	39	156	74	250000	< 0.05	3900	10	23000	783	3.2	74	118	370	2.5	< 0.8	< 0.7	0.9	3.2	439	0.11	0.82	106	2.7	46
S684537	Blasthole	CHLORITE SCHIST/LIM	0.17	73000	7.7	1.3	1.2	0.71	340	0.04	72	571	272	210000	< 0.05	130	16	71000	2384	17	16	250	550	5.9	< 0.8	2.7	2.7	1.8	141	< 0.02	0.6	204	5	259
R805920	Blasthole	SILICIFIED GRANITE	0.03	30000	< 0.5	690	0.49	0.27	1100	0.03	13	8.2	27	86000	< 0.05	21000	10	15000	395	5	350	15	490	8.5	< 0.8	< 0.7	2	2.2	1946	0.63	4.9	38	3.8	13
R804742	Blasthole	SILICIFIED GRANITE	0.23	64000	1.1	340	1.4	0.8	3000	0.11	40	314	236	130000	< 0.05	18000	29	70000	1171	1.7	320	251	1100	11	< 0.8	< 0.7	2.9	6.1	2576	0.59	4.5	137	2.1	118
R804677	Blasthole	SILICIFIED GRANITE	0.15	32000	< 0.5	319	1.5	0.16	3700	0.03	31	87	107	66000	0.2	24000	32	28000	898	2.6	460	52	570	4.6	< 0.8	< 0.7	1.3	8.5	3795	0.95	0.82	170	3.4	86
R807636	Blasthole	TILL/GNEISS	0.03	45000	< 0.5	671	0.54	0.25	1900	0.03	24	37	96	88000	< 0.05	32000	14	28000	571	18	610	48	800	9.9	< 0.8	< 0.7	5.2	3.2	3640	0.92	2.1	119	< 0.2	12
R807653	Blasthole	TILL/GNEISS	0.06	20000	0.7	351	0.53	0.2	3200	0.04	17	20	27	91000	0.06	12000	10	14000	715	4.4	200	25	630	5.6	< 0.8	< 0.7	1.2	4.7	1657	0.55	2.7	49	4.6	44
R807430	Blasthole	TILL/GNEISS	0.02	32000	< 0.5	553	0.83	0.14	1400	0.03	15	14	20	82000	< 0.05	18000	12	21000	499	0.8	330	24	450	9.2	< 0.8	< 0.7	2.3	3.3	1978	0.59	2.7	53	0.6	76
P1-0-3	Drillhole	CHLORITE SCHIST/BIF	0.045	26000	3.9	9.4	0.67	0.25	560	0.032	23	160	36	390000	< 0.05	630	8.5	28000	1600	2.6	70	85	300	2.3	< 0.8	< 0.7	1.2	2.4	170	0.028	1.4	52	5.1	53
P1-3-6	Drillhole	CHLORITE SCHIST	0.071	23000	5.1	43	0.61	0.25	600	0.023	23	190	47	430000	< 0.05	2000	11	21000	1200	3.3	78	100	300	2.7	< 0.8	< 0.7	0.85	2.5	380	0.061	0.92	72	1.8	47
P1-6-9	Drillhole	CHLORITE SCHIST/BIF	0.11	24000	7.5	83	0.72	0.36	620	0.03	27	230	45	440000	< 0.05	3000	14	19000	1100	3.8	120	120	200	4.6	< 0.8	< 0.7	1.1	2.2	520	0.092	1.3	78	2.5	48
P1-9-12	Drillhole	CHLORITE SCHIST/BIF	0.14	28000	3.1	22	0.68	0.38	340	0.029	27	150	39	380000	< 0.05	940	7.2	27000	980	5.8	62	100	170	4.4	< 0.8	< 0.7	0.86	1.2	320	0.06	2.1	68	2.9	61
P1-12-15	Drillhole	CHLORITE SCHIST/BIF	0.21	24000	2.7	15	0.76	0.83	390	0.028	25	150	44	400000	< 0.05	760	6.7	26000	1000	6.1	61	88	190	5.2	< 0.8	0.81	0.96	1.3	290	0.048	2.3	57	3.2	49
P-1-30	Drillhole	TILL/CHLORITE SCHIST	0.11	16000	2.2	31	0.56	0.44	13000	0.029	16	140	29	220000	0.06	1600	11	22000	750	8.2	210	66	260	5.7	< 0.8	< 0.7	0.89	8.5	380	0.089	1.5	43	3.5	40
P2-27-30	Drillhole	CHLORITE SCHIST/BIF	0.075	14000	2.9	21	0.56	0.35	720	0.029	19	82	22	460000	< 0.05	1100	11	11000	1100	5.4	89	50	340	4	< 0.8	< 0.7	0.59	2.9	230	0.053	2.1	34	3.8	38
P2-24-27	Drillhole	BIF	0.072	8800	1.7	20	0.45	0.43	570	0.035	16	71	19	380000	0.06	1400	9.2	6000	1000	4.8	140	37	180	8.2	< 0.8	< 0.7	0.51	2.9	190	0.049	2.9	21	4.1	27
P2-21-24	Drillhole	BIF	0.085	8800	1.8	26	0.47	0.29	580	0.038	15	73	23	410000	0.06	1700	7.9	6000	910	5.2	190	37	190	4.8	< 0.8	< 0.7	0.54	3.2	210	0.061	3.2	20	4.7	24
P2-18-21	Drillhole	BIF	0.072	10000	2.6	24	0.57	0.4	410	0.048	20	77	21	450000	0.06	1400	9.7	7400	1100	6.3	100	45	230	5.3	< 0.8	< 0.7	0.56	2.9	210	0.055	2.5	27	4.4	34
P2-15-18	Drillhole	BIF	0.12	10000	2.5	11	0.5	0.34	240	0.026	18	87	27	470000	0.06	590	6.1	8100	1100	5.6	67	50	140	4.5	< 0.8	< 0.7	0.61	1.9	160	0.042	2	24	3.8	29
P2-12-15	Drillhole	CHLORITE SCHIST/BIF	0.1	29000	2.1	13	0.71	0.59	240	0.024	31	100	28	390000	< 0.05	1400	41	24000	800	20	56	83	130	3.7	< 0.8	0.73	1.2	2.1	250	0.064	2.7	53	2.9	57
P2-9-12	Drillhole	CHLORITE SCHIST/BIF	0.072	22000	4	15	0.57	0.42	560	0.021	22	75	24	460000	< 0.05	1000	21	18000	1100	7.4	48	62	260	2.9	< 0.8	< 0.7	0.74	2	250	0.056	1.5	44	2.2	44
P2-6-9	Drillhole	CHLORITE SCHIST/BIF	0.089	18000	5.9	15	0.58	0.29	320	0.026	18	130	22	490000	< 0.05	780	6.4	16000	1200	6.7	52	79	160	3.2	< 0.8	< 0.7	0.81	1.6	260	0.052	2.1	42	2	35
P2-3-6	Drillhole	CHLORITE SCHIST/BIF	0.044	9300	2.8	25	0.36	0.27	2300	0.039	11	46	18	520000	< 0.05	1300	4.7	8200	800	2.5	120	30	790	3.5	< 0.8	< 0.7	< 0.5	4.7	260	0.05	1.2	25	3.4	22
P2-0-3	Drillhole	CHLORITE SCHIST/BIF	0.023	7000	1.5	5	0.41	0.21	2100	0.038	11	36	14	600000	< 0.05	180	4.2	9300	940	1.5	66	32	980	1.8	< 0.8	< 0.7	< 0.5	5.4	98	< 0.02	0.6	18	4.7	17
P3-0-3	Drillhole	CHLORITE SCHIST	0.044	24000	3.7	7.2	0.62	0.21	1500	0.031	23	120	51	380000	< 0.05	410	6.7	27000	1400	2.6	51	70	740	2.1	< 0.8	< 0.7	0.85	3.4	160	0.03	0.75	67	3.5	47
P3-3-8	Drillhole	CHLORITE SCHIST/BIF	0.037	13000	2	12	0.46	0.22	1100	0.024	16	86	23	540000	< 0.05	570	5.7	13000	1100	3	52	60	520	2.1	< 0.8	< 0.7	0.54	2.7	170	0.023	0.68	34	3	27
P3-8-16	Drillhole	CHLORITE SCHIST/BIF	0.044	11000	2.2	4.5	0.38	0.2	740	0.027	12	61	15	560000	< 0.05	210	4.1	11000	780	4	40	46	390	2.6	< 0.8	< 0.7	< 0.5	1.6	160	0.024	1.2	29	2.5	20
P5-0-8.5	Drillhole	CHLORITE SCHIST/BIF	0.086	18000	3.8	26	0.66	0.26	270	< 0.02	22	100	33	500000	< 0.05	1300	8.1	16000	890	4.7	66	83	130	3.5	< 0.8	< 0.7	0.56	1.2	290	0.042	2.3	44	3.1	40
P5-8.5-16	Drillhole	CHLORITE SCHIST/BIF	0.054	15000	2.1	31	0.68	0.28	330	0.03	18	82	21	470000	< 0.05	1300	9.7	13000	820	4.2	81	60	180	3.2	< 0.8	< 0.7	0.58	1.5	270	0.05	1.9	37	3	29
P5-16-19	Drillhole	CHLORITE SCHIST/BIF	0.071	14000	2.5	32	0.67	0.46	440	0.033	18	73	22	480000	0.07	1600	10	11000	910	4.7	90	58	190	4	< 0.8	< 0.7	0.69	1.9	270	0.048	1.8	37	3.2	27
P5-19-22	Drillhole	CHLORITE SCHIST/BIF	0.055	16000	2.4	29	0.52	0.29	1200	< 0.02	19	120	23	410000	< 0.05	1700	9.6	15000	770	4.8	150	67	170	3.3	< 0.8	< 0.7	0.54	2.3	320	0.058	2.5	38	4.2	28
P5-22-25	Drillhole	CHLORITE SCHIST/BIF	1.9	13000	2	52	0.52	0.29	12000	0.038	18	110	28	290000	0.07	3300	14	18000	900	4.8	240	56	390	5.1	< 0.8	< 0.7	0.74	9.3	510	0.14	2.3	30	4.9	32
P5-25-28	Drillhole	CHLORITE SCHIST/BIF	0.055	10000	1.5	38	0.4	0.21	9700	0.038	18	97	18	270000	< 0.05	2400	11	13000	920	5.1	290	45	380	5.3	< 0.8	< 0.7	0.7	8.4	400	0.11	2.4	26	4.2	26
P4-0-1	Test pit	CHLORITE SCHIST/BIF	0.12	23000	1.4	16	0.83	0.55	210	< 0.02	21	140	29	500000	0.11	760	9.1	21000	660	4.2	53	90	160	3.5	< 0.8	< 0.7	0.67	1.3	260	0.049	2.3	40	6.2	37
P4-1-2	Test pit	CHLORITE SCHIST/BIF	0.085	17000	1.3	17	0.59	0.52	3300	< 0.02	16	130	23	320000	0.05	980	8.2	17000	490	3.9	140	67	200	4.1	< 0.8	< 0.7	0.62	3.6	300	0.065	1.7	35	4.1	32
P4-2-4	Test pit	CHLORITE SCHIST/BIF	0.062	16000	0.71	3.2	0.5	0.24	150	< 0.02	15	60	15	580000	0.06	190	6.5	14000	530	3.8	36	57	58	1.7	< 0.8	< 0.7	< 0.5	0.61	140	< 0.02	1.2	23	3.3	24
P4-4-4.5	Test pit	CHLORITE SCHIST/BIF/TILL	0.12	18000	0.99	13	0.79	0.61	450	< 0.02	18	140	26	450000	0.08	580	9.2	17000	540	4.1	47	79	160	3.5	< 0.8	< 0.7	0.65	1.2	250	0.04	2	39	4.2	33

Notes:

- Price Crustal Abundance taken from: Price, W.A., 1997. Draft Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia, Ministry of Energy and Mines. p. 159.

0.7	- Denotes values greater than five times the Price Crustal Abundance.
0.7	- Denotes values greater than ten times the Price Crustal Abundance.

Sample ID	Sample Type	Lithology	Paste pH	Total Sulphur	Sulphide Sulphur	Sulphate Sulphur	Total Carbon	Carbonate	CO_3-NP[2]	NP[3]	AP[4]	Net NP[5]	Net CaNP[5]	NPR[5]	CO_3-NPR[6]
			s.u.	%					t $CaCO_3$ /1000 t					ratio	
R804546	Blasthole	HEMATITE/CHLORITE SCHIST	7.45	0.15	0.05	0.1	0.24	0.68	11.41	11.6	4.78	6.82	6.63	2.43	2.39
S684739	Blasthole	HEMATITE/CHLORITE SCHIST	5.42	0.06	0.02	0.04	0.06	< 0.025	4.58	1.8	1.84	-0.04	2.74	0.98	2.49
S077563	Blasthole	MAGNETITE/CHLORITE SCHIST	6.96	0.21	0.14	0.07	0.02	< 0.025	1.25	11.1	6.69	4.41	-5.44	1.66	0.19
S077365	Blasthole	MAGNETITE/CHLORITE SCHIST	5.88	0.15	0.05	0.1	0.07	< 0.025	6.17	9.3	4.56	4.74	1.6	2.04	1.35
S077566	Blasthole	MAGNETITE/CHLORITE SCHIST	7.73	0.1	0.07	0.03	0.02	< 0.025	1.42	17.1	3.19	13.91	-1.77	5.36	0.44
R804556	Blasthole	MAGNETITE/CHLORITE SCHIST	7.61	0.05	< 0.02	0.05	0.18	0.46	7.67	6.6	1.47	5.13	6.2	4.49	5.22
R804914	Blasthole	HEMATITE	6.16	0.11	0.02	0.09	0.05	< 0.025	4.25	2.0	3.56	-1.56	0.69	0.56	1.19
R804543	Blasthole	HEMATITE	6.98	0.13	< 0.02	0.13	0.1	< 0.025	8.5	6.0	4.0	2.0	4.5	1.5	2.13
R804554	Blasthole	HEMATITE	6.88	0.08	0.02	0.06	0.96	3.97	66.22	4.8	2.44	2.36	63.78	1.97	27.17
S076986	Blasthole	HEMATITE/MAG	7.17	0.04	< 0.02	0.04	0.01	< 0.025	1.17	4.2	1.28	2.92	-0.11	3.28	0.91
S077304	Blasthole	MAGNETITE	5.66	0.14	0.03	0.11	0.06	< 0.025	5.25	2.2	4.25	-2.05	1.0	0.52	1.24
S684626	Blasthole	MAGNETITE	6.62	0.11	0.03	0.08	0.04	< 0.025	3.33	6.4	3.56	2.84	-0.23	1.8	0.94
R804213	Blasthole	Unclassified	6.49	0.24	0.06	0.18	0.12	< 0.025	10.17	7.2	7.44	-0.24	2.73	0.97	1.37
S684745	Blasthole	Unclassified	6.53	0.07	0.03	0.04	0.07	< 0.025	5.67	27.8	2.28	25.52	3.39	12.19	2.48
S076762	Blasthole	CHLORITE SCHIST/HEMATITE	6.51	0.12	0.04	0.08	0.54	1.44	24.02	3.3	3.88	-0.58	20.14	0.85	6.2
S074992	Blasthole	CHLORITE SCHIST/HEMATITE	7.42	0.08	< 0.02	0.08	0.01	< 0.025	1.08	8.1	2.63	5.48	-1.54	3.09	0.41
R805632	Blasthole	CHLORITE SCHIST/MAGNETITE	7.23	0.13	0.02	0.11	0.07	< 0.025	6.17	37.1	4.06	33.04	2.1	9.13	1.52
S076968	Blasthole	CHLORITE SCHIST/MAGNETITE	7.21	0.05	0.02	0.03	0.06	< 0.025	5.33	28.0	1.59	26.41	3.74	17.57	3.35
S684417	Blasthole	CHLORITE SCHIST/MAGNETITE	7.07	0.09	0.03	0.06	0.27	1.0	16.66	6.2	2.75	3.45	13.91	2.25	6.06
S075744	Blasthole	CHLORITE SCHIST	6.84	0.22	0.09	0.13	0.07	< 0.025	5.67	9.5	6.97	2.53	-1.3	1.36	0.81
R807291	Blasthole	CHLORITE SCHIST	6.73	0.23	0.06	0.16	0.02	< 0.025	1.42	9.8	7.03	2.77	-5.61	1.39	0.2
S684606	Blasthole	CHLORITE SCHIST	6.99	0.22	0.05	0.17	0.06	< 0.025	4.83	10.6	6.78	3.82	-1.95	1.56	0.71
R807797	Blasthole	CHLORITE SCHIST	6.78	0.22	0.08	0.14	0.08	< 0.025	6.67	5.4	6.81	-1.41	-0.15	0.79	0.98
S076760	Blasthole	CHLORITE SCHIST	7.13	0.15	0.06	0.09	0.05	< 0.025	4.08	6.6	4.81	1.79	-0.73	1.37	0.85
S075727	Blasthole	CHLORITE SCHIST	7.36	0.2	0.04	0.16	0.07	< 0.025	6.0	10.4	6.31	4.09	-0.31	1.65	0.95
R807731	Blasthole	CHLORITE SCHIST	6.94	0.18	0.08	0.1	0.07	< 0.025	5.67	6.7	5.72	0.98	-0.05	1.17	0.99
S684530	Blasthole	CHLORITE SCHIST	7.31	0.16	< 0.02	0.16	0.06	< 0.025	4.58	13.6	5.03	8.57	-0.45	2.7	0.91
R805578	Blasthole	CHLORITE SCHIST	7.15	0.13	0.03	0.1	0.1	0.15	2.5	7.7	4.13	3.58	-1.62	1.87	0.61
S075667	Blasthole	CHLORITE SCHIST	6.86	0.15	< 0.02	0.15	0.13	0.23	3.75	6.4	4.59	1.81	-0.84	1.39	0.82
R805460	Blasthole	CHLORITE SCHIST	7.71	0.13	0.08	0.05	0.09	< 0.025	7.83	9.6	4.06	5.54	3.77	2.36	1.93
S075663	Blasthole	CHLORITE SCHIST	7.13	0.12	< 0.02	0.12	0.12	0.22	3.67	7.2	3.63	3.58	0.04	1.99	1.01
S684571	Blasthole	CHLORITE SCHIST	7.08	0.12	0.02	0.1	0.14	0.17	2.84	8.4	3.69	4.71	-0.85	2.28	0.77
S684603	Blasthole	CHLORITE SCHIST	7.33	0.05	< 0.02	0.05	0.07	0.07	1.17	8.0	1.69	6.31	-0.52	4.74	0.69
S684537	Blasthole	CHLORITE SCHIST/LIM	7.2	0.14	0.02	0.12	0.05	< 0.025	4.42	14.2	4.34	9.86	0.07	3.27	1.02
R805920	Blasthole	SILICIFIED GRANITE	8.06	0.12	0.08	0.04	0.03	< 0.025	2.33	8.2	3.81	4.39	-1.48	2.15	0.61
R804742	Blasthole	SILICIFIED GRANITE	8.24	0.08	0.05	0.03	0.07	0.14	2.25	21.5	2.63	18.88	-0.37	8.19	0.86
R804677	Blasthole	SILICIFIED GRANITE	9.26	0.05	0.03	< 0.02	0.04	< 0.025	3.58	13.5	1.47	12.03	2.11	9.19	2.44
R807636	Blasthole	TILL/GNEISS	8.21	0.17	0.1	0.07	0.01	< 0.025	1.08	9.4	5.44	3.96	-4.35	1.73	0.2
R807653	Blasthole	TILL/GNEISS	7.88	0.06	0.03	0.03	0.29	< 0.025	24.0	14.0	2.0	12.0	22.0	7.0	12.0
R807430	Blasthole	TILL/GNEISS	7.94	0.04	0.02	< 0.02	0.06	< 0.025	5.25	8.3	1.22	7.08	4.03	6.81	4.31
P1-0-3	Drillhole	CHLORITE SCHIST/BIF	8.07	0.03	< 0.02	0.03	0.06	0.06	0.92	9.9	1.06	8.84	-0.15	9.32	0.86
P1-3-6	Drillhole	CHLORITE SCHIST	7.29	0.23	0.18	0.05	0.13	0.38	6.34	8.0	7.09	0.91	-0.76	1.13	0.89
P1-6-9	Drillhole	CHLORITE SCHIST/BIF	7.51	0.23	0.18	0.05	0.11	0.24	4.0	13.7	7.28	6.42	-3.28	1.88	0.55
P1-9-12	Drillhole	CHLORITE SCHIST/BIF	6.96	0.38	0.25	0.13	0.09	0.19	3.17	8.6	11.97	-3.37	-8.8	0.72	0.26
P1-12-15	Drillhole	CHLORITE SCHIST/BIF	7.23	0.28	0.14	0.14	0.08	0.16	2.67	10.6	8.59	2.01	-5.93	1.23	0.31
P-1-30	Drillhole	TILL/CHLORITE SCHIST	7.9	0.13	0.06	0.07	0.84	2.65	44.2	68.6	4.19	64.41	40.01	16.38	10.55
P2-27-30	Drillhole	CHLORITE SCHIST/BIF	7.65	0.1	0.05	0.05	0.09	0.2	3.25	8.5	3.16	5.34	0.1	2.69	1.03
P2-24-27	Drillhole	BIF	7.94	0.05	0.02	0.03	0.1	0.22	3.67	5.3	1.47	3.83	2.2	3.61	2.5
P2-21-24	Drillhole	BIF	7.92	0.06	0.03	0.03	0.08	0.12	2.0	5.2	1.88	3.33	0.13	2.77	1.07
P2-18-21	Drillhole	BIF	7.68	0.06	0.03	0.03	0.08	0.15	2.42	5.4	1.88	3.53	0.54	2.88	1.29
P2-15-18	Drillhole	BIF	7.5	0.19	0.09	0.1	0.09	0.2	3.25	5.2	5.78	-0.58	-2.53	0.9	0.56
P2-12-15	Drillhole	CHLORITE SCHIST/BIF	7.07	0.19	0.08	0.1	0.16	0.14	2.25	6.9	5.78	1.12	-3.53	1.19	0.39
P2-9-12	Drillhole	CHLORITE SCHIST/BIF	7.32	0.14	0.06	0.08	0.16	0.39	6.42	8.6	4.38	4.23	2.05	1.97	1.47
P2-6-9	Drillhole	CHLORITE SCHIST/BIF	7.29	0.16	0.08	0.08	0.19	0.73	12.16	7.1	4.97	2.13	7.19	1.43	2.45
P2-3-6	Drillhole	CHLORITE SCHIST/BIF	7.99	0.14	0.09	0.05	0.07	0.09	1.42	10.9	4.44	6.46	-3.02	2.46	0.32
P2-0-3	Drillhole	CHLORITE SCHIST/BIF	8.15	0.06	0.02	0.04	0.03	< 0.025	2.75	11.3	1.91	9.39	0.84	5.93	1.44
P3-0-3	Drillhole	CHLORITE SCHIST	7.63	0.09	0.02	0.07	0.03	< 0.025	2.67	11.6	2.91	8.69	-0.24	3.99	0.92
P3-3-8	Drillhole	CHLORITE SCHIST/BIF	7.9	0.07	0.03	0.04	0.08	0.17	2.84	9.1	2.03	7.07	0.8	4.48	1.4
P3-8-16	Drillhole	CHLORITE SCHIST/BIF	7.71	0.11	0.06	0.05	0.09	0.25	4.09	8.1	3.38	4.73	0.71	2.4	1.21
P5-0-8.5	Drillhole	CHLORITE SCHIST/BIF	7.36	0.24	0.15	0.09	0.06	0.09	1.5	7.2	7.53	-0.33	-6.03	0.96	0.2
P5-8.5-16	Drillhole	CHLORITE SCHIST/BIF	7.63	0.1	0.06	0.04	0.04	0.07	1.08	7.7	3.22	4.48	-2.13	2.39	0.34
P5-16-19	Drillhole	CHLORITE SCHIST/BIF	7.57	0.09	0.05	0.04	0.07	0.13	2.17	6.7	2.81	3.89	-0.64	2.38	0.77
P5-19-22	Drillhole	CHLORITE SCHIST/BIF	7.77	0.09	0.03	0.06	0.1	0.17	2.84	11.5	2.72	8.78	0.12	4.23	1.04
P5-22-25	Drillhole	CHLORITE SCHIST/BIF	8.25	0.07	0.03	0.04	0.7	2.21	36.86	59.4	2.31	57.09	34.55	25.69	15.94
P5-25-28	Drillhole	CHLORITE SCHIST/BIF	8.44	0.06	0.04	< 0.02	0.59	1.79	29.86	47.5	1.84	45.66	28.01	25.76	16.19
P4-0-1	Test pit	CHLORITE SCHIST/BIF	6.88	0.34	0.24	0.1	0.01	< 0.025	1.0	5.5	10.63	-5.13	-9.62	0.52	0.09
P4-1-2	Test pit	CHLORITE SCHIST/BIF	7.75	0.19	0.11	0.08	0.21	0.55	9.09	17.8	5.88	11.93	3.21	3.03	1.55
P4-2-4	Test pit	CHLORITE SCHIST/BIF	7.51	0.17	0.11	0.06	0.01	< 0.025	1.08	6.6	5.41	1.19	-4.32	1.22	0.2
P4-4-4.5	Test pit	CHLORITE SCHIST/BIF/TILL	7.01	0.39	0.27	0.12	0.02	< 0.025	1.75	5.6	12.13	-6.53	-10.37	0.46	0.14

Table 5
Shake Flask Extraction Results

Sample ID	Sample Type	Lithology	Final pH	pH	Alkalinity	Conductivity	Acidity	SO_4	Cl	Hg	Ag	Al	As	Ba	B	Be	Bi	Ca
		Units >	no unit	no unit	mg/L as CaCO3	uS/cm	mg/L as CaCO3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
		Metal and Diamonds Mining Effluent Regulations (MDMER) value >	-	-	-	-	-	-	-	-	-	-	0.5	-	-	-	-	-
R804546	Blasthole	HEMATITE/CHLORITE SCHIST	7.57	7.16	12	884	15	450	14	< 0.00001	< 0.00005	0.054	0.0003	0.00383	0.051	< 0.000007	< 0.000007	2.17
S684739	Blasthole	HEMATITE/CHLORITE SCHIST	5.82	6.02	2	398	3	180	5	< 0.00001	< 0.00005	0.002	< 0.0002	0.0304	0.049	0.000021	< 0.000007	4.18
S077563	Blasthole	MAGNETITE/CHLORITE SCHIST	6.98	7.17	11	1010	< 2	520	3	< 0.00001	< 0.00005	0.029	0.0003	0.00207	0.093	< 0.000007	< 0.000007	51.7
S077365	Blasthole	MAGNETITE/CHLORITE SCHIST	7.09	6.33	5	1300	< 2	760	3	< 0.00001	< 0.00005	0.009	0.0003	0.0025	0.041	0.000009	< 0.000007	57.1
S077566	Blasthole	MAGNETITE/CHLORITE SCHIST	6.31	7.4	25	604	< 2	270	2	< 0.00001	< 0.00005	0.056	0.0004	0.00254	0.016	< 0.000007	< 0.000007	20.3
R804556	Blasthole	MAGNETITE/CHLORITE SCHIST	7.97	7.42	24	484	< 2	210	8	< 0.00001	< 0.00005	0.069	0.0005	0.00111	0.063	< 0.000007	< 0.000007	0.61
R804914	Blasthole	HEMATITE	6.6	6.2	3	1220	< 2	700	3	< 0.00001	< 0.00005	0.002	0.0005	0.0173	0.04	0.000018	< 0.000007	5.01
R804543	Blasthole	HEMATITE	7.21	6.79	7	1180	< 2	670	4	< 0.00001	< 0.00005	0.012	0.0009	0.00491	0.091	< 0.000007	< 0.000007	5.2
R804554	Blasthole	HEMATITE	7.19	6.79	9	680	< 2	330	10	< 0.00001	< 0.00005	0.012	0.0013	0.00337	0.478	< 0.000007	< 0.000007	5.78
S076986	Blasthole	HEMATITE/MAG	7.32	6.94	9	547	< 2	260	4	< 0.00001	< 0.00005	0.018	< 0.0002	0.018	0.058	0.000039	0.000008	0.89
S077304	Blasthole	MAGNETITE	5.81	5.75	< 2	1420	4	890	6	< 0.00001	< 0.00005	0.01	< 0.0002	0.00659	0.041	0.0001	< 0.000007	2.1
S684626	Blasthole	MAGNETITE	6.95	7.14	13	1200	< 2	680	3	< 0.00001	< 0.00005	0.017	< 0.0002	0.0069	0.033	< 0.000007	< 0.000007	110
R804213	Blasthole	Unclassified	6.17	6.3	5	2260	< 2	1600	5	< 0.00001	< 0.00005	0.01	0.0005	0.00343	0.042	0.000007	< 0.000007	2.28
S684745	Blasthole	Unclassified	6.93	6.47	4	847	< 2	450	2	< 0.00001	< 0.00005	0.004	< 0.0002	0.0125	0.032	< 0.000007	< 0.000007	1.91
S076762	Blasthole	CHLORITE SCHIST/HEMATITE	6.74	6.5	5	828	18	400	33	< 0.00001	< 0.00005	0.021	0.0011	0.00655	0.083	< 0.000007	< 0.000007	3.57
S074992	Blasthole	CHLORITE SCHIST/HEMATITE	7.75	7.08	11	1020	< 2	550	6	< 0.00001	< 0.00005	0.046	0.0011	0.00209	0.071	< 0.000007	< 0.000007	0.81
R805632	Blasthole	CHLORITE SCHIST/MAGNETITE	7.19	6.83	9	1530	< 2	960	6	< 0.00001	< 0.00005	0.021	< 0.0002	0.0335	0.056	0.000008	< 0.000007	9.1
S076968	Blasthole	CHLORITE SCHIST/MAGNETITE	7.59	6.7	11	547	< 2	220	7	< 0.00001	< 0.00005	0.033	0.0004	0.00132	0.042	< 0.000007	< 0.000007	1.28
S684417	Blasthole	CHLORITE SCHIST/MAGNETITE	7.2	6.65	8	731	< 2	340	10	< 0.00001	< 0.00005	0.013	0.0004	0.00183	0.032	< 0.000007	< 0.000007	2.08
S075744	Blasthole	CHLORITE SCHIST	6.75	6.39	8	1530	< 2	930	6	< 0.00001	< 0.00005	0.012	0.0006	0.0162	0.257	< 0.000007	< 0.000007	3.09
R807291	Blasthole	CHLORITE SCHIST	7.05	6.66	5	2010	< 2	1500	3	< 0.00001	< 0.00005	0.012	< 0.0002	0.00162	0.042	< 0.000007	< 0.000007	56.9
S684606	Blasthole	CHLORITE SCHIST	7.17	6.49	4	1830	< 2	1200	6	< 0.00001	< 0.00005	0.014	0.0003	0.0292	0.187	< 0.000007	< 0.000007	4.68
R807797	Blasthole	CHLORITE SCHIST	6.99	6.46	7	1820	< 2	1200	11	< 0.00001	< 0.00005	0.008	< 0.0002	0.00179	0.09	< 0.000007	< 0.000007	2.81
S076760	Blasthole	CHLORITE SCHIST	7.25	6.74	10	1130	< 2	600	4	< 0.00001	< 0.00005	0.016	0.0008	0.00421	0.652	< 0.000007	< 0.000007	6.12
S075727	Blasthole	CHLORITE SCHIST	7.47	6.93	11	2200	< 2	1700	7	< 0.00001	< 0.00005	0.029	< 0.0002	0.00561	0.029	< 0.000007	< 0.000007	2.88
R807731	Blasthole	CHLORITE SCHIST	7.39	6.55	7	1560	< 2	1000	8	< 0.00001	< 0.00005	0.012	0.0003	0.0113	0.184	< 0.000007	< 0.000007	4
S684530	Blasthole	CHLORITE SCHIST	7.55	7	12	1680	< 2	1100	2	< 0.00001	< 0.00005	0.029	0.0004	0.00311	0.127	< 0.000007	< 0.000007	133
R805578	Blasthole	CHLORITE SCHIST	7.38	6.81	10	940	< 2	480	9	< 0.00001	< 0.00005	0.022	0.0008	0.01	0.837	< 0.000007	< 0.000007	16.5
S075667	Blasthole	CHLORITE SCHIST	7.17	6.39	6	1440	< 2	860	6	< 0.00001	< 0.00005	0.01	< 0.0002	0.00208	0.143	< 0.000007	< 0.000007	2.24
R805460	Blasthole	CHLORITE SCHIST	7.31	7.38	26	261	< 2	80	3	< 0.00001	< 0.00005	0.049	0.0005	0.00857	0.052	< 0.000007	< 0.000007	3.55
S075663	Blasthole	CHLORITE SCHIST	7.7	6.58	9	1520	< 2	940	3	< 0.00001	< 0.00005	0.022	< 0.0002	0.00618	0.042	< 0.000007	< 0.000007	23.5
S684571	Blasthole	CHLORITE SCHIST	7.37	6.77	10	1160	< 2	540	10	< 0.00001	< 0.00005	0.023	< 0.0002	0.00232	0.02	< 0.000007	< 0.000007	0.56
S684603	Blasthole	CHLORITE SCHIST	7.61	7.75	44	674	< 2	270	7	< 0.00001	< 0.00005	0.04	< 0.0002	0.00477	0.052	< 0.000007	< 0.000007	19
S684537	Blasthole	CHLORITE SCHIST/LIM	6.87	6.74	20	1090	< 2	590	3	< 0.00001	< 0.00005	0.014	0.0004	0.00182	0.025	< 0.000007	< 0.000007	11.8
R805920	Blasthole	SILICIFIED GRANITE	8.43	7.78	36	288	< 2	55	6	< 0.00001	< 0.00005	0.378	0.0008	0.02331	0.282	0.000012	< 0.000007	1.43
R804742	Blasthole	SILICIFIED GRANITE	8.44	7.72	40	179	< 2	5	4	< 0.00001	< 0.00005	0.186	0.0007	0.0105	0.097	< 0.000007	< 0.000007	4.63
R804677	Blasthole	SILICIFIED GRANITE	9.43	8.21	85	262	< 2	6	6	< 0.00001	< 0.00005	1.05	0.0018	0.0106	0.158	0.00013	< 0.000007	1.62
R807636	Blasthole	TILL/GNEISS	8.79	7.51	32	175	< 2	12	5	< 0.00001	< 0.00005	0.565	0.0007	0.00632	0.147	0.000015	< 0.000007	0.33
R807653	Blasthole	TILL/GNEISS	8.21	7.67	57	283	< 2	50	10	< 0.00001	< 0.00005	0.079	0.0005	0.0298	0.107	< 0.000007	< 0.000007	17.6
R807430	Blasthole	TILL/GNEISS	8.3	7.83	61	250	< 2	22	8	< 0.00001	< 0.00005	0.151	< 0.0002	0.0203	0.199	< 0.000007	< 0.000007	5.02
P1-0-3	Drillhole	CHLORITE SCHIST/BIF	7.51	7.15	14	296	< 2	120	2	< 0.00001	< 0.00005	0.013	< 0.0002	0.00152	0.02	< 0.000007	< 0.000007	8.85
P1-3-6	Drillhole	CHLORITE SCHIST	6.35	6.15	< 2	740	7	390	2	< 0.00001	< 0.00005	0.002	0.0003	0.0164	0.041	0.000019	< 0.000007	21
P1-6-9	Drillhole	CHLORITE SCHIST/BIF	6.3	6.32	2	686	5	370	2	< 0.00001	< 0.00005	0.003	< 0.0002	0.0267	0.075	0.000016	< 0.000007	13
P1-9-12	Drillhole	CHLORITE SCHIST/BIF	4.92	4.89	< 2	1530	14	1100	3	< 0.00001	< 0.00005	0.13	0.0002	0.0155	0.084	0.000498	< 0.000007	23.1
P1-12-15	Drillhole	CHLORITE SCHIST/BIF	5.44	5.36	< 2	1580	13	1100	3	< 0.00001	< 0.00005	0.012	< 0.0002	0.0171	0.042	0.000059	< 0.000007	28.9
P-1-30	Drillhole	TILL/CHLORITE SCHIST	7.66	7.52	46	1090	< 2	590	5	< 0.00001	< 0.00005	0.027	< 0.0002	0.0267	0.044	< 0.000007	< 0.000007	87.6
P2-27-30	Drillhole	CHLORITE SCHIST/BIF	6.98	6.57	5	710	< 2	380	2	< 0.00001	< 0.00005	0.005	< 0.0002	0.0168	0.077	< 0.000007	< 0.000007	16.2
P2-24-27	Drillhole	BIF	7.5	6.84	9	491	< 2	230	2	< 0.00001	< 0.00005	0.019	< 0.0002	0.0163	0.056	< 0.000007	< 0.000007	18.7
P2-21-24	Drillhole	BIF	7.51	6.94	10	499	< 2	240	2	< 0.00001	< 0.00005	0.019	< 0.0002	0.0178	0.053	0.000017	< 0.000007	19.1
P2-18-21	Drillhole	BIF	7.7	7.45	34	625	< 2	310	2	< 0.00001	< 0.00005	0.028	< 0.0002	0.0185	0.053	< 0.000007	< 0.000007	15.4
P2-15-18	Drillhole	BIF	6.58	6.58	4	967	< 2	540	2	< 0.00001	< 0.00005	0.003	< 0.0002	0.0172	0.066	< 0.000007	< 0.000007	18.1
P2-12-15	Drillhole	CHLORITE SCHIST/BIF	5.93	6	< 2	1190	6	740	3	< 0.00001	< 0.00005	0.002	< 0.0002	0.0082	0.434	0.000013	< 0.000007	12.4
P2-9-12	Drillhole	CHLORITE SCHIST/BIF	6.55	6.55	3	961	3	560	3	< 0.00001	0.0001	0.002	< 0.0002	0.00983	0.257	< 0.000007	< 0.000007	13.3
P2-6-9	Drillhole	CHLORITE SCHIST/BIF	6.37	6.55	4	914	< 2	510	3	< 0.00001	< 0.00005	0.003	< 0.0002	0.0105	0.038	0.00001	< 0.000007	16.2
P2-3-6	Drillhole	CHLORITE SCHIST/BIF	7.35	7.07	14	512	< 2	250	2	< 0.00001	< 0.00005	0.014	< 0.0002	0.011	0.024	< 0.000007	< 0.000007	23.1
P2-0-3	Drillhole	CHLORITE SCHIST/BIF	7.78	7.29	26	721	< 2	370	1	< 0.00001	< 0.00005	0.017	0.0003	0.00341	0.022	< 0.000007	< 0.000007	35.7
P3-0-3	Drillhole	CHLORITE SCHIST	7.19	6.58	5	825	< 2	450	7	< 0.00001	< 0.00005	0.006	< 0.0002	0.00298	0.02	< 0.000007	< 0.000007	59.2
P3-3-8	Drillhole	CHLORITE SCHIST/BIF	7.57	7.36	12	426	< 2	210	2	< 0.00001	< 0.00005	0.012	< 0.0002	0.00756	0.036	< 0.000007	< 0.000007	14
P3-8-16	Drillhole	CHLORITE SCHIST/BIF	6.93	6.54	3	649	< 2	350	2	< 0.00001	< 0.00005	0.006	< 0.0002	0.00514	0.029	< 0.000007	< 0.000007	18.8
P5-0-8.5	Drillhole	CHLORITE SCHIST/BIF	6.51	6.32	2	905	3	490	1	< 0.00001	< 0.00005	0.002	< 0.0002	0.0186	0.05	0.000008	< 0.000007	21.4
P5-8.5-16	Drillhole	CHLORITE SCHIST/BIF	7.04	6.66	7	475	< 2	240	1	< 0.00001	< 0.00005	0.004	< 0.0002	0.0129	0.057	< 0.000007	< 0.000007	10.8
P5-16-19	Drillhole	CHLORITE SCHIST/BIF	7.17	7	14	568	< 2	290	1	< 0.00001	< 0.00005	0.006	< 0.0002	0.0151	0.063	0.000008	< 0.000007	17.4
P5-19-22	Drillhole	CHLORITE SCHIST/BIF	7.63	7.66	30	927	< 2	470	3	< 0.00001	< 0.00005	0.017	< 0.0002	0.0194	0.045	< 0.000007	< 0.000007	31.8
P5-22-25	Drillhole	CHLORITE SCHIST/BIF	7.98	7.73	60	624	< 2	280	4	< 0.00001	< 0.00005	0.114	< 0.0002	0.0217	0.049	< 0.000007	< 0.000007	46.6
P5-25-28	Drillhole	CHLORITE SCHIST/BIF	8.3	7.5	45	506	< 2	220	4	< 0.00001	< 0.00005	0.066	< 0.0002	0.0173	0.042	< 0.000007	< 0.000007	33.8
P4-0-1	Test pit	CHLORITE SCHIST/BIF	4.93	5.32	< 2	237	4	100	< 1	< 0.00001	< 0.00005	0.051	< 0.0002	0.016	0.057	0.000499	< 0.000007	5.82
P4-1-2	Test pit	CHLORITE SCHIST/BIF	7.49	7.57	50	504	< 2	220	2	< 0.00001	< 0.00005	0.01	< 0.0002	0.0158	0.041	< 0.000007	< 0.000007	39.2
P4-2-4	Test pit	CHLORITE SCHIST/BIF	6.35	6.55	8	458	< 2	230	1	< 0.00001	< 0.00005	0.001	< 0.0002	0.0154	0.055	0.000012	< 0.000007	22.4
P4-4-4.5	Test pit	CHLORITE SCHIST/BIF/TILL	7.03	7.35	66	595	< 2	270	2	< 0.00001	< 0.00005	0.003	< 0.0002	0.00705	0.04	< 0.000007	< 0.000007	44.2

Notes:

0.7 - Denotes a value exceeding the Metal and Diamonds Mining Effluent Regulations (MDMER) criterion

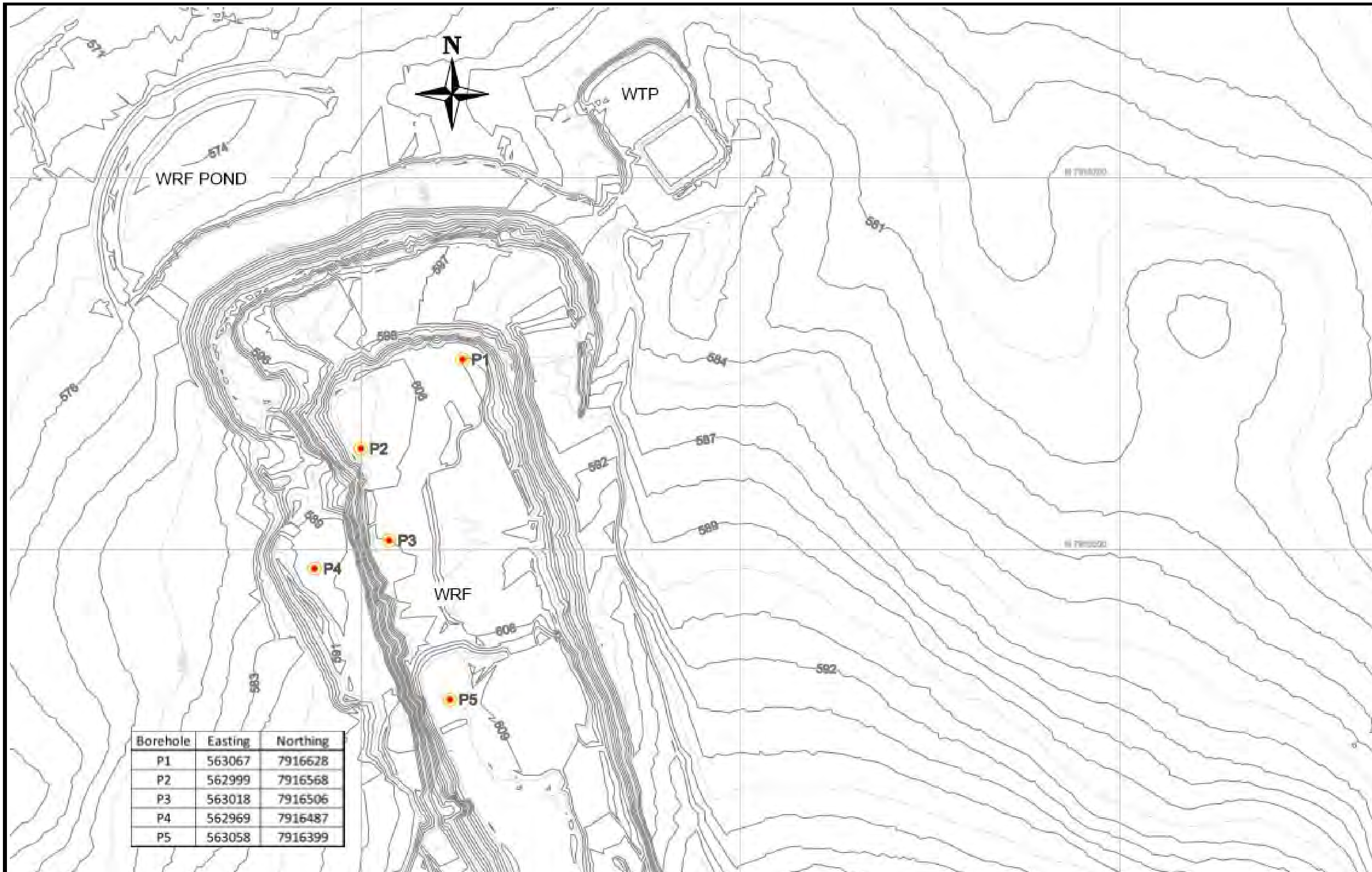
Table 5
Shake Flask Extraction Results

Cd	Co	Cr	Cu	Fe	K	Li	Mg	Mn	Mo	Na	Ni	Pb	Sb	Se	Sn	Sr	Ti	Tl	U	V	W	Y	Zn
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	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
-	-	-	0.3	-	-	-	-	-	-	-	0.5	0.2	-	-	-	-	-	-	-	-	-	-	0.5
< 0.000003	0.00035	0.00016	0.0003	0.019	0.677	0.0257	126	0.112	0.00112	0.49	0.001	0.00001	< 0.0009	0.00115	< 0.00006	0.00649	0.00007	0.000013	< 0.000002	0.00006	< 0.00002	0.000006	< 0.002
0.000019	0.00479	< 0.00008	0.0004	0.828	4.7	0.0206	44.1	3.36	0.00014	0.64	0.043	0.00002	< 0.0009	0.00182	< 0.00006	0.0245	< 0.00005	0.000057	< 0.000002	0.00002	0.00002	0.000208	< 0.002
0.000008	0.000172	0.00008	< 0.0002	0.021	0.904	0.0276	120	0.329	0.00946	0.61	0.0011	0.00002	< 0.0009	0.00395	0.00013	0.00876	0.00005	0.000005	< 0.000002	0.00004	0.00003	0.000013	< 0.002
0.000012	0.00112	0.00012	< 0.0002	0.018	0.975	0.0049	162	2.17	0.00066	0.55	0.011	0.00001	< 0.0009	0.00257	< 0.00006	0.0129	< 0.00005	0.000045	< 0.000002	< 0.00001	< 0.00002	0.000091	< 0.002
0.000018	0.000022	0.00014	< 0.0002	0.016	3.21	0.0126	66.3	0.0477	0.0536	0.76	0.0002	0.00002	< 0.0009	0.00098	0.00006	0.0169	0.0002	0.000007	0.00001	0.00007	0.0001	0.000005	0.003
< 0.000003	0.00004	0.0002	< 0.0002	0.008	1.17	0.0118	61	0.0282	0.00342	0.41	0.0003	< 0.00001	< 0.0009	0.00113	< 0.00006	0.00462	0.00011	0.000011	< 0.000002	0.00011	0.00008	0.000002	< 0.002
0.00001	0.0019	0.00014	< 0.0002	0.02	1.84	0.0614	184	1.65	0.00049	0.86	0.0251	0.00002	< 0.0009	0.00247	< 0.00006	0.012	< 0.00005	0.000072	< 0.000002	< 0.00001	< 0.00002	0.000069	< 0.002
< 0.000003	0.000348	0.00013	0.0009	< 0.007	5.72	0.0663	167	0.105	0.00098	1	0.0017	< 0.00001	< 0.0009	0.00372	< 0.00006	0.0158	< 0.00005	0.000013	0.000039	0.00011	< 0.00002	0.000002	< 0.002
0.000014	0.000443	0.00011	< 0.0002	0.008	8.01	0.186	82.8	0.167	0.00173	1.51	0.0013	< 0.00001	< 0.0009	0.00226	< 0.00006	0.0158	0.00008	0.000035	0.00115	0.00039	0.00003	0.000005	< 0.002
0.000011	0.000478	0.00016	0.0014	0.03	1.59	0.0785	73.4	0.168	0.00031	0.93	0.0018	0.00018	< 0.0009	0.00171	0.00011	0.00764	0.00024	0.00003	0.000048	0.00005	< 0.00002	0.000015	0.002
0.000068	0.00863	0.00013	0.0003	0.083	2.92	0.177	220	3.04	0.00017	1.56	0.072	0.00006	< 0.0009	0.00129	< 0.00006	0.0111	0.00012	0.000064	0.000987	0.00004	< 0.00002	0.000552	0.002
0.000004	0.000413	0.00011	0.0006	0.03	3.12	0.0138	123	0.369	0.00157	1.6	0.0018	0.00004	< 0.0009	0.00174	0.0001	0.0338	< 0.00005	0.000012	0.000019	0.00002	< 0.00002	0.000032	< 0.002
< 0.000003	0.001	< 0.00008	0.0013	0.01	2.01	0.0284	409	0.73	0.00031	3.02	0.0022	< 0.00001	< 0.0009	0.0007	< 0.00006	0.00416	0.00011	0.000031	< 0.000002	0.00008	0.00002	0.00002	< 0.002
0.000004	0.000502	0.0001	0.0006	0.018	2.82	0.0423	125	0.593	0.00108	0.78	0.0054	0.00001	< 0.0009	0.0012	0.00007	0.0105	0.00022	0.000011	< 0.000002	< 0.00001	0.00014	0.000006	< 0.002
0.000004	0.00145	0.00012	0.0016	0.008	3.17	0.04	110	1.01	0.00011	1.9	0.0061	< 0.00001	< 0.0009	0.00282	0.00006	0.0425	0.00758	0.00002	< 0.000002	0.00006	0.0001	0.000004	< 0.002
0.000004	0.000231	0.00015	0.0023	0.013	0.792	0.003	150	0.0564	0.0086	0.41	0.0018	< 0.00001	< 0.0009	0.00072	0.0001	0.00464	0.00005	0.000046	0.000007	0.00009	< 0.00002	0.000002	< 0.002
0.000005	0.000209	0.00011	0.0007	0.008	39.9	0.0138	238	0.636	0.00076	5.66	0.0009	< 0.00001	< 0.0009	0.00054	< 0.00006	0.00888	0.0001	0.000038	0.00008	0.00003	< 0.00002	0.000005	< 0.002
< 0.000003	0.000053	0.00009	< 0.0002	0.02	2.65	0.0013	72.3	0.0412	0.0031	0.84	0.0003	< 0.00001	< 0.0009	0.00149	< 0.00006	0.00208	< 0.00005	0.000019	< 0.000002	0.00003	< 0.00002	0.000003	< 0.002
< 0.000003	0.000088	0.00012	< 0.0002	0.017	2.04	0.0029	101	0.134	0.00871	0.81	0.0006	< 0.00001	< 0.0009	0.00122	< 0.00006	0.00274	0.00007	0.000055	< 0.000002	0.00003	< 0.00002	< 0.000002	< 0.002
0.000003	0.000581	0.00012	0.002	0.013	14	0.0193	240	0.22	0.00114	5.64	0.0016	0.00003	< 0.0009	0.0026	0.00017	0.0126	0.00013	< 0.000005	< 0.000002	0.0001	< 0.00002	0.000005	< 0.002
0.000011	0.000661	< 0.00008	0.0006	0.01	1.88	0.0061	319	0.627	0.0009	1.12	0.003	< 0.00001	< 0.0009	0.00111	< 0.00006	0.00386	< 0.00005	0.000096	< 0.000002	0.00012	< 0.00002	0.000007	0.002
0.000008	0.001054	< 0.00008	< 0.0002	0.027	16.6	0.014	306	0.254	0.00113	3.59	0.0033	< 0.00001	< 0.0009	0.00441	< 0.00006	0.00435	< 0.00005	0.000026	< 0.000002	0.00003	< 0.00002	0.000009	< 0.002
0.000003	0.000202	< 0.00008	0.0005	0.009	3.62	0.0159	309	0.203	0.0003	1.78	0.0015	< 0.00001	< 0.0009	0.00401	0.00008	0.00331	< 0.00005	0.000032	< 0.000002	< 0.00001	< 0.00002	0.000003	< 0.002
< 0.000003	0.000292	0.00013	0.0002	0.024	2.02	0.18	172	0.0164	0.00024	2.64	0.0025	0.00003	< 0.0009	0.00321	< 0.00006	0.0113	0.00015	0.00003	< 0.000002	0.00011	0.00003	0.000009	< 0.002
0.000014	0.000391	0.00011	0.0009	< 0.007	1.9	0.0324	426	0.135	0.00109	1.72	0.0018	< 0.00001	< 0.0009	0.00168	0.00006	0.0138	0.00013	0.000016	0.000089	0.00002	0.00005	0.000011	< 0.002
< 0.000003	0.000801	0.00011	< 0.0002	0.008	7.9	0.0359	262	0.287	0.00058	2.44	0.002	< 0.00001	< 0.0009	0.0026	< 0.00006	0.00785	0.00006	0.000079	0.000037	0.00007	< 0.00002	0.000007	< 0.002
0.000016	0.000126	0.00023	< 0.0002	< 0.007	3.41	0.0114	224	0.0772	0.00612	1.88	0.0005	< 0.00001	< 0.0009	0.00124	< 0.00006	0.0398	< 0.00005	< 0.000005	0.000372	0.00024	0.00009	0.000007	< 0.002
< 0.000003	0.000205	0.0001	0.0002	0.02	10.8	0.148	125	0.0589	0.00309	2.12	0.0007	0.00004	< 0.0009	0.00547	< 0.00006	0.0303	< 0.00005	0.000008	0.000306	0.00016	0.00022	0.000006	< 0.002
< 0.000003	0.000617	0.00008	< 0.0002	< 0.007	1.91	0.0097	230	0.55	0.00049	0.72	0.0024	< 0.00001	< 0.0009	0.00242	< 0.00006	0.00888	< 0.00005	0.000019	< 0.000002	0.00003	< 0.00002	0.000007	< 0.002
< 0.000003	0.000034	0.00008	0.0004	0.02	14.2	0.0053	25.1	0.0262	0.00794	3.96	0.0002	0.00004	< 0.0009	0.00126	0.00007	0.00582	0.00058	< 0.000005	0.00001	0.00015	0.00039	0.000002	< 0.002
0.000005	0.000465	0.00013	0.0003	0.011	13.6	0.0083	247	0.389	0.00175	2.68	0.0011	< 0.00001	< 0.0009	0.00105	0.00006	0.0145	< 0.00005	0.000006	< 0.000002	0.00005	0.00003	0.000003	< 0.002
< 0.000003	0.00015	0.00011	0.0002	0.011	2.98	0.0011	184	0.156	0.00115	0.63	0.0006	< 0.00001	< 0.0009	0.00023	0.00008	0.00303	0.00019	0.000013	< 0.000002	0.00003	0.0005	0.000004	< 0.002
< 0.000003	0.000108	0.00016	0.0003	0.017	19.6	0.0038	73.3	0.0525	0.00683	2.24	0.0004	< 0.00001	< 0.0009	0.0011	0.0001	0.00832	0.00027	0.000005	0.000007	0.00025	0.00025	0.000003	< 0.002
< 0.000003	0.000222	0.00052	0.0005	0.011	1.03	0.0036	169	0.132	0.00311	1.76	0.0011	< 0.00001	0.001	0.00626	0.00015	0.00382	< 0.00005	< 0.000005	< 0.000002	0.00013	0.00004	0.000002	< 0.002
0.000009	0.000085	0.00013	0.0002	0.296	76.1	0.0256	4.55	0.00641	0.0349	5.36	0.0001	0.00006	< 0.0009	0.00238	< 0.00006	0.00265	0.01028	0.000043	0.000218	0.00082	0.00141	0.000044	< 0.002
< 0.000003	0.000022	0.001	0.0003	0.035	22.7	0.0074	9.8	0.00261	0.0084	4.11	0.0002	< 0.00001	< 0.0009	0.00077	0.00008	0.0128	0.00105	0.00001	0.000022	0.00072	0.0004	0.000004	< 0.002
0.00006	0.000467	0.00318	0.0042	1.06	74.4	0.019	1.6	0.0164	0.147	8.19	0.0012	0.00025	< 0.0009	0.00047	< 0.00006	0.00426	0.0801	0.00006	0.000072	0.022	0.123	0.000628	< 0.002
0.000028	0.00015	0.00041	0.0007	0.537	48.3	0.0125	1.45	0.00402	0.102	4.72	0.0004	0.0001	< 0.0009	0.00043	< 0.00006	0.00118	0.0197	0.000021	0.000067	0.00228	0.00232	0.000079	< 0.002
< 0.000003	0.000065	0.00013	0.0013	0.021	22.6	0.0078	13.5	0.0222	0.01707	7.39	0.0004	< 0.00001	< 0.0009	0.00048	0.00007	0.0173	0.00071	0.000008	0.000821	0.00054	0.00254	0.000009	< 0.002
< 0.000003	0.000021	0.00011	< 0.0002	0.063	51.5	0.016	7.87	0.00451	0.00671	6.52	< 0.0001	0.00002	< 0.0009	0.00049	0.0001	0.0109	0.00243	0.000025	0.00174	0.00065	0.00174	0.000009	< 0.002
< 0.000003	0.000285	0.00008	0.0002	< 0.007	1.78	0.0046	30.9	0.152	0.00157	1.2	0.0004	< 0.00001	< 0.0009	0.0013	< 0.00006	0.00792	0.00007	0.000011	0.000018	0.00005	< 0.00002	0.000002	< 0.002
0.000026	0.00435	< 0.00008	0.0002	< 0.007	12.9	0.0309	90.4	3.15	0.00029	1.28	0.0209	< 0.00001	< 0.0009	0.00381	< 0.00006	0.0178	< 0.00005	0.000063	0.000005	0.00002	< 0.00002	0.000038	< 0.002
0.000011	0.00369	0.00012	0.0005	0.018	20.5	0.0325	85.5	2.21	0.00026	1.62	0.0319	0.00002	< 0.0009	0.00291	< 0.00006	0.0179	< 0.00005	0.000071	0.000054	0.00004	< 0.00002	0.000138	< 0.002
0.00053	0.293	0.00023	0.0027	2.45	7.73	0.0835	254	15.6	< 0.00004	1.54	**0.841**	0.00086	< 0.0009	0.00517	< 0.00006	0.0353	< 0.00005	0.000356	0.000915	0.00009	< 0.00002	0.0104	0.024
0.000196	0.133	0.00012	0.0005	0.399	6.61	0.0345	242	14.4	0.00018	1.16	0.424	< 0.00001	< 0.0009	0.00372	< 0.00006	0.035	< 0.00005	0.000265	0.000213	0.00001	< 0.00002	0.00359	0.004
0.000007	0.000444	< 0.00008	0.0006	< 0.007	16.5	0.0178	117	0.684	0.0123	3.84	0.0016	0.00002	< 0.0009	0.00161	< 0.00006	0.0564	< 0.00005	0.000017	0.000361	0.00004	0.0001	0.00001	< 0.002
0.000016	0.00183	0.00016	0.0005	< 0.007	15.9	0.0675	86.2	2.31	0.00092	1.62	0.0043	0.00002	< 0.0009	0.00141	< 0.00006	0.0222	< 0.00005	0.000085	0.000014	0.00002	< 0.00002	0.00001	< 0.002
< 0.000003	0.000393	0.00008	0.0003	< 0.007	20.6	0.0455	45.7	0.495	0.00501	3.06	0.0008	< 0.00001	< 0.0009	0.0007	< 0.00006	0.0332	< 0.00005	0.000034	0.000056	0.00001	< 0.00002	0.000008	< 0.002
0.000034	0.000463	< 0.00008	0.0003	< 0.007	23.4	0.0446	49.1	0.635	0.00633	3.19	0.001	0.00004	< 0.0009	0.00067	< 0.00006	0.0348	< 0.00005	0.000032	0.00006	0.00001	< 0.00002	0.000005	< 0.002
0.000009	0.000647	0.00011	0.0003	< 0.007	18.1	0.0498	80.5	1.15	0.00725	1.79	0.0008	< 0.00001	< 0.0009	0.0008	< 0.00006	0.0252	0.00006	0.000069	0.000102	0.00002	< 0.00002	0.000006	< 0.002
0.000042	0.00505	< 0.00008	0.0002	< 0.007	9.72	0.0534	130	4.85	0.00026	1.2	0.0129	0.00718	< 0.0009	0.00245	< 0.00006	0.0247	< 0.00005	0.000142	0.000018	< 0.00001	< 0.00002	0.000044	< 0.002
0.000015	0.00689	0.00014	0.0004	0.014	10.7	0.182	177	2.48	0.00012	1.01	0.022	0.00015	< 0.0009	0.00465	< 0.00006	0.018	< 0.00005	0.0008	0.000016	0.00003	< 0.00002	0.000107	< 0.002
0.000018	0.00281	0.00016	< 0.0002	< 0.007	11.6	0.12	133	1.68	0.00017	1.53	0.0093	0.0491	< 0.0009	0.00398	< 0.00006	0.0123	< 0.00005	0.000087	0.000026	< 0.00001	< 0.00002	0.000027	< 0.002
0.000024	0.00482	< 0.00008	< 0.0002	0.012	12.8	0.0386	121	3.31	0.00011	1.19	0.0216	0.00006	< 0.0009	0.00285	< 0.00006	0.0122	< 0.00005	0.000112	0.000018	0.00013	< 0.00002	0.000046	< 0.002
< 0.000003	0.000184	< 0.00008	0.0002	< 0.007	19.2	0.0172	47	0.133	0.00193	1.95	0.0008	< 0.00001	< 0.0009	0.00196	< 0.00006	0.0139	< 0.00005	0.000042	0.000016	0.00001	0.00002	0.000002	< 0.002
< 0.000003	0.000275	< 0.00008	0.0004	0.011	4.82	0.0115	80.4	0.0929	0.0034	1.41	0.0002	0.00007	< 0.0009	0.00176	< 0.00006	0.0112	< 0.00005	0.000012	0.000033	0.00004	< 0.00002	0.00001	< 0.002
0.000007	0.0017	0.0001	0.0002	< 0.007	3.88	0.0092	85.4	0.526	0.00094	1.3	0.0009	< 0.00001	< 0.0009	0.00127	< 0.00006	0.0263	< 0.00005	0.000014	0.000002	0.00004	< 0.00002	0.000005	< 0.002
< 0.000003	0.000171	< 0.00008	0.0002	< 0.007	8.2	0.0229	44.2	0.129	0.00284	0.84	0.0008	0.00003	< 0.0009	0.00084	< 0.00006	0.00924	< 0.00005	0.000016	0.000011	0.00001	< 0.00002	0.000002	< 0.002
0.000024	0.000669	0.00019	0.0003	< 0.007	4.09	0.0215	76.2	0.573	0.00136	0.5	0.0041	0.00004	< 0.0009	0.00189	< 0.00006	0.0111	< 0.00005	0.000073	0.000009	0.00002	< 0.00002	0.000019	< 0.002
0.00001	0.00276	0.00015	0.0015	< 0.007	16.3	0.0349	117	1.28	0.00033	1.12	0.0168	0.00004	< 0.0009	0.0051	< 0.00006	0.0224	< 0.00005	0.000076	0.000013	< 0.00001	< 0.00002	0.000054	< 0.002
0.000008	0.000639	< 0.00008	0.0002	< 0.007	14.5	0.033	50.7	0.621	0.00064	1.29	0.0043	0.00003	< 0.0009	0.00213	< 0.00006	0.00948	< 0.00005	0.000021	0.000008	0.00007	0.00006	0.000005	< 0.002
0.000003	0.000499	0.00012	0.0006	< 0.007	17.5	0.037	58.6	0.56	0.00077	1.52	0.0027	< 0.00001	< 0.0009	0.00227	< 0.00006	0.012	< 0.00005	0.000023	0.000014	0.00002	< 0.00002	0.000006	< 0.002
0.000008	0.000328	< 0.00008	0.0002	< 0.007	18.9	0.0251	107	0.172	0.00597	1.94	0.0015	< 0.00001	< 0.0009	0.00179	< 0.00006	0.0245	< 0.00005	0.000026	0.000116	0.00002	< 0.00002	0.000011	< 0.002
0.000003	0.000143	< 0.00008	0.0006	< 0.007	19.3	0.0138	54.5	0.0976	0.0115	3.9	0.0002	0.00007	< 0.0009	0.00072	< 0.00006	0.0474	< 0.00005	0.000016	0.000674	0.00004	0.00013	0.000008	< 0.002
0.000004	0.00011	0.00011	0.0005	< 0.007	17.4	0.0186	41.1	0.04	0.0155	3.98	0.0003	< 0.00001	< 0.0009	0.0008	< 0.00006	0.0362	< 0.00005	0.000012	0.000516	0.0001	0.00017	0.000009	< 0.002
0.000091	0.0458	0.00017	0.0018	0.166	3.74	0.0857	22.6	1.6	0.0003	0.26	0.191	0.00004	< 0.0009	0.00172	< 0.00006	0.00822	< 0.00005	0.000156	0.000254	< 0.00001	< 0.00002	0.00131	0.005
< 0.000003	0.000209	0.00011	< 0.0002	< 0.007	10.5	0.0269	42.3	0.0641	0.00047	1.27	0.001	< 0.00001	< 0.0009	0.0016	< 0.00006	0.0232	< 0.00005	0.000029	0.000052	< 0.00001	< 0.00002	0.000007	< 0.002
0.000019	0.00215	0.00011	< 0.0002	< 0.007	8.23	0.0463	43.1	0.606	< 0.00004	0.54	0.0198	0.00005	< 0.0009	0.00304	< 0.00006	0.0165	< 0.00005	0.000084	0.000015	< 0.00001	< 0.00002	0.000055	< 0.002
< 0.000003	0.0005	0.00015	< 0.0002	< 0.007	3.52	0.0461	57.5	0.157	0.00025	0.45	0.0038	0.0198	< 0.0009	0.00329	< 0.00006	0.0214	< 0.00005	0.000067	0.000068	< 0.00001	< 0.00002	0.000018	< 0.002

Notes:

0.7 - Denotes a value exceeding the Metal and Diamonds Mining Effluent Regulations (MDMER) criterion

Figures



Borehole	Easting	Northing
P1	563067	7916628
P2	562999	7916568
P3	563018	7916506
P4	562969	7916487
P5	563058	7916399

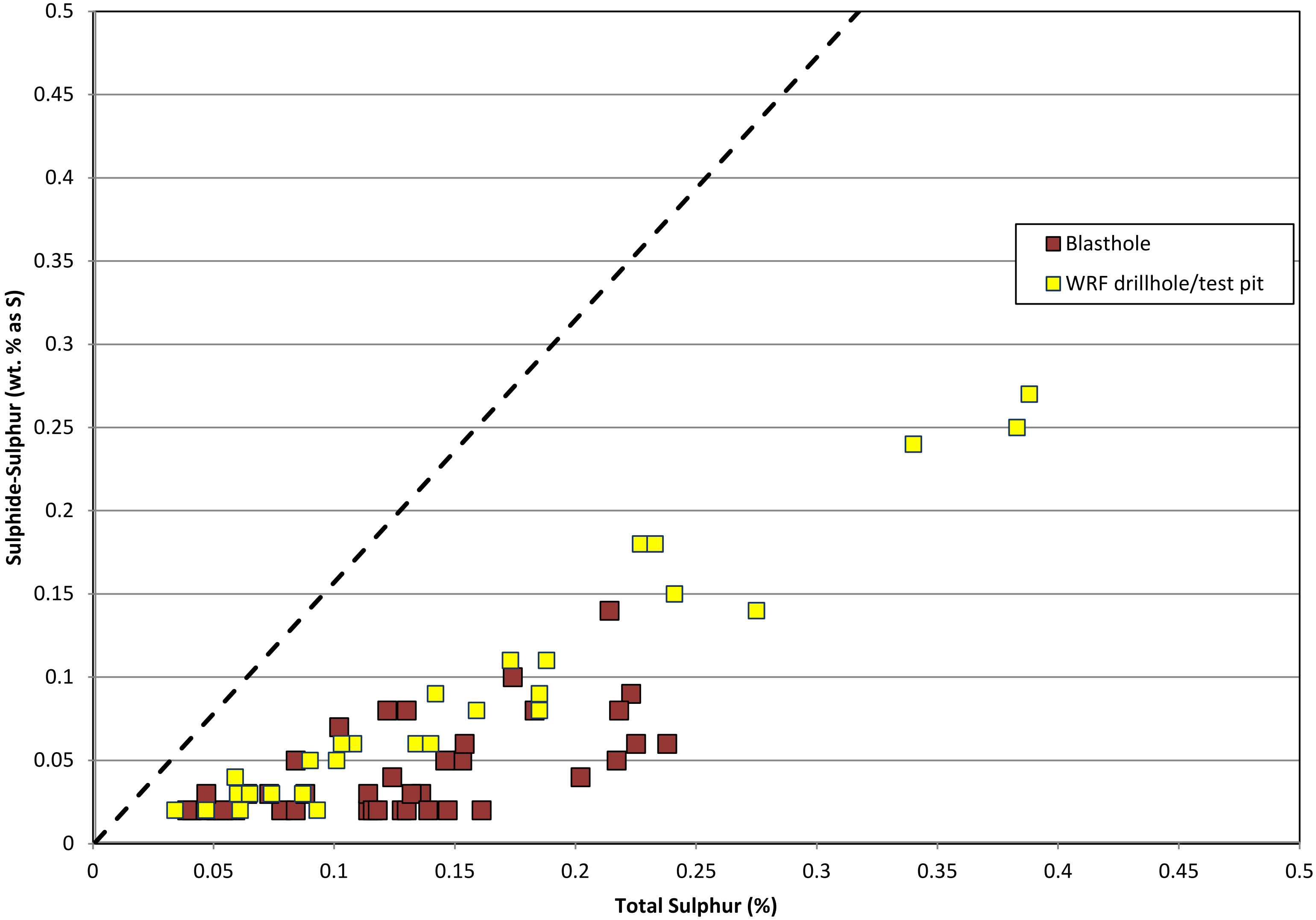
GOLDER

WRF drilling and test pitting locations for holes P1, P2, P3, P4 and P5

PROJECT NO: 1790951		DATE:	SEPT. 2019
BY:	LC	Review:	KDV

BAFFINLAND

FIGURE 1



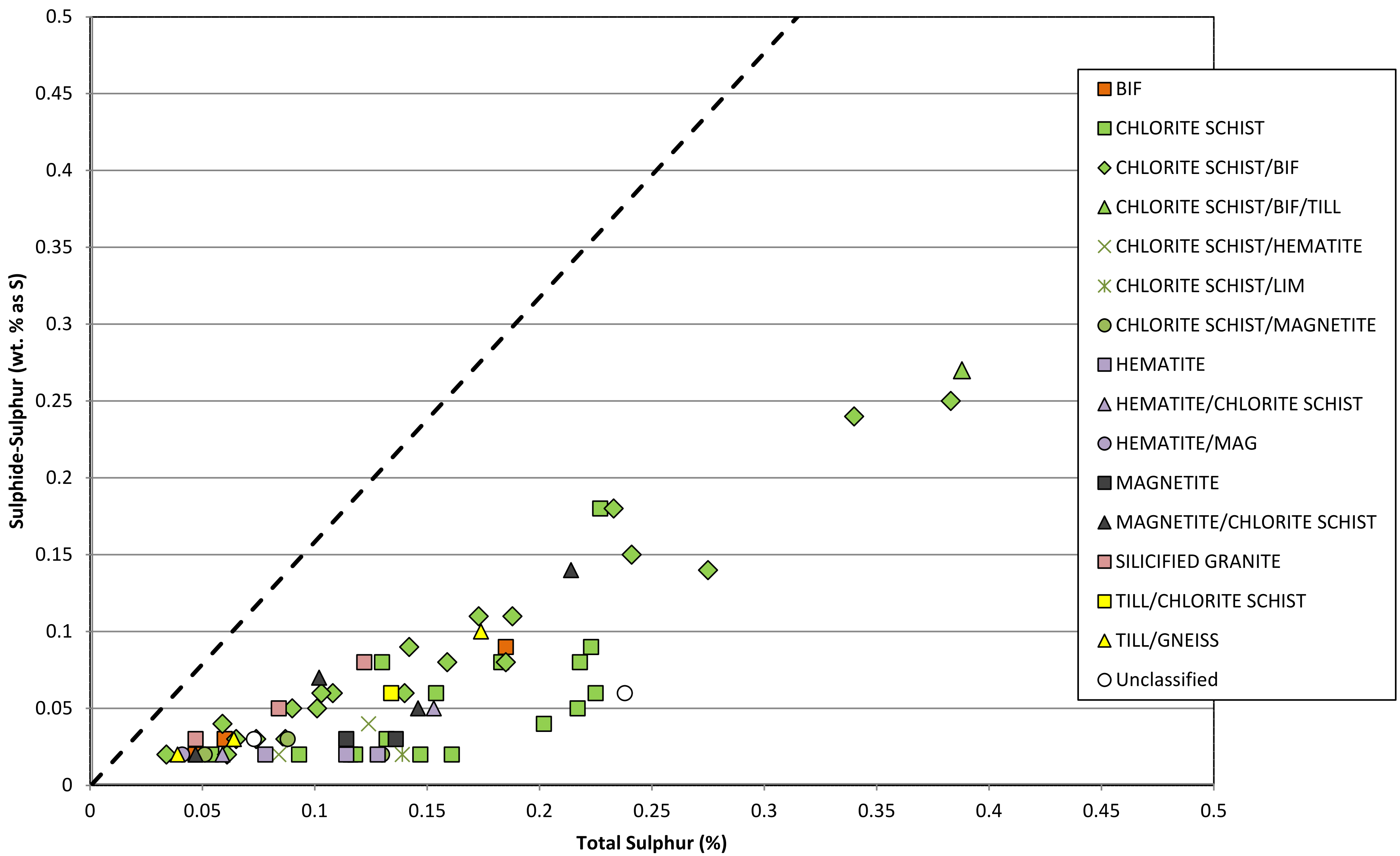
GOLDER

Sulphide-Sulphur vs Total Sulphur (Sample Type)

PROJECT NO: 1790951		DATE:	SEPT. 2019
BY:	LC	Review:	KDV

BAFFINLAND

FIGURE 2



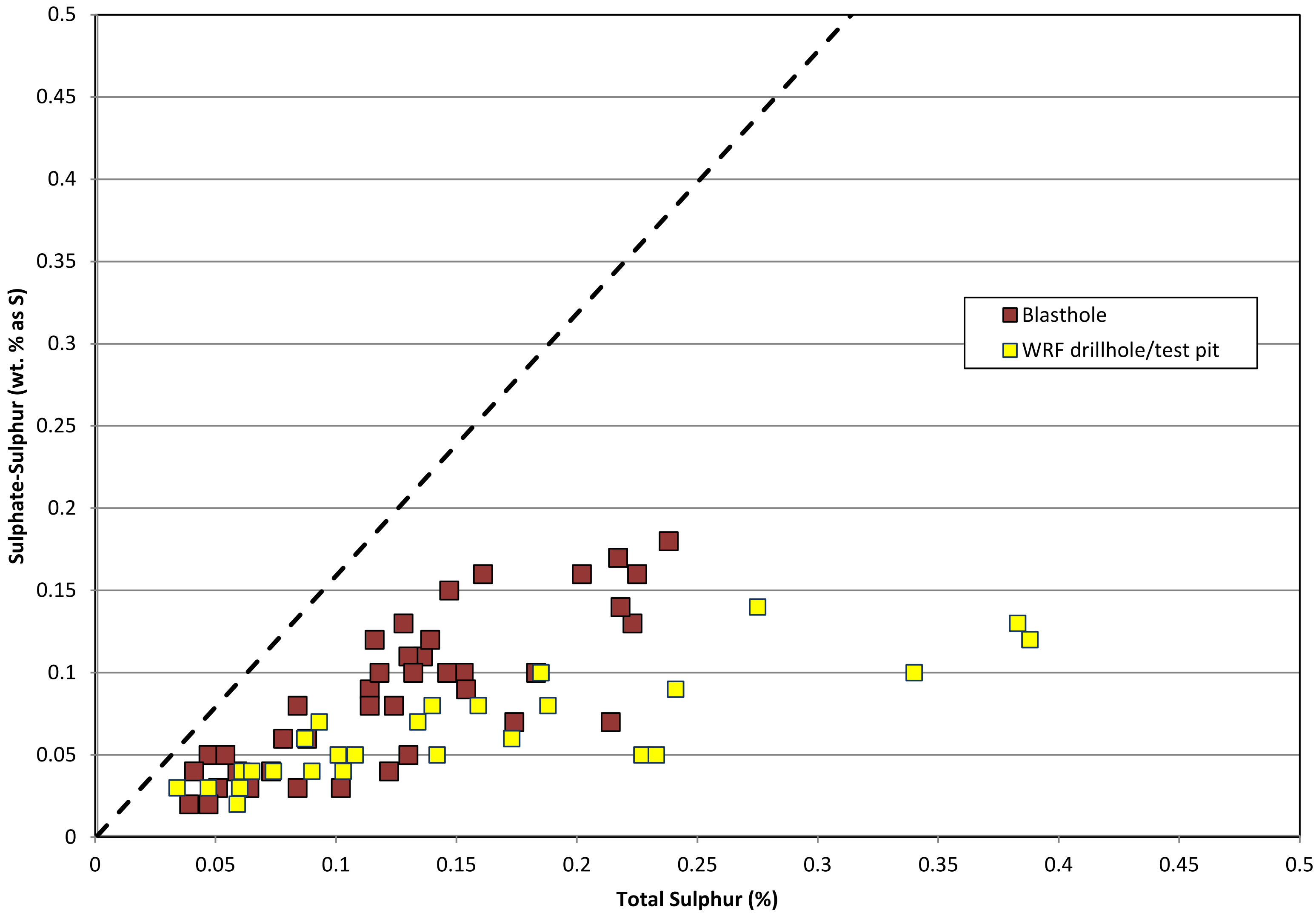
GOLDER

Sulphide-Sulphur vs Total Sulphur (Lithology)

PROJECT NO: 1790951		DATE:	SEPT. 2019
BY:	LC	Review:	KDV

BAFFINLAND

FIGURE 3



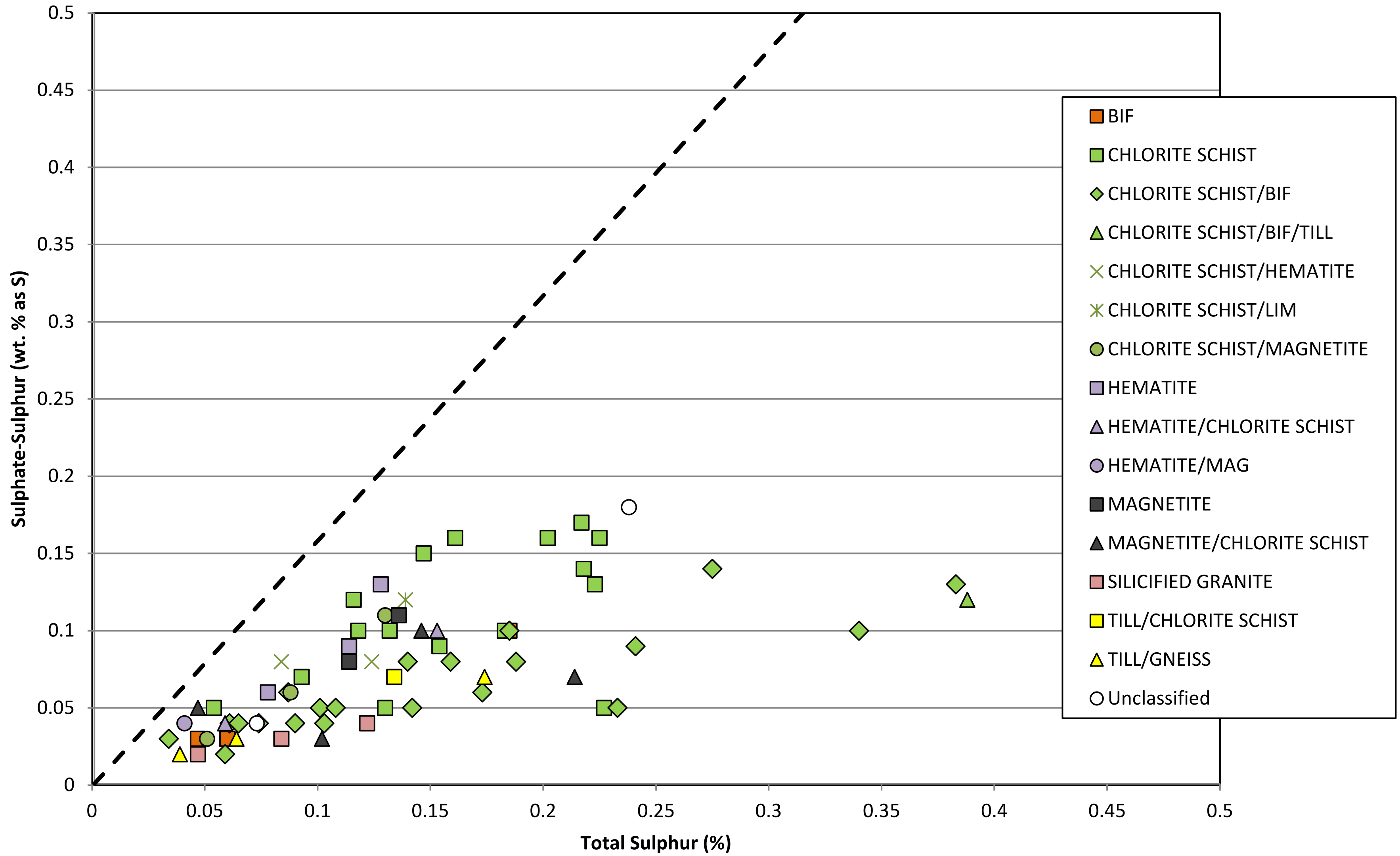
GOLDER

Sulphate-Sulphur vs Total Sulphur (Sample Type)

PROJECT NO: 1790951		DATE:	SEPT. 2019
BY:	LC	Review:	KDV

BAFFINLAND

FIGURE 4



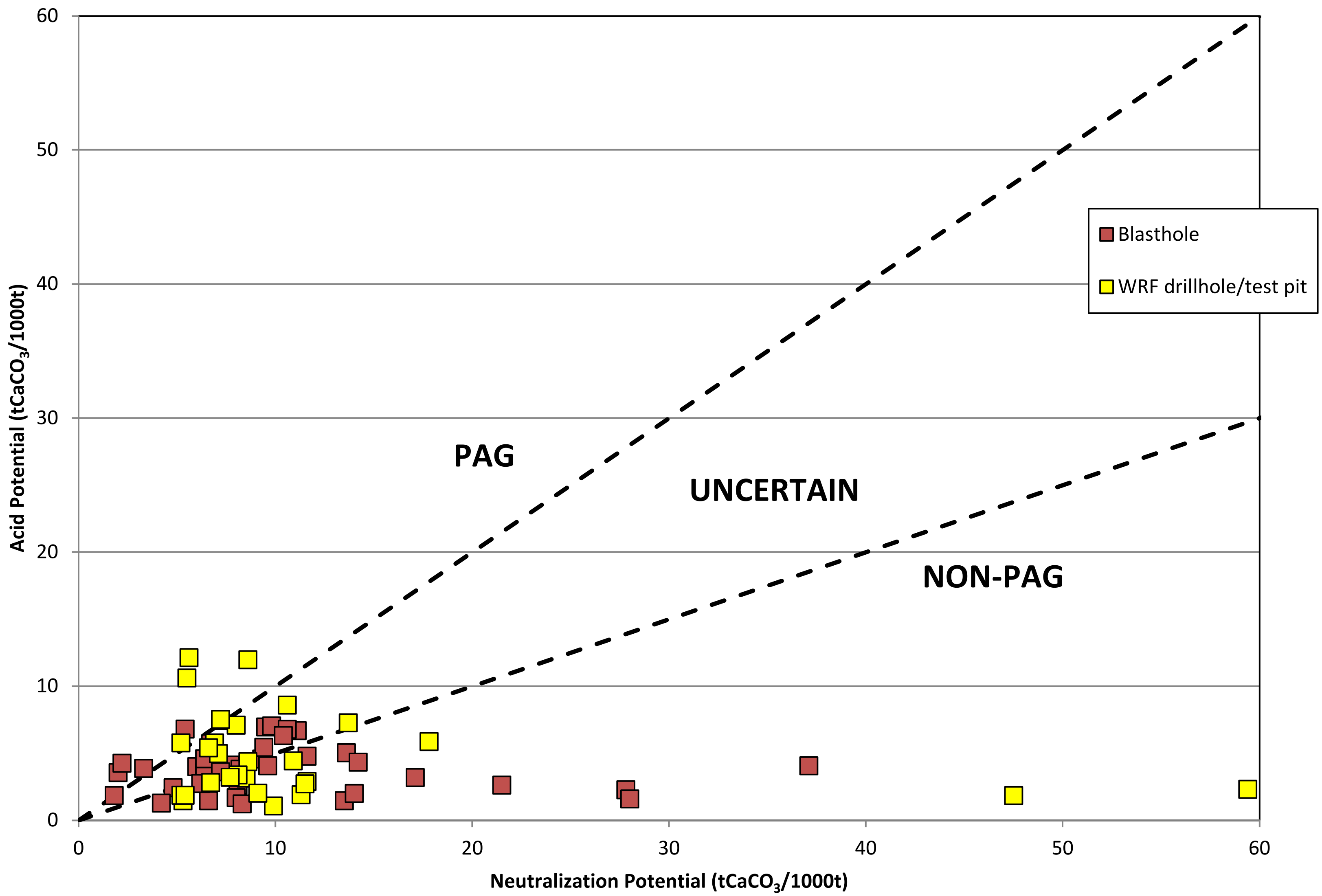
GOLDER

Sulphate-Sulphur vs Total Sulphur (Lithology)

PROJECT NO: 1790951		DATE:	SEPT. 2019
BY:	LC	Review:	KDV

BAFFINLAND

FIGURE 5



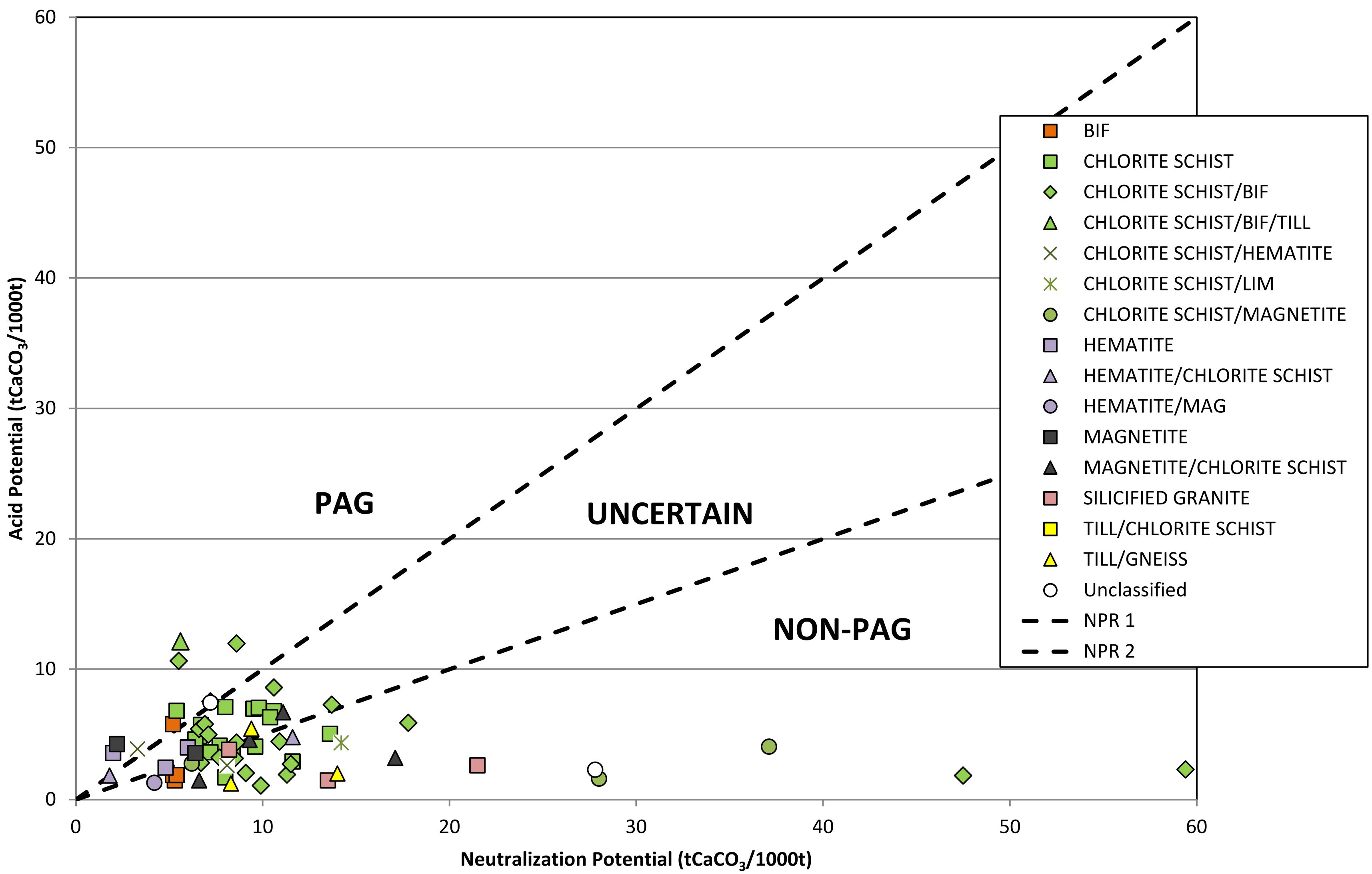
GOLDER

Acid Potential vs Neutralization Potential (Sample Type)

PROJECT NO: 1790951		DATE:	SEPT. 2019
BY:	LC	Review:	KDV

BAFFINLAND

FIGURE 6



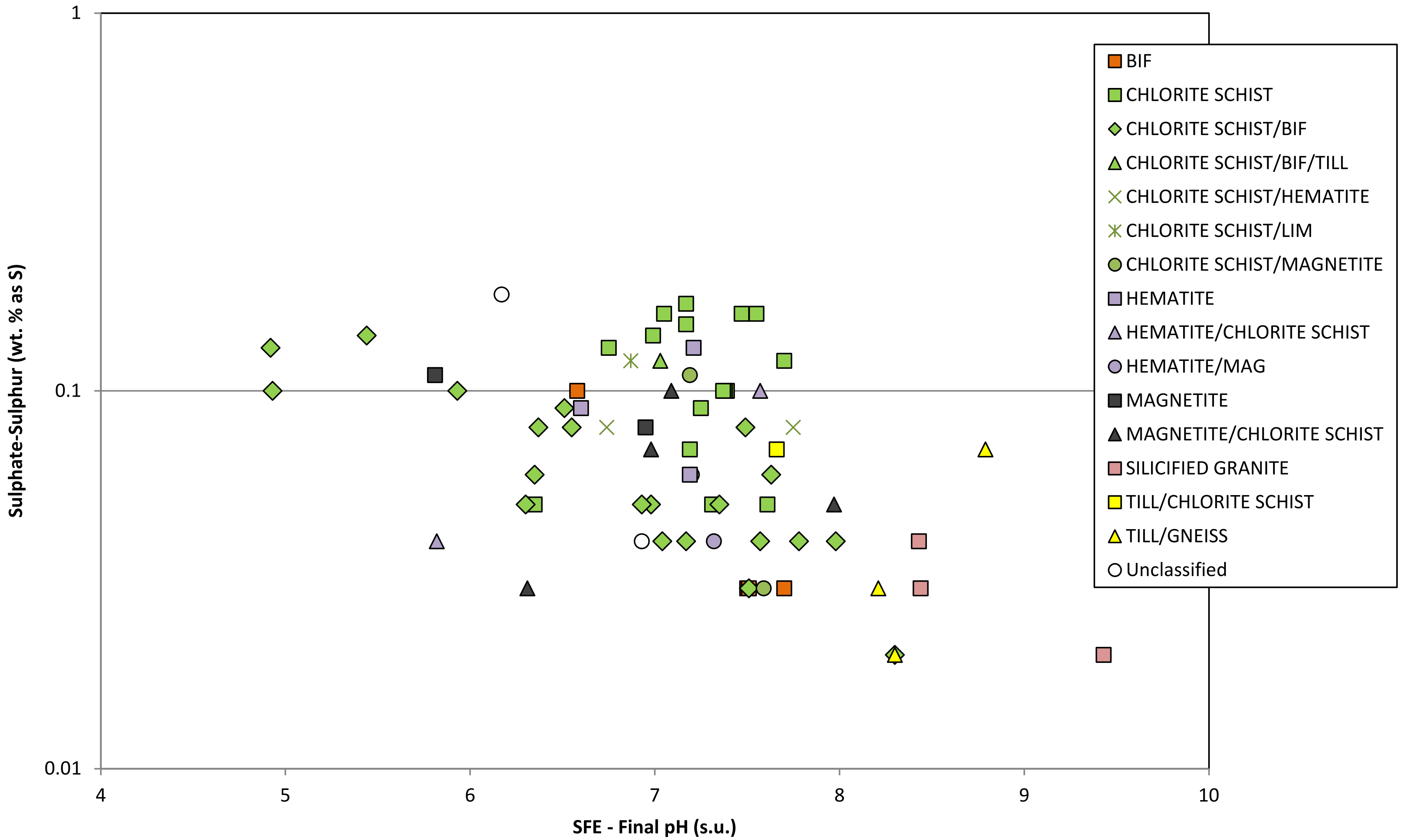
GOLDER

Acid Potential vs Neutralization Potential (Lithology)

PROJECT NO: 1790951		DATE:	SEPT. 2019
BY:	LC	Review:	KDV

BAFFINLAND

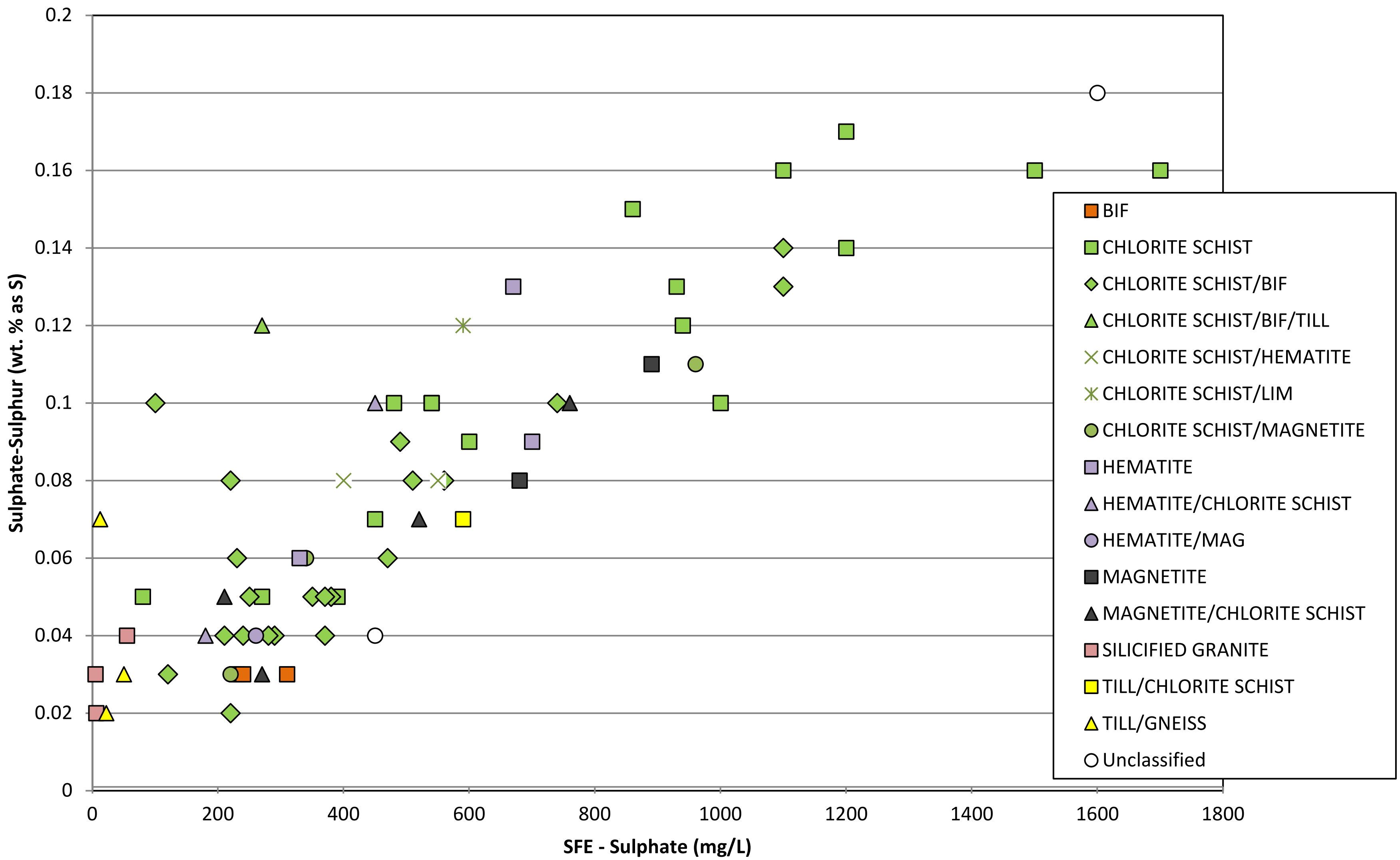
FIGURE 7



GOLDER

Sulphate-Sulphur vs SFE Final pH

PROJECT NO: 1790951		DATE:	SEPT. 2019	BAFFINLAND	FIGURE 8
BY:	LC	Review:	KDV		



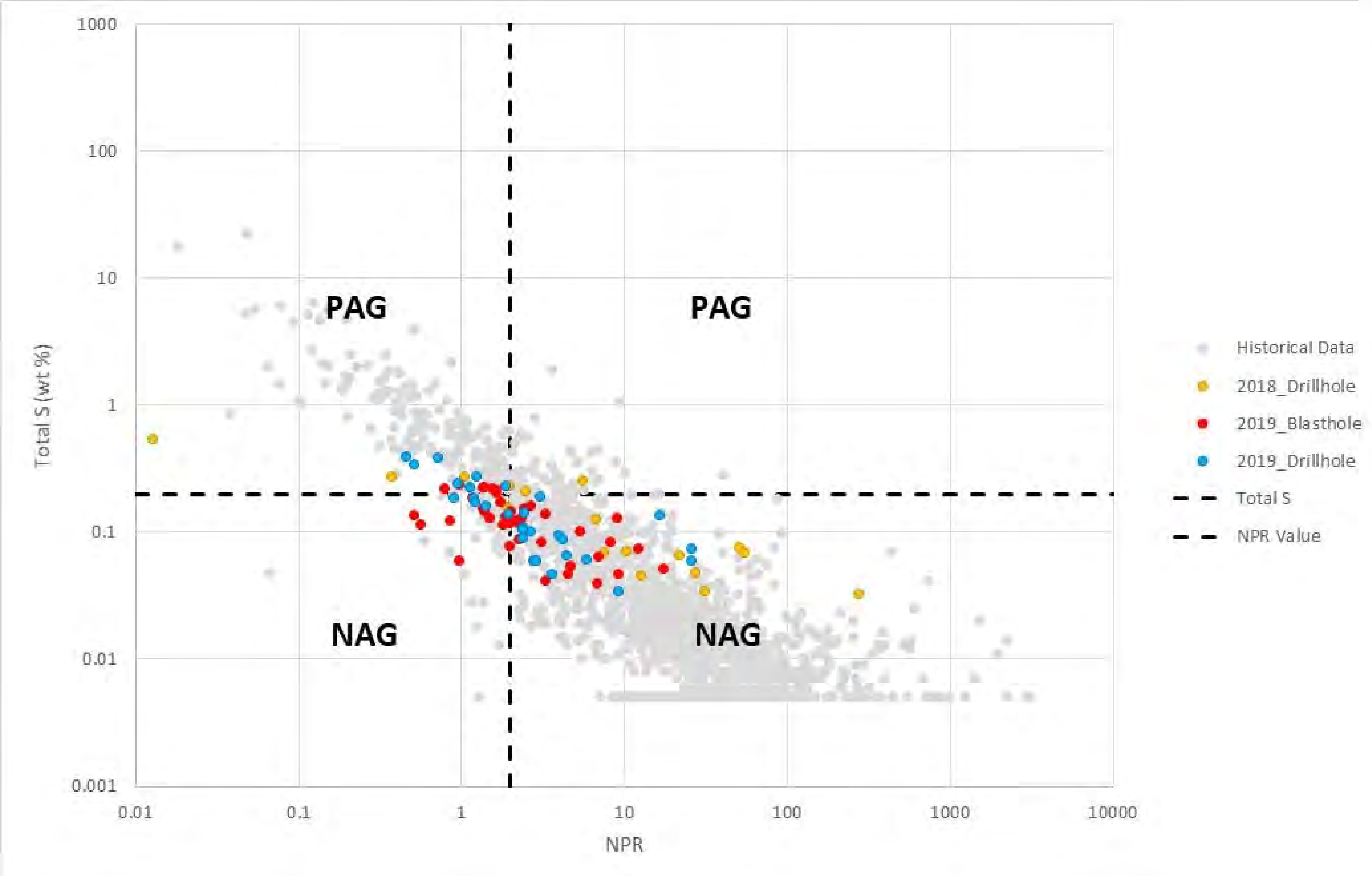
GOLDER

Sulphate-Sulphur vs SFE Sulphate

PROJECT NO: 1790951		DATE:	SEPT. 2019
BY:	LC	Review:	KDV

BAFFINLAND

FIGURE 9



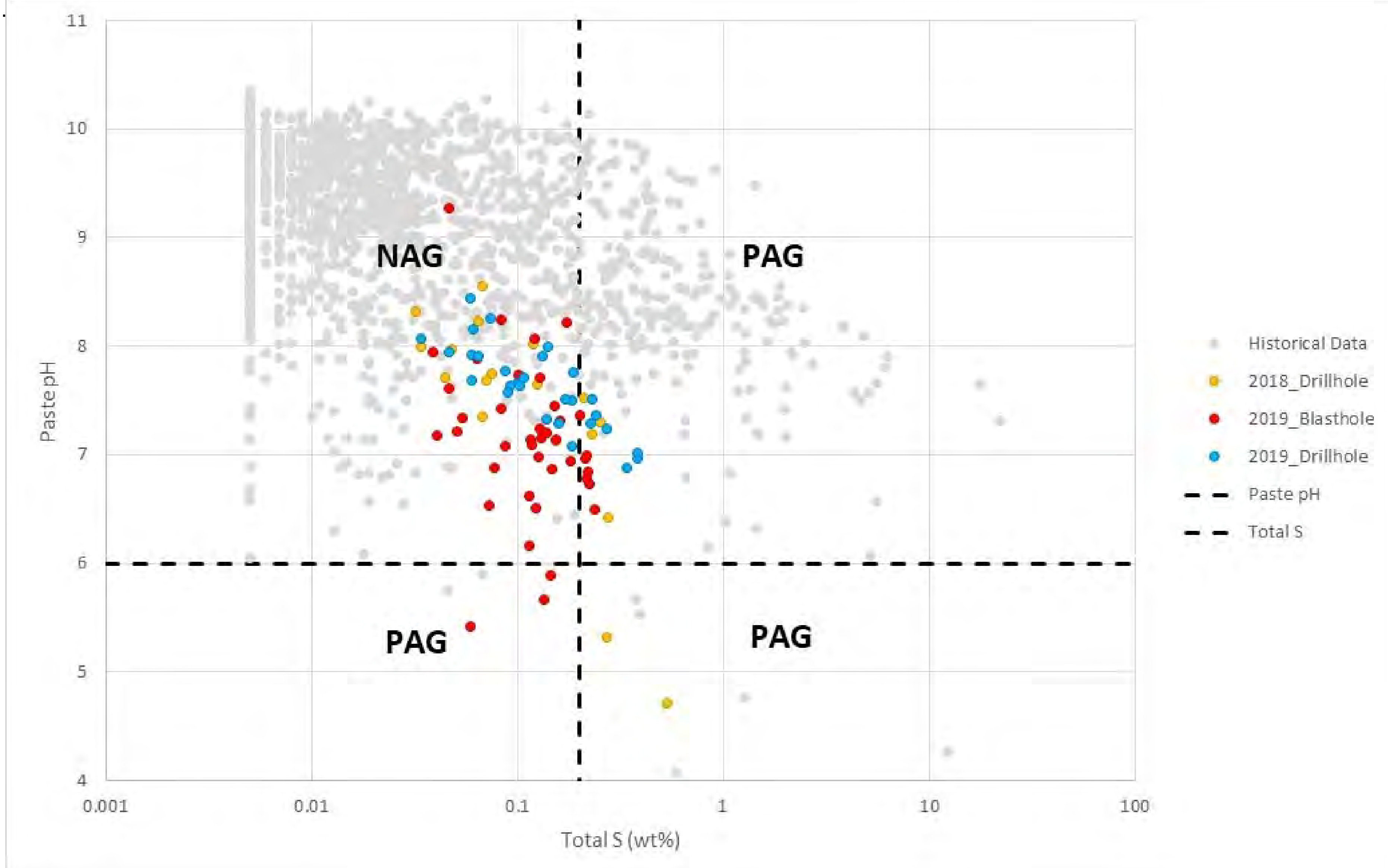
GOLDER

Total Sulphur Content compared to NPR Values

PROJECT NO: 1790951		DATE:	DEC. 2019
BY:	DFL	Review:	KDV

BAFFINLAND

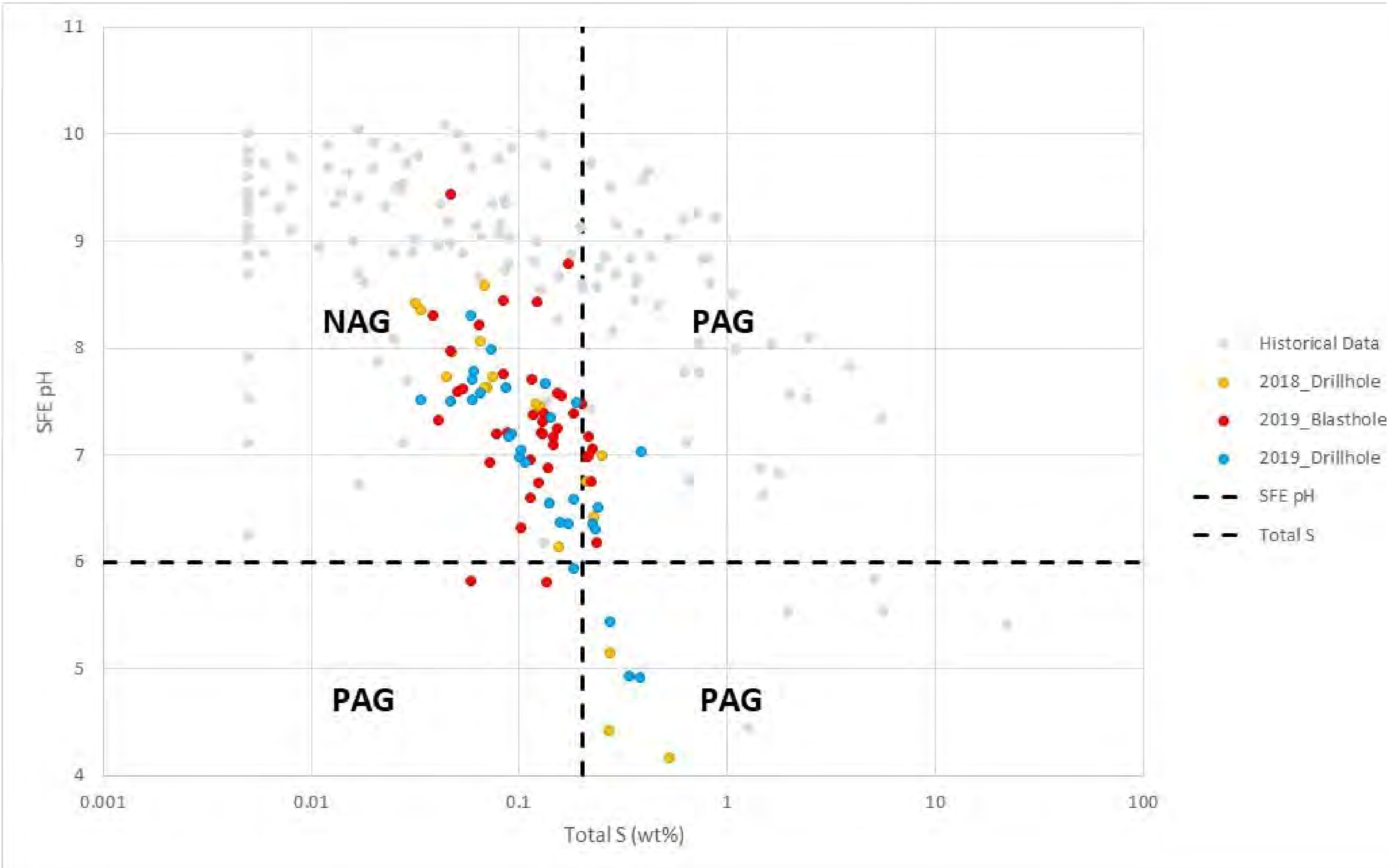
FIGURE 10



GOLDER

Paste pH values compared to Total Sulphur Content

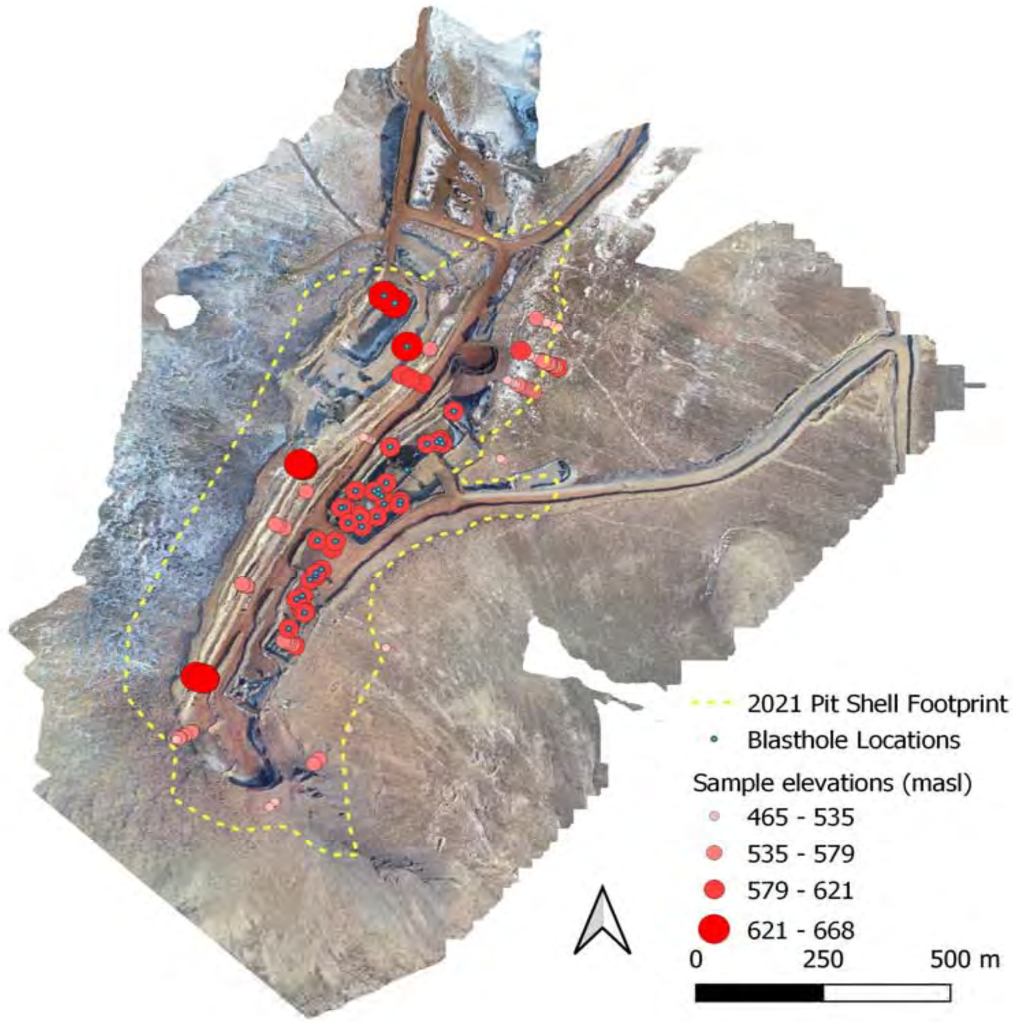
PROJECT NO: 1790951		DATE:	DEC. 2019	**BAFFINLAND**	**FIGURE 11**
BY:	DFL	Review:	KDV		



GOLDER

SFE pH values compared to Total Sulphur Content

PROJECT NO: 1790951		DATE:	DEC. 2019	BAFFINLAND	FIGURE 12
BY:	DFL	Review:	KDV		



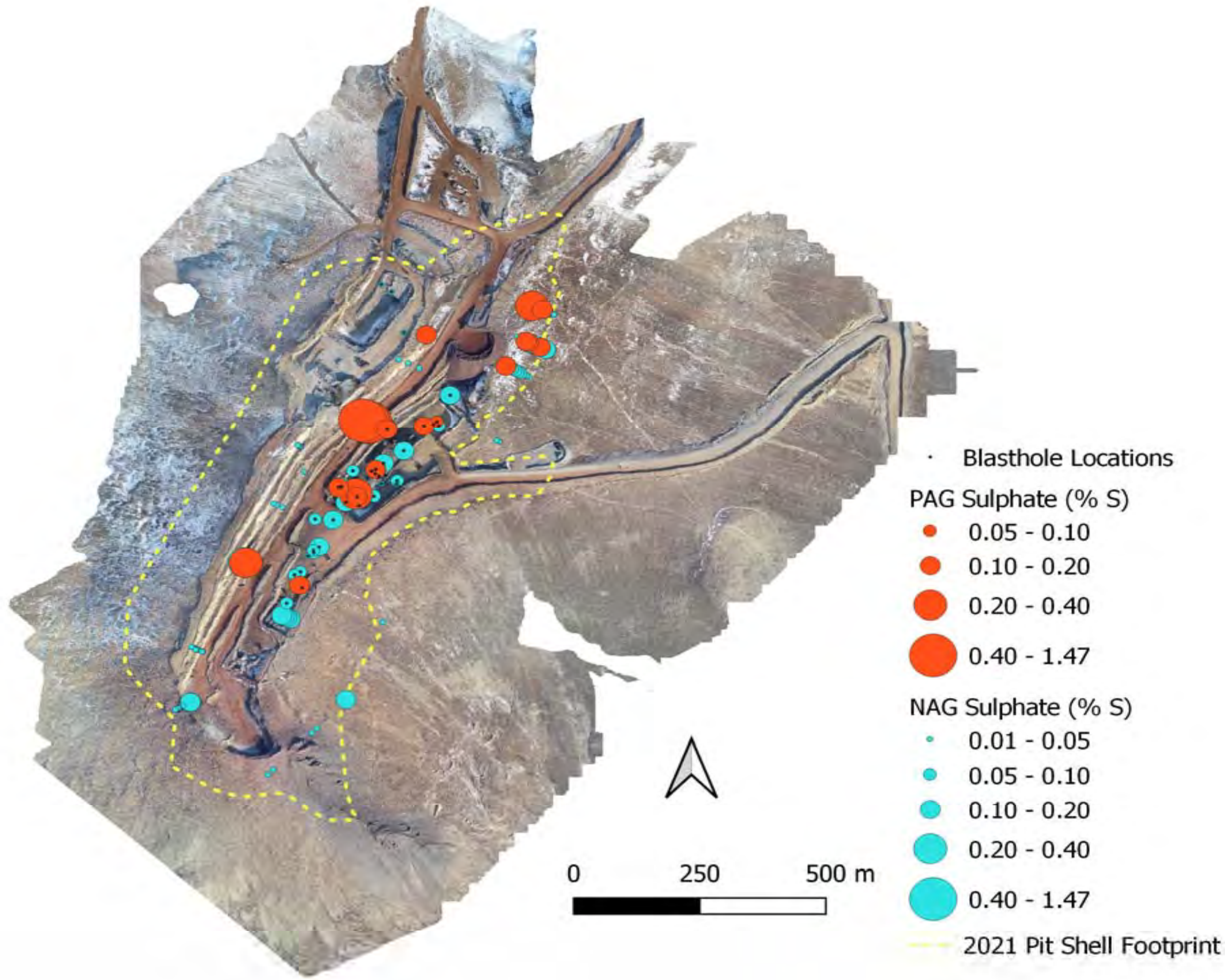
GOLDER

Spatial distribution and elevation ranges of Historical and 2019 Blasthole Samples

PROJECT NO: 1790951		DATE:	DEC. 2019
BY:	DFL	Review:	KDV

BAFFINLAND

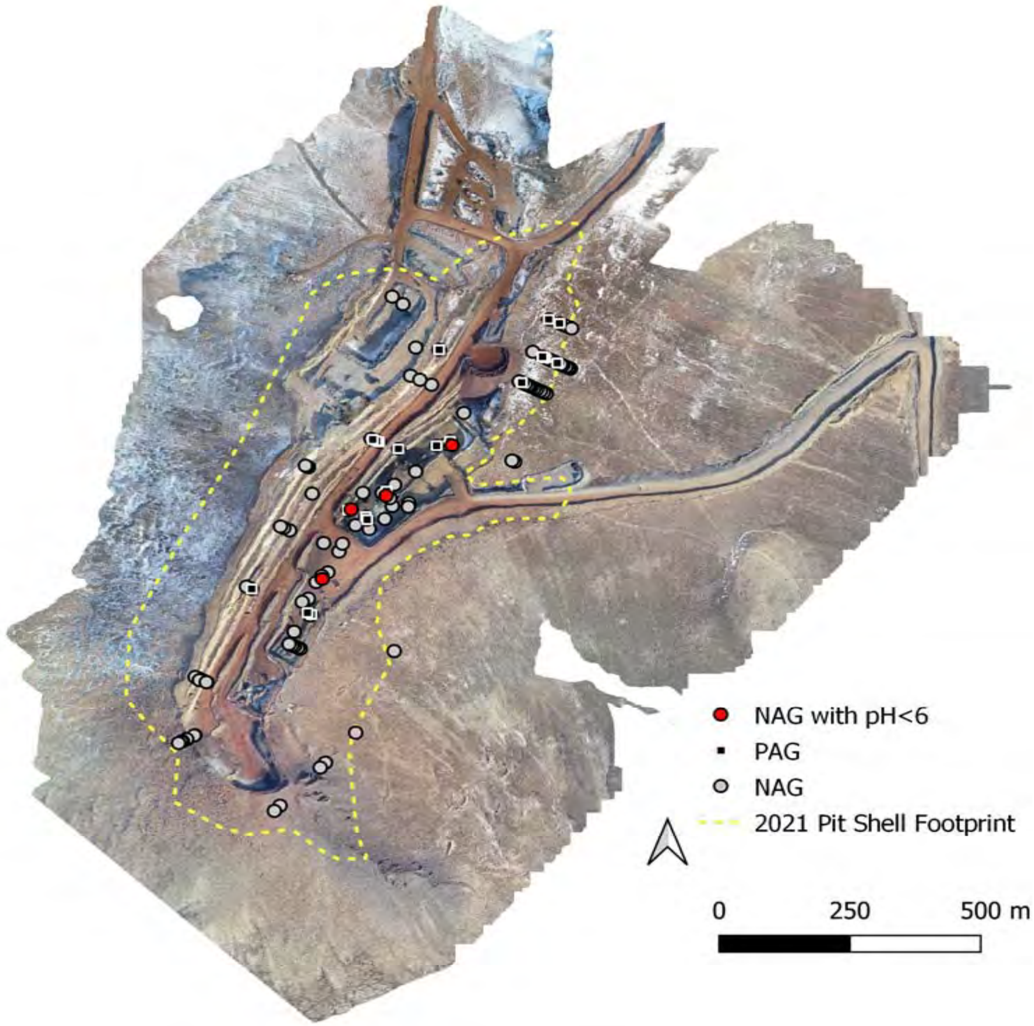
FIGURE 13



GOLDER

PAG designation and sulphate content ranges of Historical and 2019 Blasthole Samples

PROJECT NO: 1790951		DATE:	DEC. 2019	BAFFINLAND	FIGURE 14
BY:	DFL	Review:	KDV		



GOLDER

PAG designation and paste/SFE pH<6 of NAG samples for Historical and 2019 Blasthole Samples

PROJECT NO: 1790951		DATE:	DEC. 2019	BAFFINLAND	FIGURE 15
BY:	DFL	Review:	KDV		

Appendix

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

16-August-2019

Golder Associates Limited
Attn : Dan Laporte

6925 Century Avenue Suite 100
Mississauga, ON
L5N 7K2, Canada

Phone: 905-567-4444
Fax:905-567-0166

Date Rec. : 29 July 2019
LR Report: **CA15689-JUL19**
Reference: 1790951/50000

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Completed Date	4: Analysis Completed Time	5: R804546	6: S684739	7: S077563	8: S077365	9: S077566	10: R804556
Paste pH [no unit]	01-Aug-19	11:13	07-Aug-19	13:29	7.45	5.42	6.96	5.88	7.73	7.61
Fizz Rate [no unit]	01-Aug-19	11:13	07-Aug-19	13:29	1	1	1	1	1	1
Sample weight [g]	01-Aug-19	11:13	07-Aug-19	13:29	1.98	2.02	1.94	2.04	1.98	2.00
HCl Added [mL]	02-Aug-19	09:08	07-Aug-19	13:29	28.00	20.00	20.00	20.00	20.00	20.00
HCl [Normality]	01-Aug-19	11:13	07-Aug-19	13:29	0.10	0.10	0.10	0.10	0.10	0.10
NaOH [Normality]	01-Aug-19	11:13	07-Aug-19	13:29	0.10	0.10	0.10	0.10	0.10	0.10
NaOH to pH=8.3 [mL]	02-Aug-19	11:39	07-Aug-19	13:29	23.40	19.27	15.68	16.21	13.23	17.35
Final pH [no unit]	02-Aug-19	11:39	07-Aug-19	13:29	1.55	1.07	1.46	1.48	1.62	1.55
NP [t CaCO3/1000 t]	02-Aug-19	11:39	07-Aug-19	13:29	11.6	1.8	11.1	9.3	17.1	6.6
AP [t CaCO3/1000 t]	07-Aug-19	13:29	07-Aug-19	13:29	1.56	0.62	4.38	1.56	2.19	0.62
Net NP [t CaCO3/1000 t]	07-Aug-19	13:29	07-Aug-19	13:29	10.0	1.18	6.72	7.74	14.9	5.98
NP/AP [ratio]	07-Aug-19	13:29	07-Aug-19	13:29	7.42	2.88	2.54	5.95	7.82	10.6
Sulphur (total) [%]	31-Jul-19	07:09	01-Aug-19	09:46	0.153	0.059	0.214	0.146	0.102	0.047
Acid Leachable SO4-S [%]	01-Aug-19	09:46	01-Aug-19	09:46	0.10	0.04	0.07	0.10	0.03	0.05
Sulphide [%]	31-Jul-19	17:57	01-Aug-19	09:46	0.05	0.02	0.14	0.05	0.07	< 0.02
Carbon (total) [%]	31-Jul-19	07:09	01-Aug-19	09:16	0.241	0.055	0.015	0.074	0.017	0.180
Carbonate [%]	31-Jul-19	16:42	01-Aug-19	09:16	0.684	< 0.025	< 0.025	< 0.025	< 0.025	0.460

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Analysis	11: R804914	12: R804543	13: R804554	14: S076986	15: S077304	16: S684626	17: R804213	18: S684745	19: S076762	20: S074992	21: R805632
Paste pH [no unit]	6.16	6.98	6.88	7.17	5.66	6.62	6.49	6.53	6.51	7.42	7.23
Fizz Rate [no unit]	1	1	1	1	1	1	1	1	1	1	1
Sample weight [g]	2.03	1.96	2.00	2.03	1.95	2.00	2.00	2.02	2.00	1.99	2.00
HCl Added [mL]	20.00	28.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
HCl [Normality]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
NaOH [Normality]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
NaOH to pH=8.3 [mL]	19.21	25.66	18.07	18.28	19.15	17.45	17.12	8.77	18.69	16.79	5.15
Final pH [no unit]	1.13	1.62	1.59	1.09	1.15	1.27	1.49	1.14	1.39	1.55	1.68
NP [t CaCO3/1000 t]	2.0	6.0	4.8	4.2	2.2	6.4	7.2	27.8	3.3	8.1	37.1
AP [t CaCO3/1000 t]	0.62	0.62	0.62	0.62	0.94	0.94	1.88	0.94	1.25	0.62	0.62
Net NP [t CaCO3/1000 t]	1.38	5.38	4.18	3.58	1.26	5.46	5.32	26.9	2.05	7.48	36.5
NP/AP [ratio]	3.20	9.68	7.68	6.77	2.35	6.83	3.84	29.7	2.64	13.1	59.4
Sulphur (total) [%]	0.114	0.128	0.078	0.041	0.136	0.114	0.238	0.073	0.124	0.084	0.130
Acid Leachable SO4-S [%]	0.09	0.13	0.06	0.04	0.11	0.08	0.18	0.04	0.08	0.08	0.11
Sulphide [%]	0.02	< 0.02	0.02	< 0.02	0.03	0.03	0.06	0.03	0.04	< 0.02	0.02
Carbon (total) [%]	0.051	0.102	0.958	0.014	0.063	0.040	0.122	0.068	0.538	0.013	0.074
Carbonate [%]	< 0.025	< 0.025	3.97	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	1.44	< 0.025	< 0.025

Analysis	22: S076968	23: S684417	24: S075744	25: R807291	26: S684606	27: R807797	28: S076760	29: S075727	30: R807731	31: S684530	32: R805578
Paste pH [no unit]	7.21	7.07	6.84	6.73	6.99	6.78	7.13	7.36	6.94	7.31	7.15
Fizz Rate [no unit]	1	1	1	1	1	1	1	1	1	1	1
Sample weight [g]	2.01	1.97	2.02	2.00	2.06	2.03	2.03	1.97	2.01	2.01	1.95
HCl Added [mL]	20.00	20.00	28.00	20.00	29.50	20.00	27.00	20.00	20.00	26.00	27.00
HCl [Normality]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
NaOH [Normality]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
NaOH to pH=8.3 [mL]	8.75	17.54	24.17	16.07	25.15	17.79	24.30	15.91	17.32	20.53	24.00
Final pH [no unit]	1.48	1.57	1.93	1.39	1.92	1.83	1.69	1.84	1.59	1.56	1.56
NP [t CaCO3/1000 t]	28.0	6.2	9.5	9.8	10.6	5.4	6.6	10.4	6.7	13.6	7.7
AP [t CaCO3/1000 t]	0.62	0.94	2.81	1.88	1.56	2.50	1.88	1.25	2.50	0.62	0.94
Net NP [t CaCO3/1000 t]	27.4	5.26	6.69	7.92	9.04	2.90	4.72	9.15	4.20	13.0	6.76
NP/AP [ratio]	44.8	6.61	3.38	5.23	6.78	2.16	3.52	8.32	2.68	21.9	8.21

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ABA - Modified Sobek

LR Report : CA15689-JUL19

Analysis	22: S076968	23: S684417	24: S075744	25: R807291	26: S684606	27: R807797	28: S076760	29: S075727	30: R807731	31: S684530	32: R805578
Sulphur (total) [%]	0.051	0.088	0.223	0.225	0.217	0.218	0.154	0.202	0.183	0.161	0.132
Acid Leachable SO4-S [%]	0.03	0.06	0.13	0.16	0.17	0.14	0.09	0.16	0.10	0.16	0.10
Sulphide [%]	0.02	0.03	0.09	0.06	0.05	0.08	0.06	0.04	0.08	< 0.02	0.03
Carbon (total) [%]	0.064	0.271	0.068	0.017	0.058	0.080	0.049	0.072	0.068	0.055	0.102
Carbonate [%]	< 0.025	0.999	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	0.150

Analysis	33: S075667	34: R805460	35: S075663	36: S684571	37: S684603	38: S684537	39: R805920	40: R804742	41: R804677	42: R807636	43: R807653
Paste pH [no unit]	6.86	7.71	7.13	7.08	7.33	7.20	8.06	8.24	9.26	8.21	7.88
Fizz Rate [no unit]	1	1	1	1	1	1	1	2	1	1	1
Sample weight [g]	1.98	1.99	2.00	1.94	1.93	1.97	2.00	2.01	1.96	1.97	2.03
HCl Added [mL]	26.00	20.00	20.00	20.00	20.00	37.00	20.00	29.00	20.00	20.00	20.00
HCl [Normality]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
NaOH [Normality]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
NaOH to pH=8.3 [mL]	23.47	16.19	17.10	16.73	16.90	31.42	16.71	20.34	14.71	16.31	14.33
Final pH [no unit]	1.57	1.74	1.68	1.84	1.81	1.64	1.89	1.89	1.84	1.54	1.58
NP [t CaCO3/1000 t]	6.4	9.6	7.2	8.4	8.0	14.2	8.2	21.5	13.5	9.4	14.0
AP [t CaCO3/1000 t]	0.62	2.50	0.62	0.62	0.62	0.62	2.50	1.56	0.94	3.12	0.94
Net NP [t CaCO3/1000 t]	5.78	7.10	6.58	7.78	7.38	13.6	5.70	19.9	12.6	6.28	13.1
NP/AP [ratio]	10.3	3.84	11.6	13.4	12.9	22.7	3.28	13.8	14.4	3.01	14.9
Sulphur (total) [%]	0.147	0.130	0.116	0.118	0.054	0.139	0.122	0.084	0.047	0.174	0.064
Acid Leachable SO4-S [%]	0.15	0.05	0.12	0.10	0.05	0.12	0.04	0.03	< 0.02	0.07	0.03
Sulphide [%]	< 0.02	0.08	< 0.02	0.02	< 0.02	0.02	0.08	0.05	0.03	0.10	0.03
Carbon (total) [%]	0.125	0.094	0.122	0.136	0.067	0.053	0.028	0.070	0.043	0.013	0.288
Carbonate [%]	0.225	< 0.025	0.220	0.170	0.070	< 0.025	< 0.025	0.135	< 0.025	< 0.025	< 0.025

Analysis	44: R807430
Paste pH [no unit]	7.94
Fizz Rate [no unit]	1
Sample weight [g]	2.00

OnLine LIMS

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Analysis	44: R807430
HCl Added [mL]	20.00
HCl [Normality]	0.10
NaOH [Normality]	0.10
NaOH to pH=8.3 [mL]	16.68
Final pH [no unit]	1.50
NP [t CaCO3/1000 t]	8.3
AP [t CaCO3/1000 t]	0.62
Net NP [t CaCO3/1000 t]	7.68
NP/AP [ratio]	13.3
Sulphur (total) [%]	0.039
Acid Leachable SO4-S [%]	< 0.02
Sulphide [%]	0.02
Carbon (total) [%]	0.063
Carbonate [%]	< 0.025

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

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

Chris Sullivan

CHARTERED Christopher Sullivan CHEMIST — ASSOCIATION OF THE CHEMICAL PROFESSION OF ONTARIO

Chris Sullivan, B.Sc., C.Chem
Project Specialist,
Environment, Health & Safety

OnLine LIMS

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16-August-2019

Golder Associates Limited
Attn : Dan Laporte

6925 Century Avenue Suite 100
Mississauga, ON
L5N 7K2, Canada

Phone: 905-567-4444
Fax:905-567-0166

Date Rec. : 29 July 2019
LR Report: **CA15690-JUL19**
Reference: 1790951/50000

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Completed Date	4: Analysis Completed Time	5: R804546	6: S684739	7: S077563	8: S077365	9: S077566	10: R804556	11: R804914
Sample Date & Time					N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mercury [µg/g]	06-Aug-19	23:15	07-Aug-19	13:38	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.07
Silver [µg/g]	06-Aug-19	23:15	07-Aug-19	13:38	0.26	0.05	0.06	0.14	0.04	0.04	0.03
Arsenic [µg/g]	06-Aug-19	23:15	07-Aug-19	13:38	5.6	1.0	1.2	6.4	1.0	4.0	1.4
Aluminum [µg/g]	06-Aug-19	23:15	07-Aug-19	13:38	35000	1600	16000	19000	15000	27000	3400
Barium [µg/g]	06-Aug-19	23:15	07-Aug-19	13:38	3.5	2.6	1.2	1.9	2.8	0.67	6.2
Beryllium [µg/g]	06-Aug-19	23:15	07-Aug-19	13:38	0.40	0.20	1.1	0.58	1.6	0.26	0.79
Bismuth [µg/g]	06-Aug-19	23:15	07-Aug-19	13:38	0.52	0.37	0.83	0.17	0.41	0.13	< 0.09
Calcium [µg/g]	06-Aug-19	23:15	07-Aug-19	13:38	770	60	3600	3600	4400	55	86
Cadmium [µg/g]	06-Aug-19	23:15	07-Aug-19	13:38	0.08	< 0.02	0.16	0.06	0.08	0.03	< 0.02
Cobalt [µg/g]	06-Aug-19	23:15	07-Aug-19	13:38	74	2.9	7.0	8.5	11	25	7.8
Chromium [µg/g]	06-Aug-19	23:15	07-Aug-19	13:38	108	7.7	14	21	29	261	17
Copper [µg/g]	06-Aug-19	23:15	07-Aug-19	13:38	68	7.4	19	17	39	8.5	8.6
Iron [µg/g]	06-Aug-19	23:15	07-Aug-19	13:38	290000	520000	540000	510000	520000	340000	490000
Potassium [µg/g]	06-Aug-19	23:15	07-Aug-19	13:38	52	34	39	28	73	41	39
Lithium [µg/g]	06-Aug-19	23:15	07-Aug-19	13:38	13	< 2	6	< 2	9	8	< 2
Magnesium [µg/g]	06-Aug-19	23:15	07-Aug-19	13:38	27000	320	17000	16000	20000	24000	1700
Manganese [µg/g]	06-Aug-19	23:15	07-Aug-19	13:38	2209	299	771	719	683	1445	302

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LR Report : CA15690-JUL19

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Completed Date	4: Analysis Completed Time	5: R804546	6: S684739	7: S077563	8: S077365	9: S077566	10: R804556	11: R804914
Molybdenum [µg/g]	06-Aug-19	23:15	07-Aug-19	13:38	2.0	0.6	3.1	1.9	5.8	1.9	1.5
Sodium [µg/g]	06-Aug-19	23:15	07-Aug-19	13:38	19	12	21	14	40	12	13
Nickel [µg/g]	06-Aug-19	23:15	07-Aug-19	13:38	135	8.6	44	36	52	95	27
Phosphorus [µg/g]	06-Aug-19	23:15	07-Aug-19	13:38	38	100	2200	2300	1900	42	61
Lead [µg/g]	06-Aug-19	23:15	07-Aug-19	13:38	8.0	1.4	4.2	7.7	5.0	2.1	1.7
Antimony [µg/g]	06-Aug-19	23:15	07-Aug-19	13:38	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8
Selenium [µg/g]	06-Aug-19	23:15	07-Aug-19	13:38	1.0	< 0.7	1.0	< 0.7	< 0.7	< 0.7	< 0.7
Tin [µg/g]	06-Aug-19	23:15	07-Aug-19	13:38	1.2	< 0.5	0.7	0.8	0.6	< 0.5	< 0.5
Strontium [µg/g]	06-Aug-19	23:15	07-Aug-19	13:38	2.0	0.35	5.7	2.5	19	1.0	0.29
Titanium [µg/g]	06-Aug-19	23:15	07-Aug-19	13:38	256	83	127	281	92	174	167
Thallium [µg/g]	06-Aug-19	23:15	07-Aug-19	13:38	0.04	< 0.02	< 0.02	0.02	< 0.02	< 0.02	0.03
Uranium [µg/g]	06-Aug-19	23:15	07-Aug-19	13:38	1.9	0.13	1.5	2.1	1.6	1.0	0.49
Vanadium [µg/g]	06-Aug-19	23:15	07-Aug-19	13:38	48	10	26	33	40	107	14
Yttrium [µg/g]	07-Aug-19	13:24	07-Aug-19	13:38	2.9	0.8	6.4	4.2	5.0	1.7	1.8
Zinc [µg/g]	06-Aug-19	23:15	07-Aug-19	13:38	61	3.3	13	19	27	48	8.8

Analysis	12: R804543	13: R804554	14: S076986	15: S077304	16: S684626	17: R804213	18: S684745	19: S076762	20: S074992	21: R805632	22: S076968	23: S684417
Sample Date & Time	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mercury [ug/g]	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Silver [µg/g]	0.19	0.12	0.04	0.02	0.04	0.03	0.02	0.27	0.12	0.07	0.21	0.21
Arsenic [µg/g]	13	5.7	0.9	1.0	2.4	0.8	0.7	35	12	0.5	56	36
Aluminum [µg/g]	61000	24000	4300	4800	12000	19000	3100	30000	28000	28000	28000	47000
Barium [µg/g]	8.3	5.4	8.6	1.2	3.0	1.1	1.9	5.6	3.7	122	1.7	4.1
Beryllium [µg/g]	1.2	0.61	0.65	0.61	0.32	0.74	0.40	0.62	1.3	4.2	0.36	0.54
Bismuth [µg/g]	1.3	0.55	0.11	0.25	0.21	0.22	0.22	1.00	0.19	0.15	0.87	0.73
Calcium [µg/g]	140	140	37	26	1300	29	21	70	44	240	49	62
Cadmium [µg/g]	0.03	0.02	< 0.02	< 0.02	0.03	< 0.02	< 0.02	0.02	< 0.02	0.08	< 0.02	0.02
Cobalt [µg/g]	50	30	12	7.3	15	16	6.0	31	39	31	15	16
Chromium [µg/g]	248	87	16	12	43	16	8.0	52	425	83	81	43
Copper [µg/g]	38	21	6.4	2.7	28	14	5.1	52	41	6.3	56	42

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LR Report : CA15690-JUL19

Analysis	12: R804543	13: R804554	14: S076986	15: S077304	16: S684626	17: R804213	18: S684745	19: S076762	20: S074992	21: R805632	22: S076968	23: S684417
Iron [µg/g]	240000	340000	460000	550000	550000	550000	500000	230000	310000	500000	440000	310000
Potassium [µg/g]	520	520	37	55	92	56	41	100	47	7000	51	45
Lithium [µg/g]	44	83	4	4	3	10	< 2	25	5	13	< 2	4
Magnesium [µg/g]	43000	10000	3000	2400	10000	18000	2200	16000	28000	32000	23000	39000
Manganese [µg/g]	1094	1183	385	263	936	484	290	1236	527	975	1440	927
Molybdenum [µg/g]	11	6.3	0.4	1.4	4.5	4.5	0.4	6.5	4.7	0.2	7.3	55
Sodium [µg/g]	23	26	14	16	27	49	8.6	19	8.6	290	11	7.7
Nickel [µg/g]	142	84	33	27	37	58	19	102	233	124	37	63
Phosphorus [µg/g]	170	70	30	31	880	43	44	34	170	150	100	68
Lead [µg/g]	7.9	5.2	0.77	1.8	1.5	1.6	0.67	6.3	5.8	13	6.0	5.9
Antimony [µg/g]	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8
Selenium [µg/g]	1.9	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	1.8	< 0.7	< 0.7	1.0	0.8
Tin [µg/g]	1.7	1.2	< 0.5	< 0.5	0.6	< 0.5	< 0.5	0.7	0.9	1.0	1.3	1.1
Strontium [µg/g]	1.4	1.9	0.45	0.13	2.6	0.06	0.11	1.6	0.97	1.0	0.36	0.87
Titanium [µg/g]	357	263	93	174	99	72	75	203	461	871	251	278
Thallium [µg/g]	0.05	0.06	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.04	0.05	0.27	0.02	0.06
Uranium [µg/g]	2.8	1.4	0.57	0.36	0.54	1.2	0.30	2.6	2.5	12	2.1	2.2
Vanadium [µg/g]	74	36	9	13	33	24	7	54	68	57	58	60
Yttrium [µg/g]	1.6	1.6	2.4	1.3	2.3	2.6	0.9	1.2	3.0	4.0	1.3	1.0
Zinc [µg/g]	107	50	16	9.4	21	18	7.4	78	55	43	49	84

Analysis	24: S075744	25: R807291	26: S684606	27: R807797	28: S076760	29: S075727	30: R807731	31: S684530	32: R805578	33: S075667	34: R805460	35: S075663
Sample Date & Time	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mercury [ug/g]	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.06	< 0.05	< 0.05	< 0.05
Silver [µg/g]	0.14	0.13	0.12	0.17	0.34	0.05	0.16	0.03	0.14	0.20	0.07	0.06
Arsenic [µg/g]	3.2	3.0	1.7	10	6.5	2.4	5.0	1.8	33	6.3	2.2	3.8
Aluminum [µg/g]	49000	40000	75000	45000	61000	22000	34000	49000	70000	68000	37000	35000
Barium [µg/g]	220	1.2	533	2.8	6.9	4.6	17	3.3	39	5.4	142	30
Beryllium [µg/g]	1.9	0.73	3.1	0.63	2.4	1.4	1.8	1.0	1.9	1.4	1.3	0.87
Bismuth [µg/g]	0.83	0.19	0.94	0.53	1.7	0.16	0.44	0.20	1.9	1.00	0.53	0.59

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Analysis	24: S075744	25: R807291	26: S684606	27: R807797	28: S076760	29: S075727	30: R807731	31: S684530	32: R805578	33: S075667	34: R805460	35: S075663
Calcium [µg/g]	83	1800	240	42	240	56	100	1800	430	52	930	220
Cadmium [µg/g]	0.03	0.02	0.11	< 0.02	< 0.02	< 0.02	0.02	0.08	< 0.02	< 0.02	0.04	< 0.02
Cobalt [µg/g]	37	23	101	12	97	29	33	29	58	60	19	34
Chromium [µg/g]	78	616	82	73	44	222	27	431	104	564	77	85
Copper [µg/g]	55	35	16	25	46	10	34	18	46	33	30	38
Iron [µg/g]	140000	270000	160000	230000	220000	510000	230000	230000	210000	220000	100000	110000
Potassium [µg/g]	9800	63	4200	150	600	24	430	180	2000	96	9500	2400
Lithium [µg/g]	28	7	33	7	97	10	23	22	261	21	12	17
Magnesium [µg/g]	29000	51000	62000	34000	59000	22000	25000	55000	47000	57000	35000	30000
Manganese [µg/g]	528	716	945	331	317	570	576	913	734	878	1250	1064
Molybdenum [µg/g]	31	3.3	5.4	2.7	4.7	1.5	2.9	2.0	15	1.1	1.6	3.1
Sodium [µg/g]	150	27	86	16	40	12	47	45	54	9.5	210	37
Nickel [µg/g]	117	136	253	38	343	117	76	109	139	306	68	105
Phosphorus [µg/g]	47	920	370	49	87	97	140	970	300	77	450	120
Lead [µg/g]	10	6.1	8.2	4.9	8.3	2.7	5.0	2.2	4.1	5.8	11	3.3
Antimony [µg/g]	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8
Selenium [µg/g]	0.8	< 0.7	0.7	1.2	0.9	< 0.7	0.8	< 0.7	1.2	< 0.7	< 0.7	< 0.7
Tin [µg/g]	2.5	0.7	1.5	0.9	1.6	0.7	0.7	< 0.5	1.4	< 0.5	1.6	1.1
Strontium [µg/g]	3.6	1.2	2.8	0.24	1.5	0.70	0.79	8.5	3.9	1.2	4.3	1.6
Titanium [µg/g]	1900	305	506	206	516	351	118	149	554	372	1642	459
Thallium [µg/g]	0.31	0.03	0.29	0.03	0.18	0.03	0.09	< 0.02	0.09	0.02	0.35	0.10
Uranium [µg/g]	3.3	2.4	3.9	2.0	2.1	1.4	2.0	1.6	3.4	2.8	1.8	1.8
Vanadium [µg/g]	116	121	88	64	54	55	41	164	96	134	68	56
Yttrium [µg/g]	0.4	3.7	6.0	1.8	2.1	6.8	3.0	5.3	2.9	3.4	1.2	2.5
Zinc [µg/g]	54	51	90	66	91	33	54	38	102	173	34	35

Analysis	36: S684571	37: S684603	38: S684537	39: R805920	40: R804742	41: R804677	42: R807636	43: R807653	44: R807430
Sample Date & Time	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mercury [ug/g]	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.20	< 0.05	0.06	< 0.05
Silver [µg/g]	0.03	0.05	0.17	0.03	0.23	0.15	0.03	0.06	0.02

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LR Report : **CA15690-JUL19**

Analysis	**36: S684571**	**37: S684603**	**38: S684537**	**39: R805920**	**40: R804742**	**41: R804677**	**42: R807636**	**43: R807653**	**44: R807430**
Arsenic [µg/g]	23	1.6	7.7	< 0.5	1.1	< 0.5	< 0.5	0.7	< 0.5
Aluminum [µg/g]	58000	31000	73000	30000	64000	32000	45000	20000	32000
Barium [µg/g]	2.3	51	1.3	690	340	319	671	351	553
Beryllium [µg/g]	2.1	0.79	1.2	0.49	1.4	1.5	0.54	0.53	0.83
Bismuth [µg/g]	0.12	0.14	0.71	0.27	0.80	0.16	0.25	0.20	0.14
Calcium [µg/g]	23	770	340	1100	3000	3700	1900	3200	1400
Cadmium [µg/g]	< 0.02	0.04	0.04	0.03	0.11	0.03	0.03	0.04	0.03
Cobalt [µg/g]	34	39	72	13	40	31	24	17	15
Chromium [µg/g]	394	156	571	8.2	314	87	37	20	14
Copper [µg/g]	45	74	272	27	236	107	96	27	20
Iron [µg/g]	320000	250000	210000	86000	130000	66000	88000	91000	82000
Potassium [µg/g]	35	3900	130	21000	18000	24000	32000	12000	18000
Lithium [µg/g]	< 2	10	16	10	29	32	14	10	12
Magnesium [µg/g]	60000	23000	71000	15000	70000	28000	28000	14000	21000
Manganese [µg/g]	891	783	2384	395	1171	898	571	715	499
Molybdenum [µg/g]	1.7	3.2	17	5.0	1.7	2.6	18	4.4	0.8
Sodium [µg/g]	6.2	74	16	350	320	460	610	200	330
Nickel [µg/g]	108	118	250	15	251	52	48	25	24
Phosphorus [µg/g]	110	370	550	490	1100	570	800	630	450
Lead [µg/g]	2.1	2.5	5.9	8.5	11	4.6	9.9	5.6	9.2
Antimony [µg/g]	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8
Selenium [µg/g]	< 0.7	< 0.7	2.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7
Tin [µg/g]	0.6	0.9	2.7	2.0	2.9	1.3	5.2	1.2	2.3
Strontium [µg/g]	0.63	3.2	1.8	2.2	6.1	8.5	3.2	4.7	3.3
Titanium [µg/g]	480	439	141	1946	2576	3795	3640	1657	1978
Thallium [µg/g]	< 0.02	0.11	< 0.02	0.63	0.59	0.95	0.92	0.55	0.59
Uranium [µg/g]	2.6	0.82	0.60	4.9	4.5	0.82	2.1	2.7	2.7
Vanadium [µg/g]	231	106	204	38	137	170	119	49	53
Yttrium [µg/g]	6.9	2.7	5.0	3.8	2.1	3.4	< 0.2	4.6	0.6
Zinc [µg/g]	111	46	259	13	118	86	12	44	76

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CHARTERED Christopher Sullivan CHEMIST ASSOCIATION OF THE CHEMICAL PROFESSION OF ONTARIO

Chris Sullivan, B.Sc., C.Chem
Project Specialist,
Environment, Health & Safety

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SFE 3:1 (**USE 50g ONLY) ratio 24hr (MEND) prefilter pH

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16-August-2019

Golder Associates Limited
Attn : Dan Laporte

6925 Century Avenue Suite 100
Mississauga, ON
L5N 7K2, Canada

Phone: 905-567-4444
Fax:905-567-0166

Date Rec. : 29 July 2019
LR Report: **CA15691-JUL19**
Reference: 1790951/50000

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Analysis	**1: Analysis Start Date**	**2: Analysis Start Time**	**3: Analysis Completed Date**	**4: Analysis Completed Time**	**5: R804546**	**6: S684739**	**7: S077563**	**8: S077365**	**9: S077566**	**10: R804556**
Sample Date & Time					N/A	N/A	N/A	N/A	N/A	N/A
Sample weight [g]	02-Aug-19	08:29	06-Aug-19	09:47	50	50	50	50	50	50
Volume D.I. Water [mL]	02-Aug-19	08:29	06-Aug-19	09:47	150	150	150	150	150	150
Final pH [no unit]	03-Aug-19	06:42	06-Aug-19	09:47	7.57	5.82	6.98	7.09	6.31	7.97
pH [no unit]	06-Aug-19	12:00	09-Aug-19	17:23	7.16	6.02	7.17	6.33	7.40	7.42
Alkalinity [mg/L as CaCO3]	06-Aug-19	12:00	09-Aug-19	17:23	12	2	11	5	25	24
Acidity [mg/L as CaCO3]	06-Aug-19	12:00	09-Aug-19	17:23	15	3	< 2	< 2	< 2	< 2
Conductivity [uS/cm]	06-Aug-19	12:00	09-Aug-19	17:23	884	398	1010	1300	604	484
Sulphate [mg/L]	06-Aug-19	15:24	07-Aug-19	14:41	450	180	520	760	270	210
Chloride [mg/L]	06-Aug-19	15:23	07-Aug-19	12:26	14	5	3	3	2	8
Mercury [mg/L]	07-Aug-19	07:55	08-Aug-19	09:55	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001
Silver [mg/L]	08-Aug-19	12:24	09-Aug-19	16:35	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Aluminum [mg/L]	08-Aug-19	12:24	09-Aug-19	16:35	0.054	0.002	0.029	0.009	0.056	0.069
Arsenic [mg/L]	08-Aug-19	12:24	09-Aug-19	16:35	0.0003	< 0.0002	0.0003	0.0003	0.0004	0.0005
Barium [mg/L]	08-Aug-19	12:24	09-Aug-19	16:35	0.00383	0.0304	0.00207	0.00250	0.00254	0.00111
Boron [mg/L]	08-Aug-19	12:24	09-Aug-19	16:35	0.051	0.049	0.093	0.041	0.016	0.063
Beryllium [mg/L]	08-Aug-19	12:24	09-Aug-19	16:35	< 0.000007	0.000021	< 0.000007	0.000009	< 0.000007	< 0.000007

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SFE 3:1 (**USE 50g ONLY) ratio 24hr (MEND) prefilter pH

LR Report : CA15691-JUL19

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Completed Date	4: Analysis Completed Time	5: R804546	6: S684739	7: S077563	8: S077365	9: S077566	10: R804556
Bismuth [mg/L]	08-Aug-19	12:24	09-Aug-19	16:35	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007
Calcium [mg/L]	08-Aug-19	12:24	09-Aug-19	16:35	2.17	4.18	51.7	57.1	20.3	0.61
Cadmium [mg/L]	08-Aug-19	12:24	09-Aug-19	16:35	< 0.000003	0.000019	0.000008	0.000012	0.000018	< 0.000003
Cobalt [mg/L]	08-Aug-19	12:24	09-Aug-19	16:35	0.000350	0.00479	0.000172	0.00112	0.000022	0.000040
Chromium [mg/L]	08-Aug-19	12:24	09-Aug-19	16:35	0.00016	< 0.00008	0.00008	0.00012	0.00014	0.00020
Copper [mg/L]	08-Aug-19	12:24	09-Aug-19	16:35	0.0003	0.0004	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Iron [mg/L]	08-Aug-19	12:24	09-Aug-19	16:35	0.019	0.828	0.021	0.018	0.016	0.008
Potassium [mg/L]	08-Aug-19	12:24	09-Aug-19	16:35	0.677	4.70	0.904	0.975	3.21	1.17
Lithium [mg/L]	08-Aug-19	12:24	09-Aug-19	16:35	0.0257	0.0206	0.0276	0.0049	0.0126	0.0118
Magnesium [mg/L]	08-Aug-19	12:24	09-Aug-19	16:35	126	44.1	120	162	66.3	61.0
Manganese [mg/L]	08-Aug-19	12:24	09-Aug-19	16:35	0.112	3.36	0.329	2.17	0.0477	0.0282
Molybdenum [mg/L]	08-Aug-19	12:24	09-Aug-19	16:35	0.00112	0.00014	0.00946	0.00066	0.0536	0.00342
Sodium [mg/L]	08-Aug-19	12:24	09-Aug-19	16:35	0.49	0.64	0.61	0.55	0.76	0.41
Nickel [mg/L]	08-Aug-19	12:24	09-Aug-19	16:35	0.0010	0.0430	0.0011	0.0110	0.0002	0.0003
Lead [mg/L]	08-Aug-19	12:24	09-Aug-19	16:35	0.00001	0.00002	0.00002	0.00001	0.00002	< 0.00001
Antimony [mg/L]	08-Aug-19	12:24	09-Aug-19	16:35	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009
Selenium [mg/L]	08-Aug-19	12:24	09-Aug-19	16:35	0.00115	0.00182	0.00395	0.00257	0.00098	0.00113
Tin [mg/L]	08-Aug-19	12:24	09-Aug-19	16:35	< 0.00006	< 0.00006	0.00013	< 0.00006	0.00006	< 0.00006
Strontium [mg/L]	08-Aug-19	12:24	09-Aug-19	16:35	0.00649	0.0245	0.00876	0.0129	0.0169	0.00462
Titanium [mg/L]	08-Aug-19	12:24	09-Aug-19	16:35	0.00007	< 0.00005	0.00005	< 0.00005	0.00020	0.00011
Thallium [mg/L]	08-Aug-19	12:24	09-Aug-19	16:35	0.000013	0.000057	0.000005	0.000045	0.000007	0.000011
Uranium [mg/L]	08-Aug-19	12:24	09-Aug-19	16:35	< 0.000002	< 0.000002	< 0.000002	< 0.000002	0.000010	< 0.000002
Vanadium [mg/L]	08-Aug-19	12:24	09-Aug-19	16:35	0.00006	0.00002	0.00004	< 0.00001	0.00007	0.00011
Tungsten [mg/L]	08-Aug-19	12:24	09-Aug-19	16:35	< 0.00002	0.00002	0.00003	< 0.00002	0.00010	0.00008
Yttrium [mg/L]	08-Aug-19	12:24	09-Aug-19	16:35	0.000006	0.000208	0.000013	0.000091	0.000005	0.000002
Zinc [mg/L]	08-Aug-19	12:24	09-Aug-19	16:35	< 0.002	< 0.002	< 0.002	< 0.002	0.003	< 0.002

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SFE 3:1 (**USE 50g ONLY) ratio 24hr (MEND) prefilter pH

LR Report : CA15691-JUL19

Analysis	11: R804914	12: R804543	13: R804554	14: S076986	15: S077304	16: S684626	17: R804213	18: S684745	19: S076762	20: S074992	21: R805632
Sample Date & Time	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Sample weight [g]	50	50	50	50	50	50	50	50	40	50	50
Volume D.I. Water [mL]	150	150	150	150	150	150	150	150	120	150	150
Final pH [no unit]	6.60	7.21	7.19	7.32	5.81	6.95	6.17	6.93	6.74	7.75	7.19
pH [no unit]	6.20	6.79	6.79	6.94	5.75	7.14	6.30	6.47	6.50	7.08	6.83
Alkalinity [mg/L as CaCO3]	3	7	9	9	< 2	13	5	4	5	11	9
Acidity [mg/L as CaCO3]	< 2	< 2	< 2	< 2	4	< 2	< 2	< 2	18	< 2	< 2
Conductivity [uS/cm]	1220	1180	680	547	1420	1200	2260	847	828	1020	1530
Sulphate [mg/L]	700	670	330	260	890	680	1600	450	400	550	960
Chloride [mg/L]	3	4	10	4	6	3	5	2	33	6	6
Mercury [mg/L]	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001
Silver [mg/L]	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Aluminum [mg/L]	0.002	0.012	0.012	0.018	0.010	0.017	0.010	0.004	0.021	0.046	0.021
Arsenic [mg/L]	0.0005	0.0009	0.0013	< 0.0002	< 0.0002	< 0.0002	0.0005	< 0.0002	0.0011	0.0011	< 0.0002
Barium [mg/L]	0.0173	0.00491	0.00337	0.0180	0.00659	0.00690	0.00343	0.0125	0.00655	0.00209	0.0335
Boron [mg/L]	0.040	0.091	0.478	0.058	0.041	0.033	0.042	0.032	0.083	0.071	0.056
Beryllium [mg/L]	0.000018	< 0.000007	< 0.000007	0.000039	0.000100	< 0.000007	0.000007	< 0.000007	< 0.000007	< 0.000007	0.000008
Bismuth [mg/L]	< 0.000007	< 0.000007	< 0.000007	0.000008	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007
Calcium [mg/L]	5.01	5.20	5.78	0.89	2.10	110	2.28	1.91	3.57	0.81	9.10
Cadmium [mg/L]	0.000010	< 0.000003	0.000014	0.000011	0.000068	0.000004	< 0.000003	0.000004	0.000004	0.000004	0.000005
Cobalt [mg/L]	0.00190	0.000348	0.000443	0.000478	0.00863	0.000413	0.00100	0.000502	0.00145	0.000231	0.000209
Chromium [mg/L]	0.00014	0.00013	0.00011	0.00016	0.00013	0.00011	< 0.00008	0.00010	0.00012	0.00015	0.00011
Copper [mg/L]	< 0.0002	0.0009	< 0.0002	0.0014	0.0003	0.0006	0.0013	0.0006	0.0016	0.0023	0.0007
Iron [mg/L]	0.020	< 0.007	0.008	0.030	0.083	0.030	0.010	0.018	0.008	0.013	0.008
Potassium [mg/L]	1.84	5.72	8.01	1.59	2.92	3.12	2.01	2.82	3.17	0.792	39.9
Lithium [mg/L]	0.0614	0.0663	0.186	0.0785	0.177	0.0138	0.0284	0.0423	0.0400	0.0030	0.0138
Magnesium [mg/L]	184	167	82.8	73.4	220	123	409	125	110	150	238
Manganese [mg/L]	1.65	0.105	0.167	0.168	3.04	0.369	0.730	0.593	1.01	0.0564	0.636
Molybdenum [mg/L]	0.00049	0.00098	0.00173	0.00031	0.00017	0.00157	0.00031	0.00108	0.00011	0.00860	0.00076
Sodium [mg/L]	0.86	1.00	1.51	0.93	1.56	1.60	3.02	0.78	1.90	0.41	5.66
Nickel [mg/L]	0.0251	0.0017	0.0013	0.0018	0.0720	0.0018	0.0022	0.0054	0.0061	0.0018	0.0009

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Test method information available upon request. “Temperature Upon Receipt” is representative of the whole shipment and may not reflect the temperature of individual samples.

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LR Report : **CA15691-JUL19**

Analysis	11: R804914	12: R804543	13: R804554	14: S076986	15: S077304	16: S684626	17: R804213	18: S684745	19: S076762	20: S074992	21: R805632
Lead [mg/L]	0.00002	< 0.00001	< 0.00001	0.00018	0.00006	0.00004	< 0.00001	0.00001	< 0.00001	< 0.00001	< 0.00001
Antimony [mg/L]	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009
Selenium [mg/L]	0.00247	0.00372	0.00226	0.00171	0.00129	0.00174	0.00070	0.00120	0.00282	0.00072	0.00054
Tin [mg/L]	< 0.00006	< 0.00006	< 0.00006	0.00011	< 0.00006	0.00010	< 0.00006	0.00007	0.00006	0.00010	< 0.00006
Strontium [mg/L]	0.0120	0.0158	0.0158	0.00764	0.0111	0.0338	0.00416	0.0105	0.0425	0.00464	0.00888
Titanium [mg/L]	< 0.00005	< 0.00005	0.00008	0.00024	0.00012	< 0.00005	0.00011	0.00022	0.00758	0.00005	0.00010
Thallium [mg/L]	0.000072	0.000013	0.000035	0.000030	0.000064	0.000012	0.000031	0.000011	0.000020	0.000046	0.000038
Uranium [mg/L]	< 0.000002	0.000039	0.00115	0.000048	0.000987	0.000019	< 0.000002	< 0.000002	< 0.000002	0.000007	0.000080
Vanadium [mg/L]	< 0.00001	0.00011	0.00039	0.00005	0.00004	0.00002	0.00008	< 0.00001	0.00006	0.00009	0.00003
Tungsten [mg/L]	< 0.00002	< 0.00002	0.00003	< 0.00002	< 0.00002	< 0.00002	0.00002	0.00014	0.00010	< 0.00002	< 0.00002
Yttrium [mg/L]	0.000069	0.000002	0.000005	0.000015	0.000552	0.000032	0.000020	0.000006	0.000004	0.000002	0.000005
Zinc [mg/L]	< 0.002	< 0.002	< 0.002	0.002	0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002

Analysis	22: S076968	23: S684417	24: S075744	25: R807291	26: S684606	27: R807797	28: S076760	29: S075727	30: R807731	31: S684530	32: R805578
Sample Date & Time	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Sample weight [g]	50	50	40	50	50	50	50	50	50	50	50
Volume D.I. Water [mL]	150	150	120	150	150	150	150	150	150	150	150
Final pH [no unit]	7.59	7.20	6.75	7.05	7.17	6.99	7.25	7.47	7.39	7.55	7.38
pH [no unit]	6.70	6.65	6.39	6.66	6.49	6.46	6.74	6.93	6.55	7.00	6.81
Alkalinity [mg/L as CaCO3]	11	8	8	5	4	7	10	11	7	12	10
Acidity [mg/L as CaCO3]	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Conductivity [uS/cm]	547	731	1530	2010	1830	1820	1130	2200	1560	1680	940
Sulphate [mg/L]	220	340	930	1500	1200	1200	600	1700	1000	1100	480
Chloride [mg/L]	7	10	6	3	6	11	4	7	8	2	9
Mercury [mg/L]	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001
Silver [mg/L]	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Aluminum [mg/L]	0.033	0.013	0.012	0.012	0.014	0.008	0.016	0.029	0.012	0.029	0.022
Arsenic [mg/L]	0.0004	0.0004	0.0006	< 0.0002	0.0003	< 0.0002	0.0008	< 0.0002	0.0003	0.0004	0.0008

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LR Report : CA15691-JUL19

Analysis	22: S076968	23: S684417	24: S075744	25: R807291	26: S684606	27: R807797	28: S076760	29: S075727	30: R807731	31: S684530	32: R805578
Barium [mg/L]	0.00132	0.00183	0.0162	0.00162	0.0292	0.00179	0.00421	0.00561	0.0113	0.00311	0.0100
Boron [mg/L]	0.042	0.032	0.257	0.042	0.187	0.090	0.652	0.029	0.184	0.127	0.837
Beryllium [mg/L]	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007
Bismuth [mg/L]	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007
Calcium [mg/L]	1.28	2.08	3.09	56.9	4.68	2.81	6.12	2.88	4.00	133	16.5
Cadmium [mg/L]	< 0.000003	< 0.000003	0.000003	0.000011	0.000008	0.000003	< 0.000003	0.000014	< 0.000003	0.000016	< 0.000003
Cobalt [mg/L]	0.000053	0.000088	0.000581	0.000661	0.001054	0.000202	0.000292	0.000391	0.000801	0.000126	0.000205
Chromium [mg/L]	0.00009	0.00012	0.00012	< 0.00008	< 0.00008	< 0.00008	0.00013	0.00011	0.00011	0.00023	0.00010
Copper [mg/L]	< 0.0002	< 0.0002	0.0020	0.0006	< 0.0002	0.0005	0.0002	0.0009	< 0.0002	< 0.0002	0.0002
Iron [mg/L]	0.020	0.017	0.013	0.010	0.027	0.009	0.024	< 0.007	0.008	< 0.007	0.020
Potassium [mg/L]	2.65	2.04	14.0	1.88	16.6	3.62	2.02	1.90	7.90	3.41	10.8
Lithium [mg/L]	0.0013	0.0029	0.0193	0.0061	0.0140	0.0159	0.180	0.0324	0.0359	0.0114	0.148
Magnesium [mg/L]	72.3	101	240	319	306	309	172	426	262	224	125
Manganese [mg/L]	0.0412	0.134	0.220	0.627	0.254	0.203	0.0164	0.135	0.287	0.0772	0.0589
Molybdenum [mg/L]	0.00310	0.00871	0.00114	0.00090	0.00113	0.00030	0.00024	0.00109	0.00058	0.00612	0.00309
Sodium [mg/L]	0.84	0.81	5.64	1.12	3.59	1.78	2.64	1.72	2.44	1.88	2.12
Nickel [mg/L]	0.0003	0.0006	0.0016	0.0030	0.0033	0.0015	0.0025	0.0018	0.0020	0.0005	0.0007
Lead [mg/L]	< 0.00001	< 0.00001	0.00003	< 0.00001	< 0.00001	< 0.00001	0.00003	< 0.00001	< 0.00001	< 0.00001	0.00004
Antimony [mg/L]	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009
Selenium [mg/L]	0.00149	0.00122	0.00260	0.00111	0.00441	0.00401	0.00321	0.00168	0.00260	0.00124	0.00547
Tin [mg/L]	< 0.00006	< 0.00006	0.00017	< 0.00006	< 0.00006	0.00008	< 0.00006	0.00006	< 0.00006	< 0.00006	< 0.00006
Strontium [mg/L]	0.00208	0.00274	0.0126	0.00386	0.00435	0.00331	0.0113	0.0138	0.00785	0.0398	0.0303
Titanium [mg/L]	< 0.00005	0.00007	0.00013	< 0.00005	< 0.00005	< 0.00005	0.00015	0.00013	0.00006	< 0.00005	< 0.00005
Thallium [mg/L]	0.000019	0.000055	< 0.000005	0.000096	0.000026	0.000032	0.000030	0.000016	0.000079	< 0.000005	0.000008
Uranium [mg/L]	< 0.000002	< 0.000002	< 0.000002	< 0.000002	< 0.000002	< 0.000002	< 0.000002	0.000089	0.000037	0.000372	0.000306
Vanadium [mg/L]	0.00003	0.00003	0.00010	0.00012	0.00003	< 0.00001	0.00011	0.00002	0.00007	0.00024	0.00016
Tungsten [mg/L]	< 0.00002	< 0.00002	< 0.00002	< 0.00002	< 0.00002	< 0.00002	0.00003	0.00005	< 0.00002	0.00009	0.00022
Yttrium [mg/L]	0.000003	< 0.000002	0.000005	0.000007	0.000009	0.000003	0.000009	0.000011	0.000007	0.000007	0.000006
Zinc [mg/L]	< 0.002	< 0.002	< 0.002	0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002

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Analysis	33: S075667	34: R805460	35: S075663	36: S684571	37: S684603	38: S684537	39: R805920	40: R804742	41: R804677	42: R807636	43: R807653
Sample Date & Time	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Sample weight [g]	50	50	50	50	50	50	50	30	50	50	50
Volume D.I. Water [mL]	150	150	150	150	150	150	150	90	150	150	150
Final pH [no unit]	7.17	7.31	7.70	7.37	7.61	6.87	8.43	8.44	9.43	8.79	8.21
pH [no unit]	6.39	7.38	6.58	6.77	7.75	6.74	7.78	7.72	8.21	7.51	7.67
Alkalinity [mg/L as CaCO3]	6	26	9	10	44	20	36	40	85	32	57
Acidity [mg/L as CaCO3]	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Conductivity [uS/cm]	1440	261	1520	1160	674	1090	288	179	262	175	283
Sulphate [mg/L]	860	80	940	540	270	590	55	5	6	12	50
Chloride [mg/L]	6	3	3	10	7	3	6	4	6	5	10
Mercury [mg/L]	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001
Silver [mg/L]	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Aluminum [mg/L]	0.010	0.049	0.022	0.023	0.040	0.014	0.378	0.186	1.05	0.565	0.079
Arsenic [mg/L]	< 0.0002	0.0005	< 0.0002	< 0.0002	< 0.0002	0.0004	0.0008	0.0007	0.0018	0.0007	0.0005
Barium [mg/L]	0.00208	0.00857	0.00618	0.00232	0.00477	0.00182	0.02331	0.0105	0.0106	0.00632	0.0298
Boron [mg/L]	0.143	0.052	0.042	0.020	0.052	0.025	0.282	0.097	0.158	0.147	0.107
Beryllium [mg/L]	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	0.000012	< 0.000007	0.000130	0.000015	< 0.000007
Bismuth [mg/L]	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007
Calcium [mg/L]	2.24	3.55	23.5	0.56	19.0	11.8	1.43	4.63	1.62	0.33	17.6
Cadmium [mg/L]	< 0.000003	< 0.000003	0.000005	< 0.000003	< 0.000003	< 0.000003	0.000009	< 0.000003	0.000060	0.000028	< 0.000003
Cobalt [mg/L]	0.000617	0.000034	0.000465	0.000150	0.000108	0.000222	0.000085	0.000022	0.000467	0.000150	0.000065
Chromium [mg/L]	0.00008	0.00008	0.00013	0.00011	0.00016	0.00052	0.00013	0.00100	0.00318	0.00041	0.00013
Copper [mg/L]	< 0.0002	0.0004	0.0003	0.0002	0.0003	0.0005	0.0002	0.0003	0.0042	0.0007	0.0013
Iron [mg/L]	< 0.007	0.020	0.011	0.011	0.017	0.011	0.296	0.035	1.06	0.537	0.021
Potassium [mg/L]	1.91	14.2	13.6	2.98	19.6	1.03	76.1	22.7	74.4	48.3	22.6
Lithium [mg/L]	0.0097	0.0053	0.0083	0.0011	0.0038	0.0036	0.0256	0.0074	0.0190	0.0125	0.0078
Magnesium [mg/L]	230	25.1	247	184	73.3	169	4.55	9.80	1.60	1.45	13.5
Manganese [mg/L]	0.550	0.0262	0.389	0.156	0.0525	0.132	0.00641	0.00261	0.0164	0.00402	0.0222
Molybdenum [mg/L]	0.00049	0.00794	0.00175	0.00115	0.00683	0.00311	0.0349	0.00840	0.147	0.102	0.01707
Sodium [mg/L]	0.72	3.96	2.68	0.63	2.24	1.76	5.36	4.11	8.19	4.72	7.39
Nickel [mg/L]	0.0024	0.0002	0.0011	0.0006	0.0004	0.0011	0.0001	0.0002	0.0012	0.0004	0.0004

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Analysis	33: S075667	34: R805460	35: S075663	36: S684571	37: S684603	38: S684537	39: R805920	40: R804742	41: R804677	42: R807636	43: R807653
Lead [mg/L]	< 0.00001	0.00004	< 0.00001	< 0.00001	< 0.00001	< 0.00001	0.00006	< 0.00001	0.00025	0.00010	< 0.00001
Antimony [mg/L]	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009	0.0010	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009
Selenium [mg/L]	0.00242	0.00126	0.00105	0.00023	0.00110	0.00626	0.00238	0.00077	0.00047	0.00043	0.00048
Tin [mg/L]	< 0.00006	0.00007	0.00006	0.00008	0.00010	0.00015	< 0.00006	0.00008	< 0.00006	< 0.00006	0.00007
Strontium [mg/L]	0.00888	0.00582	0.0145	0.00303	0.00832	0.00382	0.00265	0.0128	0.00426	0.00118	0.0173
Titanium [mg/L]	< 0.00005	0.00058	< 0.00005	0.00019	0.00027	< 0.00005	0.01028	0.00105	0.0801	0.0197	0.00071
Thallium [mg/L]	0.000019	< 0.000005	0.000006	0.000013	0.000005	< 0.000005	0.000043	0.000010	0.000060	0.000021	0.000008
Uranium [mg/L]	< 0.000002	0.000010	< 0.000002	< 0.000002	0.000007	< 0.000002	0.000218	0.000022	0.000072	0.000067	0.000821
Vanadium [mg/L]	0.00003	0.00015	0.00005	0.00003	0.00025	0.00013	0.00082	0.00072	0.0220	0.00228	0.00054
Tungsten [mg/L]	< 0.00002	0.00039	0.00003	0.00050	0.00025	0.00004	0.00141	0.00040	0.123	0.00232	0.00254
Yttrium [mg/L]	0.000007	0.000002	0.000003	0.000004	0.000003	0.000002	0.000044	0.000004	0.000628	0.000079	0.000009
Zinc [mg/L]	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002

Analysis	44: R807430	45:BLK: $D.I. Leachate Blank
Sample Date & Time	N/A	
Sample weight [g]	50	---
Volume D.I. Water [mL]	150	150
Final pH [no unit]	8.30	5.70
pH [no unit]	7.83	5.81
Alkalinity [mg/L as CaCO3]	61	< 2
Acidity [mg/L as CaCO3]	< 2	3
Conductivity [uS/cm]	250	2
Sulphate [mg/L]	22	< 2
Chloride [mg/L]	8	< 1
Mercury [mg/L]	< 0.00001	< 0.00001
Silver [mg/L]	< 0.00005	< 0.00005
Aluminum [mg/L]	0.151	< 0.001
Arsenic [mg/L]	< 0.0002	< 0.0002

OnLine LIMS

0001860947

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Phone: 705-652-2000 FAX: 705-652-6365

Analysis	44: R807430	45:BLK: $D.I. Leachate Blank
Barium [mg/L]	0.0203	0.00022
Boron [mg/L]	0.199	0.003
Beryllium [mg/L]	< 0.000007	< 0.000007
Bismuth [mg/L]	< 0.000007	< 0.000007
Calcium [mg/L]	5.02	0.02
Cadmium [mg/L]	< 0.000003	< 0.000003
Cobalt [mg/L]	0.000021	< 0.000004
Chromium [mg/L]	0.00011	0.00016
Copper [mg/L]	< 0.0002	< 0.0002
Iron [mg/L]	0.063	< 0.007
Potassium [mg/L]	51.5	0.296
Lithium [mg/L]	0.0160	< 0.0001
Magnesium [mg/L]	7.87	0.027
Manganese [mg/L]	0.00451	0.00012
Molybdenum [mg/L]	0.00671	0.00016
Sodium [mg/L]	6.52	< 0.01
Nickel [mg/L]	< 0.0001	< 0.0001
Lead [mg/L]	0.00002	< 0.00001
Antimony [mg/L]	< 0.0009	< 0.0009
Selenium [mg/L]	0.00049	< 0.00004
Tin [mg/L]	0.00010	< 0.00006
Strontium [mg/L]	0.0109	0.00006
Titanium [mg/L]	0.00243	0.00034
Thallium [mg/L]	0.000025	< 0.000005
Uranium [mg/L]	0.00174	< 0.000002
Vanadium [mg/L]	0.00065	< 0.00001
Tungsten [mg/L]	0.00174	0.00028
Yttrium [mg/L]	0.000009	< 0.000002
Zinc [mg/L]	< 0.002	< 0.002

OnLine LIMS

0001860947

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LR Report : **CA15691-JUL19**

Chris Sullivan, B.Sc., C.Chem
Project Specialist,
Environment, Health & Safety

OnLine LIMS

0001860947

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ABA - Modified Sobek

15-August-2019

Golder Associates Limited
Attn : Dan Laporte

6925 Century Avenue Suite 100, Mississauga
Canada, L5N 7K2
Phone: 905-567-4444, Fax:905-567-0166

Date Rec. : 29 July 2019
LR Report: **CA15697-JUL19**
Reference: 1790951/50000

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Completed Date	4: Analysis Completed Time	5: P1-0-3	6: P1-3-6	7: P1-6-9	8: P1-9-12	9: P1-12-15	10: P-1-30	11: P2-27-30	12: P2-24-27
Paste pH [no unit]	07-Aug-19	10:17	08-Aug-19	17:25	8.07	7.29	7.51	6.96	7.23	7.90	7.65	7.94
Fizz Rate [no unit]	07-Aug-19	10:17	08-Aug-19	17:25	1	1	1	1	1	1	1	1
Sample weight [g]	07-Aug-19	10:17	08-Aug-19	17:25	1.98	2.03	2.06	2.00	1.99	2.02	1.99	2.05
HCl Added [mL]	08-Aug-19	08:20	08-Aug-19	17:25	20.00	20.00	36.50	27.20	27.00	55.00	20.00	20.00
HCl [Normality]	07-Aug-19	10:17	08-Aug-19	17:25	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
NaOH [Normality]	07-Aug-19	10:17	08-Aug-19	17:25	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
NaOH to pH=8.3 [mL]	08-Aug-19	10:40	08-Aug-19	17:25	16.07	16.74	30.87	23.77	22.76	27.29	16.60	17.82
Final pH [no unit]	08-Aug-19	10:40	08-Aug-19	17:25	1.67	1.72	1.67	1.54	1.55	1.62	1.62	1.36
NP [t CaCO3/1000 t]	08-Aug-19	10:40	08-Aug-19	17:25	9.9	8.0	13.7	8.6	10.6	68.6	8.5	5.3
AP [t CaCO3/1000 t]	14-Aug-19	11:30	14-Aug-19	11:17	0.62	5.62	5.62	7.81	4.38	1.88	1.56	0.62
Net NP [t CaCO3/1000 t]	14-Aug-19	11:30	14-Aug-19	11:17	9.28	2.38	8.08	0.79	6.22	66.7	6.94	4.68
NP/AP [ratio]	14-Aug-19	11:30	14-Aug-19	11:17	15.8	1.42	2.44	1.10	2.42	36.6	5.44	8.48
Sulphur (total) [%]	08-Aug-19	10:31	13-Aug-19	14:24	0.034	0.227	0.233	0.383	0.275	0.134	0.101	0.047
Acid Leachable SO4-S [%]	09-Aug-19	15:57	13-Aug-19	14:24	0.03	0.05	0.05	0.13	0.14	0.07	0.05	0.03
Sulphide [%]	09-Aug-19	15:57	13-Aug-19	14:24	< 0.02	0.18	0.18	0.25	0.14	0.06	0.05	0.02
Carbon (total) [%]	08-Aug-19	10:30	08-Aug-19	14:26	0.061	0.133	0.112	0.086	0.079	0.835	0.090	0.098
Carbonate [%]	08-Aug-19	14:03	08-Aug-19	14:26	0.055	0.380	0.240	0.190	0.160	2.65	0.195	0.220
Weight [g]	---	---	---	---	10214	5708	5764	6738	3320	2247	3923	5494

OnLine LIMS

6698558100

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Analysis	13: P2-21-24	14: P2-18-21	15: P2-15-18	16: P2-12-15	17: P2-9-12	18: P2-6-9	19: P2-3-6	20: P2-0-3	21: P3-0-3	22: P3-3-8	23: P3-8-16	24: P5-0-8.5	25: P5-8.5-16
Paste pH [no unit]	7.92	7.68	7.50	7.07	7.32	7.29	7.99	8.15	7.63	7.90	7.71	7.36	7.63
Fizz Rate [no unit]	1	1	1	1	1	1	1	1	1	1	1	1	1
Sample weight [g]	2.00	1.97	2.03	2.00	2.02	2.02	1.98	1.99	1.97	1.97	2.03	2.05	2.02
HCl Added [mL]	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
HCl [Normality]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
NaOH [Normality]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
NaOH to pH=8.3 [mL]	17.93	17.89	17.90	17.23	16.51	17.15	15.68	15.51	15.42	16.43	16.71	17.04	16.90
Final pH [no unit]	1.44	1.41	1.46	1.82	1.91	1.58	1.50	1.40	1.83	1.46	1.51	1.67	1.66
NP [t CaCO3/1000 t]	5.2	5.4	5.2	6.9	8.6	7.1	10.9	11.3	11.6	9.1	8.1	7.2	7.7
AP [t CaCO3/1000 t]	0.94	0.94	2.81	2.50	1.88	2.50	2.81	0.62	0.62	0.94	1.88	4.69	1.88
Net NP [t CaCO3/1000 t]	4.26	4.46	2.39	4.40	6.72	4.60	8.09	10.7	11.0	8.16	6.22	2.51	5.82
NP/AP [ratio]	5.55	5.76	1.85	2.76	4.59	2.84	3.88	18.1	18.6	9.71	4.32	1.54	4.11
Sulphur (total) [%]	0.060	0.060	0.185	0.185	0.140	0.159	0.142	0.061	0.093	0.065	0.108	0.241	0.103
Acid Leachable SO4-S [%]	0.03	0.03	0.10	0.10	0.08	0.08	0.05	0.04	0.07	0.04	0.05	0.09	0.04
Sulphide [%]	0.03	0.03	0.09	0.08	0.06	0.08	0.09	0.02	0.02	0.03	0.06	0.15	0.06
Carbon (total) [%]	0.084	0.078	0.092	0.160	0.157	0.188	0.069	0.033	0.032	0.077	0.093	0.056	0.044
Carbonate [%]	0.120	0.145	0.195	0.135	0.385	0.729	0.085	< 0.025	< 0.025	0.170	0.245	0.090	0.065
Weight [g]	6798	7954	10876	6219	4538	2973	5465	3682	4193	6952	10335	4483	8319

Analysis	26: P5-16-19	27: P5-19-22	28: P5-22-25	29: P5-25-28	30: P4-0-1	31: P4-1-2	32: P4-2-4	33: P4-4-4.5
Paste pH [no unit]	7.57	7.77	8.25	8.44	6.88	7.75	7.51	7.01
Fizz Rate [no unit]	1	1	1	1	1	1	1	1
Sample weight [g]	2.00	2.00	2.00	1.98	2.02	1.98	2.03	2.02
HCl Added [mL]	20.00	20.00	45.00	31.00	20.00	20.00	20.00	20.00
HCl [Normality]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
NaOH [Normality]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
NaOH to pH=8.3 [mL]	17.32	15.40	21.24	12.18	17.76	12.95	17.34	17.73
Final pH [no unit]	1.55	1.77	1.63	1.93	1.64	1.77	1.56	1.42
NP [t CaCO3/1000 t]	6.7	11.5	59.4	47.5	5.5	17.8	6.6	5.6
AP [t CaCO3/1000 t]	1.56	0.94	0.94	1.25	7.50	3.44	3.44	8.44

OnLine LIMS

0001885699

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ABA - Modified Sobek

LR Report : **CA15697-JUL19**

Analysis	26: P5-16-19	27: P5-19-22	28: P5-22-25	29: P5-25-28	30: P4-0-1	31: P4-1-2	32: P4-2-4	33: P4-4-4.5
Net NP [t CaCO3/1000 t]	5.14	10.6	58.5	46.2	-2.00	14.4	3.16	-2.84
NP/AP [ratio]	4.29	12.3	63.4	38.0	0.73	5.18	1.92	0.66
Sulphur (total) [%]	0.090	0.087	0.074	0.059	0.340	0.188	0.173	0.388
Acid Leachable SO4-S [%]	0.04	0.06	0.04	< 0.02	0.10	0.08	0.06	0.12
Sulphide [%]	0.05	0.03	0.03	0.04	0.24	0.11	0.11	0.27
Carbon (total) [%]	0.065	0.101	0.702	0.594	0.012	0.209	0.013	0.021
Carbonate [%]	0.130	0.170	2.21	1.79	< 0.025	0.545	< 0.025	< 0.025
Weight [g]	4638	886	2217	2469	6347	9903	6978	9392

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

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

Chris Sullivan

Chris Sullivan, B.Sc., C.Chem
Project Specialist,
Environment, Health & Safety

OnLine LIMS

0001859669

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07-August-2019

Golder Associates Limited
Attn : Dan Laporte

6925 Century Avenue Suite 100, Mississauga
Canada, L5N 7K2
Phone: 905-567-4444, Fax:905-567-0166

Date Rec. : 29 July 2019
LR Report: **CA15698-JUL19**
Reference: 1790951/50000

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Completed Date	4: Analysis Completed Time	5: P1-0-3	6: P1-3-6	7: P1-6-9	8: P1-9-12	9: P1-12-15	10: P-1-30	11: P2-27-30	12: P2-24-27	13: P2-21-24	14: P2-18-21
Mercury [ug/g]	06-Aug-19	23:15	07-Aug-19	13:29	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.06	< 0.05	0.06	0.06	0.06
Silver [µg/g]	06-Aug-19	23:15	07-Aug-19	13:29	0.045	0.071	0.11	0.14	0.21	0.11	0.075	0.072	0.085	0.072
Arsenic [µg/g]	06-Aug-19	23:15	07-Aug-19	13:29	3.9	5.1	7.5	3.1	2.7	2.2	2.9	1.7	1.8	2.6
Aluminum [µg/g]	06-Aug-19	23:15	07-Aug-19	13:29	26000	23000	24000	28000	24000	16000	14000	8800	8800	10000
Barium [µg/g]	06-Aug-19	23:15	07-Aug-19	13:29	9.4	43	83	22	15	31	21	20	26	24
Beryllium [µg/g]	06-Aug-19	23:15	07-Aug-19	13:29	0.67	0.61	0.72	0.68	0.76	0.56	0.56	0.45	0.47	0.57
Bismuth [µg/g]	06-Aug-19	23:15	07-Aug-19	13:29	0.25	0.25	0.36	0.38	0.83	0.44	0.35	0.43	0.29	0.40
Calcium [µg/g]	06-Aug-19	23:15	07-Aug-19	13:29	560	600	620	340	390	13000	720	570	580	410
Cadmium [µg/g]	06-Aug-19	23:15	07-Aug-19	13:29	0.032	0.023	0.030	0.029	0.028	0.029	0.029	0.035	0.038	0.048
Cobalt [µg/g]	06-Aug-19	23:15	07-Aug-19	13:29	23	23	27	27	25	16	19	16	15	20
Chromium [µg/g]	06-Aug-19	23:15	07-Aug-19	13:29	160	190	230	150	150	140	82	71	73	77
Copper [µg/g]	06-Aug-19	23:15	07-Aug-19	13:29	36	47	45	39	44	29	22	19	23	21
Iron [µg/g]	06-Aug-19	23:15	07-Aug-19	13:29	390000	430000	440000	380000	400000	220000	460000	380000	410000	450000
Potassium [µg/g]	06-Aug-19	23:15	07-Aug-19	13:29	630	2000	3000	940	760	1600	1100	1400	1700	1400
Lithium [µg/g]	06-Aug-19	23:15	07-Aug-19	13:29	8.5	11	14	7.2	6.7	11	11	9.2	7.9	9.7
Magnesium [µg/g]	06-Aug-19	23:15	07-Aug-19	13:29	28000	21000	19000	27000	26000	22000	11000	6000	6000	7400
Manganese [µg/g]	06-Aug-19	23:15	07-Aug-19	13:29	1600	1200	1100	980	1000	750	1100	1000	910	1100
Molybdenum [µg/g]	06-Aug-19	23:15	07-Aug-19	13:29	2.6	3.3	3.8	5.8	6.1	8.2	5.4	4.8	5.2	6.3
Sodium [µg/g]	06-Aug-19	23:15	07-Aug-19	13:29	70	78	120	62	61	210	89	140	190	100
Nickel [µg/g]	06-Aug-19	23:15	07-Aug-19	13:29	85	100	120	100	88	66	50	37	37	45

OnLine LIMS

0001847591

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Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Completed Date	4: Analysis Completed Time	5: P1-0-3	6: P1-3-6	7: P1-6-9	8: P1-9-12	9: P1-12-15	10: P-1-30	11: P2-27-30	12: P2-24-27	13: P2-21-24	14: P2-18-21
Phosphorus [µg/g]	06-Aug-19	23:15	07-Aug-19	13:29	300	300	200	170	190	260	340	180	190	230
Lead [µg/g]	06-Aug-19	23:15	07-Aug-19	13:29	2.3	2.7	4.6	4.4	5.2	5.7	4.0	8.2	4.8	5.3
Antimony [µg/g]	06-Aug-19	23:15	07-Aug-19	13:29	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8
Selenium [µg/g]	06-Aug-19	23:15	07-Aug-19	13:29	< 0.7	< 0.7	< 0.7	< 0.7	0.81	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7
Tin [µg/g]	06-Aug-19	23:15	07-Aug-19	13:29	1.2	0.85	1.1	0.86	0.96	0.89	0.59	0.51	0.54	0.56
Strontium [µg/g]	06-Aug-19	23:15	07-Aug-19	13:29	2.4	2.5	2.2	1.2	1.3	8.5	2.9	2.9	3.2	2.9
Titanium [µg/g]	06-Aug-19	23:15	07-Aug-19	13:29	170	380	520	320	290	380	230	190	210	210
Thallium [µg/g]	06-Aug-19	23:15	07-Aug-19	13:29	0.028	0.061	0.092	0.060	0.048	0.089	0.053	0.049	0.061	0.055
Uranium [µg/g]	06-Aug-19	23:15	07-Aug-19	13:29	1.4	0.92	1.3	2.1	2.3	1.5	2.1	2.9	3.2	2.5
Vanadium [µg/g]	06-Aug-19	23:15	07-Aug-19	13:29	52	72	78	68	57	43	34	21	20	27
Yttrium [µg/g]	07-Aug-19	13:24	07-Aug-19	13:29	5.1	1.8	2.5	2.9	3.2	3.5	3.8	4.1	4.7	4.4
Zinc [µg/g]	06-Aug-19	23:15	07-Aug-19	13:29	53	47	48	61	49	40	38	27	24	34

Analysis	15: P2-15-18	16: P2-12-15	17: P2-9-12	18: P2-6-9	19: P2-3-6	20: P2-0-3	21: P3-0-3	22: P3-3-8	23: P3-8-16	24: P5-0-8.5	25: P5-8.5-16	26: P5-16-19	27: P5-19-22	28: P5-22-25	29: P5-25-28
Mercury [ug/g]	0.06	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.07	< 0.05	0.07	< 0.05
Silver [µg/g]	0.12	0.10	0.072	0.089	0.044	0.023	0.044	0.037	0.044	0.086	0.054	0.071	0.055	1.9	0.055
Arsenic [µg/g]	2.5	2.1	4.0	5.9	2.8	1.5	3.7	2.0	2.2	3.8	2.1	2.5	2.4	2.0	1.5
Aluminum [µg/g]	10000	29000	22000	18000	9300	7000	24000	13000	11000	18000	15000	14000	16000	13000	10000
Barium [µg/g]	11	13	15	15	25	5.0	7.2	12	4.5	26	31	32	29	52	38
Beryllium [µg/g]	0.50	0.71	0.57	0.58	0.36	0.41	0.62	0.46	0.38	0.66	0.68	0.67	0.52	0.52	0.40
Bismuth [µg/g]	0.34	0.59	0.42	0.29	0.27	0.21	0.21	0.22	0.20	0.26	0.28	0.46	0.29	0.29	0.21
Calcium [µg/g]	240	240	560	320	2300	2100	1500	1100	740	270	330	440	1200	12000	9700
Cadmium [µg/g]	0.026	0.024	0.021	0.026	0.039	0.038	0.031	0.024	0.027	< 0.02	0.030	0.033	< 0.02	0.038	0.038
Cobalt [µg/g]	18	31	22	18	11	11	23	16	12	22	18	18	19	18	18
Chromium [µg/g]	87	100	75	130	46	36	120	86	61	100	82	73	120	110	97
Copper [µg/g]	27	28	24	22	18	14	51	23	15	33	21	22	23	28	18
Iron [µg/g]	470000	390000	460000	490000	520000	600000	380000	540000	560000	500000	470000	480000	410000	290000	270000
Potassium [µg/g]	590	1400	1000	780	1300	180	410	570	210	1300	1300	1600	1700	3300	2400
Lithium [µg/g]	6.1	41	21	6.4	4.7	4.2	6.7	5.7	4.1	8.1	9.7	10	9.6	14	11
Magnesium [µg/g]	8100	24000	18000	16000	8200	9300	27000	13000	11000	16000	13000	11000	15000	18000	13000
Manganese [µg/g]	1100	800	1100	1200	800	940	1400	1100	780	890	820	910	770	900	920
Molybdenum [µg/g]	5.6	20	7.4	6.7	2.5	1.5	2.6	3.0	4.0	4.7	4.2	4.7	4.8	4.8	5.1
Sodium [µg/g]	67	56	48	52	120	66	51	52	40	66	81	90	150	240	290

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LR Report : CA15698-JUL19

Analysis	15: P2-15-18	16: P2-12-15	17: P2-9-12	18: P2-6-9	19: P2-3-6	20: P2-0-3	21: P3-0-3	22: P3-3-8	23: P3-8-16	24: P5-0-8.5	25: P5-8.5-16	26: P5-16-19	27: P5-19-22	28: P5-22-25	29: P5-25-28
Nickel [µg/g]	50	83	62	79	30	32	70	60	46	83	60	58	67	56	45
Phosphorus [µg/g]	140	130	260	160	790	980	740	520	390	130	180	190	170	390	380
Lead [µg/g]	4.5	3.7	2.9	3.2	3.5	1.8	2.1	2.1	2.6	3.5	3.2	4.0	3.3	5.1	5.3
Antimony [µg/g]	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8
Selenium [µg/g]	< 0.7	0.73	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7
Tin [µg/g]	0.61	1.2	0.74	0.81	< 0.5	< 0.5	0.85	0.54	< 0.5	0.56	0.58	0.69	0.54	0.74	0.70
Strontium [µg/g]	1.9	2.1	2.0	1.6	4.7	5.4	3.4	2.7	1.6	1.2	1.5	1.9	2.3	9.3	8.4
Titanium [µg/g]	160	250	250	260	260	98	160	170	160	290	270	270	320	510	400
Thallium [µg/g]	0.042	0.064	0.056	0.052	0.050	< 0.02	0.030	0.023	0.024	0.042	0.050	0.048	0.058	0.14	0.11
Uranium [µg/g]	2.0	2.7	1.5	2.1	1.2	0.60	0.75	0.68	1.2	2.3	1.9	1.8	2.5	2.3	2.4
Vanadium [µg/g]	24	53	44	42	25	18	67	34	29	44	37	37	38	30	26
Yttrium [µg/g]	3.8	2.9	2.2	2.0	3.4	4.7	3.5	3.0	2.5	3.1	3.0	3.2	4.2	4.9	4.2
Zinc [µg/g]	29	57	44	35	22	17	47	27	20	40	29	27	28	32	26

Analysis	30: P4-0-1	31: P4-1-2	32: P4-2-4	33: P4-4-4.5
Mercury [ug/g]	0.11	0.05	0.06	0.08
Silver [µg/g]	0.12	0.085	0.062	0.12
Arsenic [µg/g]	1.4	1.3	0.71	0.99
Aluminum [µg/g]	23000	17000	16000	18000
Barium [µg/g]	16	17	3.2	13
Beryllium [µg/g]	0.83	0.59	0.50	0.79
Bismuth [µg/g]	0.55	0.52	0.24	0.61
Calcium [µg/g]	210	3300	150	450
Cadmium [µg/g]	< 0.02	< 0.02	< 0.02	< 0.02
Cobalt [µg/g]	21	16	15	18
Chromium [µg/g]	140	130	60	140
Copper [µg/g]	29	23	15	26
Iron [µg/g]	500000	320000	580000	450000
Potassium [µg/g]	760	980	190	580
Lithium [µg/g]	9.1	8.2	6.5	9.2
Magnesium [µg/g]	21000	17000	14000	17000
Manganese [µg/g]	660	490	530	540
Molybdenum [µg/g]	4.2	3.9	3.8	4.1

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LR Report : CA15698-JUL19

Analysis	30: P4-0-1	31: P4-1-2	32: P4-2-4	33: P4-4-4.5
Sodium [µg/g]	53	140	36	47
Nickel [µg/g]	90	67	57	79
Phosphorus [µg/g]	160	200	58	160
Lead [µg/g]	3.5	4.1	1.7	3.5
Antimony [µg/g]	< 0.8	< 0.8	< 0.8	< 0.8
Selenium [µg/g]	< 0.7	< 0.7	< 0.7	< 0.7
Tin [µg/g]	0.67	0.62	< 0.5	0.65
Strontium [µg/g]	1.3	3.6	0.61	1.2
Titanium [µg/g]	260	300	140	250
Thallium [µg/g]	0.049	0.065	< 0.02	0.040
Uranium [µg/g]	2.3	1.7	1.2	2.0
Vanadium [µg/g]	40	35	23	39
Yttrium [µg/g]	6.2	4.1	3.3	4.2
Zinc [µg/g]	37	32	24	33

Chris Sullivan

ASSOCIATION OF THE CHEMICAL PROFESSION OF ONTARIO
CHARTERED
Christopher Sullivan
CHEMIST

Chris Sullivan, B.Sc., C.Chem
Project Specialist,
Environment, Health & Safety

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15-August-2019

Golder Associates Limited
Attn : Dan Laporte

6925 Century Avenue Suite 100, Mississauga
Canada, L5N 7K2
Phone: 905-567-4444, Fax:905-567-0166

Date Rec. : 29 July 2019
LR Report: **CA15699-JUL19**
Reference: 1790951/50000

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Completed Date	4: Analysis Completed Time	5: P1-0-3	6: P1-3-6	7: P1-6-9	8: P1-9-12	9: P1-12-15	10: P-1-30
Sample weight [g]	06-Aug-19	13:50	07-Aug-19	15:28	250	250	250	250	250	250
Volume D.I. Water [mL]	06-Aug-19	13:50	07-Aug-19	15:28	750	750	750	750	750	750
Final pH [no unit]	07-Aug-19	13:18	07-Aug-19	15:28	7.51	6.35	6.30	4.92	5.44	7.66
pH [no unit]	08-Aug-19	13:24	09-Aug-19	11:15	7.15	6.15	6.32	4.89	5.36	7.52
Alkalinity [mg/L as CaCO3]	08-Aug-19	13:24	09-Aug-19	11:15	14	< 2	2	< 2	< 2	46
Acidity [mg/L as CaCO3]	08-Aug-19	13:24	09-Aug-19	11:15	< 2	7	5	14	13	< 2
Conductivity [uS/cm]	08-Aug-19	13:24	09-Aug-19	11:15	296	740	686	1530	1580	1090
Sulphate [mg/L]	08-Aug-19	12:12	08-Aug-19	15:41	120	390	370	1100	1100	590
Chloride [mg/L]	08-Aug-19	12:13	08-Aug-19	15:41	2	2	2	3	3	5
Mercury [mg/L]	08-Aug-19	13:45	09-Aug-19	08:03	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001
Silver [mg/L]	12-Aug-19	16:09	13-Aug-19	11:27	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Aluminum [mg/L]	12-Aug-19	16:09	13-Aug-19	11:27	0.013	0.002	0.003	0.130	0.012	0.027
Arsenic [mg/L]	12-Aug-19	16:09	13-Aug-19	11:27	< 0.0002	0.0003	< 0.0002	0.0002	< 0.0002	< 0.0002
Barium [mg/L]	12-Aug-19	16:09	13-Aug-19	11:27	0.00152	0.0164	0.0267	0.0155	0.0171	0.0267
Boron [mg/L]	12-Aug-19	16:09	13-Aug-19	11:27	0.020	0.041	0.075	0.084	0.042	0.044
Beryllium [mg/L]	12-Aug-19	16:09	13-Aug-19	11:27	< 0.000007	0.000019	0.000016	0.000498	0.000059	< 0.000007

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Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Completed Date	4: Analysis Completed Time	5: P1-0-3	6: P1-3-6	7: P1-6-9	8: P1-9-12	9: P1-12-15	10: P-1-30
Bismuth [mg/L]	12-Aug-19	16:09	13-Aug-19	11:27	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007
Calcium [mg/L]	12-Aug-19	16:09	15-Aug-19	11:13	8.85	21.0	13.0	23.1	28.9	87.6
Cadmium [mg/L]	12-Aug-19	16:09	13-Aug-19	11:27	< 0.000003	0.000026	0.000011	0.000530	0.000196	0.000007
Cobalt [mg/L]	12-Aug-19	16:09	13-Aug-19	11:27	0.000285	0.00435	0.00369	0.293	0.133	0.000444
Chromium [mg/L]	12-Aug-19	16:09	13-Aug-19	11:27	0.00008	< 0.00008	0.00012	0.00023	0.00012	< 0.00008
Copper [mg/L]	12-Aug-19	16:09	13-Aug-19	11:27	0.0002	0.0002	0.0005	0.0027	0.0005	0.0006
Iron [mg/L]	12-Aug-19	16:09	13-Aug-19	11:27	< 0.007	< 0.007	0.018	2.45	0.399	< 0.007
Potassium [mg/L]	12-Aug-19	16:09	13-Aug-19	11:27	1.78	12.9	20.5	7.73	6.61	16.5
Lithium [mg/L]	12-Aug-19	16:09	13-Aug-19	11:27	0.0046	0.0309	0.0325	0.0835	0.0345	0.0178
Magnesium [mg/L]	12-Aug-19	16:09	13-Aug-19	11:27	30.9	90.4	85.5	254	242	117
Manganese [mg/L]	12-Aug-19	16:09	15-Aug-19	11:13	0.152	3.15	2.21	15.6	14.4	0.684
Molybdenum [mg/L]	12-Aug-19	16:09	13-Aug-19	11:27	0.00157	0.00029	0.00026	< 0.00004	0.00018	0.0123
Sodium [mg/L]	12-Aug-19	16:09	13-Aug-19	11:27	1.20	1.28	1.62	1.54	1.16	3.84
Nickel [mg/L]	12-Aug-19	16:09	13-Aug-19	11:27	0.0004	0.0209	0.0319	0.841	0.424	0.0016
Lead [mg/L]	12-Aug-19	16:09	13-Aug-19	11:27	< 0.00001	< 0.00001	0.00002	0.00086	< 0.00001	0.00002
Antimony [mg/L]	12-Aug-19	16:09	13-Aug-19	11:27	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009
Selenium [mg/L]	12-Aug-19	16:09	13-Aug-19	11:27	0.00130	0.00381	0.00291	0.00517	0.00372	0.00161
Tin [mg/L]	12-Aug-19	16:09	13-Aug-19	11:27	< 0.00006	< 0.00006	< 0.00006	< 0.00006	< 0.00006	< 0.00006
Strontium [mg/L]	12-Aug-19	16:09	13-Aug-19	11:27	0.00792	0.0178	0.0179	0.0353	0.0350	0.0564
Titanium [mg/L]	12-Aug-19	16:09	13-Aug-19	11:27	0.00007	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Thallium [mg/L]	12-Aug-19	16:09	13-Aug-19	11:27	0.000011	0.000063	0.000071	0.000356	0.000265	0.000017
Uranium [mg/L]	12-Aug-19	16:09	13-Aug-19	11:27	0.000018	0.000005	0.000054	0.000915	0.000213	0.000361
Vanadium [mg/L]	12-Aug-19	16:09	13-Aug-19	11:27	0.00005	0.00002	0.00004	0.00009	0.00001	0.00004
Tungsten [mg/L]	12-Aug-19	16:09	13-Aug-19	11:27	< 0.00002	< 0.00002	< 0.00002	< 0.00002	< 0.00002	0.00010
Yttrium [mg/L]	12-Aug-19	16:09	13-Aug-19	11:27	0.000002	0.000038	0.000138	0.0104	0.00359	0.000010
Zinc [mg/L]	12-Aug-19	16:09	13-Aug-19	11:27	< 0.002	< 0.002	< 0.002	0.024	0.004	< 0.002

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Analysis	11: P2-27-30	12: P2-24-27	13: P2-21-24	14: P2-18-21	15: P2-15-18	16: P2-12-15	17: P2-9-12	18: P2-6-9	19: P2-3-6	20: P2-0-3
Sample weight [g]	250	250	250	250	250	250	250	250	250	250
Volume D.I. Water [mL]	750	750	750	750	750	750	750	750	750	750
Final pH [no unit]	6.98	7.50	7.51	7.70	6.58	5.93	6.55	6.37	7.35	7.78
pH [no unit]	6.57	6.84	6.94	7.45	6.58	6.00	6.55	6.55	7.07	7.29
Alkalinity [mg/L as CaCO3]	5	9	10	34	4	< 2	3	4	14	26
Acidity [mg/L as CaCO3]	< 2	< 2	< 2	< 2	< 2	6	3	< 2	< 2	< 2
Conductivity [uS/cm]	710	491	499	625	967	1190	961	914	512	721
Sulphate [mg/L]	380	230	240	310	540	740	560	510	250	370
Chloride [mg/L]	2	2	2	2	2	3	3	3	2	1
Mercury [mg/L]	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001
Silver [mg/L]	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	0.00010	< 0.00005	< 0.00005	< 0.00005
Aluminum [mg/L]	0.005	0.019	0.019	0.028	0.003	0.002	0.002	0.003	0.014	0.017
Arsenic [mg/L]	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	0.0003
Barium [mg/L]	0.0168	0.0163	0.0178	0.0185	0.0172	0.00820	0.00983	0.0105	0.0110	0.00341
Boron [mg/L]	0.077	0.056	0.053	0.053	0.066	0.434	0.257	0.038	0.024	0.022
Beryllium [mg/L]	< 0.000007	< 0.000007	0.000017	< 0.000007	< 0.000007	0.000013	< 0.000007	0.000010	< 0.000007	< 0.000007
Bismuth [mg/L]	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007
Calcium [mg/L]	16.2	18.7	19.1	15.4	18.1	12.4	13.3	16.2	23.1	35.7
Cadmium [mg/L]	0.000016	< 0.000003	0.000034	0.000009	0.000042	0.000015	0.000018	0.000024	< 0.000003	< 0.000003
Cobalt [mg/L]	0.00183	0.000393	0.000463	0.000647	0.00505	0.00689	0.00281	0.00482	0.000184	0.000275
Chromium [mg/L]	0.00016	0.00008	< 0.00008	0.00011	< 0.00008	0.00014	0.00016	< 0.00008	< 0.00008	< 0.00008
Copper [mg/L]	0.0005	0.0003	0.0003	0.0003	0.0002	0.0004	< 0.0002	< 0.0002	0.0002	0.0004
Iron [mg/L]	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	0.014	< 0.007	0.012	< 0.007	0.011
Potassium [mg/L]	15.9	20.6	23.4	18.1	9.72	10.7	11.6	12.8	19.2	4.82
Lithium [mg/L]	0.0675	0.0455	0.0446	0.0498	0.0534	0.182	0.120	0.0386	0.0172	0.0115
Magnesium [mg/L]	86.2	45.7	49.1	80.5	130	177	133	121	47.0	80.4
Manganese [mg/L]	2.31	0.495	0.635	1.15	4.85	2.48	1.68	3.31	0.133	0.0929
Molybdenum [mg/L]	0.00092	0.00501	0.00633	0.00725	0.00026	0.00012	0.00017	0.00011	0.00193	0.00340
Sodium [mg/L]	1.62	3.06	3.19	1.79	1.20	1.01	1.53	1.19	1.95	1.41

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Analysis	11: P2-27-30	12: P2-24-27	13: P2-21-24	14: P2-18-21	15: P2-15-18	16: P2-12-15	17: P2-9-12	18: P2-6-9	19: P2-3-6	20: P2-0-3
Nickel [mg/L]	0.0043	0.0008	0.0010	0.0008	0.0129	0.0220	0.0093	0.0216	0.0008	0.0002
Lead [mg/L]	0.00002	< 0.00001	0.00004	< 0.00001	0.00718	0.00015	0.0491	0.00006	< 0.00001	0.00007
Antimony [mg/L]	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009
Selenium [mg/L]	0.00141	0.00070	0.00067	0.00080	0.00245	0.00465	0.00398	0.00285	0.00196	0.00176
Tin [mg/L]	< 0.00006	< 0.00006	< 0.00006	< 0.00006	< 0.00006	< 0.00006	< 0.00006	< 0.00006	< 0.00006	< 0.00006
Strontium [mg/L]	0.0222	0.0332	0.0348	0.0252	0.0247	0.0180	0.0123	0.0122	0.0139	0.0112
Titanium [mg/L]	< 0.00005	< 0.00005	< 0.00005	0.00006	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Thallium [mg/L]	0.000085	0.000034	0.000032	0.000069	0.000142	0.000080	0.000087	0.000112	0.000042	0.000012
Uranium [mg/L]	0.000014	0.000056	0.000060	0.000102	0.000018	0.000016	0.000026	0.000018	0.000016	0.000033
Vanadium [mg/L]	0.00002	0.00001	0.00001	0.00002	< 0.00001	0.00003	< 0.00001	0.00013	0.00001	0.00004
Tungsten [mg/L]	< 0.00002	< 0.00002	< 0.00002	< 0.00002	< 0.00002	< 0.00002	< 0.00002	< 0.00002	0.00002	< 0.00002
Yttrium [mg/L]	0.000010	0.000008	0.000005	0.000006	0.000044	0.000107	0.000027	0.000046	0.000002	0.000010
Zinc [mg/L]	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002

Analysis	21: P3-0-3	22: P3-3-8	23: P3-8-16	24: P5-0-8.5	25: P5-8.5-16	26: P5-16-19	27: P5-19-22	28: P5-22-25	29: P5-25-28	30: P4-0-1
Sample weight [g]	250	250	250	250	250	250	250	250	250	250
Volume D.I. Water [mL]	750	750	750	750	750	750	750	750	750	750
Final pH [no unit]	7.19	7.57	6.93	6.51	7.04	7.17	7.63	7.98	8.30	4.93
pH [no unit]	6.58	7.36	6.54	6.32	6.66	7.00	7.66	7.73	7.50	5.32
Alkalinity [mg/L as CaCO3]	5	12	3	2	7	14	30	60	45	< 2
Acidity [mg/L as CaCO3]	< 2	< 2	< 2	3	< 2	< 2	< 2	< 2	< 2	4
Conductivity [uS/cm]	825	426	649	905	475	568	927	624	506	237
Sulphate [mg/L]	450	210	350	490	240	290	470	280	220	100
Chloride [mg/L]	7	2	2	1	1	1	3	4	4	< 1
Mercury [mg/L]	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001
Silver [mg/L]	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Aluminum [mg/L]	0.006	0.012	0.006	0.002	0.004	0.006	0.017	0.114	0.066	0.051

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

LR Report : CA15699-JUL19

Analysis	21: P3-0-3	22: P3-3-8	23: P3-8-16	24: P5-0-8.5	25: P5-8.5-16	26: P5-16-19	27: P5-19-22	28: P5-22-25	29: P5-25-28	30: P4-0-1
Arsenic [mg/L]	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Barium [mg/L]	0.00298	0.00756	0.00514	0.0186	0.0129	0.0151	0.0194	0.0217	0.0173	0.0160
Boron [mg/L]	0.020	0.036	0.029	0.050	0.057	0.063	0.045	0.049	0.042	0.057
Beryllium [mg/L]	< 0.000007	< 0.000007	< 0.000007	0.000008	< 0.000007	0.000008	< 0.000007	< 0.000007	< 0.000007	0.000499
Bismuth [mg/L]	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007
Calcium [mg/L]	59.2	14.0	18.8	21.4	10.8	17.4	31.8	46.6	33.8	5.82
Cadmium [mg/L]	0.000007	< 0.000003	0.000024	0.000010	0.000008	0.000003	0.000008	0.000003	0.000004	0.000091
Cobalt [mg/L]	0.00170	0.000171	0.000669	0.00276	0.000639	0.000499	0.000328	0.000143	0.000110	0.0458
Chromium [mg/L]	0.00010	< 0.00008	0.00019	0.00015	< 0.00008	0.00012	< 0.00008	< 0.00008	0.00011	0.00017
Copper [mg/L]	0.0002	0.0002	0.0003	0.0015	0.0002	0.0006	0.0002	0.0006	0.0005	0.0018
Iron [mg/L]	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	0.166
Potassium [mg/L]	3.88	8.20	4.09	16.3	14.5	17.5	18.9	19.3	17.4	3.74
Lithium [mg/L]	0.0092	0.0229	0.0215	0.0349	0.0330	0.0370	0.0251	0.0138	0.0186	0.0857
Magnesium [mg/L]	85.4	44.2	76.2	117	50.7	58.6	107	54.5	41.1	22.6
Manganese [mg/L]	0.526	0.129	0.573	1.28	0.621	0.560	0.172	0.0976	0.0400	1.60
Molybdenum [mg/L]	0.00094	0.00284	0.00136	0.00033	0.00064	0.00077	0.00597	0.0115	0.0155	0.00030
Sodium [mg/L]	1.30	0.84	0.50	1.12	1.29	1.52	1.94	3.90	3.98	0.26
Nickel [mg/L]	0.0009	0.0008	0.0041	0.0168	0.0043	0.0027	0.0015	0.0002	0.0003	0.191
Lead [mg/L]	< 0.00001	0.00003	0.00004	0.00004	0.00003	< 0.00001	< 0.00001	0.00007	< 0.00001	0.00004
Antimony [mg/L]	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009
Selenium [mg/L]	0.00127	0.00084	0.00189	0.00510	0.00213	0.00227	0.00179	0.00072	0.00080	0.00172
Tin [mg/L]	< 0.00006	< 0.00006	< 0.00006	< 0.00006	< 0.00006	< 0.00006	< 0.00006	< 0.00006	< 0.00006	< 0.00006
Strontium [mg/L]	0.0263	0.00924	0.0111	0.0224	0.00948	0.0120	0.0245	0.0474	0.0362	0.00822
Titanium [mg/L]	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Thallium [mg/L]	0.000014	0.000016	0.000073	0.000076	0.000021	0.000023	0.000026	0.000016	0.000012	0.000156
Uranium [mg/L]	0.000002	0.000011	0.000009	0.000013	0.000008	0.000014	0.000116	0.000674	0.000516	0.000254
Vanadium [mg/L]	0.00004	0.00001	0.00002	< 0.00001	0.00007	0.00002	0.00002	0.00004	0.00010	< 0.00001
Tungsten [mg/L]	< 0.00002	< 0.00002	< 0.00002	< 0.00002	0.00006	< 0.00002	< 0.00002	0.00013	0.00017	< 0.00002
Yttrium [mg/L]	0.000005	0.000002	0.000019	0.000054	0.000005	0.000006	0.000011	0.000008	0.000009	0.00131

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Analysis	21: P3-0-3	22: P3-3-8	23: P3-8-16	24: P5-0-8.5	25: P5-8.5-16	26: P5-16-19	27: P5-19-22	28: P5-22-25	29: P5-25-28	30: P4-0-1
Zinc [mg/L]	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.005

Analysis	31: P4-1-2	32: P4-2-4	33: P4-4-4.5
Sample weight [g]	250	250	250
Volume D.I. Water [mL]	750	750	750
Final pH [no unit]	7.49	6.35	7.03
pH [no unit]	7.57	6.55	7.35
Alkalinity [mg/L as CaCO3]	50	8	66
Acidity [mg/L as CaCO3]	< 2	< 2	< 2
Conductivity [uS/cm]	504	458	595
Sulphate [mg/L]	220	230	270
Chloride [mg/L]	2	1	2
Mercury [mg/L]	< 0.00001	< 0.00001	< 0.00001
Silver [mg/L]	< 0.00005	< 0.00005	< 0.00005
Aluminum [mg/L]	0.010	0.001	0.003
Arsenic [mg/L]	< 0.0002	< 0.0002	< 0.0002
Barium [mg/L]	0.0158	0.0154	0.00705
Boron [mg/L]	0.041	0.055	0.040
Beryllium [mg/L]	< 0.000007	0.000012	< 0.000007
Bismuth [mg/L]	< 0.000007	< 0.000007	< 0.000007
Calcium [mg/L]	39.2	22.4	44.2
Cadmium [mg/L]	< 0.000003	0.000019	< 0.000003
Cobalt [mg/L]	0.000209	0.00215	0.000500
Chromium [mg/L]	0.00011	0.00011	0.00015
Copper [mg/L]	< 0.0002	< 0.0002	< 0.0002
Iron [mg/L]	< 0.007	< 0.007	< 0.007
Potassium [mg/L]	10.5	8.23	3.52

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Analysis	**31: P4-1-2**	**32: P4-2-4**	**33: P4-4-4.5**
Lithium [mg/L]	0.0269	0.0463	0.0461
Magnesium [mg/L]	42.3	43.1	57.5
Manganese [mg/L]	0.0641	0.606	0.157
Molybdenum [mg/L]	0.00047	< 0.00004	0.00025
Sodium [mg/L]	1.27	0.54	0.45
Nickel [mg/L]	0.0010	0.0198	0.0038
Lead [mg/L]	< 0.00001	0.00005	0.0198
Antimony [mg/L]	< 0.0009	< 0.0009	< 0.0009
Selenium [mg/L]	0.00160	0.00304	0.00329
Tin [mg/L]	< 0.00006	< 0.00006	< 0.00006
Strontium [mg/L]	0.0232	0.0165	0.0214
Titanium [mg/L]	< 0.00005	< 0.00005	< 0.00005
Thallium [mg/L]	0.000029	0.000084	0.000067
Uranium [mg/L]	0.000052	0.000015	0.000068
Vanadium [mg/L]	< 0.00001	< 0.00001	< 0.00001
Tungsten [mg/L]	< 0.00002	< 0.00002	< 0.00002
Yttrium [mg/L]	0.000007	0.000055	0.000018
Zinc [mg/L]	< 0.002	< 0.002	< 0.002

Chris Sullivan

CHARTERED Christopher Sullivan CHEMIST — ASSOCIATION OF THE CHEMICAL PROFESSION OF ONTARIO

Chris Sullivan, B.Sc., C.Chem
Project Specialist,
Environment, Health & Safety

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APPENDIX A2

Thermal Model Memorandum

GOLDER

TECHNICAL MEMORANDUM

DATE December 31, 2019 **Project No.** 1790951

TO Baffinland Iron Mines

CC

FROM Brian Andruchow, Fernando Junqueira, and Ken De Vos **EMAIL fjunqueira@golder.com**

ASSESSMENT OF FREEZING OF WASTE ROCK MATERIALS AT BAFFINLAND IRON MINE

1.0 INTRODUCTION

Baffinland Iron Mines Corporation's (Baffinland) Mary River Project is an operational iron mine on Baffin Island in Nunavut, Canada. An estimated 640 Mt of waste rock and 32 Mt of overburden will require management from mining Deposit No. 1 (Baffinland, 2014). Baffinland has retained Golder Associates Ltd. (Golder) to assist with developing an updated waste rock management plan (WRMP) for deposition of potential acid generating (PAG) and non-PAG waste rock at their Waste Rock Facility (WRF). The mitigation strategy for development of acid rock drainage (ARD) and metal leaching (ML) from the WRF relies on managing the rate and locations of waste rock deposition, to maintain the deposited waste rock in a frozen state to the extent possible.

Modelling of the WRF thermal performance was carried out to assist with waste rock deposition planning and assess the WRF thermal performance. This memorandum provides preliminary interpretation of instrumentation installed at the WRF and results of the thermal modelling.

2.0 REVIEW OF FIELD INSTRUMENTATION RESULTS

An instrumentation program was undertaken in December 2018 and February 2019 to monitor the WRF thermal performance and to obtain data for calibrating the thermal model. Refer to Figure 1 for a plan view of the instrument installation and thermal model cross-section locations. Instrumentation included:

- Vertical thermistor strings at BH1, BH2, and BH3, with sensors located within the WRF and underlying overburden; The thermistors strings have a stability of 0.01°C.
- Vertical oxygen sensor strings installed at BH1 and BH2, with sensors located within the WRF fill. The oxygen sensors also include a thermistor;
- Vertical thermistor strings installed at T1 and T2 to monitor the WRF Pond liner south anchor trench (T2) and WRF Pond Berm foundation performance (T1);
- Horizontal thermistor strings at T3, T4, and T5, extending 40 m interior from the WRF edge and buried approximately 1.5 m below the stockpile crest at the time of installation;
- A barometer installed at BH1; and,

■ A vibrating wire piezometer (VWP) installed at the base of the WRF at BH1 and BH2, to monitor for the presence of water.

Refer to Golder, 2019 for further details on the instrumentation program and as-built documentation.

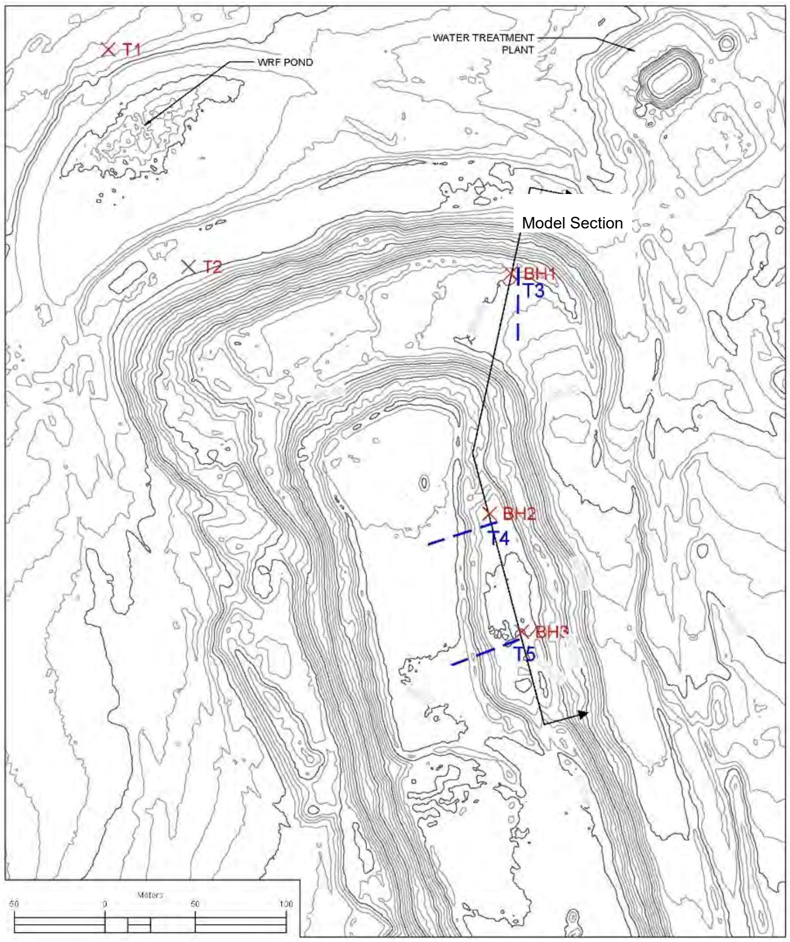


Figure 1: Locations of vertical and horizontal thermistor strings and alignment of cross section defined for the thermal models.

Based on the available instrumentation data from March 2019 through September 2019, the following preliminary trends were observed:

■ The depth of the active layer subject to seasonal freeze and thaw was between 2.6 and 2.9 m at BH2 and BH3, respectively, and less than 2.0 m at BH1 and T2. Data from T1 was inconclusive as there was a no-data period between July 5 and August 31, 2019 due to the WRF Pond expansion construction, and temperatures along the T1 string were below 0°C during the time that temperatures were recorded.

■ The depth to zero-amplitude temperature variation (i.e. minimal variation in temperature over time) is about 15 m based on thermistors at BH1 and BH2. At BH3 temperature profiles are still varying, and the zero-amplitude depth is currently not defined.

- Temperature at depths of zero-amplitude were approximately -7.2°C at BH1 and -3.2°C at BH2.

- Temperature profiles along BH1 are in general colder than at BH2 and BH3. The average temperature measured at the base of BH1 at a depth of 20 m was -7.4°C. At BH2, the average temperature at a depth of 24 m was -3.7°C, and at BH3 the average temperature at a depth of 22 m was -5.2°C.

- Several of the oxygen sensors installed at BH1 showed temporal variation starting on June 14, when an increase in temperature of up to 9°C was observed at BH1 down to about 7 m in depth. Oxygen concentrations measured near the surface (depth of 0.9 m) reduced from about 22% on June 14 to 16% by the end of June, followed by increasing concentrations until mid-July, when oxygen concentrations increased to approximately 21%. Oxygen concentrations measured at a depth of 2.42 m were erroneous after June 14, rising to above 50% on June 14 followed by progressive reduction to about 5% in the beginning of October. Oxygen concentrations measured at depths of 4.92 m and 11.41 m remained stable around 22% during the monitoring period.

- Along BH2, at a depth of 1.36 m, oxygen concentrations reduced from 22% to 16% between the beginning of June and the beginning of July, followed by a sudden increase on July 10, with values remaining around 22% after that. At a depth of 11.05 m, concentrations reduced from 22% to 19% between July 14 and 18, followed by a trend of increasing concentration after that. This coincides with temporary rising temperatures measured between depths of 7 and 13 m from July 10 to 15. At a depth of 6.36 m, concentrations rose from 22% to 30% between mid-May and mid-July, followed by a trend of reducing values until the latest date available on August 19, 2019, when oxygen concentrations were about 16%. These readings are considered erroneous as oxygen concentration rose to values much greater than standard ambient.

- The VWPs measured no positive water pressures during the monitoring period (i.e. the piezometers have remained dry).

In addition to the general trends described above, the thermistors strings have shown several instances of localized and sudden variation in temperatures such as, but not restricted to, the events below:

- At BH1: variation in temperatures of up to 9°C between June 13 and 15 to a depth of approximately 7 m, followed by quick reduction in temperatures to values that had been measured prior to June 13.

- BH2: sudden increase in temperature of up to 4°C on July 13 between depths of 4 m and 13 m (Figure 2 and Figure 3). Temperatures at depths below of 5.5 m cooled quickly, but higher temperatures (between -0.5 and -1°C) remained at depth of about 5 m until September 2019.

- T3: sudden increase in temperature of up to 15°C between April 30 and May 2 at a horizontal distance of 31 to 39 m from the edge of the WRF (Figure 4). Also, temperatures increased approximately 12°C from May 6 – 8, and May 11 – 12, at distances of 3 to 5 m from the edge of the WRF.

- T4: temperature increase of up to 5°C from May 8 – 9 at distances of 2 m to 4 m from the edge of the WRF, followed by a temperature increase of 7°C from May 12 – 13 at 3 m to 7 m from the edge of the WRF.

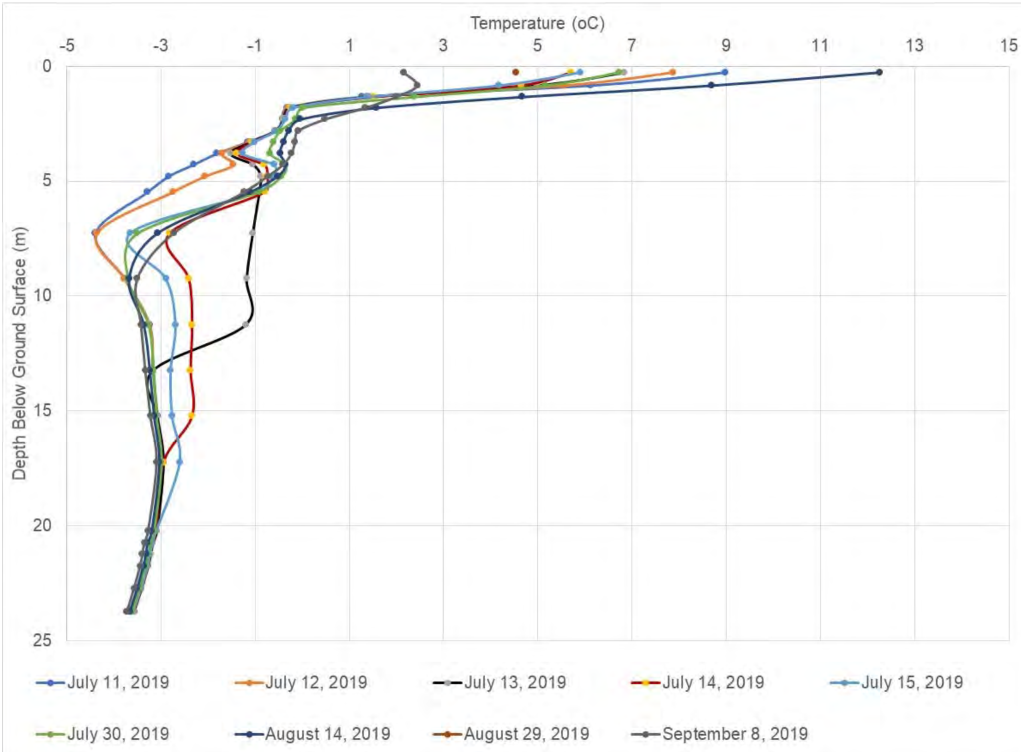


Figure 2: Sudden variation in temperatures measured on July 13, 2019 along BH2.

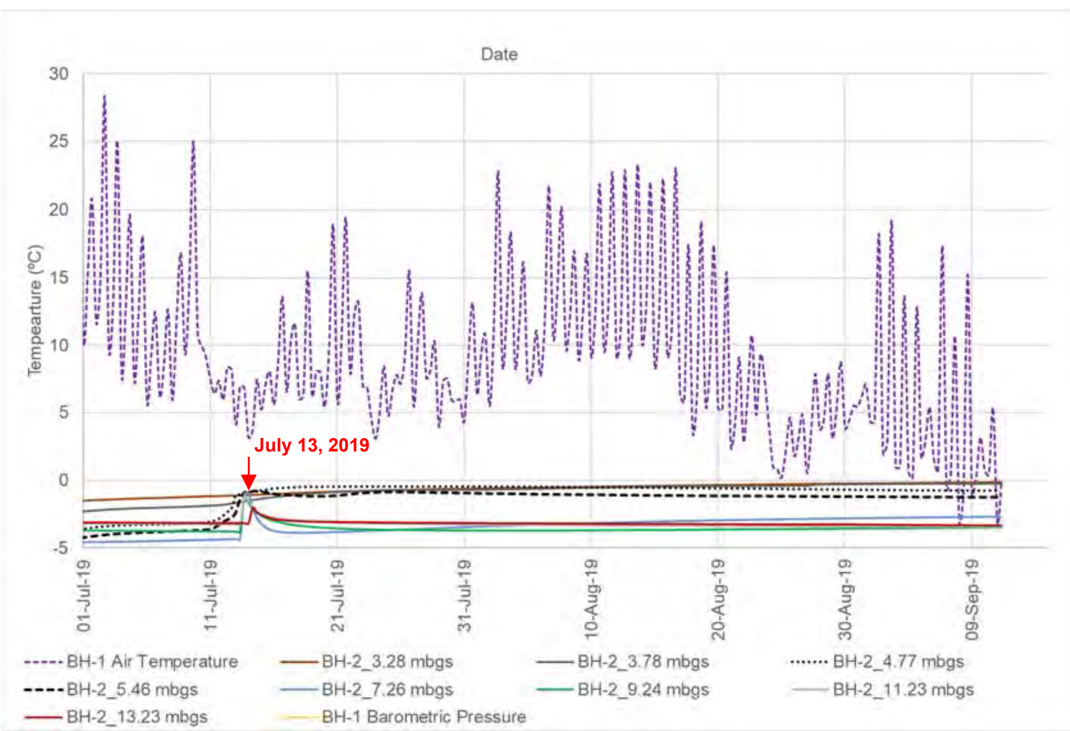


Figure 3: Variation in temperature with time at different depths along BH2, with emphasis to the July 13 sudden increase.

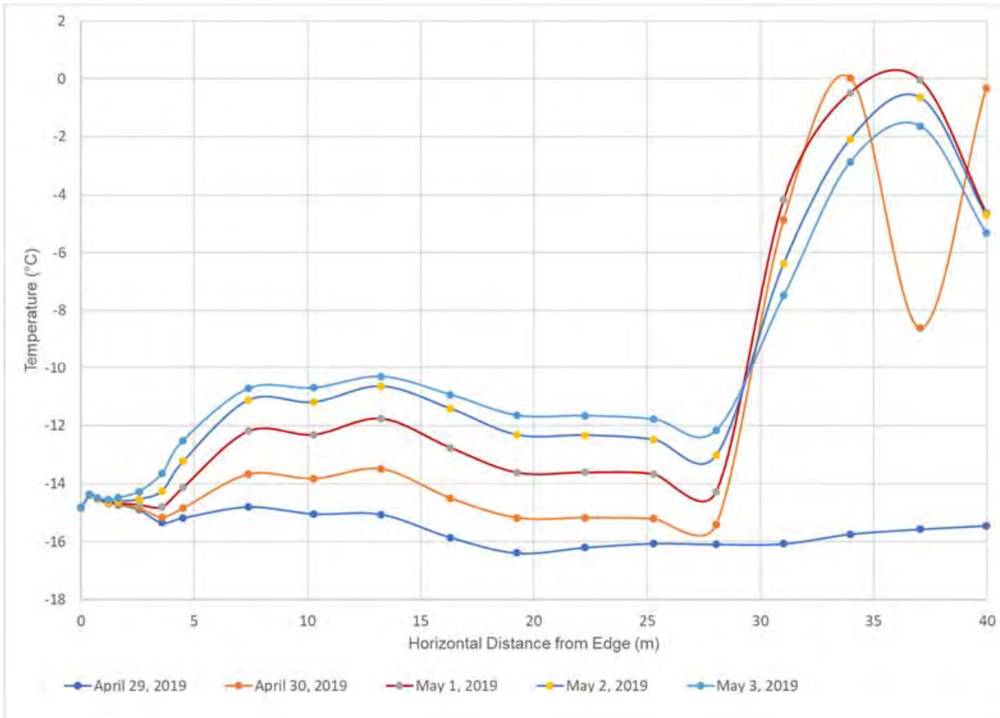


Figure 4: Variation in temperatures measured between April 30 and May 3, 2019 along the horizontal string T3.

Sudden, temporary and localized increases in temperature such as the events mentioned above cannot be associated solely with heat transfer through conduction (i.e. by direct particle contact). Air flow within the pile associated with barometric pumping, temperature-driven air convection, and/or other processes are likely influencing the observed temperature variations.

At BH2 temperatures rose suddenly between depths of 4 m and 13 m on July 13, followed by a quick reduction in temperatures below 5.5 m in depth, but higher temperatures persisted between depths of 4 and 5.5 m (higher than temperatures measured above between depths of 3 m and 4 m until the end of July 2019). This pattern suggests that a heat source could possibly have developed between depths of 4 m and 5.5 m that prevented temperatures from decreasing in that portion after the July 13 event. Possible influencing factors may include heterogeneous rock resulting in preferential gas or liquid flow pathways, or geochemical behavior of the waste rock. Additional thermal monitoring during winter and monitoring of seepage water quality is required to determine the possible cause of these results.

Localized variation in temperatures observed along the horizontal line T3 could have been related to factors such as spatial variation in the air-conductivity within the waste rock leading to preferential paths for convection of warmer air, or internal heat generation associated with variation in the geochemical behavior of the waste rock. Additional data is required to evaluate this pattern.

3.0 LABORATORY TESTING OF WASTE ROCK THERMAL PROPERTIES

Samples of PAG and Non-AG waste rock collected by Baffinland in March 2019 from the WRF were shipped to the Golder's Calgary laboratory for determination of grain-size distribution, specific gravity (SG), thermal conductivity, and volumetric heat capacity.

Both waste rock samples were granular with approximately 81% gravel, 12% sand, and 7% fine (i.e. < 0.075 mm) particles. The SG of the PAG and Non-AG samples was measured as 3.4 and 3.0, respectively. The thermal conductivity and volumetric heat capacity of the samples were measured for different test conditions to assess the impact of density and temperature on the thermal properties of the waste rock. The results are summarized in Table 1, and the detailed laboratory test results are presented in Appendix A.

Table 1: Measured Thermal properties of waste rock samples.

Rock Type	Density (kg/m³)		Moisture Content (%)	Saturation (%)	Test Temperature (°C)	Thermal K (W/m ⁰C)	Volumetric Heat Capacity (MJ/m³·C⁰)
	Dry	Wet					
PAG	1957	2048	4.7	21	4.7	0.854	1.734
					-5.0	0.983	2.154
	2097	2193	4.6	25	4.7	0.937	2.088
					-5.5	1.017	2.213
Non-AG	1862	1937	4.0	20	5.1	1.096	1.681
					-5.3	0.584	1.598
	1985	2074	4.5	26	5.1	1.833	1.904
					-5.5	1.947	2.127

The thermal conductivity of frozen materials is typically higher than that for unfrozen conditions because the thermal conductivity of ice is higher than the thermal conductivity of water. Likewise, the volumetric heat capacity of frozen materials is typically lower than that for unfrozen materials because the volumetric heat capacity of water is higher than the volumetric heat capacity of ice. As shown in Table 1, one of the Non-AG samples had measured thermal conductivity for unfrozen conditions that was higher than that for the frozen condition, and three out of four samples had measured volumetric heat capacity values at frozen conditions higher than for thawed condition.

The discrepancy between some of the test results and the expected patterns is possibly associated with changes in sample conditions during the test, such as variation in moisture content distribution associated with the samples granular nature and low water retention capacity. Before the measurements were taken, the samples were left standing for 24 hours to allow for equalization of sample temperature, and it is possible that the spatial distribution of water content within the sample changed during this standing period (i.e. water possibly drained to the bottom of the sample). Nevertheless, the test results can still be used as reference for the range of values that can be considered for modelling purposes.

4.0 NUMERICAL MODELLING

Transient two-dimensional (2D) thermal modelling was carried out using the finite element software TEMP/W of GeoStudio 2019 (Version 10.0), developed by GEO-SLOPE international Ltd. The following sections discuss the model setup, approach, and modelled material properties.

4.1 Model Setup

The 2D thermal models were prepared using a cross section of the WRF defined along the alignment of boreholes BH1, BH2 and BH3 as shown in Figure 1 (plan view) and Figure 5 (model cross-section). Data from thermistors installed at these boreholes and historic site climatic records were used to calibrate the model. Horizontal thermistor string T3 was also relatively aligned with the model cross section and was also used as a calibration reference.

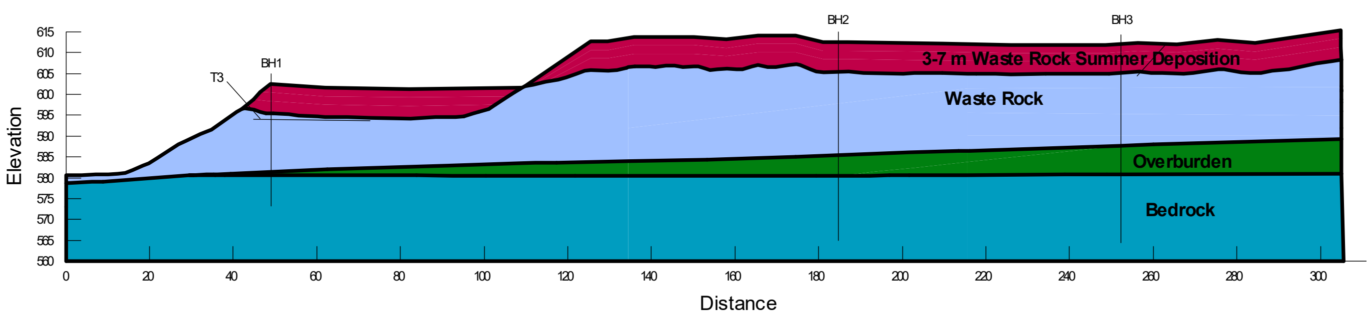


Figure 5: Cross section of the WRF defined for the thermal models.

4.2 Modelling Approach and Scenarios

Calibration models, herein referred to as the Calibration Phase, were run for the period between March 15, 2019 and September 11, 2019, with temperature profiles predicted along boreholes BH1, BH2 and BH3 and the horizontal thermistor string T3. The purpose of the calibration phase was to validate the model input parameters, material thermal properties, and boundary conditions until the predicted temperature profiles were in general good agreement with measured values at BH1, BH2, BH3, and T3.

After the Calibration Phase was completed, a second modelling stage was run to assess freezing patterns of waste rock deposited in summer and winter, herein referred to as the Waste Rock Deposition Phase. The models assumed instant placement of waste rock layers on top of the existing WRF surface at different times, and for summer-only deposition and summer-plus-winter deposition scenarios. Waste rock was assumed to be deposited at an initial temperature of +10°C for summer deposition, -1°C for waste rock deposited on October 1, and -15°C for scenarios with rock deposited on January 1. These temperatures were assessed based on ground surface temperatures measured by the thermistor strings. The models were run for a period of up to one year starting on June 1 or August 1 and ending on May 31 in the subsequent year. The evolution of temperatures within the WRF with time was computed, and temperature profiles along the location of BH2 were used to produce reference plots and estimate waste rock freezing times.

Table 2 summarizes the model scenarios evaluated for this study. The scenarios modelled are informed by potential waste rock deposition scenarios that may occur during operations.

Table 2: Thermal Model Scenarios.

Model Stage	Model Scenario	Waste Rock Deposition			
		Summer	Thickness (m)	Winter	Thickness (m)
Calibration Phase	May 2019 waste rock topography	-	-	-	-
Waste Rock Deposition Phase	Added Summer deposition	June 1 at 10°C	3, 5 and 7	-	-
		August 1 at 10°C	3, 5 and 7	-	-
	Added Summer + Winter deposition	June 1 at 10°C	3 and 5	October 1 at -1°C	5 m
		August 1 at 10°C	3 and 5	January 1 at -15°C	5 m

4.3 Material Properties

The waste rock thermal properties input into the models were defined primarily based on the results of the laboratory testing described in Section 3.0, and were adjusted during the calibration process. The thermal properties of overburden and bedrock were assumed and have less impact on the model results. Table 3 summarizes the calibrated material thermal properties input into the models.

Table 3: Thermal properties of materials included in the thermal models.

Material	Volumetric Water Content	Thermal Conductivity (W/m-°C)		Volumetric Heat Capacity (MJ/m3-°C)	
		Frozen	Unfrozen	Frozen	Unfrozen
Waste Rock	8%	1.95	1.8	1.7	2.0
Overburden	35%	2.1	1.5	2.2	2.8
Bedrock	1%	2.9	2.9	2.4	2.4

4.4 Boundary Conditions

4.4.1 Calibration Phase

A ground surface temperature function was defined based on the near-surface temperatures measured at BH1 (0.38 m deep), BH2 (0.25 m deep) and BH3 (0.05 m deep). Temperature data from BH2 was chosen because, in general, it showed warmer temperatures in summer compared to BH1 and BH3. Figure 6 shows the evolution of near-surface temperatures measured at BH1, BH2 and BH3, as well as air temperatures measured adjacent to BH1.

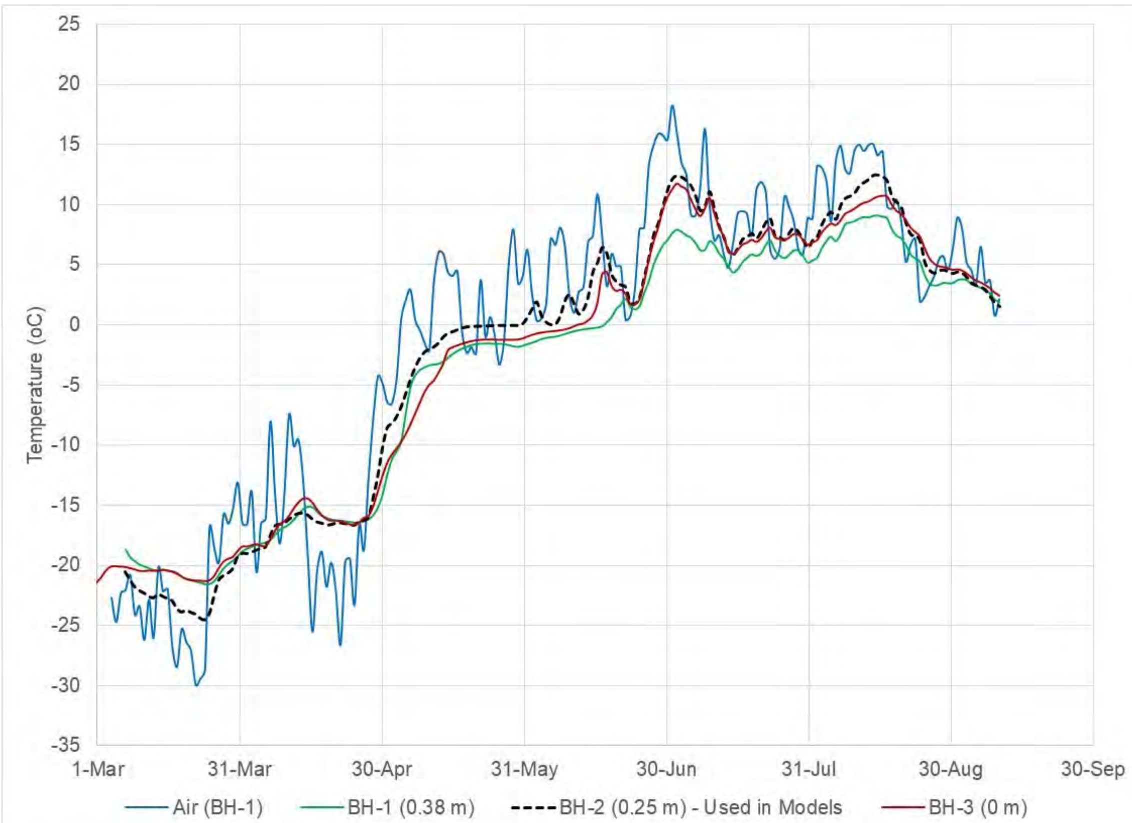


Figure 6: Measured near-surface ground temperature.

A constant temperature of -8ºC was defined as the boundary condition at the base of the model geometry at elevation 560 m, about 20 m below the original ground surface. This value was defined based on thermal gradients estimated from the deepest thermistor nodes at boreholes BH1, BH2 and BH3.

Further discussed under Section 5.1, results obtained from the Calibration Phases using the material properties and boundary conditions described above were in good agreement with temperature profiles measured along BH1, but not along BH2 and BH3, which in general showed warmer temperatures compared to the model predicted temperatures. This was associated with the model being unable to capture sudden temporary variations in temperatures along BH2 and BH3 such as those described in Section 2.0.

To improve calibration of the model results to measured values at BH2 and BH3, air flow was initially incorporated in the models by including an air pressure boundary condition at ground surface, based on barometric pressures values measured at the BH1 barometer. This approach, however, did not improve calibration of the model results at BH2 and BH3, and was discarded.

Internal heat was than included in the models by adding a heat flux boundary to waste rock portions adjacent to BH2 and BH3. A unit heat flux value of 30 kJ/day was defined as the calibrated value that produced model results that were closer to the measured temperatures at BH2 and BH3. This was an artificial way adopted to improve agreement between measured and model predicted temperatures, but the internal heat boundary applied in the models was not intended to represent any specific heat source. As discussed under Section 2.0, several factors might have influenced temperatures in the pile, and additional monitoring is required to assess the patterns of variation in temperatures within the waste rock.

4.4.2 Waste Rock Deposition Phase

A ground surface temperature function was defined for the entire year as the average monthly temperature based on available data from the site thermistors and average monthly air temperature data obtained from the Mary River weather station between 2013 and 2019. Figure 7 shows the ground temperature function adopted for the models and other sources of temperature data used as reference.

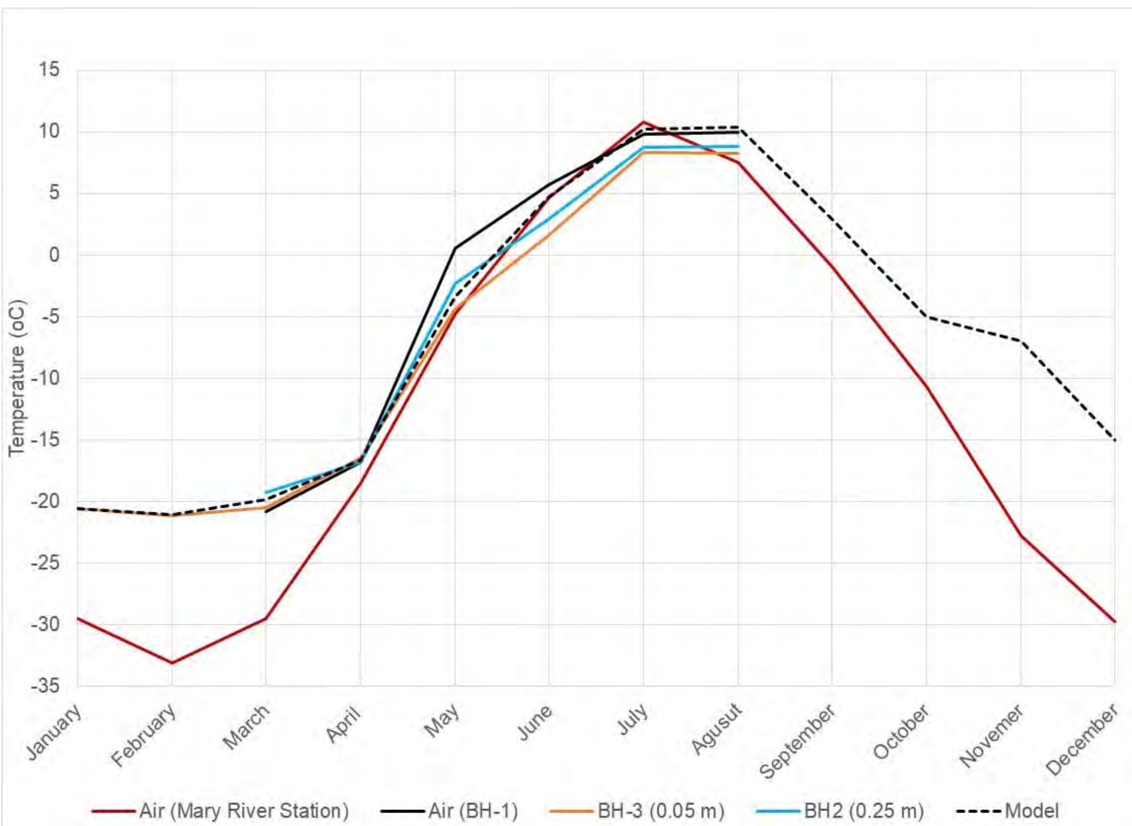


Figure 7: Ground temperature function defined for the Waste Rock Deposition Phase of the thermal model.

As in the Calibration Phase of the model, a constant temperature of -8°C was defined as the boundary condition at the base of the model geometry at elevation of 560 m, about 20 m below the original ground surface.

For comparison purposes, model scenarios were run with and without inclusion of internal heat generation adjacent to BH2 and BH3 as discussed above. The model results are discussed under Section 5.0.

4.5 Model Limitations

The models prepared for this study constitute a simplification of the field conditions and carry assumptions and limitations that shall be taken into consideration during interpretation of the model results. The principal model limitations are as follows:

- The models consider a homogeneous waste rock mass with no spatial variation in waste rock properties. Waste rock piles typically present zones of segregated materials, densification and layering that affect their thermal and hydraulic characteristics, as well as can work as preferential pathways for air flow that can impact internal temperatures.
- The models assumed instant placement of waste rock in summer at an initial rock temperature of +10^{o}C, which is a conservative approach (i.e. resulting in warmer model predicted temperatures). In reality, waste rock will be placed progressively throughout the summer with peak temperatures likely occurring in July and August. Waste rock placed in June and September would likely be at temperatures below 5^{o}C. Similarly, in model scenarios where winter deposition was considered, the waste rock temperature was set as -1^{o}C for deposition in the beginning of October and -15^{o}C for deposition in January, but the actual deposition temperatures could be lower through winter.
- The 2D nature of the thermal models can only capture heat transfer along the cross section and does not incorporate three-dimensional heat transfer coming from adjacent areas perpendicular to the model geometry.

5.0 MODEL RESULTS

5.1 Calibration Phase

Figures 8 to 11 provide the modeled temperature profiles at BH1, T3, BH2 and BH3, respectively, for various dates, together with temperatures measured by the installed thermistors. Model results presented in Figures 10 and 11 for BH2 and BH3 do not include heat generation.

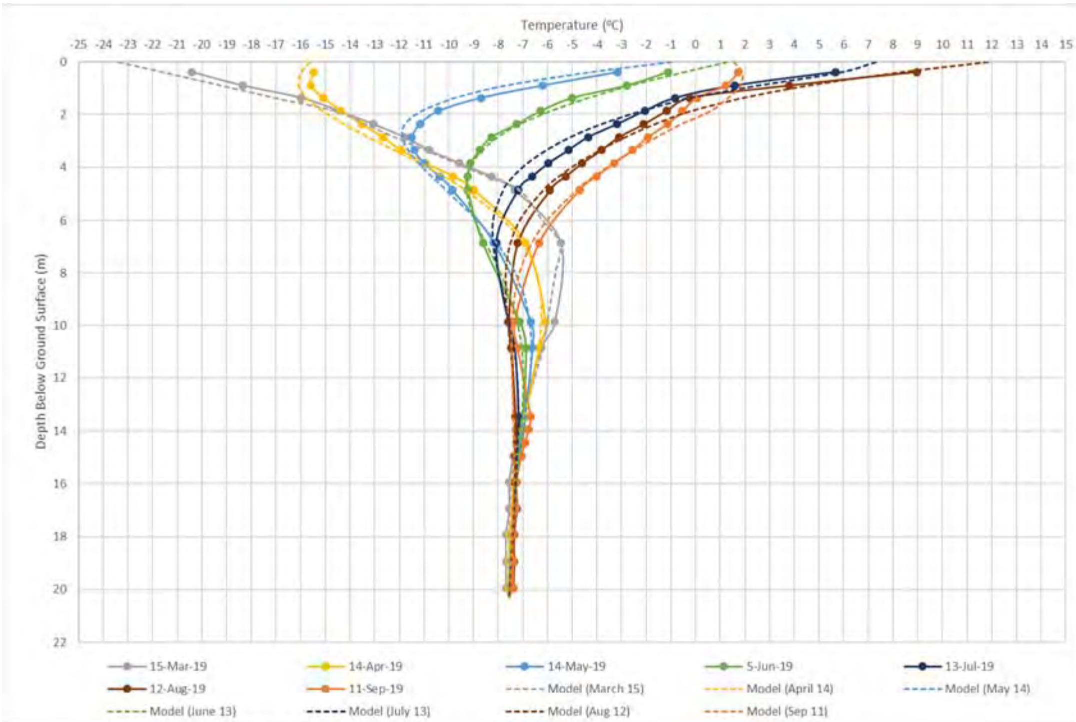


Figure 8: Comparison of predicted and measured temperature profiles along borehole BH1.

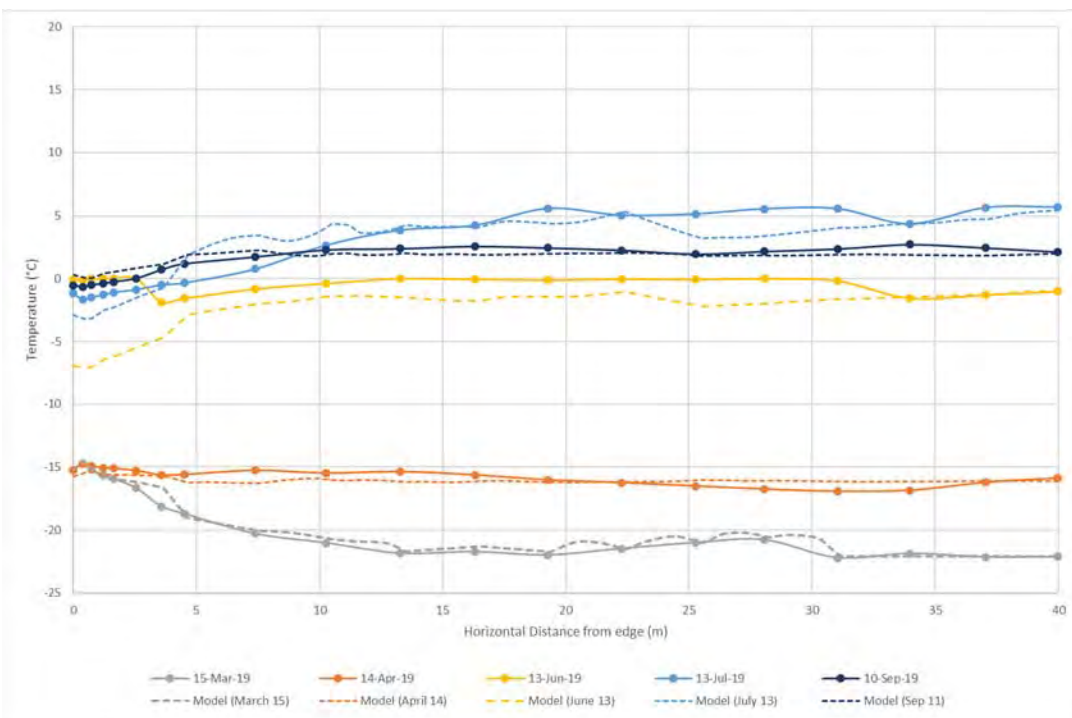


Figure 9: Comparison of predicted and measured temperature profiles along the horizontal string T3.

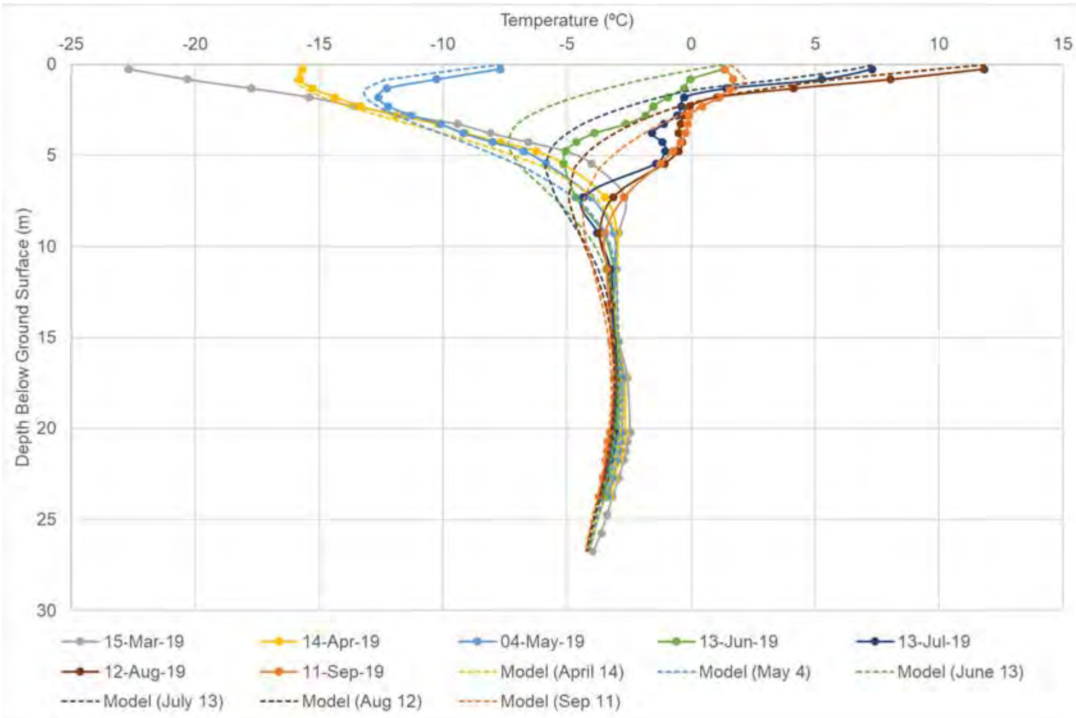


Figure 10: Comparison of predicted and measured temperature profiles along borehole BH2, without inclusion of internal heat generation.

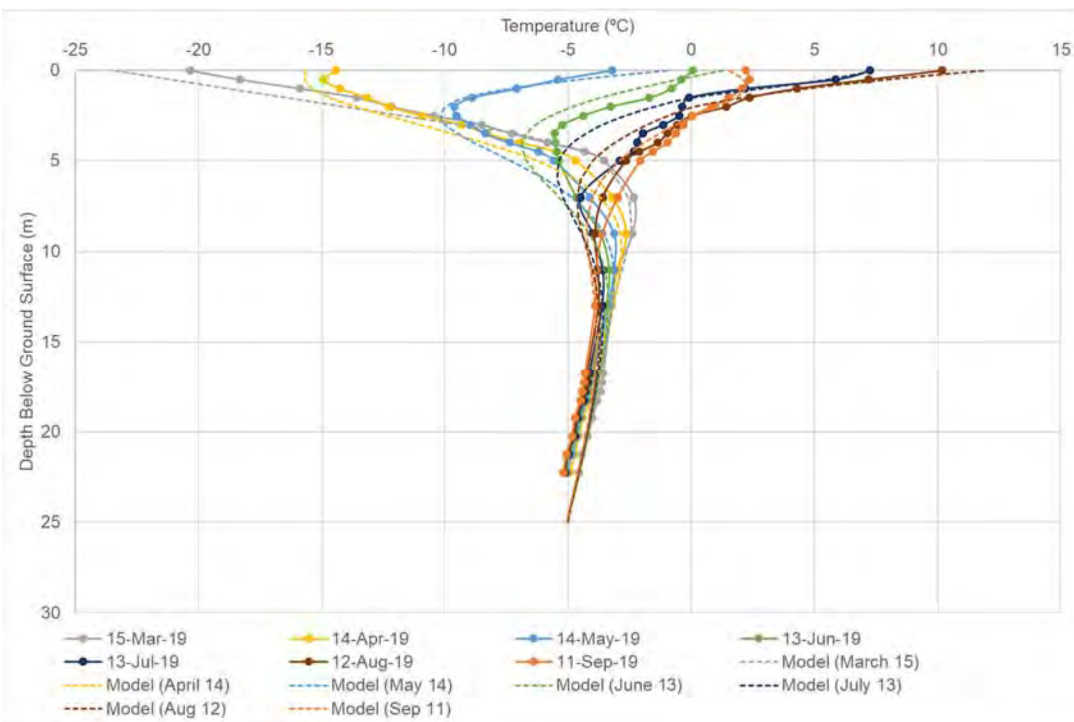


Figure 11: Comparison of predicted and measured temperature profiles along borehole BH3 without inclusion of internal heat generation.

As shown in Figures 9 to 11, predicted temperatures for modelling scenarios that did not consider internal heat generation were in general agreement with measured temperatures along BH1 and T3, but measured temperatures along BH2 and BH3 after June 2019 were warmer than predicted by the models. Figures 12 and 13 present the modeled temperature profiles at BH2 and BH3 with inclusion of a heat-flux boundary condition as described in Section 4.4.1.

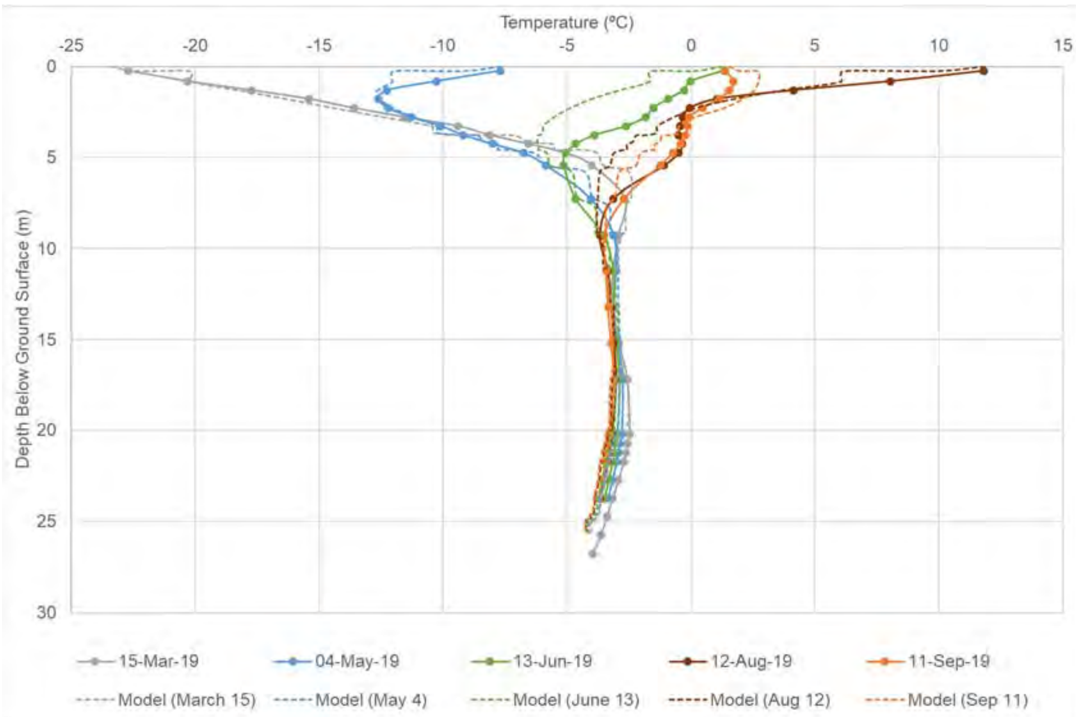


Figure 12: Predicted temperature profiles along borehole BH2 with inclusion of an internal heat source.

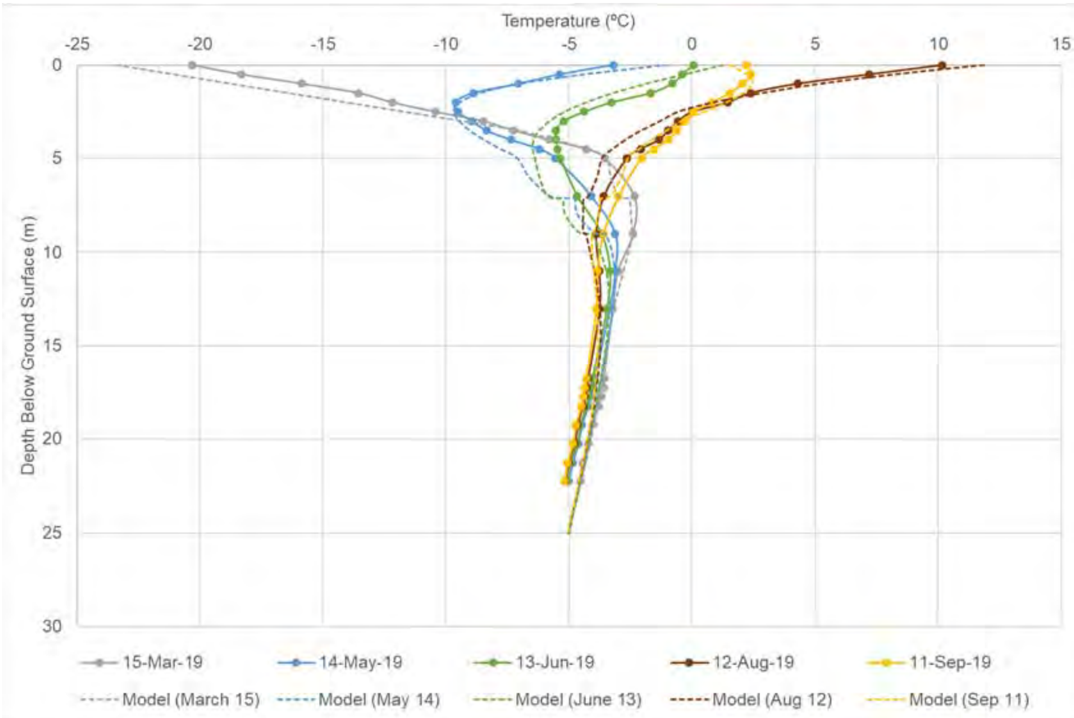


Figure 13: Predicted temperature profiles along borehole BH3 with inclusion of an internal heat source.

As shown in Figures 12 and 13, inclusion of heat generation in waste rock portions adjacent to BH2 and BH3 resulted in model predicted temperatures that were closer to measured values. Model predicted temperatures were still colder than measured along BH2, however, the temperature profiles presented in Figure 12 are the best results that could be obtained during the calibration phase of the model.

5.2 Waste Rock Deposition Phase

The following sections discuss the thermal model results. The modelled scenarios are intended to be used as guidance for waste rock deposition and consider waste rock lift thickness typical of operational requirements. Baffinland intends to manage waste rock lift thickness and timing of placement in a manner that results in freeze back of summer placed waste rock by end of the following winter.

5.2.1 Summer-Only Deposition Scenarios

Table 4 summarizes the model predicted times for complete freezing of waste rock layers deposited in summer assuming instant deposition on June 1. or August 1 with initial waste rock temperature of +10ºC, and that the waste rock remains exposed for the model duration.

Table 4: Summary of freezing times predicted for waste rock deposited in summer.

Waste Rock Deposition Date	Waste Rock Thickness (m)	Average Freezing Time along BH1, BH2 and BH3			
		No Internal Heat		With Internal Heat	
		Days	Date	Days	Date
June 1	3	185	3-Dec-2019	185	3-Dec-2019
	5	227	14-Jan-2020	245	1-Feb-2020
	7	300	27-Mar-2020	345	11-May-2020
August 1	3	125	4-Dec-2019	135	14-Dec-2020
	5	185	2-Feb-2020	215	3-Mar-2020
	7	270	27-Apr-2020	>300	Does not freeze before following summer

Results of the thermal model indicate that waste rock layers placed in the later stages of summer takes less time to freeze (i.e. predicted days for freezing since deposition date) compared to waste rock deposited earlier in summer. This is associated with the fact that waste rock placed later in summer is exposed sooner to lower temperatrues in fall and early winter, which accelerates the cooling process. As a result, the models suggest that waste rock layers deposited in June and August would be frozen more or less around the same time of the year, that is early December for 3 m thick layers, and early February to early March of the subsequent year for 5 m thick layers.

Figure 14 illustrates variations in temperatures with depth and time for the 5 m thick waste rock summer deposition scenario (deposition on June 1) with inclusion of internal heat.

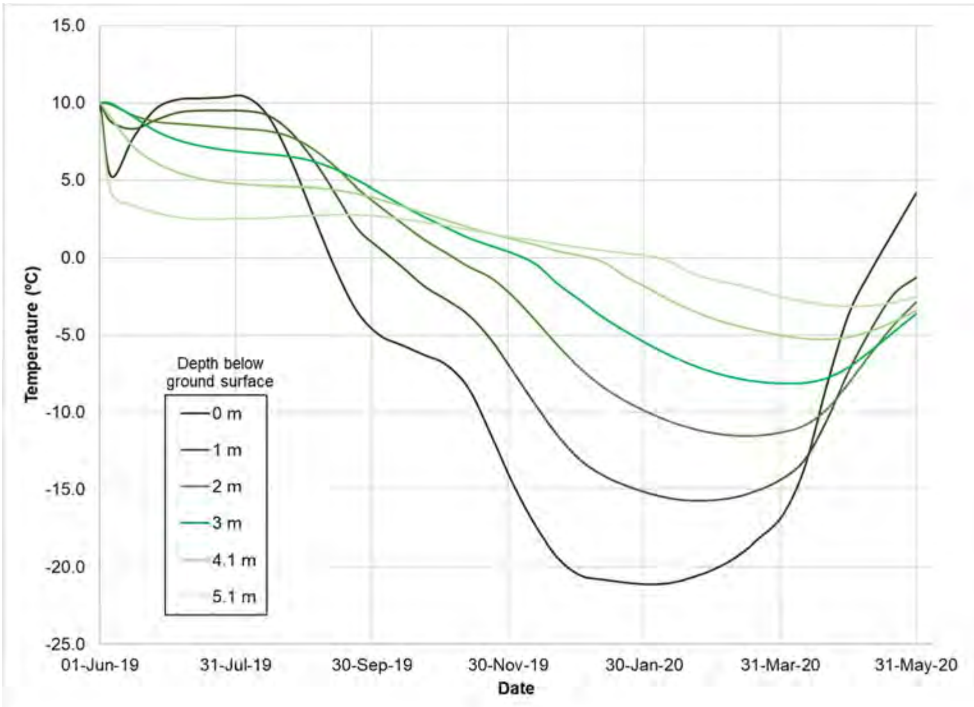
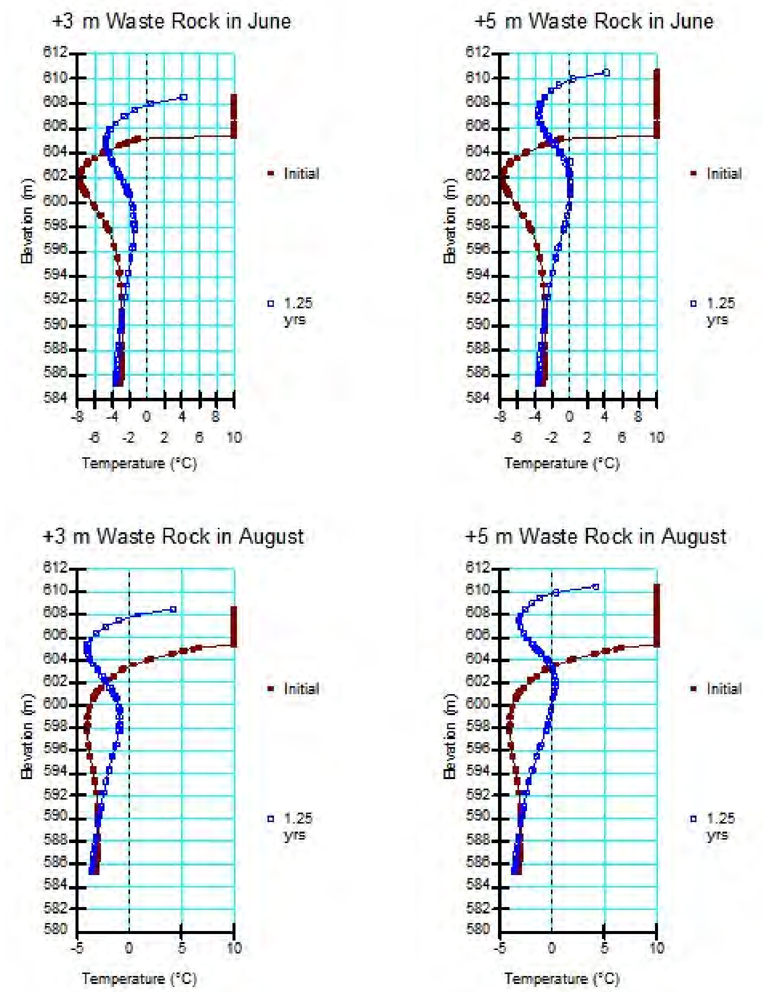


Figure 14: Evolution of temperatures within summer deposited waste rock (5.0 m thick lift) left exposed during winter

Figure 15 shows variation in waste rock temperature profiles computed along BH2 for the model scenarios with summer deposition of 3 and 5 m thick waste rock layers, with deposition occurring in June or August, and with inclusion of internal heat in the models. Each plot in Figure 15 shows temperature profiles at the beginning (i.e. June 1 or August 1) and at the end (i.e. May 31 of the subsequent year) of the model time span.



Note on Legend: initial = June 1, 2019 or August 1, 2019, and 1.25 yrs = May 31, 2020

Figure 15: Computed variation in temperature profiles within the WRF associated with summer deposition (for model scenarios with inclusion of internal heat).

Although the model results indicated that waste rock up to 7 m thick placed in summer would be mostly frozen before the beginning of summer in the subsequent year, placement of warmer waste rock on top of previously deposited frozen waste rock is predicted to cause temperatures in those areas to increase.

Figures 16 and 17 show temperature contours computed for 1 year following the June 1 deposition of 5 and 7 m thick waste rock layers, respectively, with inclusion of internal heat in the models. The white dashed line in Figures 16 and 17 represents the 0°C isoline, meaning portions of waste rock inside the areas delimited by this contour line would be thawed, while areas outside this contour are frozen.

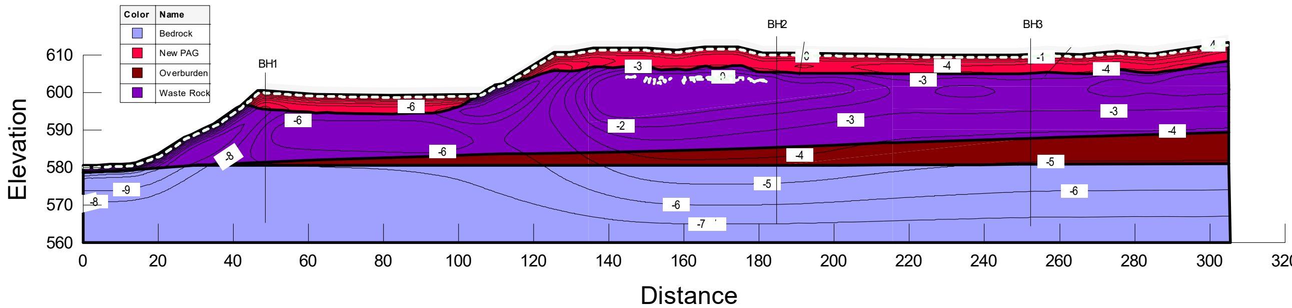


Figure 16: Temperature contours computed within the WRF after 1 year since summer (June 1) deposition of a 5 m thick waste rock layer (with inclusion of internal heat in areas adjacent to BH2 and BH3).

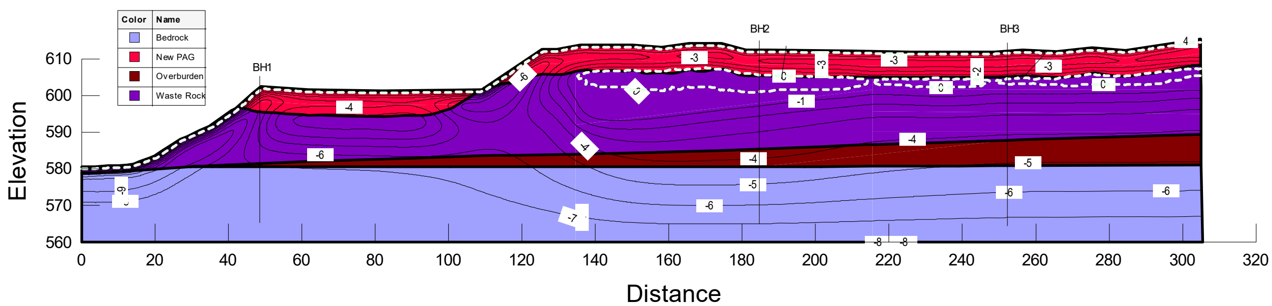


Figure 17: Temperature contours computed within the WRF after 1 year since summer (June 1) deposition of a 7 m thick waste rock layer (with inclusion of internal heat in areas adjacent to BH2 and BH3).

Under the conditions modelled with inclusion of internal heat generation, placement of a 7-m thick layer of warm waste rock in summer is predicted to cause temperatures within previously deposited waste rock to increase and lead to the development of a 5-m deep thawed zone below the summer-deposition waste rock layer (Figure 15). If the summer deposited waste rock layer is less than or equal to 5 m thick, the models showed that the thawed zone would be limited to a much smaller portion.

If internal heat generation is not included, the models showed that the entire WRF would be frozen within a year, except the uppermost portion of waste rock which is subject to seasonal freezing and thawing cycles.

5.2.2 Summer plus Winter Deposition Scenarios

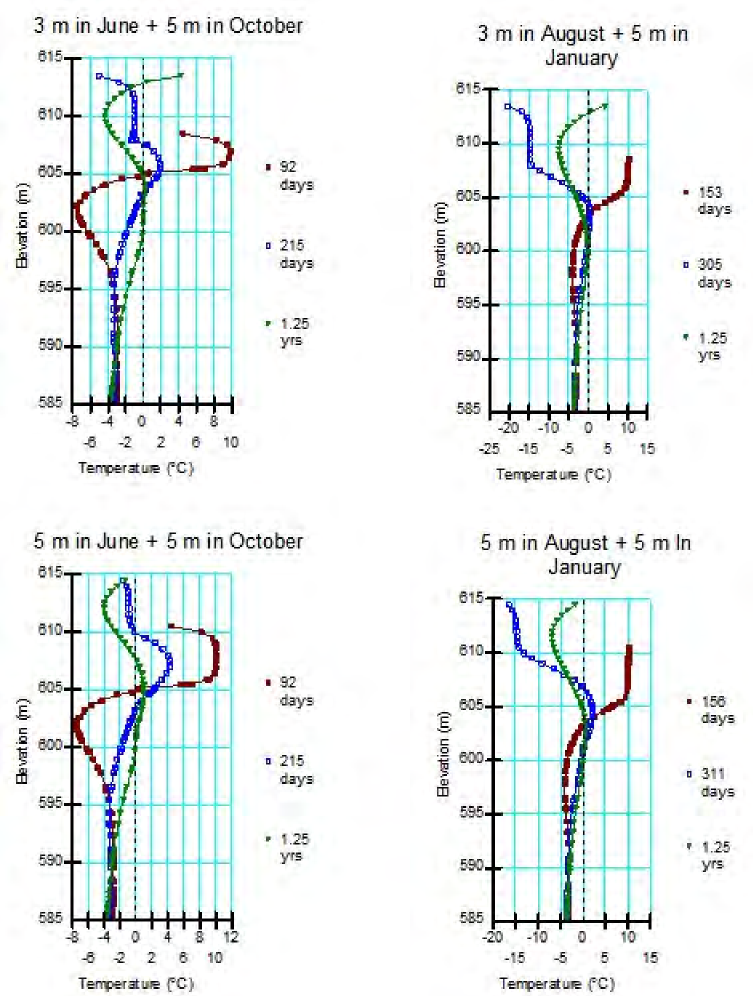
Table 5 summarizes the model predicted times for complete freezing of waste rock layers deposited in summer followed by subsequent waste rock deposition in winter. The model scenarios included 3 to 5 m of waste rock deposited on June 1 at an initial temperature of 10°C followed by 5 m of waste rock deposited on October 1 at -1°C. Additional scenarios included 3 to 5 m of waste rock deposited on August 1 at 10°C followed by 5 m of waste rock deposited on January 1 at initial temperature of -15°C.

Table 5: Summary of freezing times predicted for waste rock deposited in summer followed by winter deposition.

Summer Deposition Date	Summer Waste Rock thickness (m)	Winter Deposition (5-m thick layer)	Average Freezing Time of Summer Deposition Layer			
			No Internal Heat		With Internal Heat	
			Days	Date	Days	Date
June 1	3	October 1	305	2-Mar-2020	305	2-Mar-2020
	5		355	21-May-2020	-	Does not freeze completely prior to subsequent summer
August 1	3	January 1	125	4-Dec-2019	135	14-Dec-2019
	5		199	16-Feb-2020	223	11-Mar-2020

Based on the model results presented in Table 5, it is identified that summer placed waste rock should remain exposed during winter to the extent practical prior to covering over, to reduce potential for developing of thawed zones within the WRF.

Figure 18 shows variation in waste rock temperature profiles computed along BH2 for the model scenarios with summer deposition of 3 and 5 m thick waste rock layers in June or August, followed by winter deposition of 5 m of waste rock in October or January. Each plot in Figure 18 shows initial summer temperature profiles (i.e. June or August), initial winter deposition temperature profiles (i.e. October or January), and at the end of the model time span (i.e. May 31 of subsequent year).



Note on Legend: 92 days = June 1, 2019, 153 days = August 1,2019, 156 days = August 4, 2019, 215 days = October 2, 2019, 305 days = December 31, 2019, 311 days = January 6, 2020, and 1.25 yrs = May 31, 2020.

Figure 18: Computed variation in temperature profiles within the waste rock associated with summer (June and August) and winter (October and January) deposition (for model scenarios with inclusion of internal heat).

Figure 19 shows temperature contours computed for the model scenario with 5 m of summer waste rock deposition in June followed by 5 m winter deposition in October, with inclusion of internal heat.

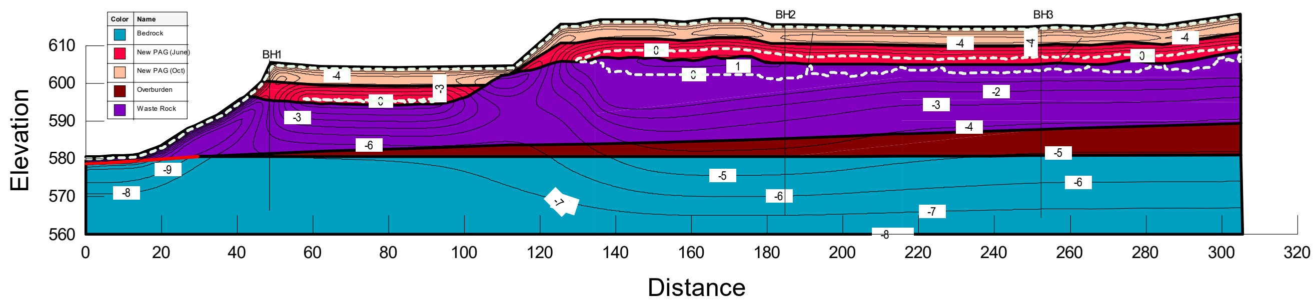


Figure 19: Temperature contours computed within the WRF after 1 year since summer deposition of a 5 m thick waste rock layer in June, followed by 5 m of waste rock deposited in October (with inclusion of internal heat generation in areas adjacent to BH2 and BH3).

The model results indicate that winter deposition on top of summer deposited waste rock layers would delay freezing of waste rock deposited in summer, but most of the summer waste rock would be frozen prior to the following summer. However, heat exchange between summer-deposition waste rock and previously deposited waste rock deeper in the pile could create a thawed zone in the interior of the pile enveloped by portions of frozen waste rock beneath and above it.

The models also indicate that waste rock layers deposited in early summer (i.e. June), that are covered with waste rock in early winter (i.e. October), would take longer to freeze compared to waste rock deposited in late summer (i.e. August) that are only covered in mid winter (i.e. January). Delaying winter deposition to allow summer-deposition layers to be exposed to cold air in the beginning of winter would decrease freezing times and help reduce the extent of thawed portions within the WRF.

6.0 CONCLUSIONS AND RECOMMENDATIONS

A thermal assessment, including review of site thermistor data and numerical modelling, was carried out to evaluate the short-term freezing patterns of waste rock deposited in summer and the subsequent winter. The thermal model was calibrated using data obtained from site thermistors as reference to allow for comparison of predicted versus measured temperature profiles. After the calibration process was complete, the models incorporated summer-only deposition of waste rock layers with increasing thickness and predicted freezing times and the impact of summer deposition on previously deposited waste rock. The models also evaluated the impact of winter deposition following summer deposition, and how freezing patterns within the pile are affected. The main conclusions from the thermal assessment are as follows:

- Review of data obtained from the site thermistors indicate that the WRF is almost entirely frozen, with exception of a 2 - 3m thick active zone subject to seasonal freeze and thaw cycles.
- Temperatures within the WRF are affected not only by air temperature, but also potentially by air flow, air convection and by internal heat generation connected to airflow through the WRF and variation in the geochemical behavior of the waste rock. Progressive increase in air temperatures slowly impacts ground temperature, while airflow and/or internal heat generation lead to sudden, localized and temporary variations in temperatures.
- Results from thermal models suggest that between 5 m and 7 m of waste rock could be placed in summer and the entire thickness of material would freeze during the following winter, assuming the summer placed material was not covered over during the winter. However, depending on the existence of heat sources within the WRF,

a 7 m thick waste rock summer deposition could cause the development of a thawed zone in portions of waste rock previously deposited. Deposition of up to 5 m of waste rock in summer would reduce the risks of creating a thawed zone at depth within the WRF.

- Winter deposition will delay freezing of the underlying material deposited during the summer. The models predict that a 5 m thick lift of waste rock deposited in summer, covered by a 5 m thick layer of waste rock in winter, would freeze prior to the following summer in most scenarios. However, heat exchange between summer deposition layers and waste rock deeper in the WRF could cause the development of a thawed zone in the interior of the WRF. Delaying winter deposition or reducing the thickness of summer deposition would decrease freezing times and reduce or possibly eliminate the extent of thawed portions within the WRF.
- If no internal heat source is present, the models indicate that the entire waste rock layer deposited in summer would freeze within a year, with or without additional deposition of waste rock in winter, and the extent of the thawed zone in the interior of the pile would be very limited.

The following activities are recommended to improve understanding of the WRF freezing patterns:

- Continue to monitor the evolution of temperatures and oxygen concentrations. This would allow for further assessment of the localized patterns of temperature variation that were observed along several thermistor strings.
- Periodically update the thermal modeling based on monitored deposition sequences and measured temperature conditions.
- Conduct periodic surveillance of the surface of the WRF as added waste rock on top of existing instrumentation will impact results, and it is important to know when and to what extent waste rock was placed to allow for meaningful interpretation of instrumentation data.
- Consider installation of additional instrumentation within future expansion of the WRF footprint.

7.0 CLOSURE

We trust the information provided in this document meet your expectation and needs. Should you have any question or requests, please do not hesitate to contact Golder.

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Principal, Geochemist

FJ/BA/KD/fj

https://golderassociates.sharepoint.com/sites/22103g/technical work/phase 40000 - thermal/2. thermal memo/text/rev.0/1790951 - thermal modelling.docx

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Golder Associates Ltd (2019). WRF Instrumentation Installation Summary Report. Technical Memorandum. July 25, 2019.

APPENDIX A

Laboratory Test Results

VOLUMETRIC SPECIFIC HEAT CAPACITY OF SOIL BY THERMAL NEEDLE PROBE

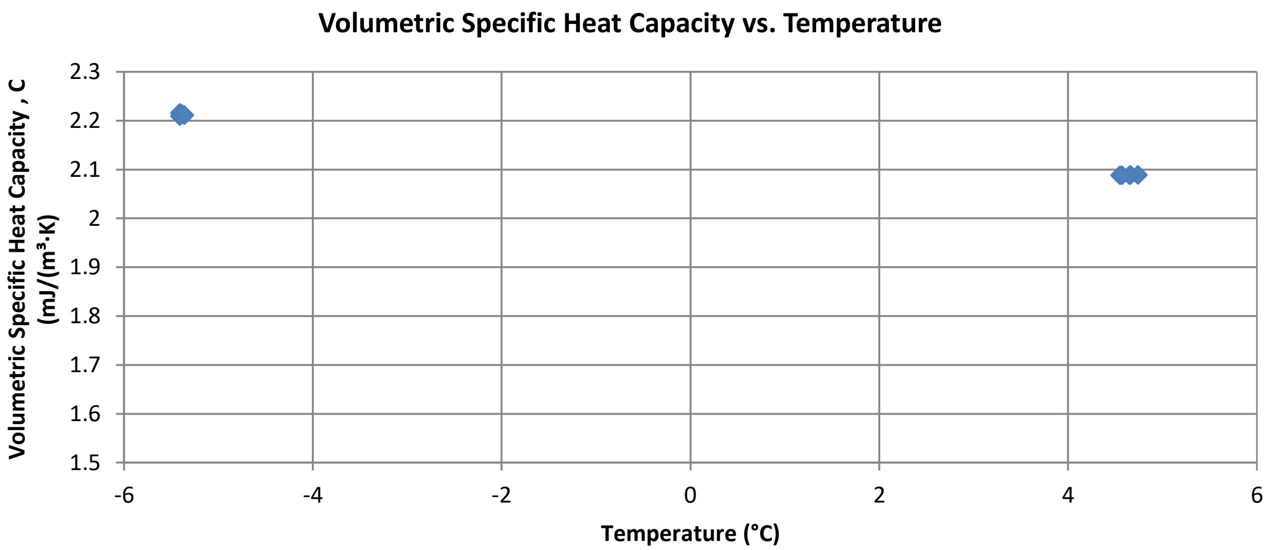
(ASTM D5334-08)

Project No.: 1790951 | Phase: 20000.20001
Short Title: Baffinland/Waste Rock Mgmt Planning | Lab No.: D132-03
Tested By: FC | Date: 19-Sep-19

Location:	-	**Undisturbed or Remolded:**	Remolded
Sample No.:	PAG	**Wet Density (kg/m³):**	2193
Height (mm):	202.8	**Water Content (%):**	4.6
Diameter (mm):	102.3	**Dry Density (kg/m³):**	2097
Mass (g):	3656.5	**Void Ratio:**	0.62
Thermal Probe No.:	SH-1	**Saturation (%):**	25
Probe Length (mm):	50	**G_s:**	3.4

Test Results:

Trial No.	Temp. (°C)	Avg. Temp. (°C)	Volumetric Specific Heat Capacity, C mJ/(m³·K)	Avg. Volumetric Specific Heat Capacity, C mJ/(m³·K)	Thermal Diffusivity, D (mm²/s)	Avg. Thermal Diffusivity, D (mm²/s)
1	4.74	4.6	2.089	2.088	0.384	0.383
2	4.55		2.088		0.383	
3	4.66		2.089		0.383	
4	4.65		2.088		0.383	
5	4.57		2.088		0.382	
1	-5.41	-5.4	2.216	2.213	0.400	0.400
2	-5.40		2.214		0.400	
3	-5.39		2.214		0.400	
4	-5.41		2.209		0.400	
5	-5.36		2.211		0.401	



Remarks:
Volumetric Heat Capacity value has a precision of +/- 10%
1. Calculated post test water content using the entire sample was 5.1%
2. Two trials was completed. Both results is similar that heat capacity was higher on frozen sample than thawed sample
3. Test Conducted using KD2-Pro Thermal Properties Analyzer
4. Minus 37.5 mm material was used and was reconstituted in 100 x 200 mm cylinder mould

GOLDER

THERMAL CONDUCTIVITY OF SOIL BY THERMAL NEEDLE PROBE

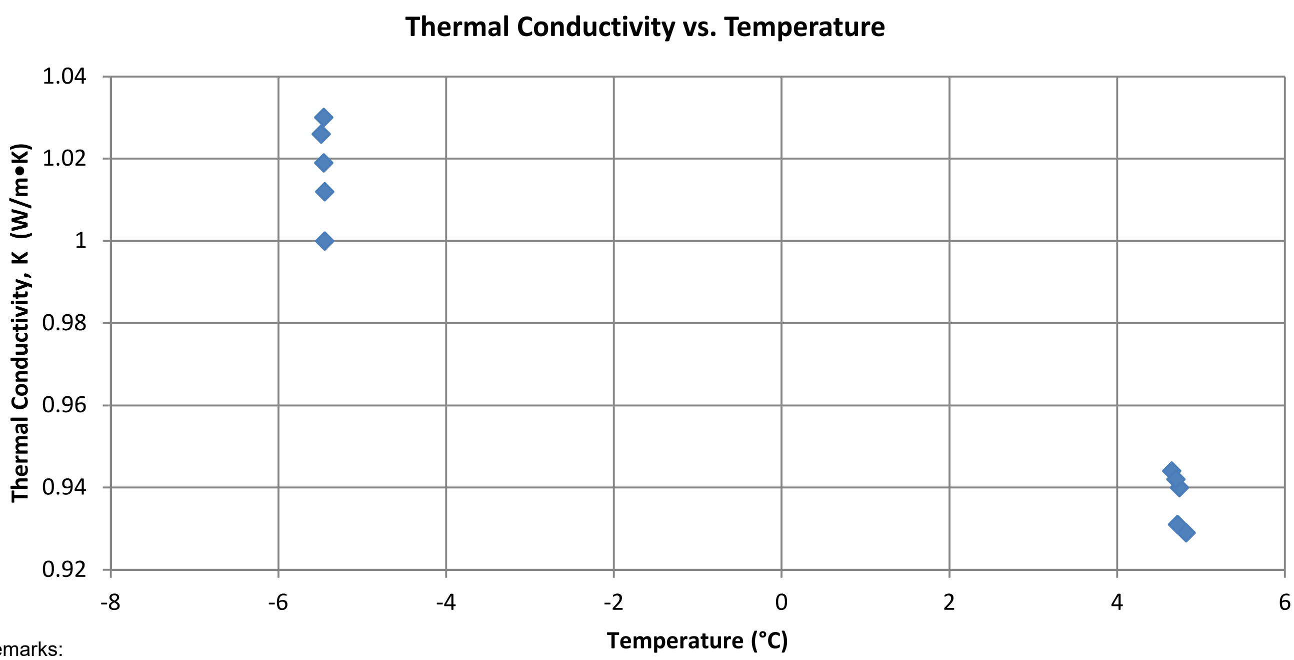
(ASTM D5334-08)

Project No.: 1790951 | Phase: 20000.20001
Short Title: Baffinland/Waste Rock Mgmt Planning | Lab No.: D132-03
Tested By: FC | Date: 19-Sep-19

Location:	-	**Undisturbed or Remolded:**	Remolded
Sample No.:	PAG	**Wet Density (kg/m^3):**	2193
Height (mm):	202.8	**Water Content (%):**	4.6
Diameter (mm):	102.3	**Dry Density (kg/m^3):**	2097
Mass (g):	3656.5	**Void Ratio:**	0.62
Thermal Probe No.:	TR-1	**Saturation (%):**	25
Probe Length (mm):	100	**G_s:**	3.4

Test Results:

Trial No.	Temp. (°C)	Avg. Temp. (°C)	Thermal Conductivity, K (W/m•K)	Avg. Thermal Conductivity, K (W/m•K)	Thermal Resistivity, R (m•K/W)	Avg. Thermal Resistivity, R (m•K/W)
1	4.72		0.931		1.074	
2	4.74		0.940		1.064	
3	4.65	4.7	0.944	0.937	1.059	1.067
4	4.70		0.942		1.062	
5	4.82		0.929		1.076	
1	-5.46		1.030		0.971	
2	-5.49		1.026		0.975	
3	-5.46	-5.5	1.019	1.017	0.981	0.983
4	-5.45		1.000		1.000	
5	-5.45		1.012		0.988	



Remarks:

Thermal conductivity value has a precision of +/- 10%

1. calculated post test water content using the entire sample was 5.1%
2. Sample allowed to reach equilibrium for 60 min before testing
3. Test Conducted using KD2-Pro Thermal Properties Analyzer
4. Minus 37.5 mm material was used and was reconstituted in 100 x 200 mm cylinder mould

GOLDER

VOLUMETRIC SPECIFIC HEAT CAPACITY OF SOIL BY THERMAL NEEDLE PROBE

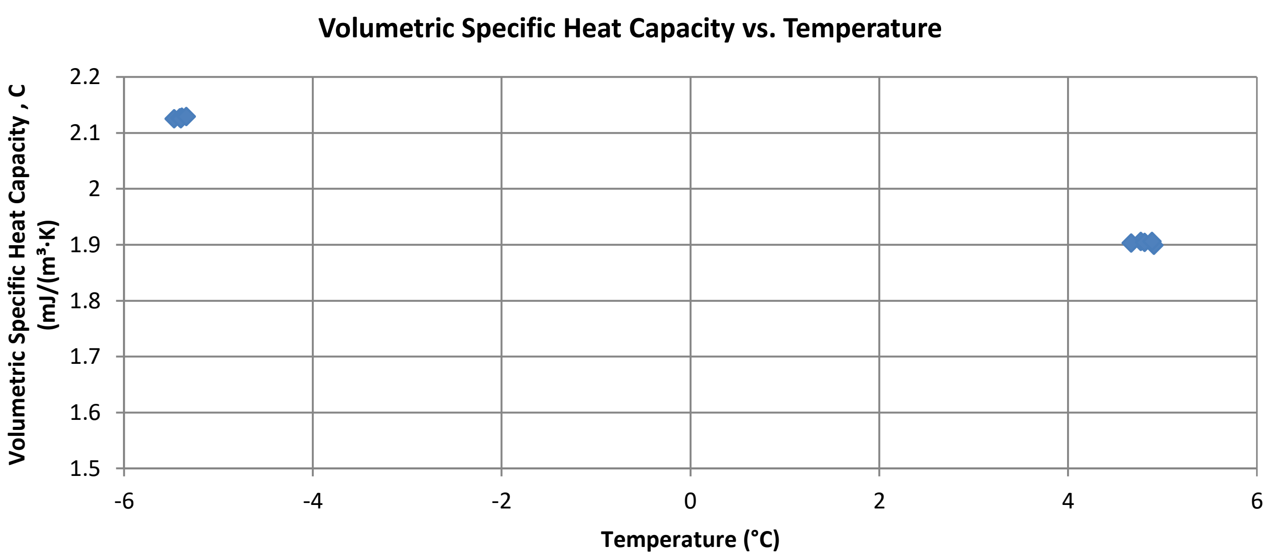
(ASTM D5334-08)

Project No.: 1790951 | Phase: 20000.20001
Short Title: Baffinland/Waste Rock Mgmt Planning | Lab No.: D132-04
Tested By: FC | Date: 19-Sep-19

Location:	-	**Undisturbed or Remolded:**	Remolded
Sample No.:	NAG	**Wet Density (kg/m^3):**	2074
Height (mm):	202.8	**Water Content (%):**	4.5
Diameter (mm):	102.2	**Dry Density (kg/m^3):**	1985
Mass (g):	3451.4	**Void Ratio:**	0.51
Thermal Probe No.:	SH-1	**Saturation (%):**	26
Probe Length (mm):	50	**G_s:**	3.0

Test Results:

Trial No.	Temp. (°C)	Avg. Temp. (°C)	Volumetric Specific Heat Capacity, C mJ/(m³·K)	Avg. Volumetric Specific Heat Capacity, C mJ/(m³·K)	Thermal Diffusivity, D (mm^2/s)	Avg. Thermal Diffusivity, D (mm^2/s)
1	4.91	4.8	1.899	1.904	0.398	0.397
2	4.77		1.906		0.397	
3	4.67		1.903		0.397	
4	4.81		1.904		0.397	
5	4.89		1.906		0.398	
1	-5.47	-5.4	2.125	2.127	0.396	0.396
2	-5.39		2.128		0.396	
3	-5.41		2.127		0.396	
4	-5.40		2.125		0.396	
5	-5.34		2.129		0.395	



Remarks:
Volumetric Heat Capacity value has a precision of +/- 10%
1. Calculated post test water content using the entire sample was 5.0%
2. Sample allowed to reach equilibrium for 60 min before testing
3. Test Conducted using KD2-Pro Thermal Properties Analyzer
4. Minus 37.5 mm material was used and was reconstituted in 100 x 200 mm cylinder mould

THERMAL CONDUCTIVITY OF SOIL BY THERMAL NEEDLE PROBE

(ASTM D5334-08)

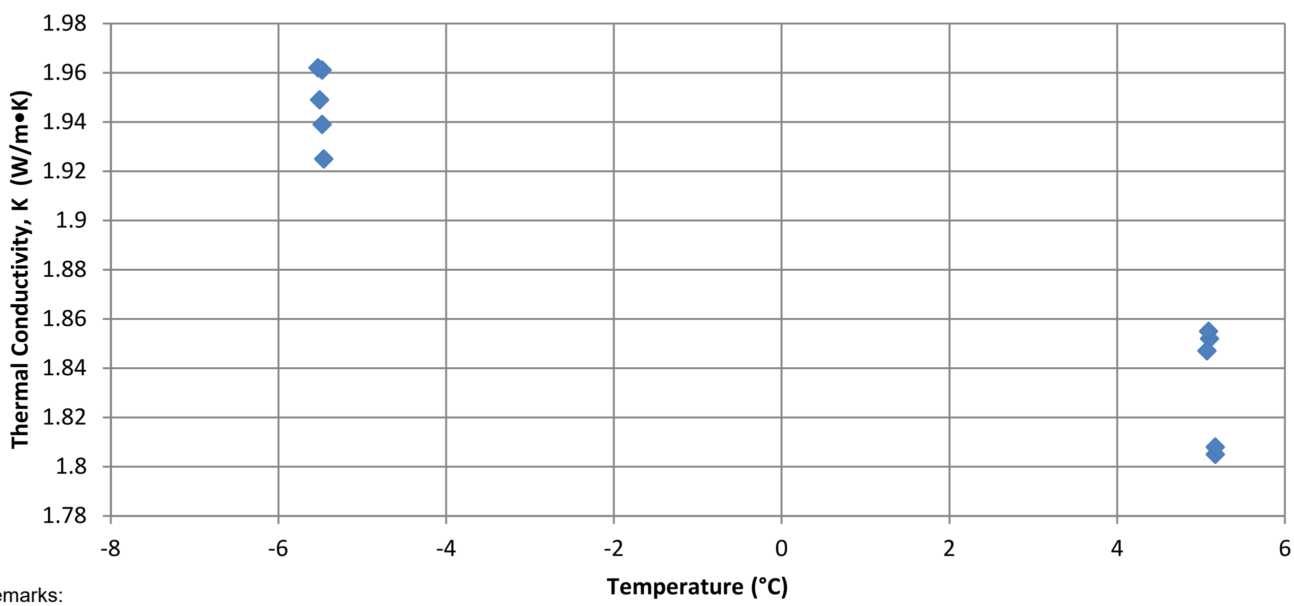
Project No.: 1790951 Phase: 20000.20001
Short Title: Baffinland/Waste Rock Mgmt Planning Lab No.: D132-04
Tested By: FC Date: 19-Sep-19

Location:	-	**Undisturbed or Remolded:**	Remolded
Sample No.:	NAG	**Wet Density (kg/m^3):**	2074
Height (mm):	202.8	**Water Content (%):**	4.5
Diameter (mm):	102.2	**Dry Density (kg/m^3):**	1985
Mass (g):	3451.4	**Void Ratio:**	0.51
Thermal Probe No.:	TR-1	**Saturation (%):**	26
Probe Length (mm):	100	**G_s:**	3.0

Test Results:

Trial No.	Temp. (°C)	Avg. Temp. (°C)	Thermal Conductivity, K (W/m•K)	Avg. Thermal Conductivity, K (W/m•K)	Thermal Resistivity, R (m•K/W)	Avg. Thermal Resistivity, R (m•K/W)
1	5.17		1.805		0.554	
2	5.10		1.852		0.540	
3	5.09	5.1	1.855	1.833	0.539	0.546
4	5.17		1.808		0.553	
5	5.07		1.847		0.541	
1	-5.48		1.939		0.516	
2	-5.48		1.961		0.510	
3	-5.53	-5.5	1.962	1.947	0.510	0.514
4	-5.51		1.949		0.513	
5	-5.46		1.925		0.519	

Thermal Conductivity vs. Temperature



Remarks:
Thermal conductivity value has a precision of +/- 10%
1. Calculated post test water content using the entire sample was 5.0%
2. Sample allowed to reach equilibrium for 60 min before testing
3. Test Conducted using KD2-Pro Thermal Properties Analyzer
4. Minus 37.5 mm material was used and was reconstituted in 100 x 200 mm cylinder mould

GOLDER

PRAIRIES AND NORTH LABORATORIES

ATTN: Brian Andruchow (P.Eng.)
Civil Engineer
Golder Associates Ltd.

Received: 09-Jun-19
Report Date: 17-Jun-19
Version: Preliminary

Geotechnical Laboratory Testing Report

Client: Baffinland Iron Mines Corporation
Project Title: Baffinland/Waste Rock Mgmt Planning
Golder Billing: 1790951.20000.20001
Lab Schedule No.: D132

Fidel Cabrera
Geotechnical Laboratory Supervisor
Calgary Geotechnical Laboratory
Golder Associates Ltd.

Our liability is limited to the cost of the test requested. The test results only relate to the sample as received. No liability in whole or in part is assumed for the collection, handling or transport of the sample, application or interpretation of the test data or results.

Golder Associates Ltd., Bay 8, 820 28th Street NE, Calgary Alberta, Canada T2K 6K1
Tel. (403) 248-6386 Fax. (403) 248-6387

GENERAL LAB TESTING SUMMARY

Project No.:	1790951	Phase:	20000.20001
Short Title:	Baffinland/Waste Rock Mgmt Planning	Sched:	D132
Tested By:	DS	Date:	17-Jun-19

Sample Identification			
Sample No.	Lab No.	Water Content (%)	Specific Gravity, Gs
PAG (147278)	D132-01	3.4	3.4
NAG (147279)	D132-02	6.1	3.0

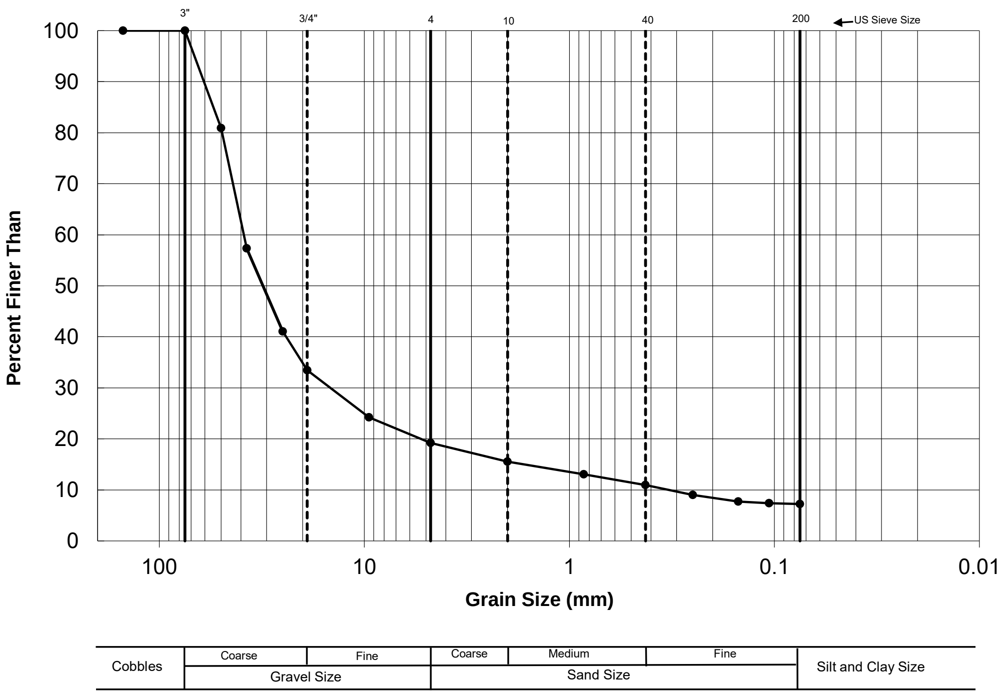
PARTICLE SIZE DISTRIBUTION OF SOILS USING SIEVE ANALYSIS

(ASTM D6913-04)

Project No.:	1790951	Phase:	20000.20001	Date:	11-Jun-19
Short Title:	Baffinland/Waste Rock Mgmt Planning				
Sub Sampled By:	OO	Washed By:	OO	Sieved By:	OO

Field Tag No.:	-	Location:	WRF	BH or TP No.:	-
Lab No.:	D132-01	Northing:	-	Sample No.:	PAG (147278)
Sampled By:	Client	Easting:	-	Depth From:	- m
Sample Date:	9-Jun-19	Elevation:	- m	Depth To:	- m

Test Method:	A	Drying Method:	Moist
Composite Sieve:	Yes	if Yes, Split on:	9.5 mm
Material Excluded from Sieve:	No	Describe:	
Prior Testing on Sample:	No	Describe:	



Sieve Size (mm)	Passing %
150.0	100
75.0	100
50.0	81
37.5	57
25.0	41
19.0	33
9.50	24
4.75	19
2.00	16
0.850	13
0.425	11
0.250	9
0.150	8
0.106	7
0.075	7

Received Water Content (%)	Cobbles (%)	Gravel (%)	Sand (%)	Fines (%)	D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc
3.4	0	81	12	7	38.9	15.5	0.3	114.3	18.0

Sample Description: (GP-GM) sandy fine to coarse sub-angular GRAVEL, fine to coarse sand, some non-plastic fines; brown; non-cohesive, moist

USCS Classification: GP-GM

Remarks:

The testing services reported herein have been performed in accordance with the indicated recognized standard, or in accordance with local industry practice. This report is for the sole use of the designated client. This report constitutes a testing service only and does not represent any results interpretation or opinion regarding specification compliance or material suitability. Engineering interpretation can be provided by Golder Associates Ltd. upon request.

GOLDER

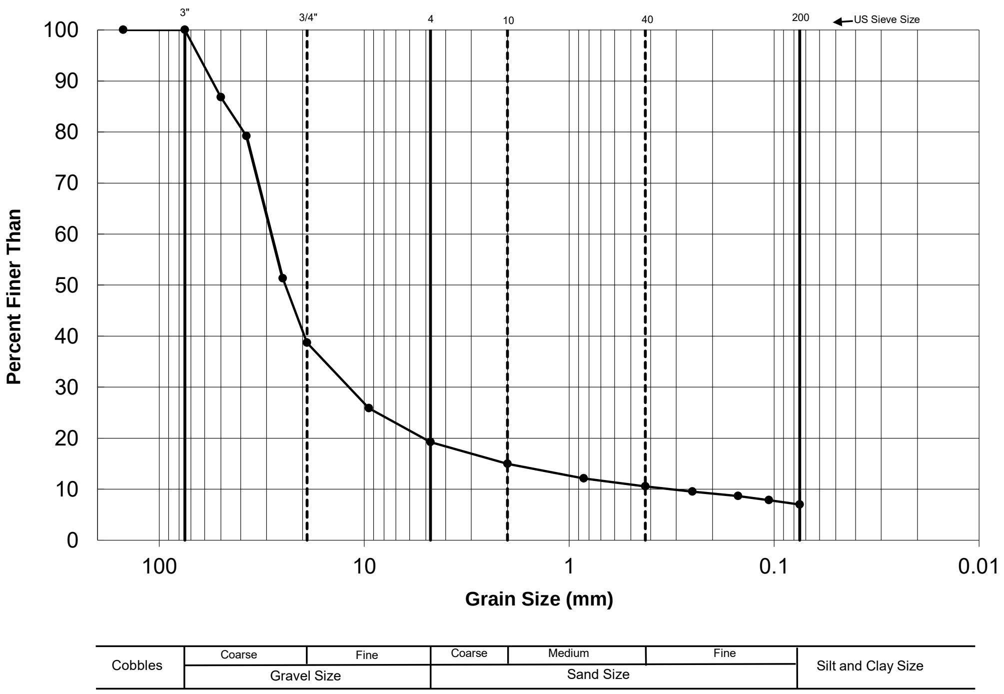
PARTICLE SIZE DISTRIBUTION OF SOILS USING SIEVE ANALYSIS

(ASTM D6913-04)

Project No.:	1790951	Phase:	20000.20001	Date:	11-Jun-19
Short Title:	Baffinland/Waste Rock Mgmt Planning				
Sub Sampled By:	DS	Washed By:	OO	Sieved By:	SP/OO

Field Tag No.:	-	Location:	WRF	BH or TP No.:	-
Lab No.:	D132-02	Northing:	-	Sample No.:	NAG (147279)
Sampled By:	Client	Easting:	-	Depth From:	- m
Sample Date:	9-Jun-19	Elevation:	- m	Depth To:	- m

Test Method:	A	Drying Method:	Moist
Composite Sieve:	Yes	if Yes, Split on:	9.5 mm
Material Excluded from Sieve:	No	Describe:	
Prior Testing on Sample:	No	Describe:	



Sieve Size (mm)	Passing %
150.0	100
75.0	100
50.0	87
37.5	79
25.0	51
19.0	39
9.50	26
4.75	19
2.00	15
0.850	12
0.425	11
0.250	10
0.150	9
0.106	8
0.075	7

Received Water Content (%)	Cobbles (%)	Gravel (%)	Sand (%)	Fines (%)	D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc
6.1	0	81	12	7	28.9	12.5	0.3	87.3	16.5

Sample Description: (GP-GM) sandy fine to coarse sub-angular GRAVEL, fine to coarse sand, some non-plastic fines; brown; non-cohesive, moist

USCS Classification: GP-GM

Remarks:

The testing services reported herein have been performed in accordance with the indicated recognized standard, or in accordance with local industry practice. This report is for the sole use of the designated client. This report constitutes a testing service only and does not represent any results interpretation or opinion regarding specification compliance or material suitability. Engineering interpretation can be provided by Golder Associates Ltd. upon request.

APPENDIX A3

Water Balance Memorandum

TECHNICAL MEMORANDUM

DATE December 31, 2019 **Project No.** 1790951

TO Baffinland Iron Mines

CC

FROM Brian Andruchow, Ken De Vos, and Adriana Parada **EMAIL Brian_Andruchow@golder.com**

BAFFINLAND WASTE ROCK FACILITY WATER BALANCE

1.0 INTRODUCTION

Baffinland Iron Mines Corporation's (Baffinland) Mary River Project (the Project) is an operational iron mine on Baffin Island in Nunavut, Canada (Figure 1). An estimated 640 Mt of waste rock and 32 Mt of overburden will require management from mining Deposit No. 1 (Baffinland, 2014). Baffinland has retained Golder Associates Ltd. (Golder) to assist with developing an updated waste rock management plan (WRMP) for deposition of potential acid generating (PAG) and non-AG waste rock at their Waste Rock Facility (WRF). An updated WRMP is required to accommodate current operational constraints, address the occurrence of acid rock drainage (ARD) from the WRF, and improve the chemical stability of future PAG waste rock deposition.

A water balance was prepared to estimate the surface water flows generated over the WRF footprint for the period of January 2020 – September 2021 and provides input to the WRF water quality model. This technical memorandum summarizes the assumptions, inputs, calibration, and water balance results to support the WRF expansion design.

2.0 BACKGROUND

The WRF area consists of the following components (Figure 2):

- Waste rock stockpile (referred to as the WRF);
- Perimeter ditch system around the WRF;
- WRF Pond; and,
- Water Treatment Plant (WTP).

Runoff from the WRF is collected by the perimeter ditches and directed towards the WRF Pond for management. An additional inflow from the Deposit 1 sump is pumped to the WRF Pond (currently) or WTP (future operational revision) if acidic water is encountered.

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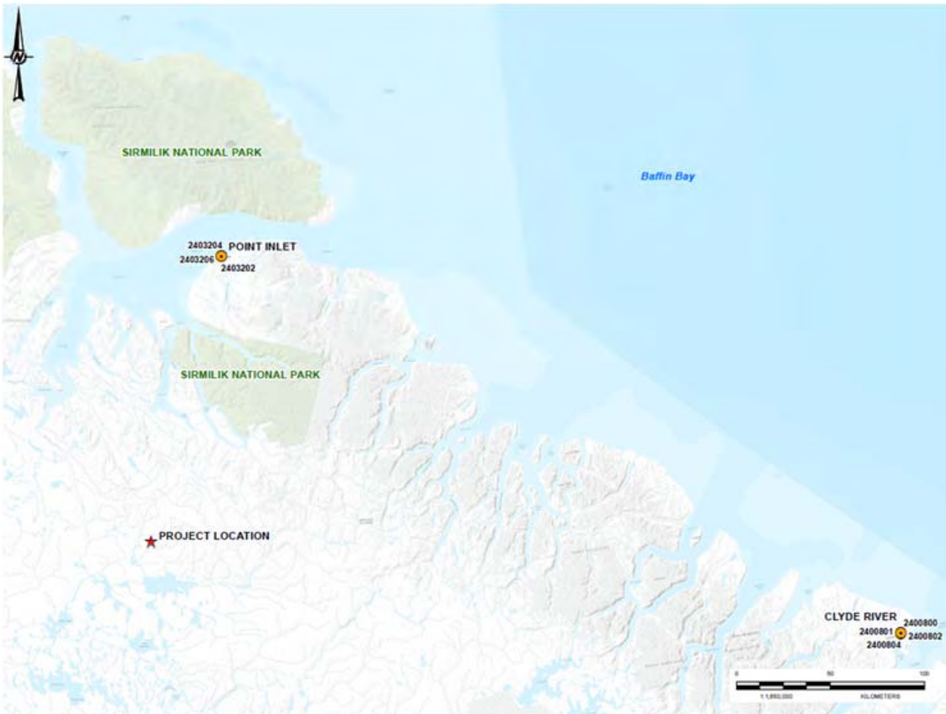


Figure 1: Project Location

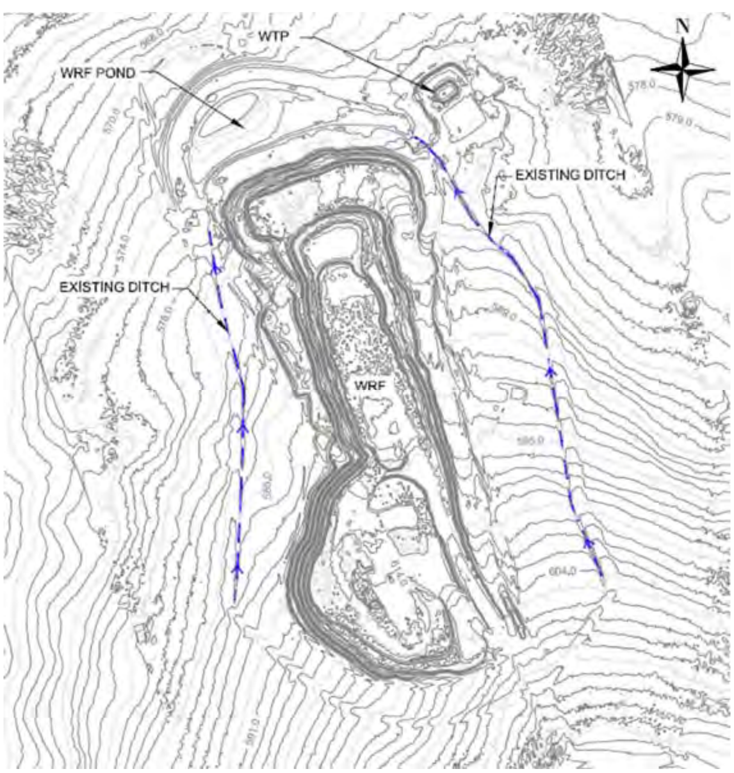


Figure 2: WRF Overview

The existing WRF Pond was constructed from September 2015 to May 2016 with the geomembrane installed to elevation 575.8 metres above sea level (masl) and a storage capacity of 9,000 m^3 (Hatch, 2017).

In 2019 the WRF Pond was designed to include a geomembrane raise from elevation 575.8 masl to elevation 579.3 masl and the WRF Pond design capacity was increased to 65,000 m^3 (Golder, 2018a). The WRF perimeter ditch system was also expanded in 2019 to allow for increased runoff as accommodated by the increased WRF Pond capacity (Golder, 2019a). Baffinland expects to complete construction of the WRF Pond raise in January 2020.

3.0 MODELLING APPROACH

The water balance was developed using the computer software package GoldSim (version 12.1.3). GoldSim is a graphical, object-oriented mathematical code where all input components and functions are defined by the user and are built as individual objects or elements linked together by mathematical expressions.

The water balance considers the climatic conditions and WRF catchment areas to estimate the flows reporting to the WRF Pond, on a daily basis, generated over the following surfaces:

- Natural ground within the boundary of the WRF perimeter ditching;
- Unclassified waste rock (existing placed waste rock where survey is not available to differentiate PAG and Non-AG materials);
- Non-AG waste rock;
- PAG waste rock; and,
- Direct precipitation to the WRF Pond.

Inflow from the Deposit 1 sump is not reliably measured and is therefore excluded from the water balance. The surface water flows reporting to the WRF Pond are the primary output from the water balance and provide input into the WRF water quality model.

3.1 Flow Diagram

The WRF flow diagram is presented on Figure 3 and the associated list of flows are presented in Table 1.

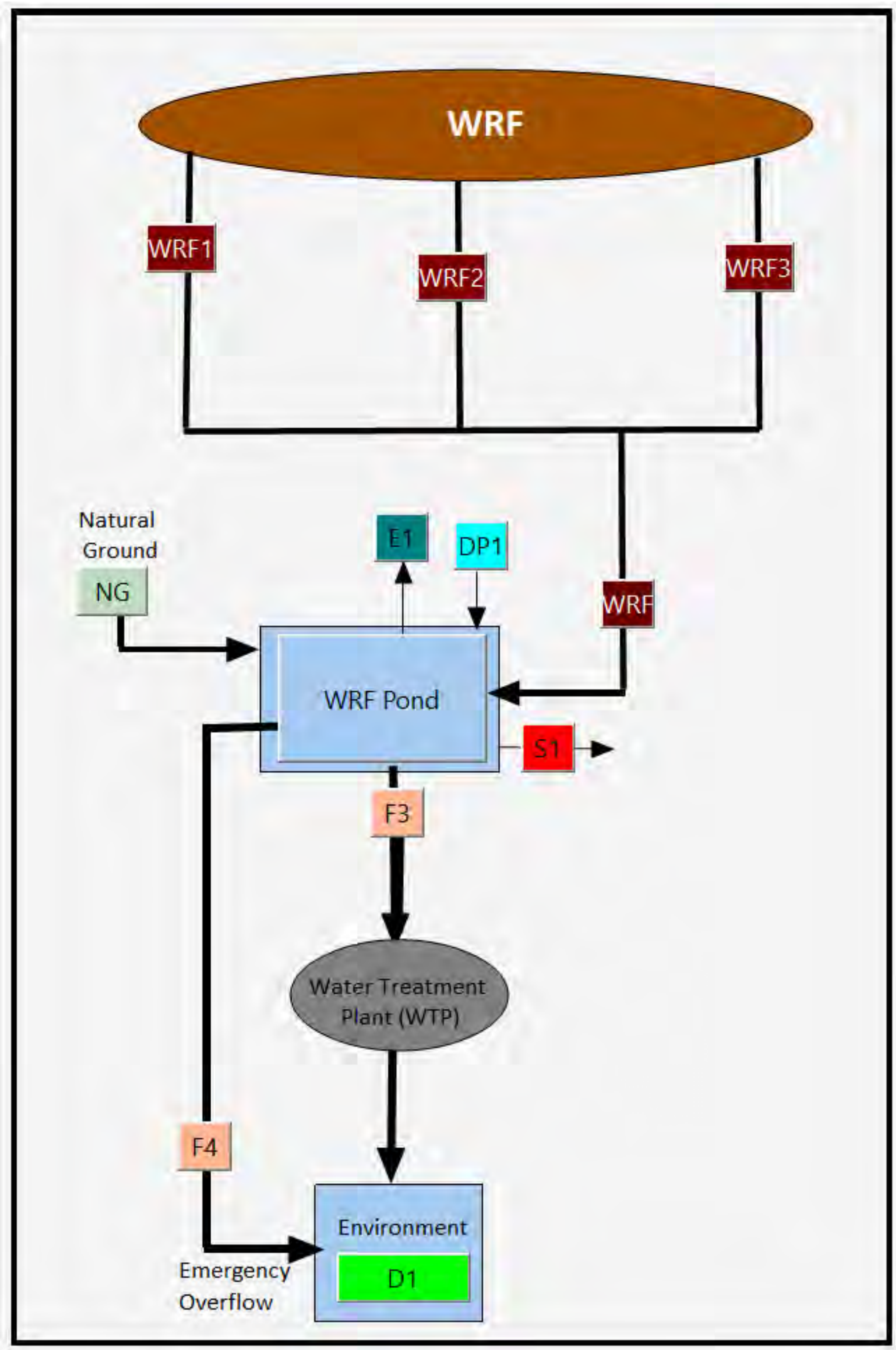


Figure 3: WRF Flow Diagram

Table 1: Water balance flows

Flow ID	Description
NG	Runoff from natural ground
WR1	Total runoff from unclassified waste rock
WR2	Total runoff from Non-AG waste rock
WR3	Total runoff from PAG waste rock
DP1	Direct precipitation on the WRF Pond surface or geomembrane
E1	Evaporation from the WRF Pond surface
S1	Seepage and interflow losses from the WRF Pond
F3	Total outflow from the WRF Pond to the WTP
F4	Overflow from the WRF Pond (via the emergency spillway)
D1	Discharge from the WTP to the environment

4.0 WATER BALANCE INPUTS AND PARAMETERS

The water balance input parameters were provided by Baffinland, and where site specific data was absent, values were assumed by Golder based on past project experience and engineering judgment. The water balance input parameters are discussed in the following sections.

4.1 Climate

The Project is located in the northern region of Baffin Island. The climate stations closest to the site are shown on Figure 1 and listed in Table 2 below.

Table 2: List of climate stations

Name	Station ID	Latitude	Longitude	Distance from Site (km)	Altitude (masl)	Period of Record
Site Station						
Mary River	-	71°18'53" N	79°16'60" W	0	-	2013-2019
Regional Stations[1]						
Clyde A	2400800	70°29'10" N	68°31'00" W	403	26.5	1933-2008
Clyde River Climate	2400802	70°29'00" N	68°31'00" W	403	26.5	2004-2019
Clyde Awos	2400801	70°29'10" N	68°31'00" W	403	26.5	2008-2013

Name	Station ID	Latitude	Longitude	Distance from Site (km)	Altitude (masl)	Period of Record
Clyde River A	2400804	70°29'09" N	68°31'01" W	403	26.5	2013-2019
Pond Inlet Climate	2403204	72°41'36" N	77°57'27" W	157	64.7	2005-2019
Pond Inlet A	2403201	72°41'22" N	77°58'08" W	154	61.6	1975-2014
Pond Inlet A	2403206	72°41'22" N	77°58'08" W	154	61.6	2013-2019
Pond Inlet Awos	2403202	72°41'22" N	77°58'08" W	154	61.6	2008-2013
Pond Inlet	2403200	72°41'00" N	77°59'00" W	154	4.0	1922-1975

Note: [1] Operated by Environment Canada Climate Change (ECCC)

Golder (2018b) carried a hydrological study aimed at the development of inflow flood events of different durations and return periods to serve as support for the design of the WRF water management systems. As part of this study, Golder reviewed available site and regional climate data between August 2013 and October 2017. No local snowfall or snowpack information was available and therefore the precipitation analysis was focused on the summer period only. The climate analysis concluded that while the temperature regime at the Mary River station and the regional stations were similar, the precipitation regime differed. Seasonal rainfall appeared to be higher at the Mary River station.

Golder updated the climate analysis developed under the Golder (2018b) with data received from the Mary River station up to September 2019 along with concurrent data from the following regional ECCC stations: Clyde River Climate, Clyde River A, and Pond Inlet Climate. The updated results are presented for temperature and precipitation in Sections 4.1.1 and 4.1.2 respectively.

Typically, a minimum of 20 years of climate data are required to estimate values for extreme return periods for wet and dry years. The six years of data recorded at the Mary River station are not sufficient for the development of the frequency analysis and therefore the data recorded at the regional ECCC stations were used. Daily records extracted from the ECCC regional stations listed in Table 2 were incomplete and therefore not adequate for the frequency analysis. A gapless dataset was developed between 1923 and 2019 using the combined long-term climate data from the regional ECCC stations Pond Inlet, Pond Inlet A, Pond Inlet AWOS and Pond Inlet Climate. The Pond Inlet climate data was prioritized as it provides the longest dataset with less missing data, and was supplemented with data from the other Pond Inlet climate stations as required.

4.1.1 Temperature

Hourly average temperature records were obtained for the Mary River climate station for the period between September 2013 and September 2019 with a missing period between October 2017 and August 2018. Figure 4 presents the comparison of the average monthly temperature records at the Mary River climate station and the ECCC regional stations closest to the site (Clyde River Climate, Clyde River A and Pond Inlet Climate).

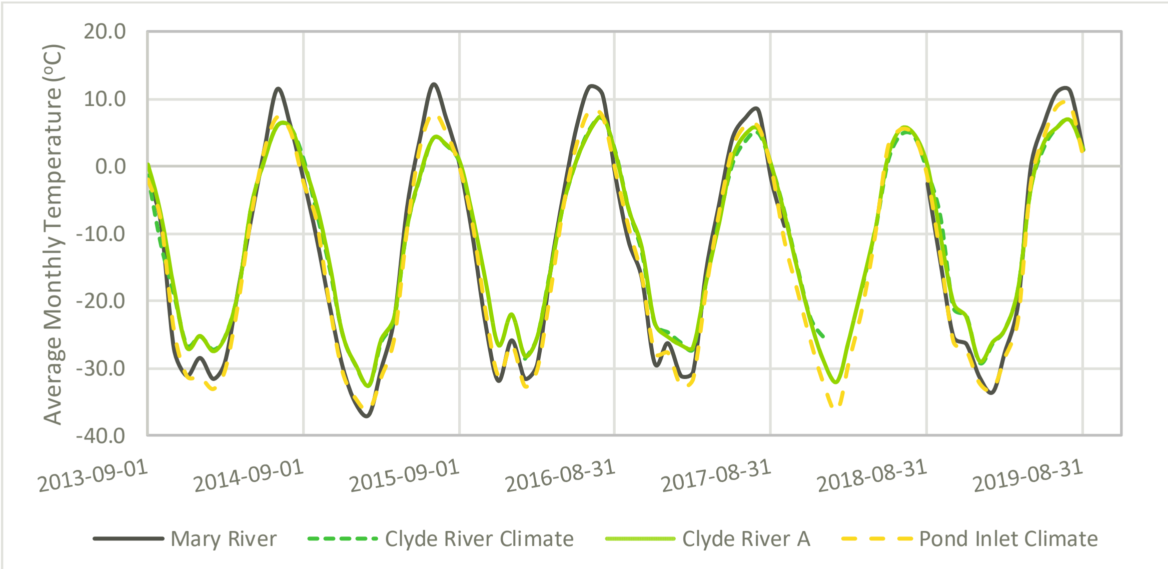
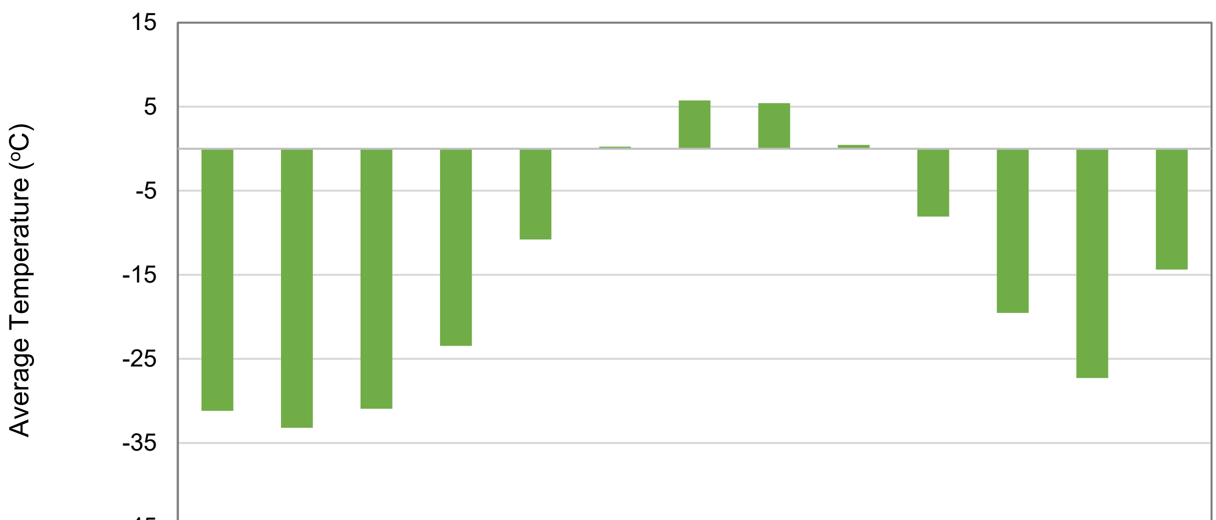


Figure 4: Average temperature recorded at various stations between 2014 and 2019

Figure 4 confirms previous observations reported in Golder (2018b) for the average temperature at the Mary River station and the ECCC regional stations. Temperatures reported on the east coast (i.e. Clyde) are slightly lower in the summer and slightly higher in the winter than the values reported at the Mary River station, which is the result of the ocean's attenuating effect. Temperatures reported at the north coast (i.e. Pond Inlet) are slightly lower in summer but comparable to the Mary River station in the winter.

The long-term record of average monthly temperatures for the gapless dataset generated from 1923 to 2019 based on the combined long-term records from the Pond Inlet climate stations is presented as Figure 5. The months with more than 90% of missing data were excluded from the analysis.



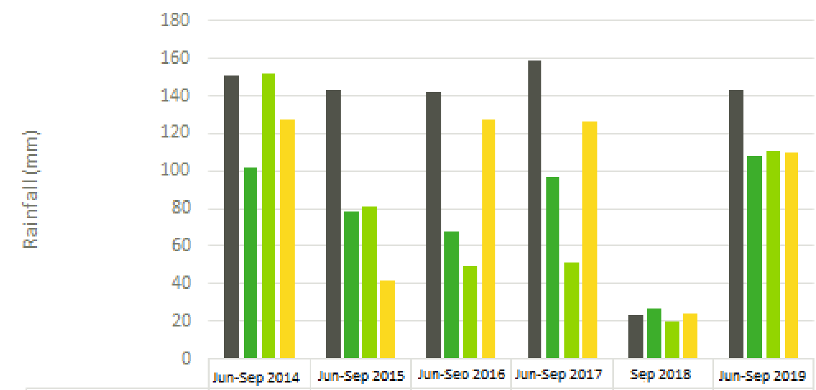
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Monthly Average	-31.2	-33.2	-30.9	-23.4	-10.8	0.2	5.7	5.4	0.4	-8.1	-19.5	-27.3	-14.4

Figure 5: Average monthly and average annual temperature for the long-term record dataset

The average temperature for the gapless long-term record is -14.4°C with an average monthly minimum of -33.2°C in February and with an average monthly maximum of 5.7°C in July.

4.1.2 Precipitation

The Mary River station is not equipped to measure snowfall and therefore the total precipitation recorded at this station corresponds to rainfall. No local snowpack information was available for the WRF. Hourly rainfall records were obtained for the Mary River Station for the period between September 2013 and September 2019 with a missing period between October 2017 and August 2018. Figure 6 shows the cumulative rainfall measured at the Mary River Station for the non-winter period (June through September) and between the years 2014 and 2019 compared to the cumulative total precipitation for the same periods for the regional stations closest to the site with concurrent climate data (Clyde River Climate, Clyde River A and Pond Inlet Climate). The non-winter period represents the time when the average monthly air temperature is above freezing.



	Jun-Sep 2014	Jun-Sep 2015	Jun-Sep 2016	Jun-Sep 2017	Sep 2018	Jun-Sep 2019
Mary River Station	150.8	143.1	142.4	159.3	23.1	142.8
Clyde River Climate	101.6	78	68	97.1	26.7	108.4
Clyde River A	152.2	80.6	49.5	51	20	111.1
Pond Inlet Climate	127.4	41.4	127.3	126.2	24.4	110.2

Figure 6: Rainfall recorded at various stations during the non-winter period (June through September) between 2014 and 2019

The average annual rainfall measured at the Mary River station ranged between 140 mm and 160 mm during the recording period and was typically higher than the rainfall data measured at the nearby regional stations. The rainfall recorded at the Pond Inlet Climate station is closest to the rainfall recorded at the Mary River station. The magnitude of the difference is variable, however, on average the rainfall recorded at the Mary River station was approximately 30% higher than the rainfall recorded at the Pond Inlet Climate station. Individual daily correlations with the two regional stations (Clyde River Climate and Pond Inlet Climate stations) were updated up to September 2019 and provided on Figure 7. Figure 7 also shows the monthly correlations with the two regional stations (Clyde River Climate and Pond Inlet Climate stations).

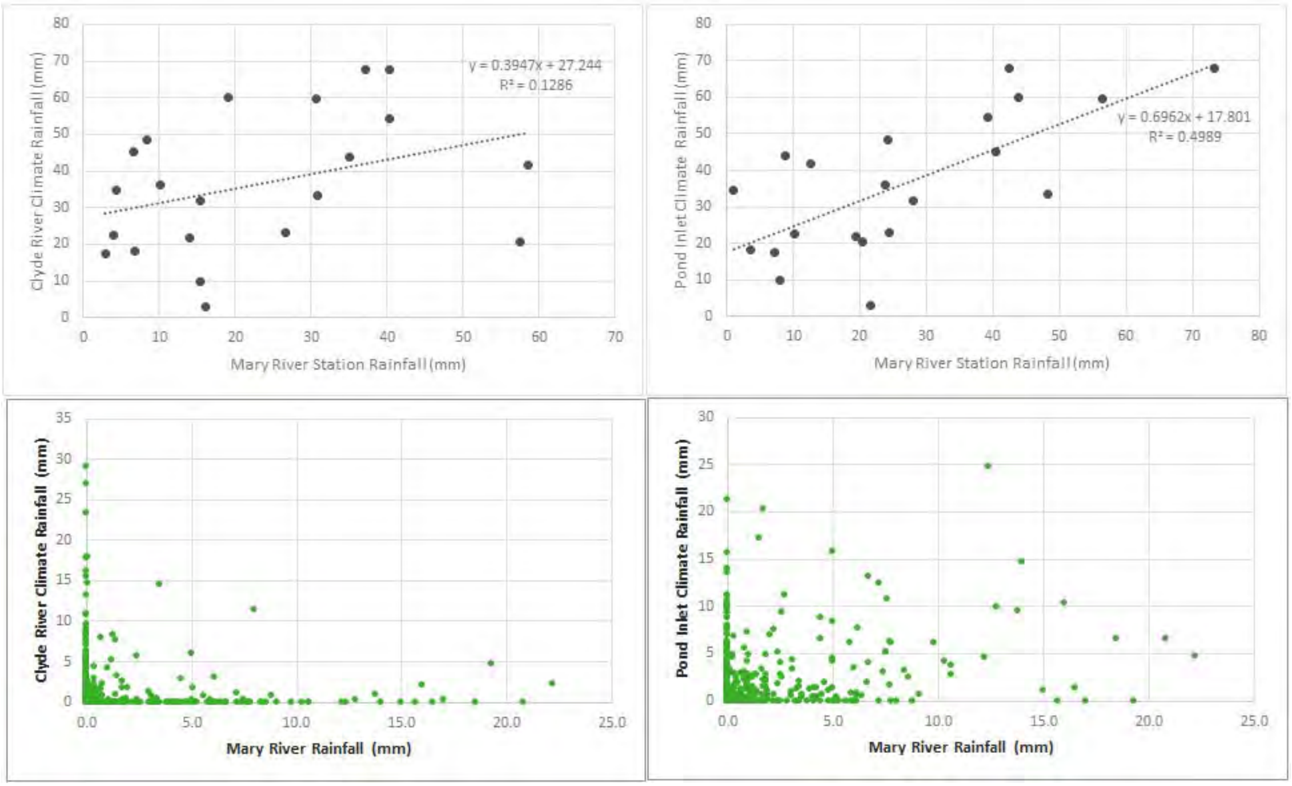
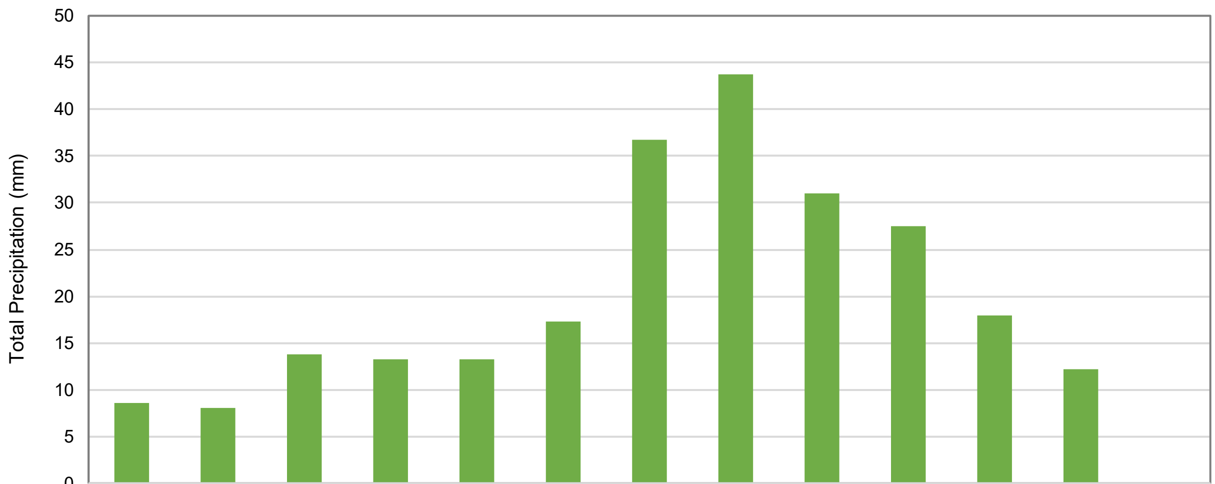


Figure 7: Comparison of concurrent daily and monthly rainfall at Mary River Station and Clyde River A and Pond Inlet Climate stations

The updated results draw the same conclusions presented in Golder (2018b) that the daily rainfall events at the regional stations are not well correlated in timing and intensity, suggesting that individual summer storms cover a smaller area than the one defined by the regional stations. The monthly rainfall at the Mary River station is better correlated to the Pond Inlet Climate station.

A gapless dataset was generated from 1923 to 2019 based on the combined long-term records from the Pond Inlet climate stations with a 30% increase to the daily precipitation values recorded. The average monthly and annual total precipitation for the combined long-term record is presented in Figure 8. The months with more than 90% of missing data were excluded from the monthly average values presented in Figure 8.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Monthly Average	8.6	8.1	13.8	13.3	13.3	17.3	36.7	43.7	31.0	27.5	17.9	12.2	243.4
Distribution (%)	4%	3%	6%	5%	5%	7%	15%	18%	13%	11%	7%	5%	100%

Figure 8: Average monthly and annual total precipitation for the long-term record

The average annual total precipitation for the long-term record is estimated at 243.4 mm/year. Maximum monthly precipitation tends to occur in August with 43.7 mm and minimum monthly precipitation tends to occur in February with 8.1 mm.

Annual total precipitation at the Project site for wet and dry years with different return periods is shown in Table 3. The frequency analysis considered the above-mentioned gapless dataset from 1923 – 2019. A total of 50 years was used in the frequency analysis as the years with more than 90% of missing data were excluded from the analysis (1923-1936, 1941, 1942, 1944-1955 and 1957-1976). The hydrological frequency analysis distribution that best fit the long-term total precipitation data was Log Normal with a correlation coefficient of 0.916.

Table 3: Annual total precipitation for various return periods

Return Period (years)	Annual Total Precipitation (mm)	
	Wet Years	Dry Years
2	236.5	
10	385.0	145.3
25	460.2	121.6
50	516.3	108.3
100	572.7	97.7

Based on the frequency analysis results presented in Table 3 and the long-term record precipitation generated for the ECCC Pond Inlet stations, the years selected to represent different climate conditions at the Project site and used in the water balance are provided in Table 4. The distribution of the precipitation years nearest to the return periods presented in Table 4 were used along with total precipitation values shown in Table 3 as input into the water balance.

Table 4: Selected precipitation climate conditions for various return periods

Parameter	Dry Years				Average	Wet Years			
	100-yr	50-yr	25-yr	10-yr		10-yr	25-yr	50-yr	100-yr
Year	2017	2017	2006	2003	1991	2000	2015	2015	2007

4.1.3 Evaporation

Evaporation and evapotranspiration are important hydrologic processes that influence the amount of runoff from a watershed. Several terms are commonly used to describe evaporation and evapotranspiration losses and for clarity these are defined below:

- Evaporation is the process by which water is changed from liquid to a vapour.
  - Potential evaporation is the maximum amount of water that can be evaporated from a surface (e.g. ground, vegetation) if surface moisture is not limited.
  - Lake evaporation is the evaporation that occurs from a lake or pond surface, and is lower than potential evaporation because blowing air has a cooling effect over a large lake surface.
  - Potential evapotranspiration (PET) if the maximum quantity of water capable of being evaporated from the soil and transpired from the vegetation of a specified region in a given time interval under existing climatic conditions and without limiting available surface moisture.

The PET is used in the water balance model to represent evaporation losses from the soil or transpiration from the vegetation. The lake evaporation is used in the water balance model to represent losses from pond surfaces.

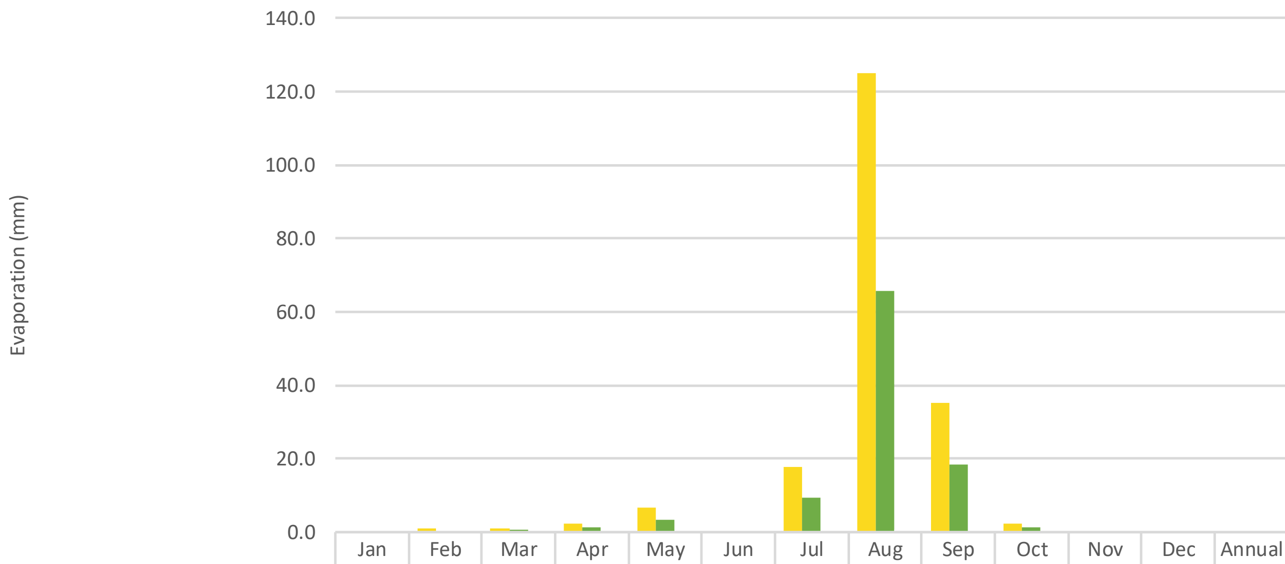
The PET was calculated using the equations provided by Thornthwaite and Mather (1995) and the following inputs:

- Gapless temperature dataset for the Project site presented in Figure 5;
- The Thornthwaite heat index; and
- An adjustment factor to correct for the length of day (sunrise to sunset).

The average annual PET of 191 mm used in the water balance was estimated from the gapless temperature dataset (Figure 9).

The Hydrological Atlas of Canada (Natural Resources Canada 1978) provides annual lake evaporation iso-contours for the country from compilation of meteorological data from 1941 to 1970 and indicates that the Project site has an annual lake evaporation of approximately 0 to 100 mm.

The annual PET for the non-winter months was adjusted by 54% to stay within the upper limit of the lake evaporation range provided in the Hydrological Atlas of Canada, while maintaining the monthly distributions estimated for the PET. Figure 9 shows the long-term average monthly distribution and annual total PET and lake evaporation used in the water balance. Maximum monthly evaporation tends to occur in August.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Monthly PET (mm)	0	1	1	2	7	0	18	125	35	2	0	0	191
Monthly Lake Evaporation (mm)	0	0	0	1	3	0	9	66	19	1	0	0	100
Distribution	0%	0%	0%	1%	3%	0%	9%	65%	18%	1%	0%	0%	100%

Figure 9: Average monthly and annual total lake evaporation and PET for the Project site

The lake evaporation and PET used in the water balance are summarized in Table 5 below and correspond to the years selected to represent the precipitation return periods from Table 4.

Table 5: Selected lake evaporation climate conditions for various return periods

Parameter	Dry Years				Average	Wet Years			
	100-yr	50-yr	25-yr	10-yr		10-yr	25-yr	50-yr	100-yr
Year	2017	2017	2006	2003	1991	2000	2015	2015	2007
Annual Lake Evaporation (mm)	147	147	175	198	188	179	146	167	167
PET (mm)	77	77	92	104	99	94	77	87	87

4.2 Catchment Areas

In support of the water quality model, the water balance was setup to calculate flows generated over the following land types:

- Natural ground;
- Unclassified waste rock (existing placed waste rock where survey is not available to differentiate PAG and non-AG materials);
- Non-AG waste rock;
- PAG waste rock; and,
- Direct precipitation to the WRF Pond

The surface area of each land type changes with time based on the WRF waste rock deposition plan and expansion of the WRF ditch system. The catchment areas by land type were calculated based on survey and forward planning information provided by Baffinland and are presented in Table 6.

Table 6: Catchment areas by material for the period between October 2018 to September 2021

Date	Waste Rock (m^2)			Natural Ground (m^2)	WRF Pond Footprint (m^2)	Total Catchment (m^2)
	Unclassifed	Non-AG	PAG			
01-Oct-2018 (Calibration)	190,000	0	0	141,100	8,900	340,000
01-Sep-2019	190,000	0	0	141,100	8,900	340,000
31-May-2020	105,000	171,928	33,072	10,000	20,000	340,000
30-Sep-2020	0	269,633	40,367	10,000	20,000	340,000
31-May-2021	0	293,820	98,463	162,717	20,000	575,000
30-Sep-2021	0	353,113	57,518	144,369	20,000	575,000

Changes to the WRF Pond catchment area, as informed by the waste rock deposition plan (Golder, 2019b) include:

- The WRF Pond footprint increases during winter 2019/2020 (January 1, 2020) as a result of the WRF Pond expansion (Golder, 2018a).
- The WRF Pond footprint expands in winter 2019/2020 to the WRF perimeter ditch limits, increasing the proportion of the WRF Pond catchment that is waste rock and decreasing the amount of natural ground.
- In early 2021 the WRF ditches are expanded and the WRF Pond catchment increased.

4.3 WRF Pond

The WRF Pond is fully lined with a geomembrane, and therefore, the seepage losses are assumed to be zero.

The water level in the WRF Pond is controlled by the inflow from the upstream catchment, pumping from the Deposit 1 sump, and the discharge rate to the WTP. Baffinland has communicated that the WTP has a maximum capacity of 280 m^3/hr and is operated 24 hours a day (Baffinland, 2019).

Following completion of the WRF Pond raise (Golder, 2018a) in January 2020 the design WRF Pond operating parameters are defined as follows:

- Crest elevation of 579.7 masl;
- Geomembrane elevation of 579.3 masl;
- Emergency spillway invert elevation of 578.9 masl;
- Maximum operating water level (MOWL) of 578.3 masl; and,
- Minimum operating water level of 574.0 masl (1 m of dead storage above lower point of pond floor).
  - It is noted that in order to manage the design storm event the WRF Pond must be operated at the minimum operating water level (Golder, 2018a).

The WRF Pond stage-storage curve is provided in Figure 10, and represents the design capacity following completion of the WRF Pond expansion (Golder, 2018a).

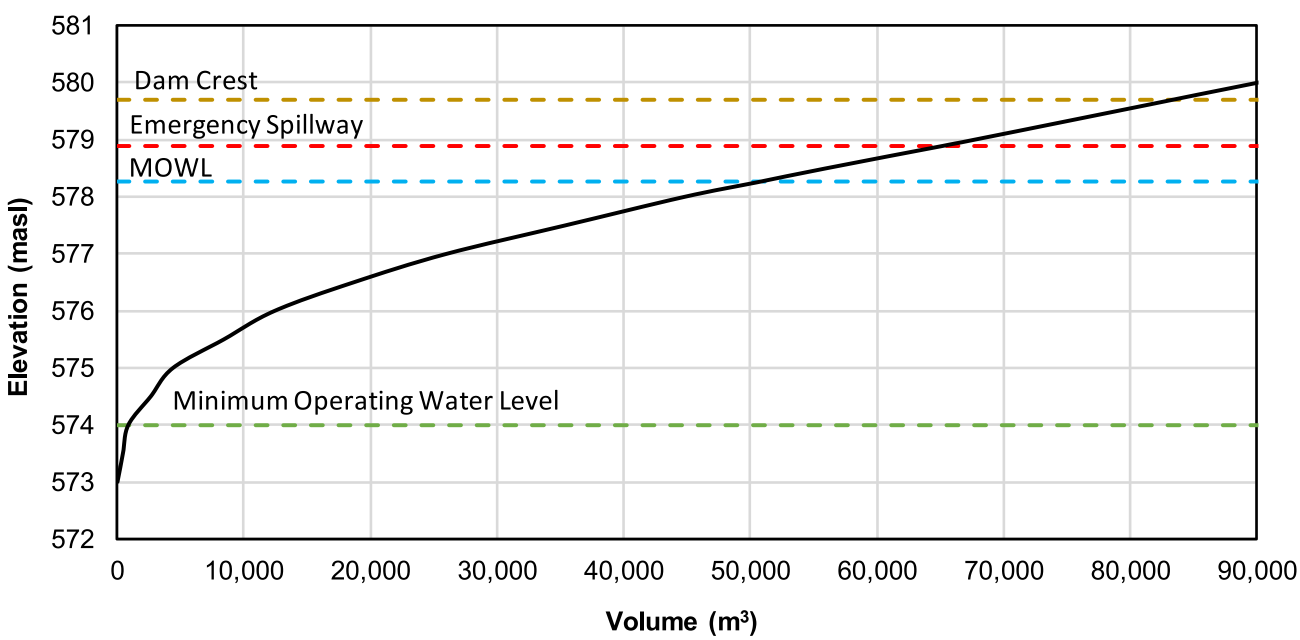


Figure 10: Stage-storage curve for the WRF Pond

Following completion of the WRF Pond expansion the design capacity at the MOWL is 50,000 m^3 and the capacity at spillway activation 65,000 m^3.

4.4 Rainfall-Runoff Model

A rainfall-runoff model was built in GoldSim to represent the physical processes of surface runoff, seepage and interflow, and infiltration.

The water balance was developed on the basis of standard hydrological water balance procedures (Maidment 1993). The water flux per unit area of catchment is described on a daily basis and is dependent on the balance of precipitations (rainfall and snowmelt), evapotranspiration (ET), water storage in the soil and runoff.

The water balance can be described as follows:

$$Rainfall + Snowmelt - ET - \Delta Storage\ in\ soil = Runoff$$

The different components of the water balance associated with each surface area are typically represented in millimeters (mm) and present the water quantity per unit area of catchment (mm/m^2).

The rainfall-runoff system is composed of the following:

- Snow storage:
  - Supplied by snowfall;
  - Subject to sublimation.
- Upper storage (US):
  - Supplied by snowmelt and rainfall;
  - Subject to evapotranspiration, surface runoff and infiltration to the lower reservoir.
- Lower storage (LS):
  - Supplied by infiltration (interflow) from the US;
  - Subject to toe seepage (only applicable for the WRF) and deep percolation.

The total model runoff is the sum of surface runoff and intermediate runoff from the US and toe seepage from the LS (i.e. interflow). LS infiltration is defined as deep percolation and is considered as a loss in the runoff model. The other losses considered in the rainfall-runoff model are sublimation and evapotranspiration. Figure 11 provides a graphical representation of the GoldSim model system.

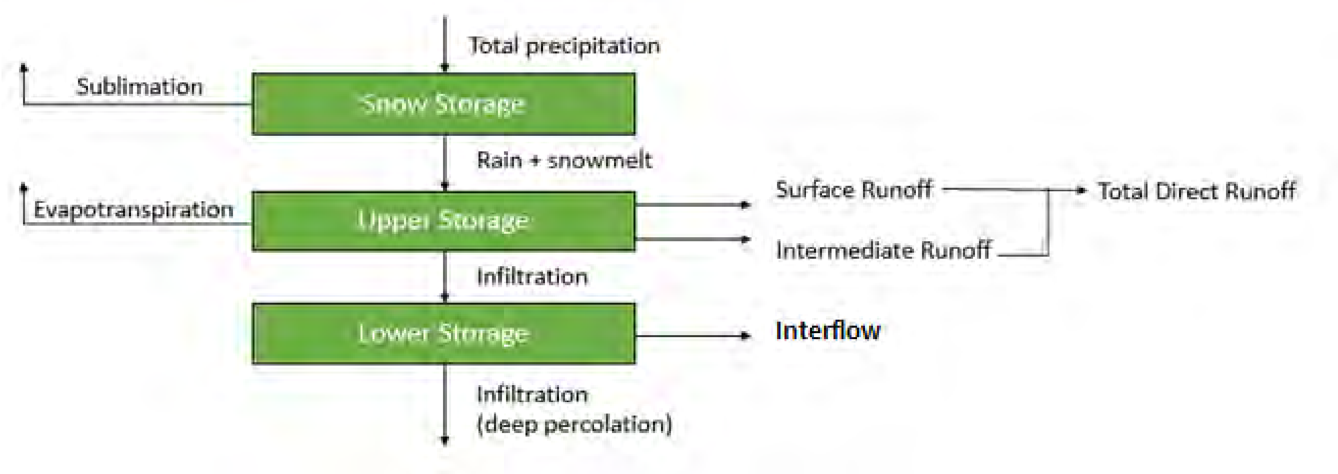


Figure 11: Rainfall-runoff model schematic

Selection of the rainfall-runoff parameters was based on the physical properties and qualitative descriptions for each of the modelled surfaces. The snowmelt parameters used in the model are provided in Table 7.

Table 7: Snowmelt parameters used in the GoldSim model

Parameter	Value	Unit	Assumption
Degree day factor coefficient	2.74	$^{o}C^{-1}$	Typical value
Melt base Temp	-1.0	^{o}C	Temperature at which snowmelt begins (assumed)
Average Temp	Calculated	^{o}C	Calculated at each time step based on daily temperature from six previous days
Snowpack depth	0	cm	The simulation starts in a summer month
Ice Melt Coefficient	19.0		a constant ice melt coefficient over lakes (assumed)
Snow Threshold	0.0	^{o}C	Threshold temperature for converting precipitation to snow or rainfall
Sublimation	0.1	mm/day	Assumed

The runoff parameters for the various land types are summarized in Table 8. These parameters were selected based on engineering judgement and professional experience with similar projects in northern Canada as not enough information was available to calibrate these parameters to measured site conditions (Section 5.0).

Table 8: Runoff parameters used in the GoldSim model

Parameter	Unit	Land Type	
		Natural Ground	Waste Rock
Evapotranspiration (% evapotranspiration potential available)	%	0.3	0.2
Upper Storage capacity	mm	90	48
Upper Storage coefficient [1]	1/day	0.5	0.08
Potential infiltration US to LS	mm/ day	10	15
Lower Storage capacity	mm	296	100
Lower Storage coefficient [2]	1/day	0.04	2.0
Deep Percolation from Lower Storage (system loss)	mm/day	0.1	0
Interflow delay	days	-	2

Note 1: US runoff is calculated by dividing the US water storage by the US coefficient.

Note 2: LS runoff is calculated by dividing the LS water storage by the LS coefficient.

Based on information received from Baffinland, snow from the WRF surface is cleared in the winter and stockpiled outside of the WRF Pond catchment. As provided by Baffinland, the water balance assumes only a total snow accumulation 0.5 m over the WRF crest.

5.0 WATER BALANCE CALIBRATION

The following data measured between June and September 2019 were received from the Baffinland:

- Pumping rates from WRF Pond to the WTP;
- WRF Pond freeboard relative to the spillway invert elevation of 576.3 masl; and
- Flows measured at WRF perimeter ditches collected by wading using conventional current meter equipment (i.e., Hach flowmate) in accordance with standard practice (computed as the product of the cross-sectional area and the average velocity).

The water balance values could not be calibrated to the site measured data for the following reasons:

- The measured WRF Pond water levels were occasionally below the WRF Pond surveyed floor.

- Differences between the predicted and observed water levels cannot be reconciled because the inflow from the Deposit 1 sump, which ultimately reports to the WRF Pond, is not measured with sufficient accuracy.
- The flow measurements from the west and east ditches did not align with the WTP discharge totalizer. From June 1, 2019 to September 12, 2019 the WTP discharge totalizer recorded approximately 90,000 m^3 more flow than that calculated from the WRF east and west ditch flow measurements.
  - It is acknowledged that the WRF east and west ditch flow measurements would not provide a reliable method for estimating the total inflow to the WRF Pond unless frequent measurements were taken or continuous devices were installed to capture precipitation events.

The water balance calibration was therefore set to reflect typical values based on engineering judgement. It is assumed that the WRF Pond will be operated at the minimum water level of 574.0 masl.

6.0 WATER BALANCE RESULTS

The results from the water balance under the three climate scenario considered (100-yr wet, average and 100-yr dry) are presented as monthly flows in Figure 12, Figure 13 and Figure 14, respectively.

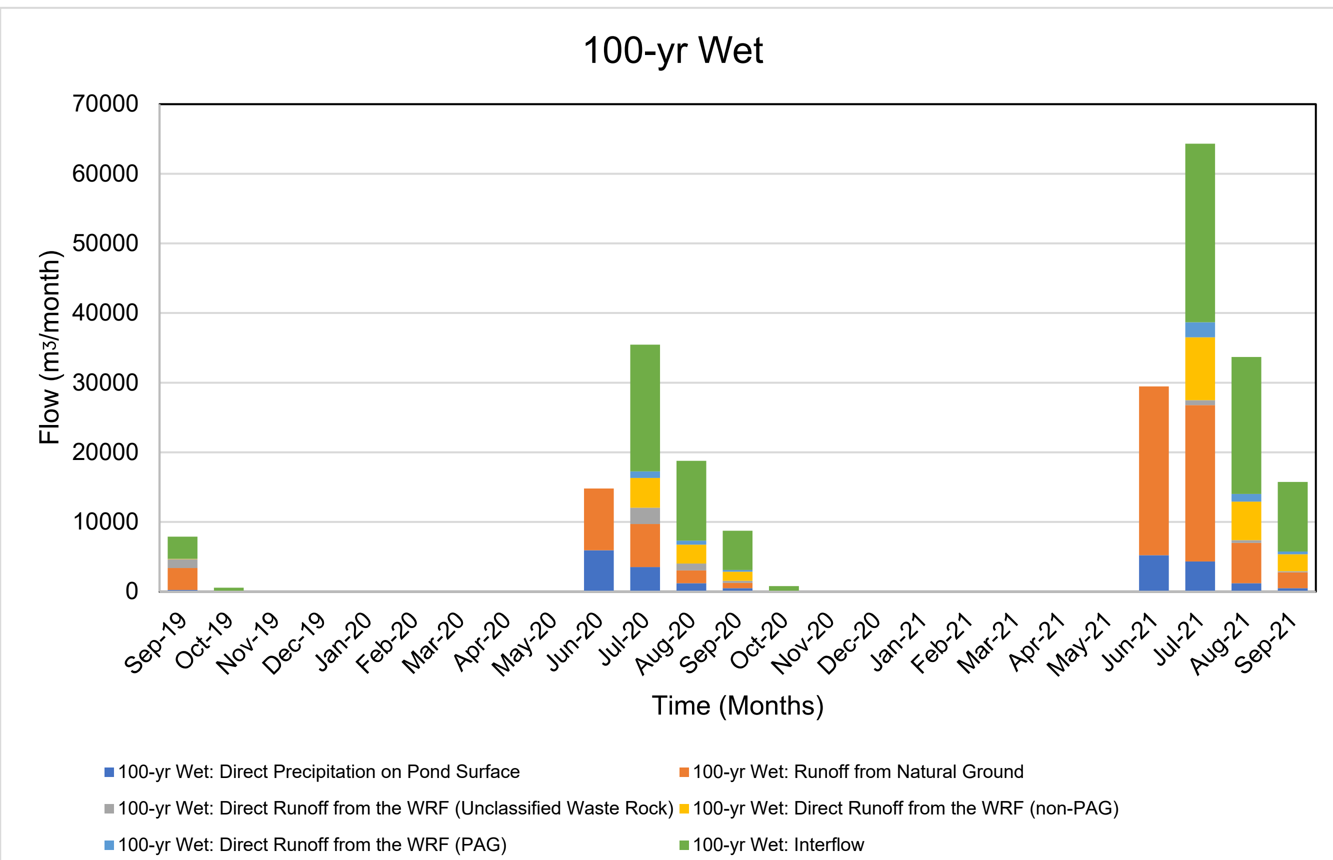


Figure 12: Monthly inflow to the WRF Pond by catchment type for the 100-yr wet scenario (September 2019 – September 2021)

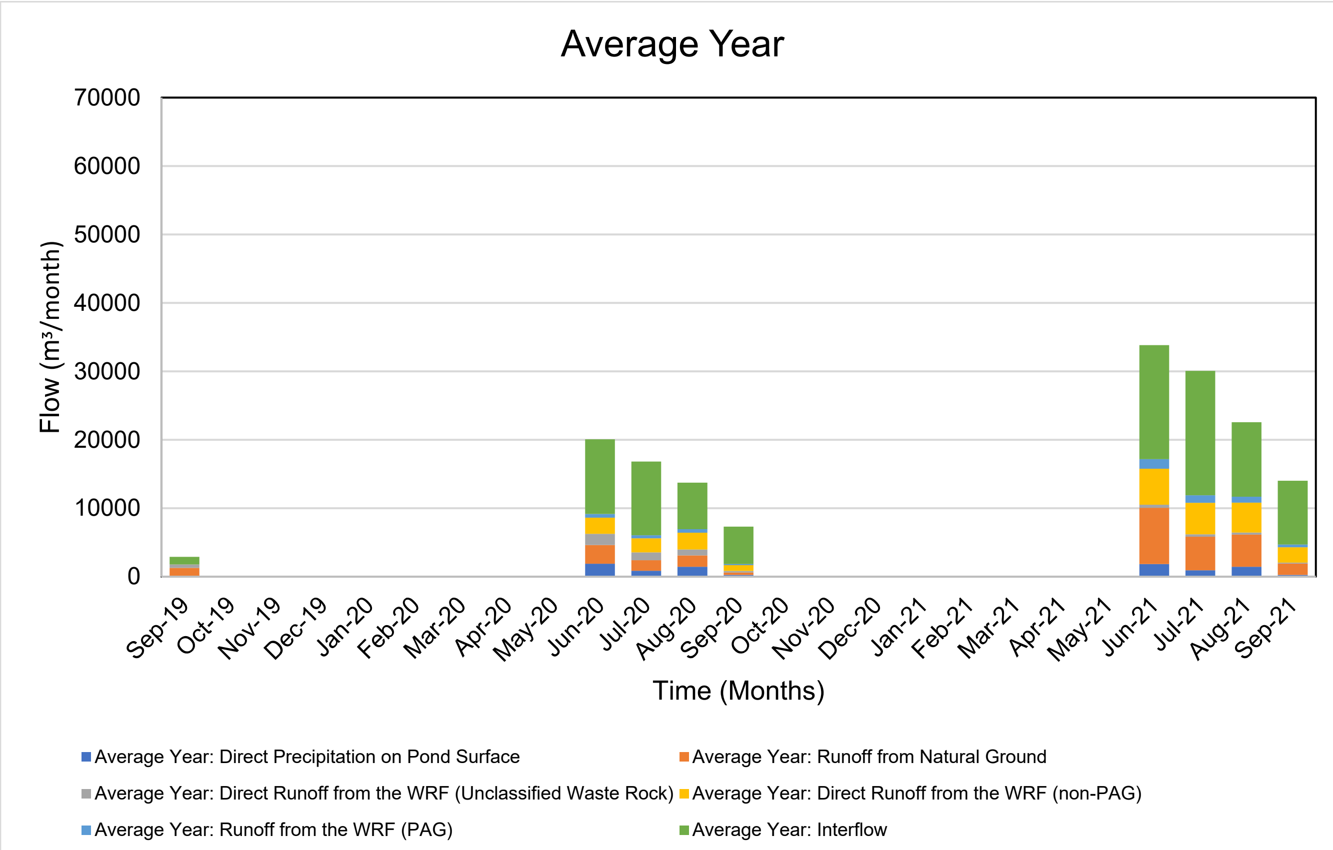


Figure 13: Monthly inflow to the WRF Pond by catchment type for the average scenario (September 2019 – September 2021)

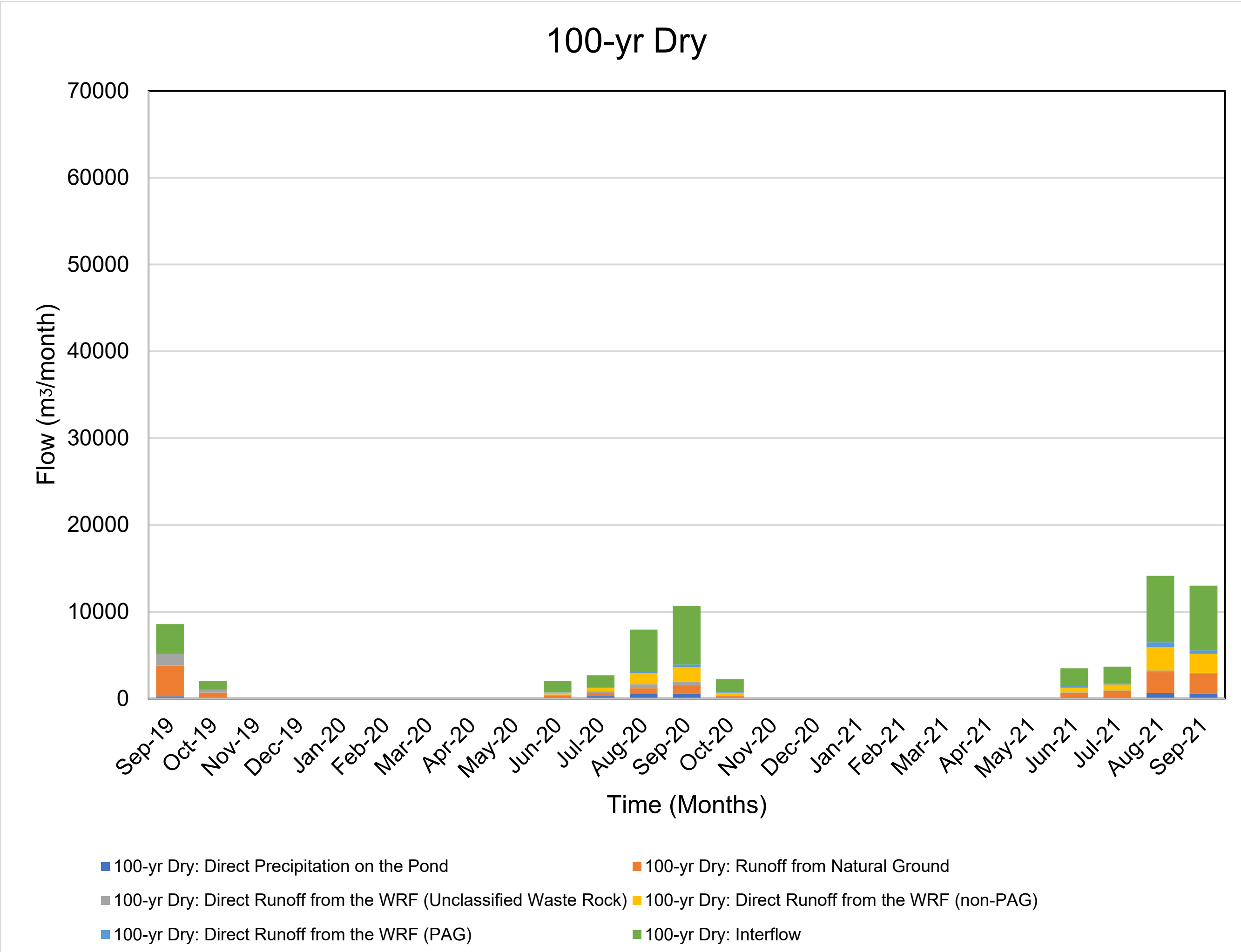


Figure 14: Monthly inflow to the WRF Pond by catchment type for the 100-yr dry scenario (September 2019 – September 2021)

The predicted water balance monthly flows provide input into the WRF runoff water quality model (issued under separate cover).

7.0 LIMITATIONS AND RECOMMENDATIONS

Several limitations impact the results of the water balance and are listed below:

- Review of the precipitation data from the Mary River and regional climate stations supports the same conclusions presented in Golder (2018b) that the daily rainfall events at the regional stations are not correlated in timing and intensity suggesting that individual summer storms cover a smaller area than the one defined by the regional stations.
- Seasonal and monthly rainfall appeared to be approximately 30% higher at the Mary River station compared to the Pond Inlet regional station. This should be verified in the future when more site rainfall data is collected.

The water balance could not be calibrated using the data provided by Baffinland due to missing inflow from the Deposit 1 sump that ultimately reports to the WRF Pond. The following recommendations are provided to assist with future calibration of the water balance:

- Improve monitoring of the WRF water management system:
  - Install a pressure transducer in the WRF Pond to provide a reliable and complete record of water level measurements;
  - Install a staff gauge and develop a rating curve at the east and west ditches;
  - Install a totalizer to monitor the inflow from the Deposit 1 sump; and,
  - Additional consideration of snowfall and snowpack within the WRF Pond catchment.
- Continue collection of climate data at the Mary River station.
- Update water balance calibration following collection of additional site data following the recommendations above.

8.0 CLOSURE

We trust that the information provided in this technical memorandum meets your present needs. Should you have any questions or require clarification, please do not hesitate to contact the undersigned.

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https://golderassociates.sharepoint.com/sites/22103g/technical work/phase 50000 - geochem/task 50002 - water balance/5. technical memorandum/4. rev. 0/1790951 - water balance.docx

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APPENDIX A4

Water Quality Memorandum

TECHNICAL MEMORANDUM

DATE December 31, 2019 **Project No.** 1790951

TO Baffinland Iron Mines

CC

FROM Dan LaPorte and Ken De Vos **EMAIL dlaporte@golder.com**

2019 WASTE ROCK FACILITY WATER QUALITY PREDICTIONS – BAFFINLAND IRON MINES MARY RIVER PROJECT

1.0 INTRODUCTION

Potential acid generating (PAG) and non-acid generating (Non-AG) waste rock are currently being deposited in the waste rock facility (WRF) at the Mary River Project (the Project), operated by Baffinland Iron Mine Corporation (Baffinland) and located on Baffin Island in Nunavut. The mitigation strategy defined for prevention of acid generation and metal leaching from the pile centers around freezing of the PAG waste rock during winter, with deposition of additional rock in summer to keep the frozen rock isolated from the active zone, which is subject to seasonal freeze and thaw.

A water quality model was developed to estimate the WRF runoff water quality under varying climatic conditions between 2019 and 2021 as part of the ongoing waste rock management. The intention of the model is to assess the potential impact of the waste rock pile design on runoff water quality and inform any necessary modifications. The current model as presented is not intended to predict overall final WRF closure. Previous closure water quality modelling was completed (AMEC, 2012) as part of the initial closure planning and design.

2.0 WATER QUALITY REVIEW

The 2019 water quality results for the WRF runoff, ditch drainage and WRF Pond were provided by Baffinland. The results, summarized in the sections below, were reviewed to identify parameters of potential concern and define inputs for water quality modelling. The water quality data was compared against the Metal and Diamond Mining Effluent Regulations (MDMER) Schedule 4 criteria to identify parameters of potential concern; however, these samples are not representative of discharge to the receiving environment or the final discharge point (FDP) regulated under MDMER at the WRF. The full water quality results can be found in Appendices A to D. All water quality results are presented as total concentrations.

2.1 WRF Runoff Water Quality

Runoff water quality from the WRF was sampled at locations on the pile where flow was observed, and the drainage ditches on the east and west side of the pile at the discharge locations to the WRF Pond. The 2019 water quality results are discussed below.

Pile Runoff

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Results of 58 water quality samples collected from 13 locations on the WRF where flow was observed and where samples were collected by Baffinland between June 18 and September 3, 2019, were provided for review. Sampling locations were surveyed for water flow on a weekly basis and, if flowing, a water quality sample was collected. Each sample was analysed for pH, TDS, TSS, turbidity, conductivity, ammonia and total metals. Due to low flows, samples were often collected using a small container or syringe which resulted in disturbance and mobilizing of sediment from the substrate. Based on the data collected, chemical characteristics of runoff from the WRF are as follows:

- pH ranged from 4.1 to 8.3 and varied widely over the sampling period with an observed decrease in pH at most locations after the first sampling event and a minor overall decrease over time (likely a result of sample location discrepancy) (Figure 1).
- Total suspended solids (TSS) ranged from 2 mg/L to 426 mg/L, and 32 of 57 samples (56%) exceeded the 15 mg/L MDMER criteria (Figure 2). Exceedances may be a result of modified sampling methodology resulting in disturbances to substrate during sample collection due to low flows.
- Total copper ranged from <0.01 mg/L to 0.34 mg/L, and 1 of 43 samples (2%) exceeded the 0.30 mg/L MDMER criteria (Figure 3). The exceedance occurred on July 9, 2019 at station WRP-S10.
- Total nickel ranged from 0.00092 mg/L to 25.9 mg/L, and 23 of 43 samples (53%) exceeded the 0.50 mg/L MDMER criteria. The concentration varied widely and overall increased with time, reaching the maximum value on the final sample date (September 3, 2019) (Figure 4). Note that the maximum concentration is also associated with high TSS (318 mg/L).
- Total zinc ranged from <0.003 mg/L to 3.3 mg/L, and 1 of 43 samples (2%) exceeded the 0.50 mg/L MDMER criteria (Figure 5). The exceedance occurred on September 3, 2019 at station MS-SP-02. Note that the maximum concentration is also associated with high TSS (318 mg/L).
- There were no other exceedances of the MDMER criteria in the collected samples.

<u>WRF Drainage Ditches</u>

Results of 54 water quality samples collected by Baffinland between June 12 and September 11, 2019, were provided for review. The samples were collected daily from the east and west ditches, including analyses for pH, TDS, TSS and turbidity. Eleven of the 55 sampling events (weekly to biweekly) included more comprehensive analysis for conductivity, ammonia and total metals. The west ditch sampling location is downstream of the Deposit 1 sump discharge location. Therefore, the water quality at this location is a mixture of WRF and Deposit 1 inputs.

The chemical characteristics of drainage water in the **East Ditch** are as follows:

- pH ranged from 6.2 to 8.1. Temporally, pH generally decreased until mid July then steadily rose until the end of the sampling period (Figure 1).
- TSS ranged from 8.8 mg/L to 454 mg/L, and 48 of 54 samples (89%) exceeded the 15 mg/L MDMER criteria (Figure 2). Exceedances may be a result of modified sampling methodology resulting in disturbances to substrate during sample collection due to low flows.
- Total nickel ranged from 0.03 mg/L to 0.29 mg/L and no samples exceeded the 0.50 mg/L MDMER criteria. Nickel concentrations increased until July 17, 2019 then decreased after that date (Figure 4).

- There were no other exceedances of the MDMER criteria in the collected samples.

The chemical characteristics of drainage water in the **West Ditch** are as follows:

- pH ranged from 4.4 to 7.5 and tended to have lower levels in July, 2019, during the period of active pumping of acidic pit water from Deposit 1 (Figure 1).
- TSS ranged from 16 mg/L to 1180 mg/L and 100% of samples exceeded the 15 mg/L MDMER criteria (Figure 2). Exceedances may be a result of modified sampling methodology resulting in disturbances to substrate during sample collection.
- Total nickel ranged from 0.0975 mg/L to 1.7 mg/L, and 4 of 11 samples (36%) exceeded the 0.50 mg/L MDMER criteria. Nickel concentrations increased until July 9, 2019, then generally decreased, with the exception of the maximum value measured on September 3, 2019 associated with the maximum WRF runoff concentration (Figure 4).
- There were no other exceedances of the MDMER criteria in the collected samples.

2.2 WRF Pond Water Quality

Results of 79 water quality samples collected by Baffinland from the WRF Pond between June 3 and October 2, 2019, were provided for review. TDS, TSS, turbidity and pH were tested for each sampling event, while other parameters (including anions and total metals) were measured less frequently. The pond water quality can be summarized as follows:

- pH ranged from 4.6 to 9.0. The pH was lowest from July to mid August and was variable and increasing afterward mid August (Figure 1). High pH in the pond may be the result of water treatment plant recirculation to the pond.
- TSS ranged from 3.2 mg/L to 263 mg/L and 36 of 67 samples (54%) exceeded the 15 mg/L MDMER criteria (Figure 2).
- Total nickel ranged from 0.017 mg/L to 0.42 mg/L and no samples exceeded the MDMER criteria. Nickel concentrations increase until August 20, 2019, then decrease slightly (Figure 4).
- There were no other exceedances of the MDMER criteria in the collected samples.

3.0 MODEL APPROACH

A water quality model was created to predict the potential runoff water quality from the WRF based on the proposed design of the pile.

The water quality model for the WRF runoff was conducted based on the following approach:

- Development of a water balance model presented in Golder (2019a);
- Development of water quality inputs for natural runoff (within the boundaries of the WRF ditching), WRF PAG runoff and WRF Non-AG runoff; and
- Development of a water quality model based on the flow logic for current and projected conditions through 2021 at the WRF.

3.1 Water Balance

A water balance for the WRF and associated water management structures was prepared for the period of the waste rock deposition plan (January 2020 – September 2021). The purpose of the water balance is to estimate the surface flows generated over the various components of the WRF in support of the water quality modelling. The water balance is also intended to assist with forward planning of the WRF Pond capacity requirements resulting from expansion of the WRF footprint. The water balance was prepared using GoldSim (version 12.1.3). GoldSim is a graphical and object-oriented software package that allows for simulation of engineering systems. The results of the water balance model are presented in Golder (2019a).

The water balance was setup to calculate flows reporting to the WRF Pond on a daily basis for several climatic scenarios. The surface flows were calculated over each of the following surfaces:

- Direct precipitation to the WRF Pond;
- Runoff from natural ground within the boundaries of the WRF ditching;
- Runoff from impervious areas (dam/gravel);
- Direct Runoff from WRF (unclassified waste rock);
- Seepage from WRF (unclassified waste rock);
- Direct Runoff from WRF (non-AG waste rock);
- Seepage from WRF (non-AG waste rock);
- Direct Runoff from WRF (PAG waste rock), and
- Seepage from WRF (PAG waste rock).

The daily flows were estimated for the period of January 2020 through August 2021. Annual flow from each of the catchment areas are presented in Table 1. The annual flows were used to develop percentages of the WRF runoff flow on an annual basis.

Table 1: Water balance results for the 100-yr wet, average year and 100-yr dry climate scenarios

Parameter	Average		100 year wet		100 year dry	
	2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021
Runoff from Natural Ground	7,111	18,189	20,079	53,256	5,376	4,804
Direct Runoff from WRF (unclassified)	4,100	1,332	4,629	1,392	2,482	804
Seepage from WRF (unclassified)	9,716	3,709	11,657	3,616	6,185	2,110
Direct Runoff from WRF (non-AG)	6,888	15,074	7,044	15,914	1,960	5,884
Seepage from WRF (non-AG)	16,261	38,513	17,783	39,421	4,652	14,672

Parameter	Average		100 year wet		100 year dry	
	2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021
Direct Runoff from WRF (PAG)	1,518	3,524	1,532	3,522	421	1,241
Seepage from WRF (PAG)	3,591	8,938	3,857	8,643	1,000	3,079
Total Inflow to the Pond	**49,186**	**89,278**	**66,580**	**12,5764**	**22,077**	**32,594**

3.2 Water Quality Inputs

Water quality inputs were developed to represent the water quality of each flow component of the water quality model, including WRF runoff from exposed PAG and Non-AG waste rock and natural ground runoff from within the boundaries of the WRF ditching.

The 2019 WRF runoff water quality were used to develop inputs for the PAG and Non-AG runoff. Since nickel is the primary metal of concern, the inputs were selected based on the range in nickel concentrations observed in the runoff water quality. The water quality sample collected from WRP-S17 on July 9, 2019 had the lowest nickel concentration and was selected to represent water interaction with Non-AG waste rock. The selection of the PAG waste rock runoff was based on the model calibration as outlined in Section 3.3.4. Based on the calibration results, the 95th percentile nickel concentration was selected to represent runoff from PAG waste rock.

The PAG and Non-AG water quality model inputs are presented in Table 2. All parameters reflect the concentrations measured in the selected WRF runoff samples from locations WRP-S17 (July 9th) and MS-SP-02 (August 26th), with the exception of Eh, alkalinity, chloride and sulphate. All WRF runoff was assumed to be equilibrated with surface atmospheric conditions and therefore were assumed to be oxidized, with Eh values of 400 mV. Alkalinity and chloride were not analysed as part of the WRF water quality sampling. A value of 20 mg/L (as $CaCO_3$) was assigned for alkalinity and chloride was used to charge balance each solution in PHREEQC. Alkalinity is likely lower in the low pH solutions, however the assigned concentration does not have an impact on mineral solubility. Sulphate concentrations were calculated from the measured total sulphur concentration. This calculation assumes that all sulphur is present in the form of sulphate. One 2019 pond water quality sample had measured data for both sulphate and total sulphur. Sulphate calculated from total sulphur for this sample was within 3% of the measured sulphate value which supports the assumption.

Natural ground runoff is assumed to have negligible chemical concentrations compared to the WRF runoff inputs. Therefore, in the absence of readily available data, the model input for natural runoff was assigned zero concentrations (0 mg/L), neutral pH (7) and Eh of 400 mV.

Table 2: Non-AG and PAG input chemistry from the WRF

Parameter[1]	Units	Estimated Non-AG Runoff (WRP-S17, July 9th)	Estimated PAG Runoff (MS-SP-02, Aug 27th)
pH	s.u.	8.2	4.6
Eh *(assumed)*	mV	400	400

Parameter[1]	Units	Estimated Non-AG Runoff (WRP-S17, July 9th)	Estimated PAG Runoff (MS-SP-02, Aug 27th)
Alkalinity *(assumed)*	mg/L $CaCO_3$	20	20
Conductivity	µmhos/cm	249	16,600
Silver (Ag)	mg/L	0.000025	0.0025
Aluminum (Al)	mg/L	0.31	13
Arsenic (As)	mg/L	0.00005	0.005
Boron (B)	mg/L	0.005	0.5
Barium (Ba)	mg/L	0.012	0.035
Beryllium (Be)	mg/L	0.00005	0.005
Calcium (Ca)	mg/L	22	243
Cadmium (Cd)	mg/L	0.0000025	0.0037
Chloride (Cl) *(assumed)*	mg/L	1	1
Cobalt (Co)	mg/L	0.00033	3.9
Chromium (Cr)	mg/L	0.00082	0.025
Copper (Cu)	mg/L	0.001	0.05
Iron (Fe)	mg/L	0.41	385
Potassium (K)	mg/L	1.9	9.6
Magnesium (Mg)	mg/L	17	4,420
Manganese (Mn)	mg/L	-	195
Molybdenum (Mo)	mg/L	0.0012	0.0025
Sodium (Na)	mg/L	0.66	13
Nickel (Ni)	mg/L	0.00092	4.5
Phosphorus (P)	mg/L	0.025	2.5
Lead (Pb)	mg/L	0.00027	0.0025

Parameter[1]	Units	Estimated Non-AG Runoff (WRP-S17, July 9th)	Estimated PAG Runoff (MS-SP-02, Aug 27th)
Sulphate (SO_4) *(calculated)*	mg/L	60	19,829
Antimony (Sb)	mg/L	0.00005	0.005
Selenium (Se)	mg/L	0.00048	0.029
Silicon (Si)	mg/L	1.5	5
Tin (Sn)	mg/L	0.00005	0.005
Thorium (Th)	mg/L	0.00014	0.005
Titanium (Ti)	mg/L	0.013	0.015
Thallium (Tl)	mg/L	0.000011	0.0005
Uranium (U)	mg/L	0.0023	0.017
Vanadium (V)	mg/L	0.00068	0.025
Zinc (Zn)	mg/L	0.0015	0.44

[1] Total concentrations

3.3 Water Quality Model

This section presents the conceptual model, geochemical model, and model assumptions that were included in the water quality model development process. The intention of the water quality model is to predict yearly concentrations of the WRF runoff. The WRF Pond water quality is not currently included as part of the model due to other inputs to the pond that are currently not well defined.

3.3.1 Conceptual Model

The WRF runoff water quality is driven by a mixture of water draining from the key catchment areas (as presented in Section 3.1) which includes; runoff from natural ground within the boundaries of the WRF ditching, runoff from impervious areas (dam/gravel), WRF runoff (split into Non-AG, PAG and unclassified) and WRF seepage (split into Non-AG, PAG and unclassified). For modelling purposes, the catchment areas were merged into 3 groups:

- Natural and impervious runoff (called "Natural Runoff");
- Non-AG runoff, seepage and portion of unclassified seepage and runoff (called "Non-AG Runoff"), and;
- PAG runoff, seepage and portion of unclassified seepage and runoff (called "PAG Runoff").

The model makes the following assumptions:

- Flow from the WRF only occurs as runoff or from interflow within the active layer (noted as seepage in water balance). Therefore, catchment areas from the water balance can be used to assign the percentage of contributions from each area to the WRF runoff water quality.

- The model does not include waters pumped from other catchments, specifically water from the mining areas (e.g. Deposit 1).
- No seepage from the WRF as water that infiltrates vertically within the WRF will become frozen due to permafrost aggradation.
- Unclassified WRF flows from the water balance were assigned PAG or Non-AG water qualities based on percentages of PAG (24%) and Non-AG (76%) that were deposited within the WRF in 2019.
- PAG waste rock geochemistry is consistent with results presented in Golder (2019b) and Golder (2019c) which identified readily soluble minerals (e.g., soluble sulphates) within the PAG waste rock that produces acidic pH and high metal concentrations, in particular iron and nickel. This material is the primary source of low pH runoff observed from the WRF.
- Geochemistry of the exposed waste rock will be consistent with existing conditions at site over the modelled timeframe.

The model was run for the periods of September 2019 to August 2020 and September 2020 to August 2021. Each time period was run for 3 different climatic scenarios: Average, 100-year wet and 100-year dry. The percentage breakdown for each catchment area for all scenarios is presented in Table 3. The percentage of PAG runoff is relatively consistent (11% - 16%) throughout all scenarios with the lowest percentage in the 2020-2021 wet scenario. Natural/impervious runoff and Non-AG runoff vary greatly (14% - 42% and 47% - 70%, respectively) reflective of the WRF expansion over the two periods modelled.

Table 3: Flow inputs to the WRF Pond

Scenario	Time Period	Natural Runoff [1]	Non-AG Runoff [2]	PAG Runoff [3]
Average	2019-2020	14%	68%	17%
	2020-2021	20%	64%	15%
Wet	2019-2020	30%	56%	14%
	2020-2021	42%	47%	11%
Dry	2019-2020	24%	60%	16%
	2020-2021	15%	70%	15%

[1]Combined percentage of runoff from natural ground and impervious ground (dams/gravel).
[2]Combined percentage of Non-AG runoff, Non-AG seepage, and unclassified WRF assigned to Non-AG.
[3]Combined percentage of PAG runoff, PAG seepage, and unclassified WRF assigned to PAG.

3.3.2 Water Quality Model

A water quality and geochemical model was created using a combination of Microsoft Excel and PHREEQC Interactive (PHREEQCi) version 3.3.12 (USGS 2015). PHREEQC is an aqueous geochemical modelling code developed by the United States Geological Survey (USGS), widely used and accepted by the regulatory and scientific community. The suite of parameters used in the water quality model was limited to those included in the minteq.v4.dat thermodynamic database. PHREEQC simulates thermodynamic equilibrium of input solutions with the aqueous species, mineral phases and atmospheric gases in the model. The model code simulates the precipitation of secondary mineral phases (which can immobilize dissolved constituents), allowing the attenuation of constituents to levels expected in natural surface water.

The geochemical model was conducted in the following steps:

(1) Aqueous solutions developed as model source terms were brought to thermodynamic equilibrium.

PHREEQC requires that all input solutions be electrically neutral to achieve numerical stability in solving the simultaneous equations that are used in the calculations. Non-electrically neutral input solutions were adjusted to neutrality through the addition of chloride (when anion deficient) or potassium (when cation deficient). Both are ions that are generally highly mobile and form highly soluble salts and, therefore, unlikely to be associated with reactions involving the fate and transport of the key metals.

(2) The equilibrated aqueous solutions were mixed in proportions equal to the mixing ratios determined for each catchment area in the water balance model and as presented in Table 3 in PHREEQC using the following equation:

$$C = \sum^{n} CiFi$$

where:

C = predicted concentration in the catchment identifier (milligrams per litre [mg/L]);

Ci = source term concentration ‘i’ (mg/L);

Fi = source term flow proportion “i” (unitless); and

n = number of inflows (unitless).

Each flow proportion was multiplied by the corresponding input concentration value, and the sum of all these calculations was used to predict the final concentration at the WRF Pond.

(3) The resulting predicted chemical solution for the modelled WRF Pond was equilibrated with atmospheric conditions, and mineral precipitation was allowed to occur based on selected mineral phases presented in Appendix F. Comparison of the results with available water quality data suggest that equilibration step was leading to an increase in pH and subsequent removal of some metals that was not observed in the site water quality results. Therefore, equilibration and mineral precipitation was only applied as part of the sensitivity analysis.

The potential for mineral precipitation was assessed using the saturation index (SI) calculated according to the following equation:

$$SI = \log \frac{IAP}{K_{sp}}$$

The saturation index is the ratio of the ion activity product (IAP) for a given mineral and the solubility product (K_{sp}). An SI greater than 0.5 indicates that the solution is supersaturated with respect to a particular mineral phase, and mineral precipitation may occur. An SI less than 0.5 denotes undersaturation and indicates that the mineral in question will have a general propensity to dissolve. Mineral phases with SI values between 0.5 and -0.5 are considered to be in equilibrium with the solution.

3.3.3 Model Assumptions

The water quality model was developed with the following assumptions:

- Model predicts yearly concentrations of WRF runoff. The WRF Pond is not included as part of this model to due to other inputs to the pond that are currently not well defined.
- Input water quality concentrations that were less than the detection limit were assumed to be equal to one-half the detection limit.
- A concentration-based approach was used with total concentrations assigned as inputs to the water quality model.
- Redox potential of modelled solutions is equal to 400 mV and water temperature of 4 degrees Celsius (ºC).
- Model results represent average predicted concentrations of WRF runoff. Actual concentrations will vary throughout the year depending on flow.

3.3.4 Model Calibration

Model calibration was conducted in order to determine appropriate water quality inputs for Non-AG and PAG catchment areas. Using the water balance results for existing conditions, the water quality inputs for Non-AG and PAG were adjusted and input into PHREEQC. The predicted water quality of the WRF runoff was compared against 2019 average WRF runoff from individual locations and the east drainage ditch water quality. A comparison to the west drainage water quality is not possible as the sampling location represents a mixture of WRF runoff and Deposit 1 sump water quality. Nickel was chosen as the primary comparison parameter due to known elevated levels above MDMER criteria in the WRF runoff data. Using 2019 WRF runoff samples with minimum and 95th percentile nickel concentrations as the Non-AG and PAG inputs, respectively, resulted in a predicted WRF runoff nickel concentration of 0.60 mg/L compared to the WRF runoff and east ditch average concentrations of 1.39 mg/L and 0.11 mg/L, respectively. The model calibration underpredicts the WRF runoff concentrations for aluminum, arsenic, copper, iron and lead and has good agreement with the observed average range of concentrations for cadmium and zinc. All these parameters are at least an order of magnitude below their respective MDMER criteria (where applicable) in the WRF runoff water quality and are therefore, not considered as parameters of concern. The predicted concentrations of key parameters and the average concentrations observed in the WRF east ditch and runoff are presented in Table 4. The inputs selected are considered appropriate to predict average yearly nickel concentrations of the WRF runoff noting that concentrations would be expected to fluctuate above and below this concentration throughout the year.

Table 4: PHREEQC calibration output compared to observed maximum concentrations in the pond

Parameter	Units	MDMER (1) Criteria	Calibration Output	2019 Average WRF East Ditch	2019 Average WRF Runoff
pH	s.u.	6.0 – 9.5	**5.3**	6.2 *[min]*	**4.0** *[min]*
Sulphate	mg/L	—	2,663	923	5,407
Aluminum	mg/L	—	1.9	3.36	3.48
Arsenic	mg/L	0.50	0.00069	0.0021	0.0090

Parameter	Units	MDMER (1) Criteria	Calibration Output	2019 Average WRF East Ditch	2019 Average WRF Runoff
Cadmium	mg/L	—	0.00050	0.00020	0.0018
Chromium	mg/L	—	0.0037	0.019	0.017
Copper	mg/L	0.30	0.0071	0.019	0.090
Iron	mg/L	—	51	204	138
Nickel	mg/L	0.50	**0.60**	0.11	**1.39**
Lead	mg/L	0.20	0.00045	0.0040	0.005
Zinc	mg/L	0.50	0.059	0.048	0.32

Notes:
(1) Metal and Diamond Mining Effluent Regulations Schedule 4 maximum authorized monthly mean concentration
(2) **Bold** values are concentrations higher than the MDMER criteria or outside the pH range.

4.0 RESULTS

4.1 Predicted Water Quality Results

WRF runoff water quality estimates are presented below for different climate scenarios representing the predicted water quality in 2019-2020 and 2020-2021 that will result from mixing of runoff from natural ground, Non-AG runoff and PAG runoff at the WRF. The complete set of predictions for the WRF runoff, including the full suite of modelled parameters, are presented in Appendix E, where results were compared to MDMER criteria. Table 5 presents a summary of predicted concentrations for key parameters and distinguishes those predicted to exceed MDMER criteria. The key results include:

- pH ranges from 5.3 to 5.4 and is predicted to be below the MDMER criteria range (6.0 to 9.5) in both years for all three climate scenarios.
- Nickel concentrations are predicted to range from 0.48 mg/L to 0.77 mg/L and exceed the MDMER criteria (0.50 mg/L) in all model scenarios except for the 2020-2021 wet scenario.
- All other parameters were predicted to be below the MDMER criteria.

Table 5: WRF Runoff Yearly Modeled Results for each Climate Scenario

Parameter	Units	MDMER (1) Criteria	Average		Wet		Dry	
			2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021
pH	s.u.	6.0 – 9.5	**5.4**	**5.4**	**5.4**	**5.4**	**5.3**	**5.4**
Sulphate	mg/L	—	3,429	3,073	2,790	2,132	3,166	3,096
Aluminum	mg/L	—	2.5	2.2	2.0	1.5	2.3	2.2

Parameter	Units	MDMER (1) Criteria	Average		Wet		Dry	
			2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021
Arsenic	mg/L	0.50	0.00089	0.0008	0.00072	0.00055	0.00082	0.0008
Cadmium	mg/L	—	0.00064	0.00057	0.00052	0.0004	0.00059	0.00058
Chromium	mg/L	—	0.0048	0.0044	0.0039	0.003	0.0044	0.0044
Copper	mg/L	0.30	0.0092	0.0083	0.0075	0.0058	0.0085	0.0084
Iron	mg/L	—	66	59	54	41	61	60
Nickel	mg/L	0.50	**0.77**	**0.69**	**0.63**	0.48	**0.71**	**0.7**
Lead	mg/L	0.20	0.00061	0.00056	0.0005	0.00039	0.00056	0.00058
Zinc	mg/L	0.50	0.076	0.068	0.062	0.047	0.07	0.069

Notes:
(1) Metal and Diamond Mining Effluent Regulations Schedule 4 maximum authorized monthly mean concentration
(2) **Bold** values are concentrations higher than the MDMER criteria or outside the pH range.

Saturation indices were analysed by PHREEQC for the minerals listed in Appendix F. The PHREEQC output indicated that some mineral species were supersaturated, though were not allowed to precipitate in the model as noted in Section 3.3.2. The supersaturated phases were largely aluminum and iron-bearing minerals, including $AlOHSO_4$, $Al_4(OH)_{10}SO_4$, Alunite, Gibbsite, Diaspore, Goethite, Hematite and Barite.

4.2 Sensitivity Analysis

Three sensitivity analyses were completed to assess the impact of certain assumptions in the water quality model on predicted water quality including:

- Allow for equilibration and precipitation of saturated mineral phases, and;
- Effect of decreasing PAG waste rock exposure within the active layer on the WRF runoff water quality.

To assess mineral solubility constraints, the modelled WRF seepage water quality was equilibrated with atmospheric CO_2 and saturated minerals were allowed to precipitate. The equilibrated solutions are presented in Table 6 and exhibit elevated pH and decreased concentrations of aluminum, copper, lead and zinc (compared to model results) due to precipitation of associated minerals. While the predicted pH is within the range of observed values, the predicted concentrations for other parameters are, in some cases, several orders of magnitude below the observed concentration ranges in the WRF runoff and east drainage ditch. Furthermore, equilibration and mineral precipitation does not have a control on nickel concentrations.

Table 6: Modelled WRF runoff water quality equilibrated with atmospheric CO_2 and allowing mineral precipitation

Parameter	Units	MDMER [1] Criteria	Average		Wet		Dry	
			2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021
pH	s.u.	6.0 – 9.5	6.6	6.7	6.5	6.6	6.4	6.7
Sulphate	mg/L	—	3,428	3,072	2,790	2,132	3,166	3,095
Aluminum	mg/L	—	0.00021	0.00019	0.00022	0.00019	0.00026	0.00017
Arsenic	mg/L	0.50	0.00089	0.0008	0.00072	0.00055	0.00082	0.0008
Cadmium	mg/L	—	0.00064	0.00057	0.00052	0.0004	0.00059	0.00058
Chromium	mg/L	—	0.0048	0.0044	0.0039	0.003	0.0044	0.0044
Copper	mg/L	0.30	3.9E-12	2.0E-11	1.1E-11	4.2E-12	1.7E-10	2.1E-10
Iron	mg/L	—	65	58	53	40	60	58
Nickel	mg/L	0.50	**0.77**	**0.69**	**0.63**	0.48	**0.71**	**0.70**
Lead	mg/L	0.20	6.6E-08	1.4E-08	0.00000085	4.7E-08	0.000026	1.5E-08
Zinc	mg/L	0.50	0.000019	0.0000033	0.00024	0.000014	0.0073	0.00000062

Notes:

(1) Metal and Diamond Mining Effluent Regulations.

(2) **Bold** values are concentrations higher than the MDMER monthly maximum concentration or outside the pH range.

A sensitivity model was run to determine the effect of covering PAG waste rock with Non-AG material yearly prior to freshet. To complete the sensitivity model, it was assumed that a percentage of the area assigned as PAG would be covered with Non-AG waste rock to remove PAG waste rock from the active layer. Sensitivity models were run with a decrease in PAG contribution of 25%, 50% and 75%. Note that a 0% PAG contribution was not analysed as it is likely not practical as part of the management strategy. The percentage of PAG decrease was assigned the Non-AG water quality input. All key parameter concentrations decrease with decreasing PAG exposure (Table 8). Nickel concentrations decrease below the MDMER criteria in the 50% and 25% exposure scenarios. It should be noted, that processes not accounted for within the model (e.g., oxygen infiltration and associated oxidation processes) may result in concentrations of some parameters greater than predicted in the sensitivity simulation. Furthermore, the sensitivity models are not intended to predict final closure water quality results.

Table 7: Pond sensitivity to PAG exposure scenarios

Parameter	Units	MDMER (1) monthly mean concentration	75% Exposed PAG		50% Exposed PAG		25% Exposed PAG	
			2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021
pH	s.u.	6.0 – 9.5	**5.5**	**5.5**	**5.6**	**5.7**	**5.9**	**6.0**
Hardness	mg/L CaCO3	—	2,489	2,238	1,689	1,515	907	808
Sulphate	mg/L	—	2,582	2,319	1,732	1,550	901	799
Aluminum	mg/L	—	1.9	1.7	1.4	1.2	0.81	0.73
Arsenic	mg/L	0.50	0.00068	0.00061	0.00046	0.00042	0.00026	0.00023
Cadmium	mg/L	—	0.00048	0.00043	0.00032	0.00029	0.00016	0.00014
Chromium	mg/L	—	0.0038	0.0034	0.0028	0.0025	0.0017	0.0016
Copper	mg/L	0.30	0.0071	0.0064	0.005	0.0045	0.003	0.0027
Iron	mg/L	—	50	45	33	30	17	15
Nickel	mg/L	0.50	**0.58**	**0.52**	0.38	0.34	0.19	0.17
Lead	mg/L	0.20	0.00052	0.00047	0.00042	0.00039	0.00033	0.0003
Zinc	mg/L	0.50	0.057	0.052	0.039	0.035	0.02	0.018

Notes:
(1) Metal and Diamond Mining Effluent Regulations.
(2) **Bold** values are concentrations higher than the MDMER monthly maximum concentration or outside the pH range.

5.0 DISCUSSION AND CONCLUSIONS

A water quality model was constructed to predict yearly water quality concentrations of the WRF runoff for 2020 and 2021 based on proposed WRF design. The purpose of the model was to assess the potential impact of the WRF design on runoff water quality. WRF Pond water quality was not predicted as part of the current model due to the lack of available data for other water inputs to the pond. Closure conditions were also not evaluated as part of the current model. Water quantity inputs were assigned for defined catchment areas, based on the water balance model. Water quality inputs to the model were based on observed site water quality from WRF runoff in 2019 to represent water interaction with PAG and Non-AG waste rock within the active layer. Three climate scenarios were modelled for each year including; average, 100-year wet and 100-year dry. The water quality model assumes that flow from the WRF only occurs via direct runoff or as shallow interflow within the active layer of the pile. Water that infiltrates the WRF will become frozen due to permafrost aggradation and no seepage occurs.

The model was calibrated to the observed water quality trends within the WRF runoff with the primary focus on predicting average yearly nickel concentrations as nickel was identified as the primary parameter of concern. The calibration predicted nickel concentrations (0.60 mg/L) were slightly higher than MDMER criteria (0.5 mg/L) and within the range of average nickel concentrations observed within the WRF east drainage ditch and runoff locations (0.11 – 1.39 mg/L). The actual nickel concentrations within the WRF runoff are expected to fluctuate above or below the predicted concentration over the year however, the model results are considered reasonable to estimate average concentrations for the WRF runoff.

The water quality model was used to predict concentrations for 2019-2020 and 2020-2021 based on the current mine plan and predict water balance model. The water quality model predicts mildly acidic pH values (5.3 – 5.4) and concentrations of nickel (0.48 – 0.77 mg/L) above the MDMER criteria (0.5 mg/L) (Table 6). It is expected that actual nickel concentrations will vary from the predicted concentrations over the course of the year as the model is intended to predict average yearly concentrations within the WRF runoff. Although the model results are compared to MDMER, the results are not representative of discharge to the receiving environment or FDP regulated under MDMER at the WRF.

The low pH and high nickel concentrations can be attributed to the consistent contribution of PAG runoff between all climate scenarios and the assumption that exposure of PAG waste rock at surface (within the active layer) will continue to produce low pH and high metal leachate. Encapsulation of at least 50% of the exposed PAG waste rock with Non-AG prior to the spring freshet, to remove PAG material from the active layer, may assist with limiting low pH and high metal runoff from the WRF.

Future iterations of the water quality model should be completed as necessary. Updates to the model should include the use of mass loading rates based on the observed runoff flow, water quality and geochemistry of the WRF as well as better definition of other inputs to the WRF Pond.

6.0 LIMITATIONS

Care was taken to incorporate known processes into the water quality model, as understood during model development. However, in natural systems and complex man-made systems, observed conditions will almost certainly vary with respect to estimated conditions. Water quality modelling requires the use of many assumptions due to the uncertainty related to determining the physical and geochemical characteristics of a complex system. Given the inherent uncertainties and assumptions of the model approach, the results of the model should be used as a tool to aide in the design of the WRF and to outline potential risks rather than to provide absolute values.

This model was constructed based on the conceptualization of sources and release mechanisms, combined with data interpretation, to describe water quality conditions at the WRF. Where uncertainty exists in model input values, conservative inputs and assumptions have been applied. Climatic controls, which may limit infiltration, geochemical processes and flow within the catchment, were not modelled. Therefore, the model could potentially overestimate the predicted concentrations in the catchment.

The model results are based on the input data collected from WRF runoff during 2019 by Baffinland. Changes in the WRF conditions, input data, or assumptions regarding the WRF conditions will necessarily result in changes to water quality model predictions.

7.0 CLOSURE

The reader is referred to the study Limitations presented in Section 6.0 and forms an integral part of this report.

We trust that this technical memorandum meets your needs at this time. If you have any questions, please do not hesitate to contact the undersigned.

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Attachments: Appendix A: WRF Pond 2019 Water Quality Data
Appendix B: East Ditch 2019 Water Quality Data
Appendix C: West Ditch 2019 Water Quality Data
Appendix D: WRF Runoff 2019 Water Quality Data
Appendix E: Water Quality Modelling Results
Appendix F: PHREEQC Mineral Phases

https://golderassociates.sharepoint.com/sites/22103g/technical work/phase 50000 - geochem/5. water quality model/3. report/1. text/rev.0/1790951 - wq prediction.docx

8.0 REFERENCES

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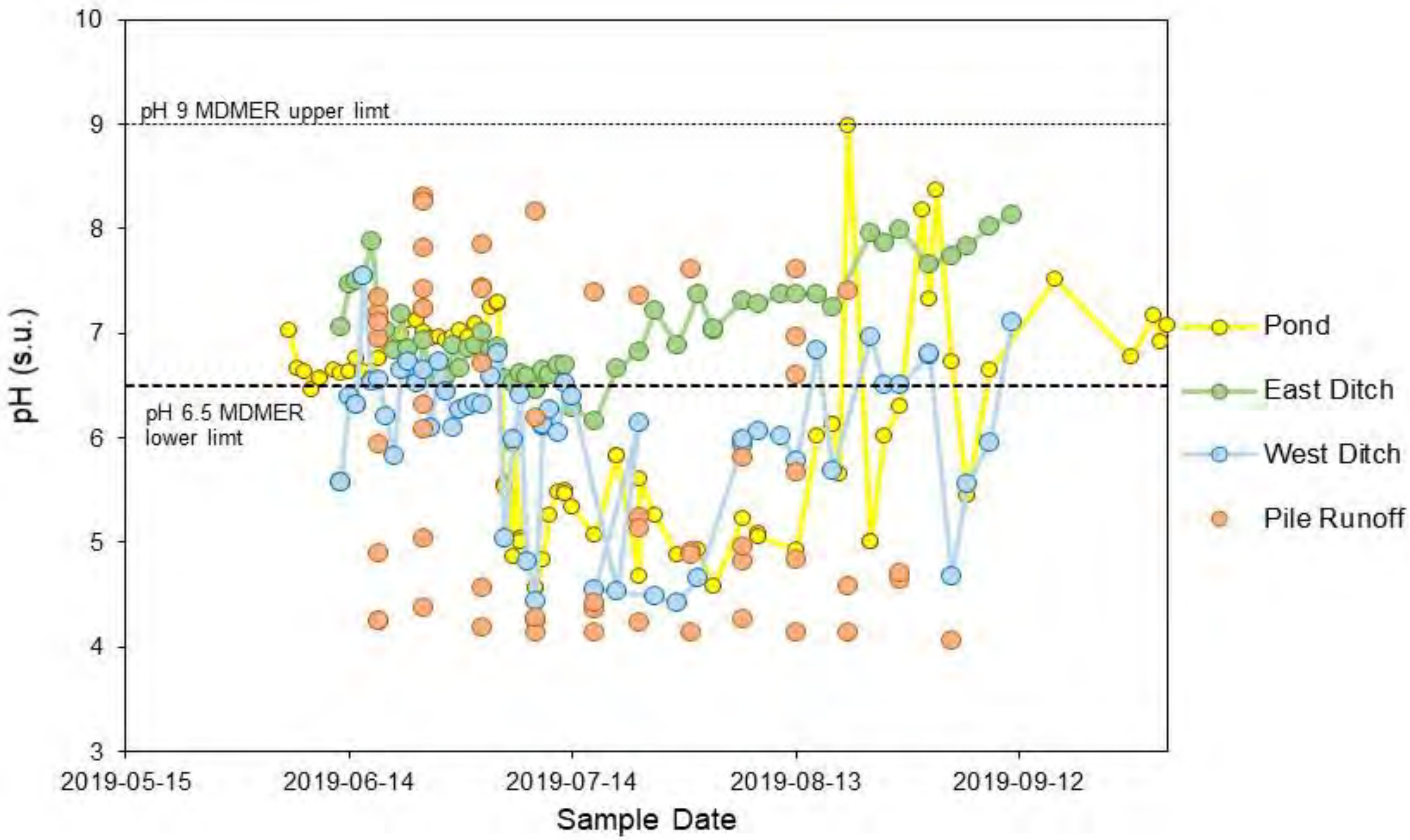
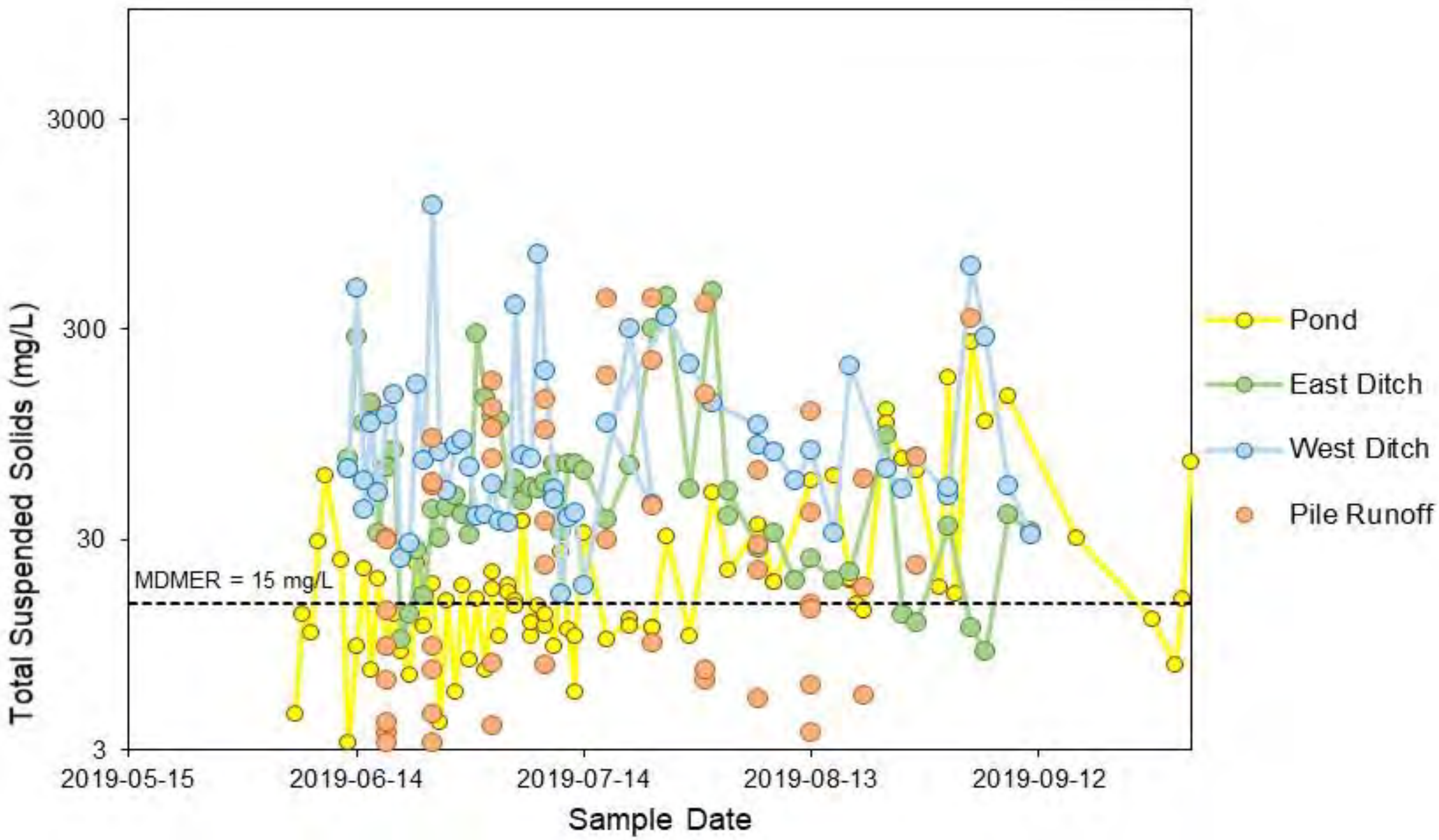
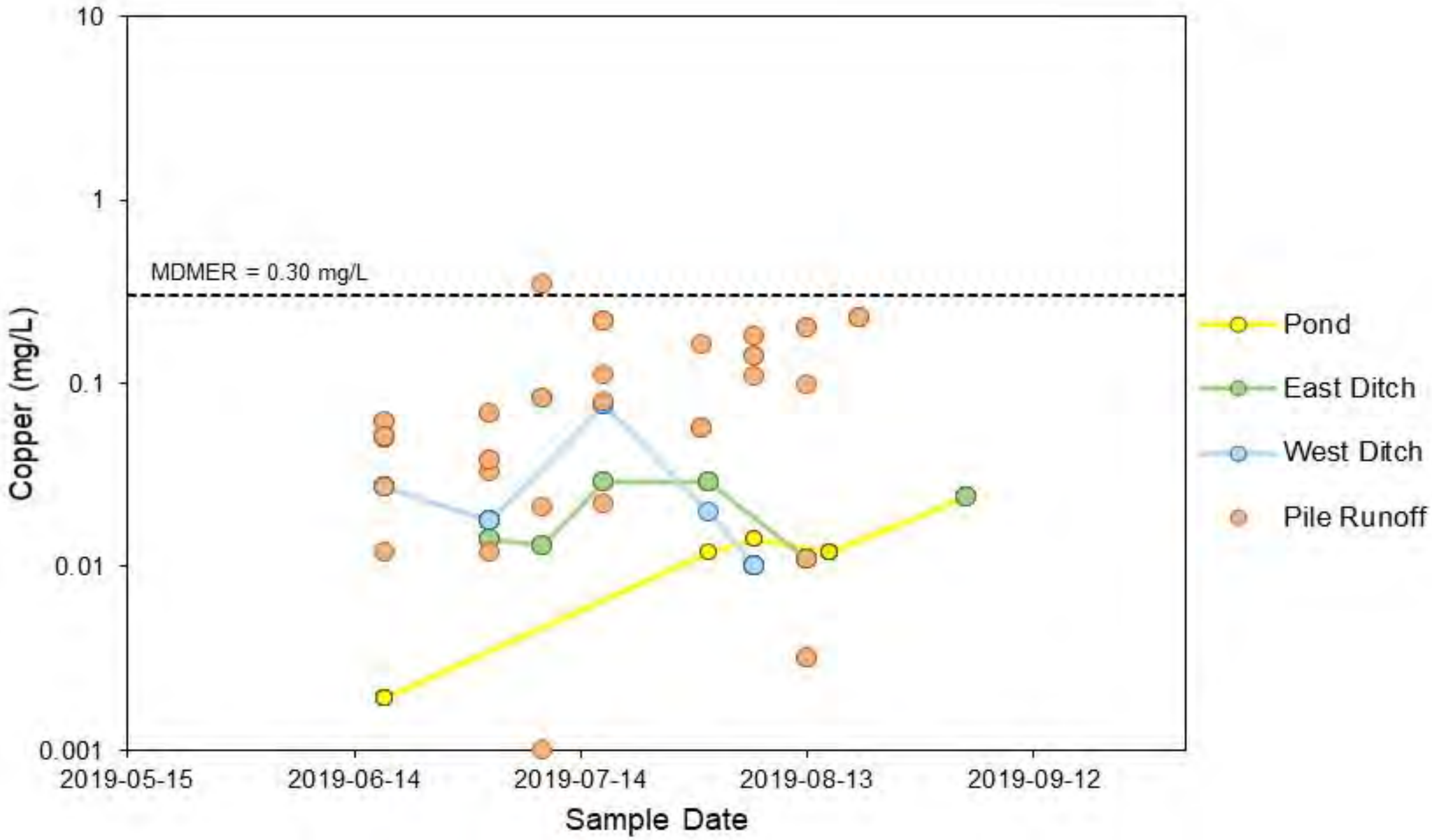
Figures



GOLDER				2019 pH from the WRF Pond and upstream sampling points	
PROJECT NO: 1790951		DATE:	DEC. 2019	BAFFINLAND	FIGURE 1
BY:	LC	Review:	KDV		



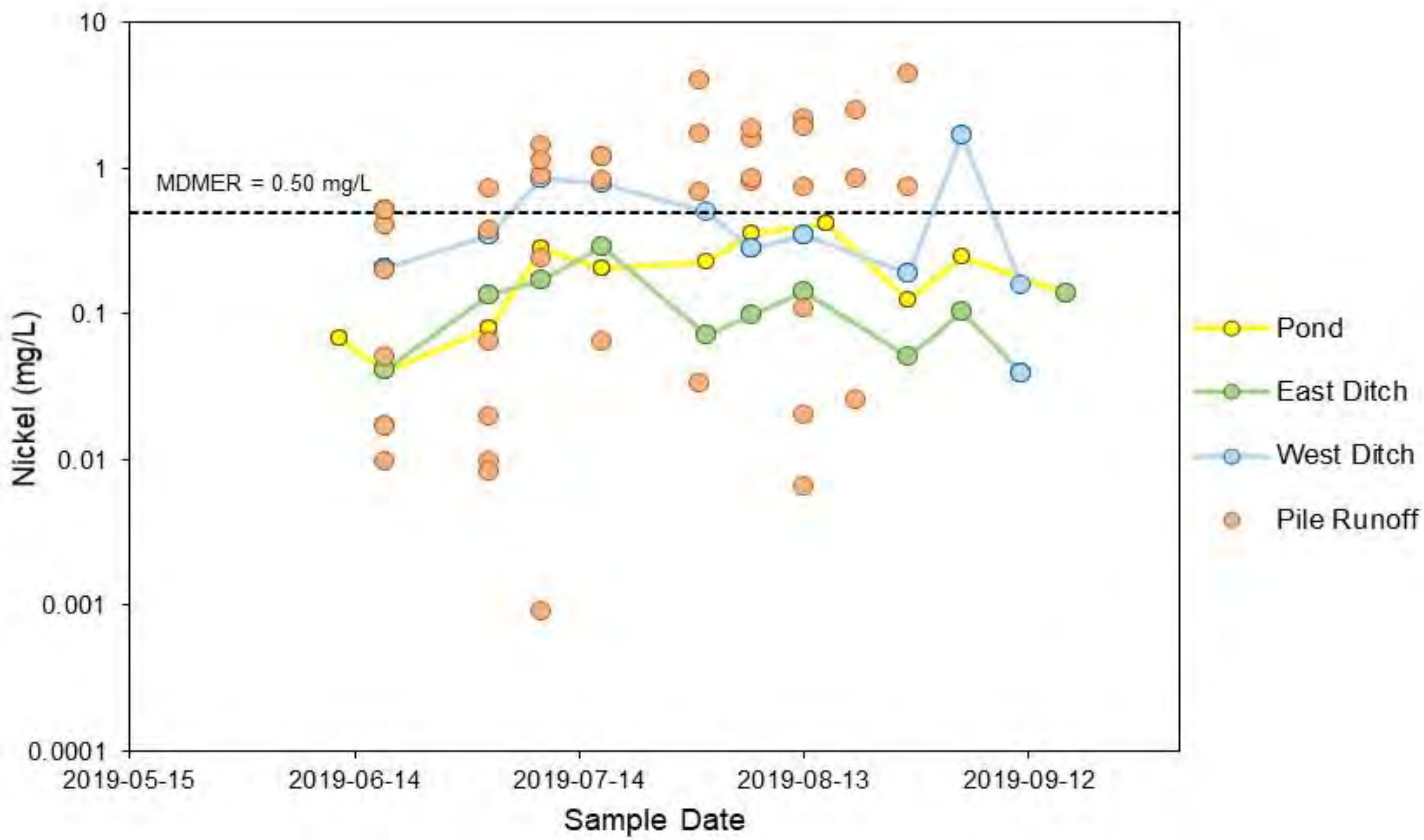
GOLDER	**2019 TSS from the WRF Pond and upstream sampling points**	
PROJECT NO: 1790951 DATE: DEC. 2019 BY: LC Review: KDV	**BAFFINLAND**	**FIGURE 2**



GOLDER

2019 copper concentrations from the WRF Pond and upstream sampling points

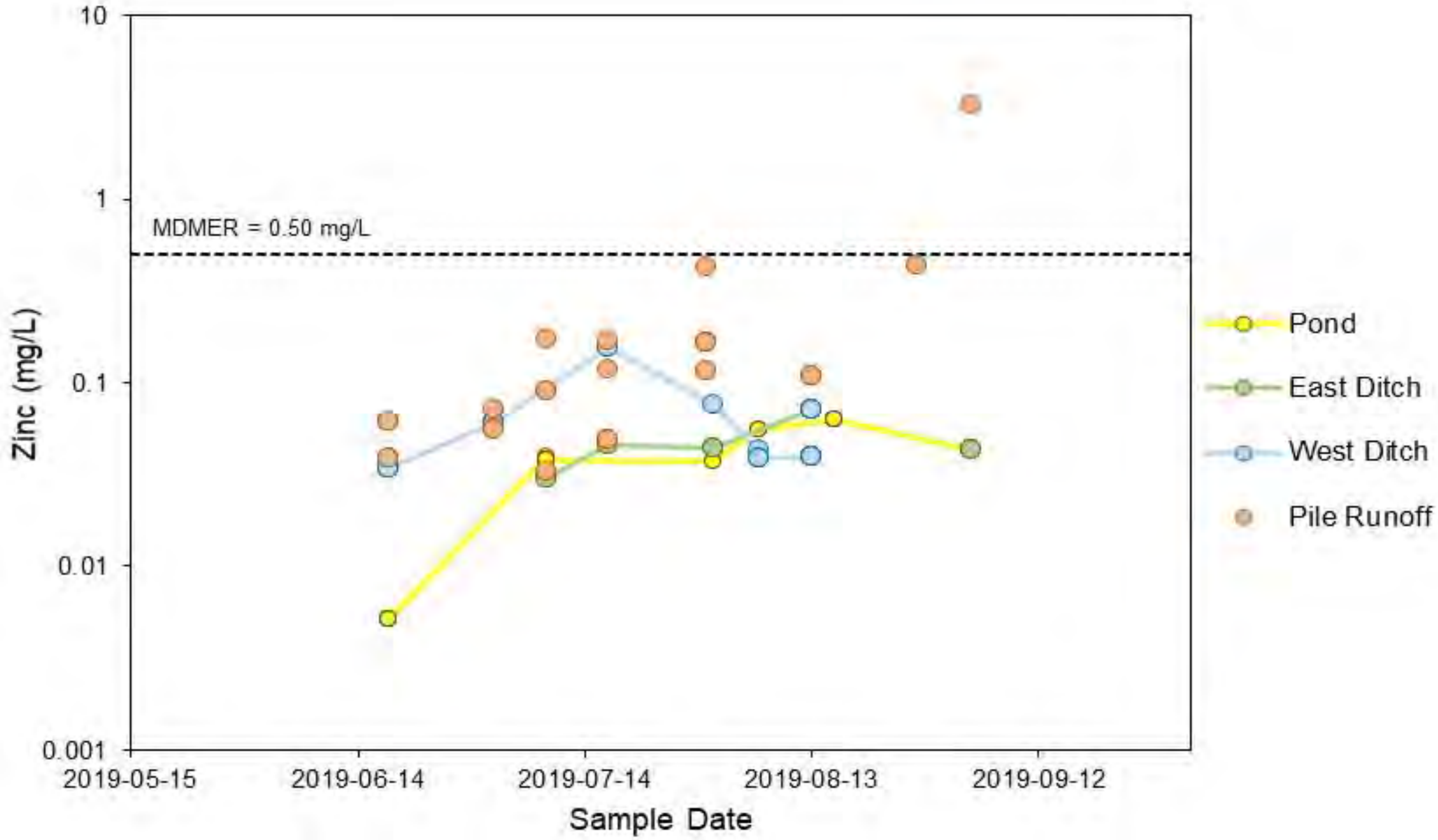
PROJECT NO: 1790951		DATE:	DEC. 2019	BAFFINLAND	FIGURE 3
BY:	LC	Review:	KDV		



GOLDER

2019 nickel concentrations from the WRF Pond and upstream sampling points

PROJECT NO: 1790951		DATE:	DEC. 2019	**BAFFINLAND**	**FIGURE 4**
BY:	LC	Review:	KDV		



GOLDER

2019 zinc concentrations from the WRF Pond and upstream sampling points

PROJECT NO: 1790951		DATE:	DEC. 2019
BY:	LC	Review:	KDV

BAFFINLAND

FIGURE 5

APPENDIX A

WRF Pond 2019 Water Quality Data

Appendix A
WRF Pond 2019 Water Quality Data
Mary River Project - Baffinland Iron Mines

Station ID	Sample Date	Conductivity	Hardness	pH	Total Suspended Solids	Total Dissolved Solids	Turbidity	Acidity	Alkalinity, Total	Ammonia, Total	Chloride (Cl)	Fluoride (F)	Nitrate	Total Kjeldahl Nitrogen	Phosphorus, Total	Sulfate (SO4)	Cyanide, Total	Dissolved Organic Carbon	Total Organic Carbon	Aluminum (Al)-Total	Antimony (Sb)-Total
		umhos/cm	mg/L CaCO3	pH units	mg/L	mg/L	NTU	mg/L as CaCO3	mg/L as CaCO3	mg/L as N	mg/L	mg/L	mg/L as N	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
MS-08-PONDEXPLORE	2019-06-03	393	180	6.87	10.3	274	18.4	3.7	<10	0.249	1.06	0.035	0.825	0.31	0.0031	179	<0.0020	1.06	1.4	0.395	<0.00010
MS-08-POND-EXPLORE	2019-06-06	-	-	7.02	4.4	292	6.45	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EXPLORE	2019-06-07	-	-	6.66	13.2	496	18.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-08	-	-	6.63	10.8	779	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-09	-	-	6.45	29.2	907	32.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-10	-	-	6.56	60.4	812	55.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-12	837	-	6.65	24	609	33	-	-	0.385	-	-	-	-	-	-	-	-	-	1.18	<0.0010
MS-08-POND-EXPLORE	2019-06-13	-	-	6.62	3.2	607	17.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-14	-	-	6.63	9.2	598	22.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-15	-	-	6.75	21.6	501	14.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-16	-	-	6.63	7.2	527	19.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-17	-	-	6.56	19.6	552	13.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-18	711	-	6.76	9.2	524	5.77	-	-	0.449	-	-	-	-	-	-	-	-	-	0.322	<0.00010
MS-08-POND-EXPLORE	2019-06-19	-	-	6.92	13.2	535	13.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-20	-	-	6.84	8.8	846	7.73	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-21	-	-	6.99	6.8	596	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-22	-	-	7.12	22.8	660	21.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-23	-	-	7.12	11.6	704	7.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-24	-	-	7.01	18.4	705	17.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-25	-	-	6.95	4	716	13.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-26	-	-	6.97	15.2	737	12.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-27	-	-	6.93	5.6	756	10.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-28	-	-	6.96	18	819	26.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-29	-	-	7.03	8	840	10.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-30	-	-	6.96	15.6	897	14.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-01	-	-	7.09	7.2	878	9.18	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-02	1260	-	7.01	20.9	1090	24.8	-	-	0.67	-	-	-	-	-	-	-	-	-	0.445	<0.0010
MS-08-POND-EXPLORE01	2019-07-02	1250	-	7	17.4	1060	29.5	-	-	0.71	-	-	-	-	-	-	-	-	-	0.777	<0.0010
MS-08-POND-EXPLORE	2019-07-03	-	-	7.24	10.4	1140	15.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-04	-	-	7.28	18	1310	19.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE01	2019-07-04	-	-	7.29	16.8	1330	20.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-05	-	-	5.55	15.2	2150	59.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE01	2019-07-05	-	-	5.52	14.4	2180	59.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-06	-	-	4.87	36.8	3010	60.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE02	2019-07-06	-	-	5.93	<2.0	<20	<0.10	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-07	-	-	5.03	10.4	3270	26	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE01	2019-07-07	-	-	5.01	12	3190	26.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-08	-	-	4.81	14.4	4220	40.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-09	3960	-	4.57	11.6	4560	26.8	-	-	4.69	-	-	-	-	-	-	-	-	-	0.267	<0.0010
MS-08-POND-EXPLORE01	2019-07-09	3960	-	4.56	13.2	4620	26.4	-	-	4.9	-	-	-	-	-	-	-	-	-	0.245	<0.0010
MS-08-POND-EXPLORE	2019-07-10	-	-	4.83	9.2	5720	17.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-11	-	-	5.26	26	3490	113	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-12	-	-	5.48	11.2	4930	34	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-13	-	-	5.5	5.6	4610	47.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE01	2019-07-13	-	-	5.47	10.4	4620	51.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-14	-	-	5.34	32	3210	75	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-17	3300	-	5.06	10	3490	39.6	-	-	3.39	-	-	-	-	-	-	-	-	-	0.27	<0.0010
MS-08-POND-EXPLORE	2019-07-20	-	-	5.83	12.4	2720	62.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE01	2019-07-20	-	-	5.82	11.6	2730	60.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-23	-	-	4.68	11.4	4910	22.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE02	2019-07-23	-	-	5.6	<2.0	<20	0.13	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-25	-	-	5.25	30.8	2600	128	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-28	-	-	4.88	10.4	2950	59	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-31	2430	-	4.93	50	2430	145	-	-	3.01	-	-	-	-	-	-	-	-	-	1.03	<0.0010
MS-08-POND-EXPLORE	2019-08-02	-	-	4.58	21.2	4550	74.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-08-06	4120	-	5.23	35.2	4710	120	-	-	4.27	-	-	-	-	-	-	-	-	-	0.59	<0.0010
MS-08-POND-EXPLORE	2019-08-08	-	-	5.08	18.8	5620	35.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE01	2019-08-08	-	-	5.05	18.8	5660	41.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-08-13	4670	-	4.92	57.2	5420	105	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-08-16	-	-	6.01	60.6	5000	115	-	-	5.08	-	-	-	-	-	-	-	-	-	0.708	<0.0010
MS-08-POND-EXPLORE	2019-08-18	-	-	6.13	19.2	5480	76.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE01	2019-08-18	-	-	6.12	19.6	5450	77	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08 RECIRC	2019-08-19	-	-	5.65	14.8	11700	70.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-RECIRC	2019-08-20	-	-	8.98	13.6	8720	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-08-23	-	-	5.01	124	7030	225	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE01	2019-08-23	-	-	5.01	108	6450	216	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08POND-EXPLORE	2019-08-25	-	-	6.01	72.7	2530	277	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-08-27	2540	-	6.3	64.2	2660	214	-	-	1.51	-	-	-	-	-	-	-	-	-	1.94	<0.0010
MS-08	2019-08-30	-	-	8.18	17.6	3310	9.95	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-08-31	-	-	7.33	178	1620	223	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08	2019-09-01	-	-	8.37	16.5	2870	11.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-09-03	3350	-	6.73	263	3720	394	-	-	1.38	-	-	-	-	-	-	-	-	-	8.66	<0.0010
MS-08-POND-EXPLORE	2019-09-05	-	-	5.45	109	15100	332	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-09-08	-	-	6.65	145	3780	469	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-09-17	3910	-	7.52	30.1	4250	35.3	-	-	1.7	-	-	-	-	-	-	-	-	-	0.99	<0.0010
MS-08-POND-EXPLORE	2019-09-27	-	-	6.77	12.5	613	13.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-09-30	-	-	7.16	7.6	165	14.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-10-01	-	-	6.92	15.6	529	24.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-10-02	-	-	7.08	70.5	1540	109	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Appendix A
WRF Pond 2019 Water Quality Data
Mary River Project - Baffinland Iron Mines

Station ID	Sample Date	Arsenic (As)-Total	Barium (Ba)-Total	Beryllium (Be)-Total	Bismuth (Bi)-Total	Boron (B)-Total	Cadmium (Cd)-Total	Calcium (Ca)-Total	Cesium (Cs)-Total	Chromium (Cr)-Total	Cobalt (Co)-Total	Copper (Cu)-Total	Iron (Fe)-Total	Lead (Pb)-Total	Lithium (Li)-Total	Magnesium (Mg)-Total	Manganese (Mn)-Total	Mercury (Hg)-Total	Molybdenum (Mo)-Total	Nickel (Ni)-Total	Phosphorus (P)-Total
		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	mg/L	mg/L
MS-08-PONDEXPLORE	2019-06-03	<0.00010	0.0087	<0.00010	<0.000050	0.013	0.0000287	13.3	0.000044	0.00112	0.0162	0.0014	1.09	0.000385	0.0061	37.2	1.23	<0.000010	0.000424	0.0171	<0.050
MS-08-POND-EXPLORE	2019-06-06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EXPLORE	2019-06-07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-09	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-12	<0.0010	0.0162	<0.0010	<0.00050	<0.10	0.000087	20.6	<0.00010	<0.0050	0.0621	<0.010	5.3	0.00064	<0.010	102	3.55	-	0.00072	0.0675	<0.50
MS-08-POND-EXPLORE	2019-06-13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-18	<0.00010	0.0128	<0.00010	<0.000050	0.015	0.0000592	23.3	0.000036	0.00089	0.0384	0.0019	1.55	0.000291	0.0089	77.7	2.44	-	0.000565	0.0399	<0.050
MS-08-POND-EXPLORE	2019-06-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-02	<0.0010	0.0177	<0.0010	<0.00050	<0.10	0.000102	41.4	<0.00010	<0.0050	0.0788	<0.010	1.62	<0.00050	0.011	165	6.03	-	0.00109	0.0804	<0.50
MS-08-POND-EXPLORE01	2019-07-02	<0.0010	0.0189	<0.0010	<0.00050	<0.10	0.000098	40.1	<0.00010	<0.0050	0.0772	<0.010	2.28	0.00056	<0.010	161	5.91	-	0.00113	0.0805	<0.50
MS-08-POND-EXPLORE	2019-07-03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE01	2019-07-04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE01	2019-07-05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE02	2019-07-06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE01	2019-07-07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-09	<0.0010	0.0398	<0.0010	<0.00050	<0.10	0.000266	137	<0.00010	<0.0050	0.29	<0.010	146	<0.00050	0.047	557	23.4	-	<0.00050	0.276	<0.50
MS-08-POND-EXPLORE01	2019-07-09	<0.0010	0.0414	<0.0010	<0.00050	<0.10	0.000286	134	<0.00010	<0.0050	0.297	<0.010	149	<0.00050	0.042	567	24	-	<0.00050	0.283	<0.50
MS-08-POND-EXPLORE	2019-07-10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE01	2019-07-13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-17	<0.0010	0.031	<0.0010	<0.00050	<0.10	0.000253	148	<0.00010	<0.0050	0.211	<0.010	62.1	<0.00050	0.038	483	16.6	-	<0.00050	0.203	<0.50
MS-08-POND-EXPLORE	2019-07-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE01	2019-07-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE02	2019-07-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-31	<0.0010	0.0348	<0.0010	<0.00050	<0.10	0.000298	70	0.00011	<0.0050	0.248	0.012	98.7	0.00081	0.032	337	15.3	-	0.00102	0.228	<0.50
MS-08-POND-EXPLORE	2019-08-02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-08-06	<0.0010	0.0314	<0.0010	<0.00050	<0.10	0.00047	164	<0.00010	<0.0050	0.363	0.014	171	<0.00050	0.047	600	26.1	-	0.00097	0.358	<0.50
MS-08-POND-EXPLORE	2019-08-08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE01	2019-08-08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-08-13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-08-16	<0.0010	0.0333	<0.0010	<0.00050	<0.10	0.00055	172	0.00012	<0.0050	0.429	0.012	168	0.00063	0.053	697	28.6	-	<0.00050	0.421	<0.50
MS-08-POND-EXPLORE	2019-08-18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE01	2019-08-18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08 RECIRC	2019-08-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-RECIRC	2019-08-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-08-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE01	2019-08-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08POND-EXPLORE	2019-08-25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-08-27	<0.0010	0.0275	<0.0010	<0.00050	<0.10	0.000142	119	0.00021	0.0066	0.125	<0.010	25.9	0.00153	0.015	356	10.1	-	0.00118	0.126	<0.50
MS-08	2019-08-30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-08-31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08	2019-09-01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-09-03	0.0021	0.0481	<0.0010	<0.00050	<0.10	0.000302	173	0.00076	0.0278	0.218	0.024	37.8	0.00559	0.031	552	20.7	-	0.0017	0.249	<0.50
MS-08-POND-EXPLORE	2019-09-05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-09-08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-09-17	<0.0010	0.0334	<0.0010	<0.00050	<0.10	0.000194	236	0.00011	<0.0050	0.144	<0.010	3.57	0.00108	0.015	585	20.2	-	0.00319	0.137	<0.50
MS-08-POND-EXPLORE	2019-09-27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-09-30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-10-01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-10-02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Appendix A
WRF Pond 2019 Water Quality Data
Mary River Project - Baffinland Iron Mines

Station ID	Sample Date	Potassium (K)-Total	Rubidium (Rb)-Total	Selenium (Se)-Total	Silicon (Si)-Total	Silver (Ag)-Total	Sodium (Na)-Total	Strontium (Sr)-Total	Sulfur (S)-Total	Sulphate - calculated	Tellurium (Te)-Total	Thallium (Tl)-Total	Thorium (Th)-Total	Tin (Sn)-Total	Titanium (Ti)-Total	Tungsten (W)-Total	Uranium (U)-Total	Vanadium (V)-Total	Zinc (Zn)-Total	Zirconium (Zr)-Total
		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	mg/L
MS-08-PONDEXPLORE	2019-06-03	1.53	0.00236	0.000626	1.21	<0.000050	0.618	0.0149	61.8	185	<0.00020	0.000016	0.00046	<0.00010	0.0213	<0.00010	0.000195	0.00079	0.0043	0.00051
MS-08-POND-EXPLORE	2019-06-06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EXPLORE	2019-06-07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-09	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-12	2.28	0.0038	0.00119	2.4	<0.00050	1.01	0.026	150	449	<0.0020	<0.00010	<0.0010	<0.0010	0.0425	<0.0010	0.00055	<0.0050	<0.030	<0.0020
MS-08-POND-EXPLORE	2019-06-13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-18	1.93	0.00264	0.00114	1.24	<0.000050	0.938	0.0405	129	386	<0.00020	0.000023	0.00027	<0.00010	0.017	<0.00010	0.000271	0.00065	0.0051	0.00045
MS-08-POND-EXPLORE	2019-06-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-06-30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-02	3.26	0.0041	0.00216	1.8	<0.00050	1.8	0.053	251	752	<0.0020	<0.00010	<0.0010	<0.0010	0.0204	<0.0010	0.00085	<0.0050	<0.030	<0.0020
MS-08-POND-EXPLORE01	2019-07-02	3.34	0.0055	0.00212	2.5	<0.00050	1.76	0.055	252	755	<0.0020	<0.00010	<0.0010	<0.0010	0.0332	<0.0010	0.00086	<0.0050	<0.030	<0.0020
MS-08-POND-EXPLORE	2019-07-03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE01	2019-07-04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE01	2019-07-05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE02	2019-07-06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE01	2019-07-07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-09	5.72	0.0101	0.0062	2.2	<0.00050	3.81	0.239	1010	3025	<0.0020	0.00018	<0.0010	<0.0010	0.0113	<0.0010	0.00102	<0.0050	0.04	<0.0020
MS-08-POND-EXPLORE01	2019-07-09	5.73	0.0109	0.00644	2.1	<0.00050	3.82	0.256	1010	3025	<0.0020	0.00016	<0.0010	<0.0010	0.0126	<0.0010	0.00112	<0.0050	0.038	<0.0020
MS-08-POND-EXPLORE	2019-07-10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE01	2019-07-13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-17	6.67	0.0089	0.00495	2.1	<0.00050	3.74	0.247	799	2393	<0.0020	0.00014	<0.0010	<0.0010	<0.0070	<0.0010	0.00308	<0.0050	<0.030	<0.0020
MS-08-POND-EXPLORE	2019-07-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE01	2019-07-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE02	2019-07-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-07-31	5.27	0.0094	0.00375	3.6	<0.00050	3.06	0.068	571	1710	<0.0020	0.00016	0.0011	<0.0010	0.0455	<0.0010	0.00245	<0.0050	0.037	<0.0020
MS-08-POND-EXPLORE	2019-08-02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-08-06	6.16	0.0103	0.00578	3.5	<0.00050	4.69	0.218	1080	3235	<0.0020	0.00023	<0.0010	<0.0010	0.0219	<0.0010	0.00571	<0.0050	0.056	<0.0020
MS-08-POND-EXPLORE	2019-08-08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE01	2019-08-08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-08-13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-08-16	7.1	0.0123	0.00741	4.1	<0.00050	5.63	0.203	1220	3654	<0.0020	0.00025	<0.0010	<0.0010	0.0319	<0.0010	0.00434	<0.0050	0.063	<0.0020
MS-08-POND-EXPLORE	2019-08-18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE01	2019-08-18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08 RECIRC	2019-08-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-RECIRC	2019-08-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-08-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE01	2019-08-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08POND-EXPLORE	2019-08-25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-08-27	5.18	0.01	0.00311	4.9	<0.00050	4.24	0.133	586	1755	<0.0020	<0.00010	0.0018	<0.0010	0.105	<0.0010	0.00523	<0.0050	<0.030	0.0024
MS-08	2019-08-30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-08-31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08	2019-09-01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-09-03	6.82	0.0249	0.00619	14.9	<0.00050	6.39	0.142	878	2630	<0.0020	0.00025	0.0062	<0.0010	0.371	<0.0010	0.0101	0.0143	0.043	0.0075
MS-08-POND-EXPLORE	2019-09-05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-09-08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-09-17	7.72	0.0083	0.00613	4.3	<0.00050	8.14	0.221	986	2953	<0.0020	<0.00010	<0.0010	<0.0010	0.0579	<0.0010	0.0201	<0.0050	<0.030	<0.0020
MS-08-POND-EXPLORE	2019-09-27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-09-30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-10-01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-POND-EXPLORE	2019-10-02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX B

East Ditch 2019 Water Quality Data

Station ID	Sample Date	Conductivity	Hardness	pH	Total Suspended Solids	Total Dissolved Solids	Turbidity	Acidity	Alkalinity, Total	Ammonia, Total	Chloride (Cl)	Fluoride (F)	Nitrate	Total Kjeldahl Nitrogen	Phosphorus, Total	Sulfate (SO4)	Cyanide, Total	Dissolved Organic Carbon	Total Organic Carbon	Aluminum (Al)-Total	Antimony (Sb)-Total
		umhos/cm	mg/L CaCO3	pH units	mg/L	mg/L	NTU	mg/L as CaCO3	mg/L as CaCO3	mg/L as N	mg/L	mg/L	mg/L as N	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
MS-08-EAST-INFLOW	2019-06-12	316	-	7.16	99.6	239	109	-	-	0.335	-	-	-	-	-	-	-	-	-	6.05	<0.0010
MS-08-EAST-INFLOW	2019-06-13	-	-	7.06	72.4	260	58.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-14	-	-	7.47	276	323	263	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-15	-	-	7.5	108	363	115	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-16	-	-	7.54	134	403	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-17	-	-	7.88	32	351	71.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-18	753	-	7.12	65.6	574	77	-	-	0.615	-	-	-	-	-	-	-	-	-	2.2	<0.0010
MS-08-EAST-INFLOW	2019-06-19	-	-	7.03	79.1	773	30.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-20	-	-	6.83	10	1020	24.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-21	-	-	7.19	13.2	388	64.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-22	-	-	6.85	26.5	1040	52.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-23	-	-	6.58	16.3	1590	52.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-24	-	-	6.93	41.8	873	74	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-25	-	-	6.58	30.4	1350	111	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-26	-	-	6.64	42.5	1160	104	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-27	-	-	6.58	48.4	1020	91.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-28	-	-	6.88	39.2	706	56.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-29	-	-	6.67	31.6	1380	67.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-30	-	-	6.85	286	1450	338	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-DITCH	2019-07-01	-	-	6.88	142	1340	193	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-02	1810	-	7.01	115	1680	168	-	-	1.24	-	-	-	-	-	-	-	-	-	4.69	<0.0010
MS-08-EAST-INFLOW	2019-07-03	-	-	6.83	111	2040	150	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-04	-	-	6.86	51.6	2290	115	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-05	-	-	6.56	57.6	2370	141	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-06	-	-	6.52	45.6	2590	136	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-07	-	-	6.62	53.2	2590	144	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-08	-	-	6.58	52	2360	125	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-09	2330	-	6.45	55.6	2320	101	-	-	1.06	-	-	-	-	-	-	-	-	-	1.24	<0.0010
MS-08-EAST-INFLOW	2019-07-10	-	-	6.65	68.8	2220	55.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-11	-	-	6.6	32.8	1230	285	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-12	-	-	6.7	69.2	2200	145	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-13	-	-	6.7	69.2	2200	145	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-14	-	-	6.28	63.6	1170	130	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-17	2660	-	6.15	37.2	2730	376	-	-	89	-	-	-	-	-	-	-	-	-	5.98	<0.0010
MS-08-EAST-INFLOW	2019-07-20	-	-	6.67	67.2	1720	151	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-23	-	-	6.82	300	1560	221	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-25	-	-	7.22	428	725	319	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-28	-	-	6.89	52.4	117	1520	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-31	697	-	7.38	454	521	353	-	-	0.322	-	-	-	-	-	-	-	-	-	13.8	<0.0010
MS-08-EAST-INFLOW	2019-08-02	-	-	7.03	38.8	1690	82.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW01	2019-08-02	-	-	7.04	50.8	1740	86.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-08-06	1610	-	7.31	27.2	1390	59.6	-	-	0.68	-	-	-	-	-	-	-	-	-	0.374	<0.0010
MS-08-EAST-INFLOW	2019-08-08	-	-	7.28	32	1900	43.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-08-11	-	-	7.38	19	2030	44.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-08-13	2200	-	7.38	24.5	2120	37.2	-	-	1.12	-	-	-	-	-	-	-	-	-	1.12	<0.0010
MS-08-EAST-INFLOW	2019-08-16	-	-	7.38	19	2030	44.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-08-18	-	-	7.24	20.8	2310	52.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-08-23	-	-	7.96	94.8	1980	64.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-08-25	-	-	7.87	13.2	1200	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-08-27	1310	-	7.99	12	1130	10.6	-	-	0.416	-	-	-	-	-	-	-	-	-	0.394	<0.0010
MS-08-EAST-INFLOW	2019-08-31	-	-	7.65	34.3	969	30.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-09-03	1700	-	7.74	11.4	1850	12.1	-	-	0.88	-	-	-	-	-	-	-	-	-	0.212	<0.0010
MS-08-EAST-INFLOW	2019-09-05	-	-	7.83	8.8	1630	2.69	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INLFOW	2019-09-08	-	-	8.02	39.3	1330	35.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-09-11	1400	-	8.13	32.7	1160	18.9	-	-	0.327	-	-	-	-	-	-	-	-	-	0.859	<0.0010

Station ID	Sample Date	Arsenic (As)-Total	Barium (Ba)-Total	Beryllium (Be)-Total	Bismuth (Bi)-Total	Boron (B)-Total	Cadmium (Cd)-Total	Calcium (Ca)-Total	Cesium (Cs)-Total	Chromium (Cr)-Total	Cobalt (Co)-Total	Copper (Cu)-Total	Iron (Fe)-Total	Lead (Pb)-Total	Lithium (Li)-Total	Magnesium (Mg)-Total	Manganese (Mn)-Total	Mercury (Hg)-Total	Molybdenum (Mo)-Total	Nickel (Ni)-Total	Phosphorus (P)-Total
		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	mg/L	mg/L
MS-08-EAST-INFLOW	2019-06-12	<0.0010	0.0278	<0.0010	<0.00050	<0.10	<0.000050	11.4	0.00048	0.0212	0.015	0.015	10.9	0.00355	<0.010	32.8	0.826	-	0.00175	0.03	<0.50
MS-08-EAST-INFLOW	2019-06-13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-18	<0.0010	0.0211	<0.0010	<0.00050	<0.10	0.000119	25.1	0.00023	0.0065	0.0639	<0.010	5.12	0.00363	<0.010	83.5	4.36	-	0.00132	0.0413	<0.50
MS-08-EAST-INFLOW	2019-06-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-DITCH	2019-07-01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-02	<0.0010	0.0371	<0.0010	<0.00050	<0.10	0.000285	60.2	0.00033	0.0135	0.182	0.014	12.8	0.00502	0.024	254	12.8	-	0.00206	0.135	<0.50
MS-08-EAST-INFLOW	2019-07-03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-09	<0.0010	0.0304	<0.0010	<0.00050	<0.10	0.000296	77.7	<0.00010	<0.0050	0.238	0.013	12.1	0.00118	0.027	325	14.5	-	0.00144	0.172	<0.50
MS-08-EAST-INFLOW	2019-07-10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-17	<0.0010	0.0535	<0.0010	<0.00050	<0.10	0.000434	86.3	0.00046	0.0157	0.327	0.029	48.1	0.00538	0.036	394	17	-	0.00254	0.288	<0.50
MS-08-EAST-INFLOW	2019-07-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-31	0.0021	0.0886	<0.0010	<0.00050	<0.10	0.000115	36.3	0.0016	0.0405	0.0613	0.029	23.6	0.0113	0.03	86.8	3.06	-	0.00168	0.072	<0.50
MS-08-EAST-INFLOW	2019-08-02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW01	2019-08-02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-08-06	<0.0010	0.0196	<0.0010	<0.00050	<0.10	0.000153	67.2	<0.00010	<0.0050	0.125	<0.010	5.4	<0.00050	0.013	216	8.68	-	0.00158	0.0982	<0.50
MS-08-EAST-INFLOW	2019-08-08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-08-11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-08-13	<0.0010	0.0255	<0.0010	<0.00050	<0.10	0.000263	89.4	<0.00010	<0.0050	0.172	0.011	5.43	0.00138	0.018	300	11.7	-	0.002	0.143	<0.50
MS-08-EAST-INFLOW	2019-08-16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-08-18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-08-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-08-25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-08-27	<0.0010	0.0184	<0.0010	<0.00050	<0.10	0.000082	64	<0.00010	<0.0050	0.0602	<0.010	0.93	<0.00050	<0.010	162	4.93	-	0.0022	0.0514	<0.50
MS-08-EAST-INFLOW	2019-08-31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-09-03	<0.0010	0.0186	<0.0010	<0.00050	<0.10	0.00016	76.5	<0.00010	<0.0050	0.118	<0.010	1.85	<0.00050	<0.010	230	8.66	-	0.00158	0.105	<0.50
MS-08-EAST-INFLOW	2019-09-05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INLFOW	2019-09-08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-09-11	<0.0010	0.0246	<0.0010	<0.00050	<0.10	0.000059	71.3	0.00011	<0.0050	0.0382	<0.010	1.52	0.00088	<0.010	156	4.04	-	0.00213	0.0393	<0.50

Station ID	Sample Date	Potassium (K)-Total	Rubidium (Rb)-Total	Selenium (Se)-Total	Silicon (Si)-Total	Silver (Ag)-Total	Sodium (Na)-Total	Strontium (Sr)-Total	Sulfur (S)-Total	Sulphate - calculated	Tellurium (Te)-Total	Thallium (Tl)-Total	Thorium (Th)-Total	Tin (Sn)-Total	Titanium (Ti)-Total	Tungsten (W)-Total	Uranium (U)-Total	Vanadium (V)-Total	Zinc (Zn)-Total	Zirconium (Zr)-Total
		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	mg/L
MS-08-EAST-INFLOW	2019-06-12	3.43	0.013	0.00063	9.9	<0.00050	0.96	0.015	39.3	118	<0.0020	<0.00010	0.0032	<0.0010	0.233	<0.0010	0.00376	0.0091	<0.030	<0.0020
MS-08-EAST-INFLOW	2019-06-13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-18	2.99	0.0079	0.00183	4.5	<0.00050	1.23	0.023	130	389	<0.0020	<0.00010	0.0017	<0.0010	0.0999	<0.0010	0.00283	<0.0050	<0.030	<0.0020
MS-08-EAST-INFLOW	2019-06-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-06-30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-DITCH	2019-07-01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-02	5.16	0.0134	0.00401	8.1	<0.00050	2.82	0.054	384	1150	<0.0020	0.00012	0.0022	<0.0010	0.173	<0.0010	0.00903	0.0064	<0.030	0.0061
MS-08-EAST-INFLOW	2019-07-03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-09	4.71	0.0092	0.00492	3.6	<0.00050	2.76	0.065	529	1585	<0.0020	<0.00010	<0.0010	<0.0010	0.0456	<0.0010	0.00701	<0.0050	0.03	<0.0020
MS-08-EAST-INFLOW	2019-07-10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-17	6.51	0.0168	0.00522	10.1	<0.00050	3.39	0.076	618	1851	<0.0020	0.00014	0.0029	<0.0010	0.243	<0.0010	0.0127	0.0077	0.046	0.0056
MS-08-EAST-INFLOW	2019-07-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-07-31	7.61	0.0424	0.00122	24.8	<0.00050	1.53	0.032	110	329	<0.0020	0.00029	0.0102	<0.0010	0.799	<0.0010	0.00501	0.0267	0.044	0.004
MS-08-EAST-INFLOW	2019-08-02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW01	2019-08-02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-08-06	3.92	0.005	0.00296	2.6	<0.00050	3.13	0.05	321	961	<0.0020	<0.00010	<0.0010	<0.0010	0.0102	<0.0010	0.00745	<0.0050	<0.030	<0.0020
MS-08-EAST-INFLOW	2019-08-08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-08-11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-08-13	5.11	0.0069	0.00452	3.3	<0.00050	4.58	0.073	465	1393	<0.0020	<0.00010	<0.0010	<0.0010	0.03	<0.0010	0.00981	<0.0050	0.072	<0.0020
MS-08-EAST-INFLOW	2019-08-16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-08-18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-08-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-08-25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-08-27	4.28	0.0047	0.00174	2.8	<0.00050	4.11	0.05	233	698	<0.0020	<0.00010	<0.0010	<0.0010	0.0232	<0.0010	0.0104	<0.0050	<0.030	<0.0020
MS-08-EAST-INFLOW	2019-08-31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-09-03	4.21	0.0055	0.0028	2.6	<0.00050	5.25	0.063	335	1003	<0.0020	<0.00010	<0.0010	<0.0010	0.0063	<0.0010	0.0101	<0.0050	<0.030	<0.0020
MS-08-EAST-INFLOW	2019-09-05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INLFOW	2019-09-08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-EAST-INFLOW	2019-09-11	4.75	0.0063	0.00155	4.2	<0.00050	5.67	0.061	220	659	<0.0020	<0.00010	<0.0010	<0.0010	0.053	<0.0010	0.0148	<0.0050	<0.030	<0.0020

APPENDIX C

West Ditch 2019 Water Quality Data

Appendix C
West Ditch 2019 Water Quality Data
Mary River Project - Baffinland Iron Mines

Station ID	Sample Date	Conductivity	Hardness	pH	Total Suspended Solids	Total Dissolved Solids	Turbidity	Acidity	Alkalinity, Total	Ammonia, Total	Chloride (Cl)	Fluoride (F)	Nitrate	Total Kjeldahl Nitrogen	Phosphorus, Total	Sulfate (SO4)	Cyanide, Total	Dissolved Organic Carbon	Total Organic Carbon	Aluminum (Al)-Total	Antimony (Sb)-Total
		umhos/cm	mg/L CaCO3	pH units	mg/L	mg/L	NTU	mg/L as CaCO3	mg/L as CaCO3	mg/L as N	mg/L	mg/L	mg/L as N	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
MS-08-WEST-INFLOW	2019-06-12	790	-	5.34	29.6	617	61	-	-	0.482	-	-	-	-	-	-	-	-	-	2.46	<0.0010
MS-08-WEST-INFLOW	2019-06-13	-	-	5.58	65.2	1340	43.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW01	2019-06-13	-	-	5.58	64.4	1400	11.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-14	-	-	6.39	474	1030	190	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-15	-	-	6.31	57.2	1130	210	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW01	2019-06-15	-	-	6.31	41.6	1180	61.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-16	-	-	7.54	108	921	304	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-17	-	-	6.54	50.4	854	72.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-18	1920	-	6.55	118	1790	154	-	-	1.11	-	-	-	-	-	-	-	-	-	5.4	<0.0010
MS-08-WEST-INFLOW	2019-06-19	-	-	6.2	146	2140	82.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-20	-	-	5.82	24.4	3270	73.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-21	-	-	6.64	28.8	1700	59.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-22	-	-	6.72	164	3000	134	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-23	-	-	6.52	71.7	3790	89.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-24	-	-	6.65	1180	1440	619	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-25	-	-	6.09	78	2420	121	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-26	-	-	6.72	50.9	2150	110	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-27	-	-	6.44	84	2320	145	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-28	-	-	6.1	89.6	1900	140	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-29	-	-	6.26	66.4	2880	104	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-30	-	-	6.3	38.4	3580	110	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-DITCH	2019-07-01	-	-	6.33	39.2	3930	124	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-02	3260	-	6.32	55	3550	115	-	-	1.5	-	-	-	-	-	-	-	-	-	2.2	<0.0010
MS-08-WEST-INFLOW	2019-07-03	-	-	6.59	36.8	4070	130	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-04	-	-	6.81	36	4480	113	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-05	0	-	5.04	394	12100	395	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-06	-	-	5.99	75.2	6330	157	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-07	-	-	6.41	72.4	6270	148	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-08	-	-	4.81	691	14700	582	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-09	7500	-	4.44	191	10300	144	-	-	10	-	-	-	-	-	-	-	-	-	2.84	<0.010
MS-08-WEST-INFLOW	2019-07-10	-	-	6.11	52.4	6600	104	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW01	2019-07-10	-	-	6.12	46.4	6500	139	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-11	-	-	6.26	16.4	2600	116	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-12	-	-	6.04	38	3900	80.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-13	-	-	6.52	40.4	3310	153	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-14	-	-	6.4	18	1850	110	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-20	-	-	4.53	304	5320	158	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-23	-	-	6.14	43.8	6310	126	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-17	5470	-	4.55	107	6560	172	-	-	9.21	-	-	-	-	-	-	-	-	-	12.3	<0.0010
MS-08-WEST-INFLOW	2019-07-25	-	-	4.48	344	6430	216	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2018-07-28	-	-	4.42	207	8810	143	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-31	4160	-	4.65	133	5010	230	-	-	3.14	-	-	-	-	-	-	-	-	-	3.39	<0.0010
MS-08-WEST-INFLOW	2019-08-06	4140	-	5.93	106	4800	346	-	-	2.15	-	-	-	-	-	-	-	-	-	1.21	<0.0010
MS-08-WEST-INFLOW01	2019-08-06	4130	-	5.98	84.4	4740	335	-	-	2.13	-	-	-	-	-	-	-	-	-	0.797	<0.0010
MS-08-WEST-INFLOW	2019-08-08	-	-	6.07	78.8	5480	244	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-08-11	-	-	6.02	57.1	5410	383	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-08-13	4980	-	5.78	79.4	6020	430	-	-	3.31	-	-	-	-	-	-	-	-	-	0.195	<0.0010
MS-08-WEST-INFLOW	2019-08-16	-	-	6.84	32.1	5080	283	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-08-18	-	-	5.68	200	10600	322	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS08-WEST-INFLOW	2019-08-23	-	-	6.97	65	4530	186	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INLOW	2019-08-25	-	-	6.51	52	3580	231	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-08-27	3670	-	6.5	73.5	3990	232	-	-	1.29	-	-	-	-	-	-	-	-	-	1.88	<0.0010
MS-08-WEST-INFLOW	2019-08-31	-	-	6.79	48.5	3260	174	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW01	2019-08-31	-	-	6.8	52.5	3290	171	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-09-03	14100	-	4.67	606	22600	745	-	-	22.9	-	-	-	-	-	-	-	-	-	18.6	<0.010
MS-08-WEST-INFLOW	2019-09-05	-	-	5.55	278	17300	430	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-09-08	-	-	5.95	53.9	9540	134	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-09-11	4180	-	7.1	31.3	4610	120	-	-	0.81	-	-	-	-	-	-	-	-	-	0.843	<0.0010

Appendix C
West Ditch 2019 Water Quality Data
Mary River Project - Baffinland Iron Mines

Station ID	Sample Date	Arsenic (As)-Total	Barium (Ba)-Total	Beryllium (Be)-Total	Bismuth (Bi)-Total	Boron (B)-Total	Cadmium (Cd)-Total	Calcium (Ca)-Total	Cesium (Cs)-Total	Chromium (Cr)-Total	Cobalt (Co)-Total	Copper (Cu)-Total	Iron (Fe)-Total	Lead (Pb)-Total	Lithium (Li)-Total	Magnesium (Mg)-Total	Manganese (Mn)-Total	Mercury (Hg)-Total	Molybdenum (Mo)-Total	Nickel (Ni)-Total	Phosphorus (P)-Total
		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	mg/L	mg/L
MS-08-WEST-INFLOW	2019-06-12	<0.0010	0.0176	0.0017	<0.00050	<0.10	0.000199	15.6	0.00012	<0.0050	0.108	0.031	28.2	0.00262	0.018	82.6	4.9	-	0.00077	0.0975	<0.50
MS-08-WEST-INFLOW	2019-06-13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW01	2019-06-13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW01	2019-06-15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-18	0.001	0.0406	0.0011	<0.00050	<0.10	0.00032	53.7	0.00046	0.0131	0.165	0.027	22.5	0.004	0.029	275	10.2	-	0.00064	0.203	<0.50
MS-08-WEST-INFLOW	2019-06-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-DITCH	2019-07-01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-02	<0.0010	0.0319	<0.0010	<0.00050	<0.10	0.000475	101	0.00017	<0.0050	0.308	0.018	15.9	0.00188	0.039	532	21.7	-	0.00099	0.351	<0.50
MS-08-WEST-INFLOW	2019-07-03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-09	<0.010	0.046	<0.010	<0.0050	<1.0	0.00058	178	<0.0010	<0.050	0.858	<0.10	480	<0.0050	<0.10	1270	57.3	-	<0.0050	0.853	<5.0
MS-08-WEST-INFLOW	2019-07-10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW01	2019-07-10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-17	0.0022	0.0652	0.0036	<0.00050	<0.10	0.0011	107	0.00096	0.0358	0.861	0.077	435	0.00648	0.117	846	55.6	-	0.0007	0.784	<0.50
MS-08-WEST-INFLOW	2019-07-25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2018-07-28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-31	<0.0010	0.0347	<0.0010	<0.00050	<0.10	0.000488	130	0.00023	0.0104	0.433	0.02	265	0.00199	0.049	647	25.6	-	<0.00050	0.502	<0.50
MS-08-WEST-INFLOW	2019-08-06	<0.0010	0.0283	<0.0010	<0.00050	<0.10	0.000351	175	0.00013	<0.0050	0.267	0.01	98.7	0.00071	0.026	636	24.2	-	0.00061	0.283	<0.50
MS-08-WEST-INFLOW01	2019-08-06	<0.0010	0.0281	<0.0010	<0.00050	<0.10	0.000366	178	<0.00010	<0.0050	0.27	<0.010	96.6	0.00052	0.028	660	24.8	-	0.00054	0.284	<0.50
MS-08-WEST-INFLOW	2019-08-08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-08-11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-08-13	<0.0010	0.0343	<0.0010	<0.00050	<0.10	0.000451	223	<0.00010	<0.0050	0.344	<0.010	111	<0.00050	0.033	838	32.4	-	0.00071	0.346	<0.50
MS-08-WEST-INFLOW	2019-08-16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-08-18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS08-WEST-INFLOW	2019-08-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INLOW	2019-08-25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-08-27	<0.0010	0.0348	<0.0010	<0.00050	<0.10	0.000248	200	0.00014	0.0054	0.177	<0.010	27.8	0.00133	0.011	584	20.9	-	0.00082	0.188	<0.50
MS-08-WEST-INFLOW	2019-08-31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW01	2019-08-31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-09-03	<0.010	0.088	<0.010	<0.0050	<1.0	0.0012	208	0.0011	0.077	1.75	<0.10	1080	0.0068	<0.10	2990	102	-	<0.0050	1.7	<5.0
MS-08-WEST-INFLOW	2019-09-05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-09-08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-09-11	<0.0010	0.0412	<0.0010	<0.00050	<0.10	0.000179	249	0.0001	<0.0050	0.177	<0.010	11.5	0.0009	<0.010	621	24.7	-	0.00089	0.16	<0.50

Station ID	Sample Date	Potassium (K)-Total	Rubidium (Rb)-Total	Selenium (Se)-Total	Silicon (Si)-Total	Silver (Ag)-Total	Sodium (Na)-Total	Strontium (Sr)-Total	Sulfur (S)-Total	Sulphate - calculated	Tellurium (Te)-Total	Thallium (Tl)-Total	Thorium (Th)-Total	Tin (Sn)-Total	Titanium (Ti)-Total	Tungsten (W)-Total	Uranium (U)-Total	Vanadium (V)-Total	Zinc (Zn)-Total	Zirconium (Zr)-Total
		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	mg/L
MS-08-WEST-INFLOW	2019-06-12	2.72	0.0055	0.00209	3.7	<0.00050	0.9	0.013	135	404	<0.0020	<0.00010	<0.0010	<0.0010	0.0595	<0.0010	0.00799	<0.0050	0.15	<0.0020
MS-08-WEST-INFLOW	2019-06-13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW01	2019-06-13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW01	2019-06-15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-18	4.1	0.0161	0.00362	9.2	<0.00050	1.49	0.041	427	1279	<0.0020	0.00014	0.0037	<0.0010	0.248	<0.0010	0.00329	0.0088	0.034	0.0036
MS-08-WEST-INFLOW	2019-06-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-06-30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-DITCH	2019-07-01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-02	5.97	0.0103	0.00628	5.1	<0.00050	3.03	0.078	810	2426	<0.0020	0.00011	<0.0010	<0.0010	<0.080	<0.0010	0.00433	<0.0050	0.061	0.0023
MS-08-WEST-INFLOW	2019-07-03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-09	8.1	0.025	0.0118	<10	<0.0050	6.3	0.14	2120	6350	<0.020	<0.0010	<0.010	<0.010	0.155	<0.010	0.0037	<0.050	<0.30	<0.020
MS-08-WEST-INFLOW	2019-07-10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW01	2019-07-10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-17	10	0.0333	0.00985	18.2	<0.00050	6.46	0.109	1580	4733	<0.0020	0.00081	0.0078	<0.0010	0.522	<0.0010	0.00826	0.0174	0.157	0.0084
MS-08-WEST-INFLOW	2019-07-25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2018-07-28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-07-31	5.55	0.0123	0.00645	7.2	<0.00050	3.49	0.092	1130	3385	<0.0020	0.00023	0.0024	<0.0010	0.18	<0.0010	0.00363	0.0055	0.077	<0.0020
MS-08-WEST-INFLOW	2019-08-06	5.15	0.0102	0.00573	5	<0.00050	3.91	0.126	1070	3205	<0.0020	0.00016	0.001	<0.0010	0.0636	<0.0010	0.00714	<0.0050	0.043	<0.0020
MS-08-WEST-INFLOW01	2019-08-06	5.04	0.0082	0.00617	3.7	<0.00050	3.93	0.128	1070	3205	<0.0020	0.00016	<0.0010	<0.0010	0.0315	<0.0010	0.00725	<0.0050	0.039	<0.0020
MS-08-WEST-INFLOW	2019-08-08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-08-11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-08-13	5.99	0.0084	0.00761	3.5	<0.00050	5.52	0.178	1390	4163	<0.0020	0.00017	<0.0010	<0.0010	<0.0050	<0.0010	0.0102	<0.0050	0.04	<0.0020
MS-08-WEST-INFLOW	2019-08-16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-08-18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS08-WEST-INFLOW	2019-08-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INLOW	2019-08-25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-08-27	5.44	0.0085	0.00534	5.5	<0.00050	5.52	0.16	995	2980	<0.0020	<0.00010	0.0013	<0.0010	0.16	<0.0010	0.00943	<0.0050	<0.030	<0.0020
MS-08-WEST-INFLOW	2019-08-31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW01	2019-08-31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-09-03	12.1	0.045	0.0214	25	<0.0050	12.2	0.15	4770	14288	<0.020	<0.0010	<0.010	<0.010	0.553	<0.010	0.0106	<0.050	<0.30	<0.020
MS-08-WEST-INFLOW	2019-09-05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-09-08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-08-WEST-INFLOW	2019-09-11	5.44	0.0068	0.00552	4.7	<0.00050	7.04	0.213	1070	3205	<0.0020	<0.00010	<0.0010	<0.0010	0.0607	<0.0010	0.0138	<0.0050	<0.030	<0.0020

APPENDIX D

WRF Runoff 2019 Water Quality Data

Station ID	Sample Date	Conductivity	Hardness	pH	Total Suspended Solids	Total Dissolved Solids	Turbidity	Acidity	Alkalinity, Total	Ammonia, Total	Chloride (Cl)	Fluoride (F)	Nitrate	Total Kjeldahl Nitrogen	Phosphorus, Total	Sulfate (SO4)	Cyanide, Total	Dissolved Organic Carbon	Total Organic Carbon	Aluminum (Al)-Total	Antimony (Sb)-Total
		umhos/cm	mg/L CaCO3	pH units	mg/L	mg/L	NTU	mg/L as CaCO3	mg/L as CaCO3	mg/L as N	mg/L	mg/L	mg/L as N	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
WRP-S5	2019-06-18	122	-	8.03	25.2	109	81.4	-	-	0.01	-	-	-	-	-	-	-	-	-	2.95	<0.0010
WRP-S10	2019-06-18	2180	-	4.89	3.6	2010	7.67	-	-	2.57	-	-	-	-	-	-	-	-	-	4.24	<0.0010
WRP-S11	2019-06-18	486	-	6.95	13.6	329	70.1	-	-	0.73	-	-	-	-	-	-	-	-	-	2.02	<0.0010
WRP-S12	2019-06-18	469	-	7.2	3.2	333	8.69	-	-	0.585	-	-	-	-	-	-	-	-	-	0.41	<0.0010
MS-SP-02	2019-06-18	2980	-	5.94	9.2	3390	22.5	-	-	2.21	-	-	-	-	-	-	-	-	-	0.611	<0.0010
MS-SP-04	2019-06-18	2420	-	4.25	6.4	2390	8.93	-	-	2.01	-	-	-	-	-	-	-	-	-	4.88	<0.0010
WRP-S17	2019-06-18	101	-	7.34	30.4	89	148	-	-	0.099	-	-	-	-	-	-	-	-	-	5.16	<0.0010
WRP-S15	2019-06-18	611	-	7.1	30	441	285	-	-	0.041	-	-	-	-	-	-	-	-	-	6.57	<0.0010
MS-SP-0401	2019-06-18	2450	-	4.25	4	2340	8.37	-	-	2.01	-	-	-	-	-	-	-	-	-	4.92	<0.0010
WRP-S5	2019-06-24	-	-	8.31	9.2	168	111	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WRP-S4	2019-06-24	-	-	8.25	4.4	90	32.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WRP-S15	2019-06-24	-	-	6.31	54	880	82.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WRP-S16	2019-06-24	-	-	7.42	90	120	229	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WRP-S10	2019-06-24	-	-	4.38	2	2960	6.17	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WRP-S12	2019-06-24	-	-	7.23	<2.0	430	2.67	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WRP-S11	2019-06-24	-	-	7.23	<2.0	391	2.68	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-SP-02	2019-06-24	-	-	5.03	7.2	2200	22.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-SP-04	2019-06-24	-	-	6.08	3.2	1930	7.12	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WRP-S18	2019-06-24	-	-	7.82	56.1	289	138	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WRP-S17	2019-07-02	92.7	-	7.85	127	75	237	-	-	0.17	-	-	-	-	-	-	-	-	-	7.27	<0.0010
WRP-S4	2019-07-02	124	-	7.44	170	103	319	-	-	0.17	-	-	-	-	-	-	-	-	-	9.53	<0.0010
WRP-S15	2019-07-02	3120	-	4.57	72	3240	89.9	-	-	2.27	-	-	-	-	-	-	-	-	-	2.99	<0.0010
WRP-S12	2019-07-02	1320	-	6.71	3.9	1140	5.35	-	-	1.59	-	-	-	-	-	-	-	-	-	0.13	<0.0010
MS-SP-02	2019-07-02	2870	-	4.18	7.7	2920	13.2	-	-	2.1	-	-	-	-	-	-	-	-	-	7.36	<0.0010
WRP-S18	2019-07-02	645	-	7.42	102	498	67.8	-	-	0.488	-	-	-	-	-	-	-	-	-	1.37	<0.0010
WRP-S10	2019-07-09	6330	-	4.24	22.4	8260	29	-	-	3.88	-	-	-	-	-	-	-	-	-	21.1	<0.0010
WRP-S15	2019-07-09	2530	-	6.19	99.2	2630	137	-	-	1.22	-	-	-	-	-	-	-	-	-	0.777	<0.0010
MS-SP-04	2019-07-09	3400	-	4.13	7.6	3790	9.55	-	-	2.4	-	-	-	-	-	-	-	-	-	8.98	<0.0010
WRP-S18	2019-07-09	8750	-	4.28	139	12400	129	-	-	14	-	-	-	-	-	-	-	-	-	2.35	<0.010
WRP-S17	2019-07-09	249	-	8.16	36.4	174	19.7	-	-	<0.010	-	-	-	-	-	-	-	-	-	0.31	<0.00010
MS-SP-04	2019-07-17	4060	-	4.14	2.8	4450	11.5	-	-	3.07	-	-	-	-	-	-	-	-	-	12.4	<0.0010
WRP-S18	2019-07-17	5460	-	4.36	181	6310	180	-	-	9.4	-	-	-	-	-	-	-	-	-	12.8	<0.0010
CENTRAL-KEY-IN	2019-07-17	1530	-	7.39	425	1300	160	-	-	2.26	-	-	-	-	-	-	-	-	-	15.7	<0.0010
WRP-S16	2019-07-17	6040	-	4.42	30	7500	50.2	-	-	3.01	-	-	-	-	-	-	-	-	-	11.1	<0.010
CENTRAL-KEY-IN	2019-07-23	-	-	7.36	426	1160	223	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WRP-S12	2019-07-23	-	-	5.24	43.2	4280	45.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-SP-02	2019-07-23	-	-	5.13	213	14500	158	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-SP-04	2019-07-23	-	-	4.23	9.6	5890	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WRP-S10	2019-07-30	2340	-	4.91	397	2290	2.93	-	-	1.27	-	-	-	-	-	-	-	-	-	20.3	<0.0010
WRP-S12	2019-07-30	1640	-	7.61	6.4	1550	5.47	-	-	1.03	-	-	-	-	-	-	-	-	-	0.219	<0.0010
MS-SP-02	2019-07-30	13800	-	4.88	148	18900	105	-	-	4.76	-	-	-	-	-	-	-	-	-	21.8	<0.010
MS-SP-04	2019-07-30	5300	-	4.14	7.2	6560	13.4	-	-	3.77	-	-	-	-	-	-	-	-	-	18.4	<0.0010
WRP-S15	2019-08-06	5390	-	4.82	28.4	6890	39.7	-	-	2.73	-	-	-	-	-	-	-	-	-	5.24	<0.010
WRP-S16	2019-08-06	5340	-	4.96	21.2	6390	20.1	-	-	2.76	-	-	-	-	-	-	-	-	-	5.82	<0.010
MS-SP-02	2019-08-06	8670	-	5.81	63.2	11800	53.6	-	-	4.01	-	-	-	-	-	-	-	-	-	3.27	<0.010
MS-SP-04	2019-08-06	5940	-	4.26	5.2	7560	8.05	-	-	3.67	-	-	-	-	-	-	-	-	-	20.8	<0.010
MS-SP-04	2019-08-13	6710	-	4.13	6	8640	9.04	-	-	4.67	-	-	-	-	-	-	-	-	-	22.8	<0.010
MS-SP-02	2019-08-13	10000	-	5.67	121	14300	104	-	-	4.85	-	-	-	-	-	-	-	-	-	3.34	<0.010
WRP-S5	2019-08-13	1440	-	6.97	14.8	1190	18.8	-	-	3	-	-	-	-	-	-	-	-	-	0.802	<0.0010
WRP-S16	2019-08-13	5190	-	4.83	40	6260	29	-	-	3.53	-	-	-	-	-	-	-	-	-	4.31	<0.0010
WRP-S4	2019-08-13	1060	-	7.61	3.6	798	1.73	-	-	1.77	-	-	-	-	-	-	-	-	-	0.0764	0.0001
INFLUENT-CENTRAL-KEYIN	2019-08-13	2610	-	6.6	14	2540	24.3	-	-	3.6	-	-	-	-	-	-	-	-	-	0.832	<0.0010
MS-SP-04	2019-08-20	6850	-	4.13	17.8	10000	7.43	-	-	4.72	-	-	-	-	-	-	-	-	-	26.3	<0.010
WRP-S5	2019-08-20	1220	-	7.41	5.4	1130	13.8	-	-	1.39	-	-	-	-	-	-	-	-	-	0.433	<0.0010
WRP-S16	2019-08-20	5320	-	4.58	57.6	7370	62.4	-	-	3.54	-	-	-	-	-	-	-	-	-	4.3	<0.010
MS-SP-02	2019-08-27	16600	-	4.64	74.4	27300	87.5	-	-	11.4	-	-	-	-	-	-	-	-	-	13.1	<0.010
WRP-S15	2019-08-27	5600	-	4.71	22.7	6880	29.2	-	-	3.59	-	-	-	-	-	-	-	-	-	1.95	<0.010
MS-SP-02	2019-09-03	40800	-	4.05	337	110000	318	-	-	23.1	-	-	-	-	-	-	-	-	-	289	<0.10

Station ID	Sample Date	Arsenic (As)-Total	Barium (Ba)-Total	Beryllium (Be)-Total	Bismuth (Bi)-Total	Boron (B)-Total	Cadmium (Cd)-Total	Calcium (Ca)-Total	Cesium (Cs)-Total	Chromium (Cr)-Total	Cobalt (Co)-Total	Copper (Cu)-Total	Iron (Fe)-Total	Lead (Pb)-Total	Lithium (Li)-Total	Magnesium (Mg)-Total	Manganese (Mn)-Total	Mercury (Hg)-Total	Molybdenum (Mo)-Total	Nickel (Ni)-Total	Phosphorus (P)-Total
		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	mg/L	mg/L
WRP-S5	2019-06-18	<0.0010	0.0246	<0.0010	<0.00050	<0.10	0.00005	12.6	0.00043	0.0069	0.0018	<0.010	3.81	0.00577	<0.010	9.45	-	-	0.0007	0.0063	<0.50
WRP-S10	2019-06-18	<0.0010	0.016	0.0042	<0.00050	<0.10	0.000472	48.4	<0.00010	<0.0050	0.312	0.062	23.3	<0.00050	0.07	296	-	-	0.00092	0.409	<0.50
WRP-S11	2019-06-18	<0.0010	0.0196	<0.0010	<0.00050	<0.10	<0.000050	24.9	0.00019	0.0053	0.0108	<0.010	3.93	0.00103	<0.010	39	-	-	<0.00050	0.0172	<0.50
WRP-S12	2019-06-18	<0.0010	0.0123	<0.0010	<0.00050	<0.10	<0.000050	15.7	<0.00010	<0.0050	0.0061	<0.010	0.57	<0.00050	<0.010	46.2	-	-	<0.00050	0.0098	<0.50
MS-SP-02	2019-06-18	<0.0010	0.0329	0.0012	<0.00050	<0.10	0.000169	44.7	<0.00010	<0.0050	0.108	0.027	12.1	<0.00050	0.02	238	-	-	<0.00050	0.199	<0.50
MS-SP-04	2019-06-18	0.0012	0.0093	0.0021	<0.00050	<0.10	0.000546	33.8	<0.00010	<0.0050	0.418	0.05	38.8	<0.00050	0.037	345	-	-	<0.00050	0.521	<0.50
WRP-S17	2019-06-18	<0.0010	0.0274	<0.0010	<0.00050	<0.10	<0.000050	7.37	0.00052	0.0179	0.0088	<0.010	7.93	0.00317	<0.010	11.7	-	-	0.00113	0.0168	<0.50
WRP-S15	2019-06-18	0.0011	0.0351	<0.0010	<0.00050	<0.10	0.000126	23	0.00064	0.0237	0.0788	0.012	11.6	0.00418	0.011	65.8	-	-	0.00084	0.0515	<0.50
MS-SP-0401	2019-06-18	0.0012	0.0123	0.002	<0.00050	<0.10	0.000552	33.9	<0.00010	<0.0050	0.422	0.051	39.6	0.00058	0.036	348	-	-	<0.00050	0.521	<0.50
WRP-S5	2019-06-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WRP-S4	2019-06-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WRP-S15	2019-06-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WRP-S16	2019-06-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WRP-S10	2019-06-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WRP-S12	2019-06-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WRP-S11	2019-06-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-SP-02	2019-06-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-SP-04	2019-06-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WRP-S18	2019-06-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WRP-S17	2019-07-02	<0.0010	0.0305	<0.0010	<0.00050	<0.10	<0.000050	8.67	0.00048	0.022	0.0061	0.012	11.2	0.00471	0.011	12.1	-	-	0.0007	0.0195	<0.50
WRP-S4	2019-07-02	0.0017	0.0578	<0.0010	<0.00050	<0.10	0.000051	9.5	0.00072	0.0074	0.0076	0.033	13.9	0.0288	0.014	14.1	-	-	0.00649	0.0097	<0.50
WRP-S15	2019-07-02	<0.0010	0.0243	0.0013	<0.00050	<0.10	0.000818	95	0.00013	0.0086	0.606	0.038	26.9	0.00076	0.062	499	-	-	<0.00050	0.378	<0.50
WRP-S12	2019-07-02	<0.0010	0.017	<0.0010	<0.00050	<0.10	0.000069	53.9	<0.00010	<0.0050	0.0483	<0.010	0.52	<0.00050	0.012	167	-	-	<0.00050	0.0652	<0.50
MS-SP-02	2019-07-02	0.0018	0.0158	0.0028	<0.00050	<0.10	0.000668	42.4	<0.00010	<0.0050	0.542	0.069	36.8	<0.00050	0.076	444	-	-	<0.00050	0.725	<0.50
WRP-S18	2019-07-02	<0.0010	0.0279	<0.0010	<0.00050	<0.10	<0.000050	37.8	0.00014	<0.0050	0.0058	<0.010	2.26	0.00095	<0.010	63.9	-	-	0.00062	0.0082	<0.50
WRP-S10	2019-07-09	0.0034	0.0392	0.0126	<0.00050	0.14	0.0015	122	0.00034	0.0146	1.4	0.344	124	0.00229	0.257	1150	-	-	0.0008	1.45	<0.50
WRP-S15	2019-07-09	<0.0010	0.0269	<0.0010	<0.00050	<0.10	0.000454	101	<0.00010	<0.0050	0.412	0.021	17.9	<0.00050	0.039	356	-	-	0.00067	0.242	<0.50
MS-SP-04	2019-07-09	0.0024	0.017	0.0039	<0.00050	<0.10	0.000699	53.3	<0.00010	<0.0050	0.673	0.083	50.4	<0.00050	0.115	511	-	-	<0.00050	0.896	<0.50
WRP-S18	2019-07-09	<0.010	0.046	<0.010	<0.0050	<1.0	0.00073	147	<0.0010	<0.050	1.17	<0.10	799	<0.0050	<0.10	1500	-	-	<0.0050	1.13	<5.0
WRP-S17	2019-07-09	<0.00010	0.0119	<0.00010	<0.000050	<0.010	<0.0000050	22.1	0.000028	0.00082	0.00033	0.001	0.406	0.000272	0.0021	17.4	-	-	0.0012	0.00092	<0.050
MS-SP-04	2019-07-17	0.0019	0.0192	0.0055	<0.00050	<0.10	0.00108	68.5	0.00012	<0.0050	0.867	0.112	62.3	<0.00050	0.143	686	39.1	-	<0.00050	1.2	<0.50
WRP-S18	2019-07-17	0.0026	0.0522	0.0038	<0.00050	<0.10	0.00112	104	0.00071	0.0423	0.904	0.08	467	0.0044	0.13	869	60.5	-	0.0009	0.829	<0.50
CENTRAL-KEY-IN	2019-07-17	0.0012	0.12	<0.0010	<0.00050	<0.10	0.000122	38.6	0.00168	0.0217	0.0344	0.022	24.8	0.0136	0.045	220	4.92	-	0.014	0.0648	<0.50
WRP-S16	2019-07-17	<0.010	0.036	<0.010	<0.0050	<1.0	0.00143	146	<0.0010	<0.050	1.52	0.22	302	<0.0050	<0.10	1070	64.3	-	<0.0050	1.19	<5.0
CENTRAL-KEY-IN	2019-07-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WRP-S12	2019-07-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-SP-02	2019-07-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-SP-04	2019-07-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WRP-S10	2019-07-30	0.0032	0.069	0.0015	0.00053	<0.10	0.000362	30.2	0.00126	0.042	0.728	0.057	115	0.00733	0.077	325	24.8	-	0.00174	0.682	<0.50
WRP-S12	2019-07-30	<0.0010	0.0163	<0.0010	<0.00050	<0.10	0.000051	86.7	<0.00010	<0.0050	0.0205	<0.010	0.26	<0.00050	0.019	214	3.73	-	<0.00050	0.033	<0.50
MS-SP-02	2019-07-30	<0.010	0.085	<0.010	<0.0050	<1.0	0.00297	199	0.0022	<0.050	3.22	<0.10	477	0.0126	0.12	3280	143	-	<0.0050	4.05	<5.0
MS-SP-04	2019-07-30	0.0035	0.0218	0.0089	<0.00050	<0.10	0.00182	96.5	0.00016	<0.0050	1.3	0.164	119	<0.00050	0.209	973	53.2	-	<0.00050	1.74	<0.50
WRP-S15	2019-08-06	<0.010	0.028	<0.010	<0.0050	<1.0	0.00109	161	<0.0010	<0.050	1.12	0.11	107	<0.0050	<0.10	999	62.9	-	<0.0050	0.801	<5.0
WRP-S16	2019-08-06	<0.010	0.021	<0.010	<0.0050	<1.0	0.0014	152	<0.0010	<0.050	1.21	0.14	122	<0.0050	<0.10	962	63.2	-	<0.0050	0.847	<5.0
MS-SP-02	2019-08-06	<0.010	0.018	<0.010	<0.0050	<1.0	0.00151	223	<0.0010	<0.050	1.11	<0.10	65.7	<0.0050	<0.10	1940	82.6	-	<0.0050	1.6	<5.0
MS-SP-04	2019-08-06	<0.010	0.024	<0.010	<0.0050	<1.0	0.0021	102	<0.0010	<0.050	1.41	0.18	143	<0.0050	0.16	1130	66.3	-	<0.0050	1.89	<5.0
MS-SP-04	2019-08-13	<0.010	0.024	0.011	<0.0050	<1.0	0.00275	110	<0.0010	<0.050	1.65	0.2	165	<0.0050	0.16	1240	68.8	-	<0.0050	2.22	<5.0
MS-SP-02	2019-08-13	<0.010	0.028	<0.010	<0.0050	<1.0	0.00163	236	<0.0010	<0.050	1.32	<0.10	66.7	<0.0050	<0.10	2110	88.2	-	<0.0050	1.95	<5.0
WRP-S5	2019-08-13	<0.0010	0.0446	<0.0010	<0.00050	<0.10	<0.000050	102	<0.00010	<0.0050	0.0205	0.011	2.9	0.00076	<0.010	131	3.08	-	0.00615	0.0202	<0.50
WRP-S16	2019-08-13	<0.0010	0.0202	0.0023	<0.00050	0.1	0.0014	156	0.00011	<0.0050	1.1	0.099	85.6	<0.00050	0.074	893	52.5	-	<0.00050	0.755	<0.50
WRP-S4	2019-08-13	0.00014	0.0353	<0.00010	<0.000050	0.036	0.0000868	95.5	0.000017	<0.00050	0.00454	0.0032	0.105	0.000198	0.0052	74.1	2.26	-	0.00603	0.00651	<0.050
INFLUENT-CENTRAL-KEYIN	2019-08-13	<0.0010	0.0298	<0.0010	<0.00050	<0.10	0.000217	79	<0.00010	0.0067	0.0802	<0.010	1.89	0.00272	0.026	391	11.1	-	0.00452	0.108	<0.50
MS-SP-04	2019-08-20	<0.010	0.025	0.013	<0.0050	<1.0	0.0038	126	<0.0010	<0.050	1.87	0.23	189	<0.0050	0.17	1450	75.6	-	<0.0050	2.49	<5.0
WRP-S5	2019-08-20	<0.0010	0.0256	<0.0010	<0.00050	<0.10	0.000065	47.7	<0.00010	<0.0050	0.0199	<0.010	0.95	0.0012	<0.010	165	2.41	-	0.00538	0.0259	<0.50
WRP-S16	2019-08-20	<0.010	0.025	<0.010	<0.0050	<1.0	0.00153	173	<0.0010	<0.050	1.13	<0.10	87.1	<0.0050	<0.10	1040	56.9	-	<0.0050	0.846	<5.0
MS-SP-02	2019-08-27	<0.010	0.035	<0.010	<0.0050	<1.0	0.00373	243	<0.0010	<0.050	3.87	<0.10	385	<0.0050	<0.10	4420	195	-	<0.0050	4.52	<5.0
WRP-S15	2019-08-27	<0.010	0.022	<0.010	<0.0050	<1.0	0.00152	179	<0.0010	<0.050	1.05	<0.10	47.9	<0.0050	<0.10	1070	57.9	-	<0.0050	0.75	<5.0
MS-SP-02	2019-09-03	0.1	0.11	<0.10	<0.050	<10	0.0272	388	<0.010	<0.50	18.1	<1.0	1800	<0.050	<1.0	16100	753	-	<0.050	25.9	<50

Station ID	Sample Date	Potassium (K)-Total	Rubidium (Rb)-Total	Selenium (Se)-Total	Silicon (Si)-Total	Silver (Ag)-Total	Sodium (Na)-Total	Strontium (Sr)-Total	Sulfur (S)-Total	Sulphate - calculated	Tellurium (Te)-Total	Thallium (Tl)-Total	Thorium (Th)-Total	Tin (Sn)-Total	Titanium (Ti)-Total	Tungsten (W)-Total	Uranium (U)-Total	Vanadium (V)-Total	Zinc (Zn)-Total	Zirconium (Zr)-Total
		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	mg/L
WRP-S5	2019-06-18	2.18	0.0104	<0.00050	5.8	<0.00050	<0.50	<0.010	<5.0	<15	<0.0020	0.00012	0.0029	<0.0010	0.153	<0.0010	0.00358	0.0053	<0.030	<0.0020
WRP-S10	2019-06-18	5.22	0.0061	0.00612	5.2	<0.00050	1.79	0.066	482	1444	<0.0020	0.00014	<0.0010	<0.0010	0.0077	<0.0010	0.012	<0.0050	0.039	<0.0020
WRP-S11	2019-06-18	3.42	0.0064	0.00132	4.6	<0.00050	0.96	0.027	60.4	181	<0.0020	<0.00010	0.0013	<0.0010	0.0731	<0.0010	0.00065	<0.0050	<0.030	<0.0020
WRP-S12	2019-06-18	2.63	0.0038	0.0012	1.9	<0.00050	0.62	0.018	69.3	208	<0.0020	<0.00010	<0.0010	<0.0010	0.0166	<0.0010	0.00016	<0.0050	<0.030	<0.0020
MS-SP-02	2019-06-18	2.88	0.0042	0.00301	3	<0.00050	1.36	0.044	376	1126	<0.0020	0.00011	<0.0010	<0.0010	0.0076	<0.0010	0.00117	<0.0050	<0.030	<0.0020
MS-SP-04	2019-06-18	1.53	0.0036	0.00363	1.8	<0.00050	1.68	0.037	545	1632	<0.0020	0.00015	<0.0010	<0.0010	<0.0030	<0.0010	0.00668	<0.0050	0.062	<0.0020
WRP-S17	2019-06-18	2.21	0.0128	0.00069	8.6	<0.00050	<0.50	<0.010	6.7	20	<0.0020	<0.00010	0.0028	<0.0010	0.227	<0.0010	0.00077	0.0085	<0.030	<0.0020
WRP-S15	2019-06-18	3.22	0.0168	0.00165	11.2	<0.00050	0.9	0.017	96	288	<0.0020	0.00012	0.0044	<0.0010	0.286	<0.0010	0.00137	0.0113	<0.030	<0.0020
MS-SP-0401	2019-06-18	1.56	0.0039	0.0038	1.9	<0.00050	1.71	0.037	552	1653	<0.0020	0.00015	<0.0010	<0.0010	<0.0070	<0.0010	0.00676	<0.0050	0.062	<0.0020
WRP-S5	2019-06-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WRP-S4	2019-06-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WRP-S15	2019-06-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WRP-S16	2019-06-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WRP-S10	2019-06-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WRP-S12	2019-06-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WRP-S11	2019-06-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-SP-02	2019-06-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-SP-04	2019-06-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WRP-S18	2019-06-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WRP-S17	2019-07-02	2.63	0.0131	<0.00050	10.9	<0.00050	<0.50	<0.010	<5.0	<15	<0.0020	<0.00010	0.0026	<0.0010	0.248	<0.0010	0.00172	0.01	<0.030	<0.0020
WRP-S4	2019-07-02	4.94	0.021	<0.00050	14.1	<0.00050	1.78	0.016	<5.0	<15	<0.0020	0.00011	0.0079	<0.0010	0.407	<0.0010	0.0162	0.0112	<0.030	0.0035
WRP-S15	2019-07-02	5.95	0.0113	0.0108	5.7	<0.00050	3.53	0.065	811	2429	<0.0020	0.00017	<0.0010	<0.0010	0.0384	<0.0010	0.00253	<0.0050	0.056	<0.0020
WRP-S12	2019-07-02	3.77	0.0065	0.00217	1.8	<0.00050	1.47	0.045	273	818	<0.0020	<0.00010	<0.0010	<0.0010	0.005	<0.0010	0.00016	<0.0050	<0.030	<0.0020
MS-SP-02	2019-07-02	2.4	0.0064	0.00471	2.6	<0.00050	1.99	0.059	713	2136	<0.0020	0.00028	<0.0010	<0.0010	<0.0030	<0.0010	0.00892	<0.0050	0.072	<0.0020
WRP-S18	2019-07-02	2.77	0.0067	0.00096	3.3	<0.00050	1.12	0.029	95	285	<0.0020	<0.00010	<0.0010	<0.0010	0.0706	<0.0010	0.00094	<0.0050	<0.030	<0.0020
WRP-S10	2019-07-09	8.52	0.0187	0.0162	13.5	<0.00050	4.66	0.177	1880	5631	<0.0020	0.00042	0.0023	<0.0010	0.153	<0.0010	0.0353	0.0062	0.172	0.0037
WRP-S15	2019-07-09	4.36	0.0068	0.00662	2.7	<0.00050	2.71	0.071	601	1800	<0.0020	<0.00010	<0.0010	<0.0010	0.0127	<0.0010	0.00628	<0.0050	0.033	<0.0020
MS-SP-04	2019-07-09	2.74	0.0073	0.00563	3.3	<0.00050	2.25	0.073	853	2555	<0.0020	0.00038	<0.0010	<0.0010	<0.0030	<0.0010	0.0108	<0.0050	0.091	<0.0020
WRP-S18	2019-07-09	8.7	0.02	0.0118	<10	<0.0050	7.8	0.14	2680	8027	<0.020	<0.0010	<0.010	<0.010	0.058	<0.010	0.0038	<0.050	<0.30	<0.020
WRP-S17	2019-07-09	1.88	0.00225	0.000483	1.45	<0.000050	0.661	0.0154	20.1	60	<0.00020	0.000011	0.00014	<0.00010	0.0133	<0.00010	0.00232	0.00068	<0.0030	0.00044
MS-SP-04	2019-07-17	3.91	0.0085	0.00832	4.6	<0.00050	2.86	0.097	1080	3235	<0.0020	0.00047	<0.0010	<0.0010	0.0035	<0.0010	0.0138	<0.0050	0.118	<0.0020
WRP-S18	2019-07-17	9.83	0.0284	0.0102	16.9	<0.00050	6.79	0.114	1640	4912	<0.0020	0.00081	0.0044	<0.0010	0.325	<0.0010	0.00827	0.0139	0.168	0.0064
CENTRAL-KEY-IN	2019-07-17	13.2	0.0589	0.00289	26.3	<0.00050	6.13	0.064	286	857	<0.0020	0.0004	0.0069	<0.0010	1.3	<0.0010	0.056	0.0248	0.049	0.0065
WRP-S16	2019-07-17	8.9	<0.020	0.0143	<10	<0.0050	<5.0	0.11	1730	5182	<0.020	<0.0010	<0.010	<0.010	<0.030	<0.010	0.0142	<0.050	<0.30	<0.020
CENTRAL-KEY-IN	2019-07-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WRP-S12	2019-07-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-SP-02	2019-07-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MS-SP-04	2019-07-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WRP-S10	2019-07-30	6.65	0.0321	0.00223	27.3	<0.00050	1.79	0.045	517	1549	<0.0020	0.00023	0.0123	<0.0010	0.648	<0.0010	0.00761	0.0243	0.117	0.0095
WRP-S12	2019-07-30	3.92	0.0074	0.00255	1.9	<0.00050	1.72	0.055	344	1030	<0.0020	<0.00010	<0.0010	<0.0010	0.0127	<0.0010	0.00053	<0.0050	<0.030	<0.0020
MS-SP-02	2019-07-30	9.4	0.049	0.0192	28	<0.0050	8.9	0.19	5000	14977	<0.020	0.001	0.016	<0.010	0.887	<0.010	0.0118	<0.050	0.43	0.024
MS-SP-04	2019-07-30	4.45	0.0107	0.0108	6.5	<0.00050	3.86	0.125	1560	4673	<0.0020	0.00056	<0.0010	<0.0010	<0.0030	<0.0010	0.0226	<0.0050	0.165	<0.0020
WRP-S15	2019-08-06	5.8	<0.020	0.0163	<10	<0.0050	<5.0	0.1	1570	4703	<0.020	<0.0010	<0.010	<0.010	<0.030	<0.010	0.0056	<0.050	<0.30	<0.020
WRP-S16	2019-08-06	6.1	<0.020	0.0125	<10	<0.0050	5.1	<0.10	1490	4463	<0.020	<0.0010	<0.010	<0.010	<0.030	<0.010	0.007	<0.050	<0.30	<0.020
MS-SP-02	2019-08-06	9	<0.020	0.0155	<10	<0.0050	7.9	0.16	2810	8417	<0.020	<0.0010	<0.010	<0.010	0.095	<0.010	0.0087	<0.050	<0.30	<0.020
MS-SP-04	2019-08-06	<5.0	<0.020	0.0103	<10	<0.0050	<5.0	0.13	1750	5242	<0.020	<0.0010	<0.010	<0.010	<0.030	<0.010	0.0216	<0.050	<0.30	<0.020
MS-SP-04	2019-08-13	5.3	<0.020	0.0154	<10	<0.0050	<5.0	0.14	1930	5781	<0.020	<0.0010	<0.010	<0.010	<0.030	<0.010	0.0294	<0.050	<0.30	<0.020
MS-SP-02	2019-08-13	10.9	<0.020	0.0233	<10	<0.0050	8.6	0.2	3190	9555	<0.020	<0.0010	<0.010	<0.010	0.133	<0.010	0.0115	<0.050	<0.30	<0.020
WRP-S5	2019-08-13	11.7	0.0071	0.00203	4.9	<0.00050	16	0.108	188	563	<0.0020	<0.00010	<0.0010	<0.0010	0.0366	<0.0010	0.0122	<0.0050	<0.030	0.0024
WRP-S16	2019-08-13	6.39	0.0103	0.0147	4.6	<0.00050	5.42	0.106	1430	4283	<0.0020	0.00019	<0.0010	<0.0010	<0.020	<0.0010	0.0056	<0.0050	0.11	<0.0020
WRP-S4	2019-08-13	8.9	0.00544	0.00128	3.06	<0.000050	12.4	0.0875	149	446	<0.00020	0.000024	<0.00010	<0.00010	0.00447	<0.00010	0.0339	<0.00050	<0.0030	0.00028
INFLUENT-CENTRAL-KEYIN	2019-08-13	5.83	0.009	0.00443	2.9	<0.00050	7.73	0.084	594	1779	<0.0020	0.00014	<0.0010	<0.0010	0.0312	<0.0010	0.0183	<0.0050	<0.030	0.0021
MS-SP-04	2019-08-20	6.3	<0.020	0.0152	<10	<0.0050	5.6	0.15	2320	6949	<0.020	<0.0010	<0.010	<0.010	<0.030	<0.010	0.0345	<0.050	<0.30	<0.020
WRP-S5	2019-08-20	5.14	0.0042	0.00151	2.6	<0.00050	5.93	0.073	226	677	<0.0020	<0.00010	<0.0010	<0.0010	0.0188	<0.0010	0.0337	<0.0050	<0.030	0.002
WRP-S16	2019-08-20	7.2	<0.020	0.0162	<10	<0.0050	6.7	0.12	1630	4882	<0.020	<0.0010	<0.010	<0.010	0.034	<0.010	0.0045	<0.050	<0.30	<0.020
MS-SP-02	2019-08-27	9.6	<0.020	0.0285	<10	<0.0050	13.4	0.25	6620	19829	<0.020	<0.0010	<0.010	<0.010	<0.030	<0.010	0.0173	<0.050	0.44	<0.020
WRP-S15	2019-08-27	7	<0.020	0.0155	<10	<0.0050	6.8	0.12	1630	4882	<0.020	<0.0010	<0.010	<0.010	<0.030	<0.010	0.0027	<0.050	<0.30	<0.020
MS-SP-02	2019-09-03	<50	<0.20	0.1	<100	<0.050	<50	<1.0	24100	72187	<0.20	<0.010	<0.10	<0.10	<0.30	<0.10	0.388	<0.50	3.3	<0.20

APPENDIX E

Water Quality Modelling Results

Parameter	Units	MDMER	Average		Wet		Dry	
			2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021
pH	s.u.	6.0 - 9.5	**5.4**	**5.4**	**5.4**	**5.4**	**5.3**	**5.4**
Hardness	mg/L CaCO3	-	3286	2947	2674	2047	3032	2973
Alkalinity	mg/L CaCO3	-	17	16	14	12	15	17
pe	s.u.	-	5.8	5.7	5.7	5.6	5.8	5.7
Redox	mV	-	340	338	336	331	339	337
Silver	mg/L	-	0.00044	0.00040	0.00036	0.00028	0.00041	0.00040
Aluminum	mg/L	-	2.5	2.2	2.0	1.5	2.3	2.2
Arsenic	mg/L	0.5	0.00089	0.00080	0.00072	0.00055	0.00082	0.00080
Boron	mg/L	-	0.089	0.080	0.072	0.055	0.082	0.080
Barium	mg/L	-	0.014	0.013	0.012	0.0093	0.013	0.014
Berylium	mg/L	-	0.00089	0.00080	0.00072	0.00055	0.00082	0.00080
Calcium	mg/L	-	57	51	46	36	52	53
Cadmium	mg/L	-	0.00064	0.00057	0.00052	0.00040	0.00059	0.00058
Chloride	mg/L	-	24	23	20	17	21	25
Cobalt	mg/L	-	0.66	0.59	0.54	0.41	0.61	0.60
Chromium	mg/L	-	0.0048	0.0044	0.0039	0.0030	0.0044	0.0044
Copper	mg/L	0.3	0.0092	0.0083	0.0075	0.0058	0.0085	0.0084
Iron	mg/L	-	66	59	54	41	61	60
Potassium	mg/L	-	97	87	79	60	89	87
Magnesium	mg/L	-	767	687	624	477	708	693
Manganese	mg/L	-	33	30	27	21	31	30
Molybdenum	mg/L	-	0.0012	0.0012	0.0010	0.00083	0.0011	0.0012
Sodium	mg/L	-	2.7	2.5	2.2	1.7	2.5	2.5
Nickel	mg/L	0.5	**0.77**	**0.69**	**0.63**	0.48	**0.71**	**0.70**
Lead	mg/L	0.2	0.00061	0.00056	0.00050	0.00039	0.00056	0.00058
Sulphate	mg/L	-	3429	3073	2790	2132	3166	3096
Antimony	mg/L	-	0.00089	0.00080	0.00072	0.00055	0.00082	0.00080
Selenium	mg/L	-	0.0052	0.0047	0.0042	0.0033	0.0048	0.0047
Tin	mg/L	-	0.00089	0.00080	0.00072	0.00055	0.00082	0.00080
Thallium	mg/L	-	0.000093	0.000084	0.000076	0.000058	0.000086	0.000085
Uranium	mg/L	-	0.0045	0.0041	0.0037	0.0029	0.0041	0.0043
Vanadium	mg/L	-	0.0047	0.0043	0.0039	0.0030	0.0044	0.0043
Zinc	mg/L	0.5	0.076	0.068	0.062	0.047	0.070	0.069

*Total concentrations
*MDMER = Metals and Diamond Mining Effluent Regulations
***Bold** values indicate an exceedance of the MDMER guideline

APPENDIX F

PHREEQC Mineral Phases

Appendix F
PHREEQC Model Mineral Phases
Mary River Project - Baffinland Iron Mines

Mineral Name	Chemical Formula
Aluminum Minerals	
$Al(OH)_{3(am)}$	
$AlOHSO_4$	
$Al_4(OH)_{10}SO_4$	
Alunite	$KAl_3(SO_4)_2(OH)_6$
Gibbsite	$Al(OH)_3$
Diaspore	AlOOH
Boehmite	AlOOH
Kaolinite	$Al_2S_2O_5(OH)_4$
Barium minerals	
Barite	$BaSO_4$
Witherite	$BaCO_3$
Calcium minerals	
Gypsum	$CaSO_4{:}2H_2O$
Fluorite	CaF_2
Cadmium minerals	
Otavite	$CdCO_3$
Cobalt minerals	
$CoCO_3$	
Chromium Minerals	
Cr_2O_3	
Copper minerals	
Brochantite	$Cu_4(OH)_6SO_4$
$Cu(OH)_2$	
Malachite	$Cu_2(OH)_2CO_3$
Azurite	$Cu_3(OH)_2(CO_3)_2$
Chalcanthite	$CuSO_4{:}5H_2O$
Antlerite	$Cu_3(OH)_4SO_4$
Atacamite	$Cu_2(OH)_3Cl$
Covellite	CuS
Iron minerals	
Ferrihydrite	$Fe(OH)_3$
Siderite	$FeCO_3$
Melanterite	$FeSO_4{:}7H_2O$
$FeAsO_4{:}2H_2O$	
Goethite	FeOOH
$FeS_{(ppt)}$	
Sphalerite	ZnS
Lead minerals	
Anglesite	$PbSO_4$
$Pb(OH)_2$	
Galena	PbS
Magnesium minerals	
Epsomite	$MgSO_4{:}7H_2O$
Manganese minerals	
Rhodochrosite	$MnCO_3$
Birnessite	MnO2
Manganite	MnOOH
Nickel minerals	
$Ni(OH)_2$	
Silicon minerals	
$SiO_{2(am-ppt)}$	
Strontium minerals	
celestite	$SrSO_4$
Uranium Minerals	
$UO_{2(am)}$	
$UO_2(OH)_{2(beta)}$	
Zinc minerals	
$Zn(OH)_{2(am)}$	
Smithsonite	$ZnCO_3$
Goslarite	$ZnSO_4{:}7H_2O$
$Zn(OH)_{2(gamma)}$	
$ZnCO_3{:}1H_2O$	

APPENDIX B

Baffinland CQA/CQC Plan

The monitoring of waste material placement at the Deposit 1 Waste Rock Facility (WRF) is a critical to ensure compliance with our Environmental Protection Plan (EPP) at the Mary River Mine. Waste rock material speciation within Deposit 1 consists of two broad material types, Potential Acid Generating waste or PAG and Non-Potentially Acid Generating waste or NPAG based on the criteria detailed in Section XX. To mitigate the risk for ARD at the WRF, a broad quality control (QC) and quality assurance (QA) program is required. which involves the following:

<u>Quality Control Program:</u>

Monitoring and collecting data associated with waste rock deposition, specifically:

1. In-Pit Material Identification
2. WRF Foundation Preparation and Tracking
3. WRF Material Placement Tracking
4. WRF Dump Thermal Modeling
5. WRF Instrumentation Monitoring

1. In-Pit Material Identification

In-pit waste, PAG & NAG, materials are classified and delineated by the Mine Geologist based upon the following parameters:

- Determination of material class through assessment of geochemical analyses and spatial relationships within dig blocks (Figure 1).
- Areas of NAG and PAG rock within mining advances are flagged and staked according to material type present for ease of operator differentiation when mining (Figure 2).
- The Mine Geologist monitors the advances daily to ensure the PAG materials are being properly separated and sent to the right destination in the WRF

2. WRF Foundation Preparation and Tracking

Before any PAG waste materials can be deposited ex-pit, a 2-3 m base layer of NPAG must be installed on the existing ground, preferably in the colder months of the year. The winter foundation placement ensures that an insulated frozen barrier of NPAG rock exists between the PAG and the existing tundra.

Tracking the placement of this foundation at the WRF will consist of the following actions:

- Survey of prepared foundation extents
  - Once prior to placement of footprint expansion
  - Survey required following preparation of foundation

- Foundation construction material confirmation
  - Once prior to placement of footprint expansion
  - Identify NPAG source within the pit for use in construction of the foundation through geochemical evaluation

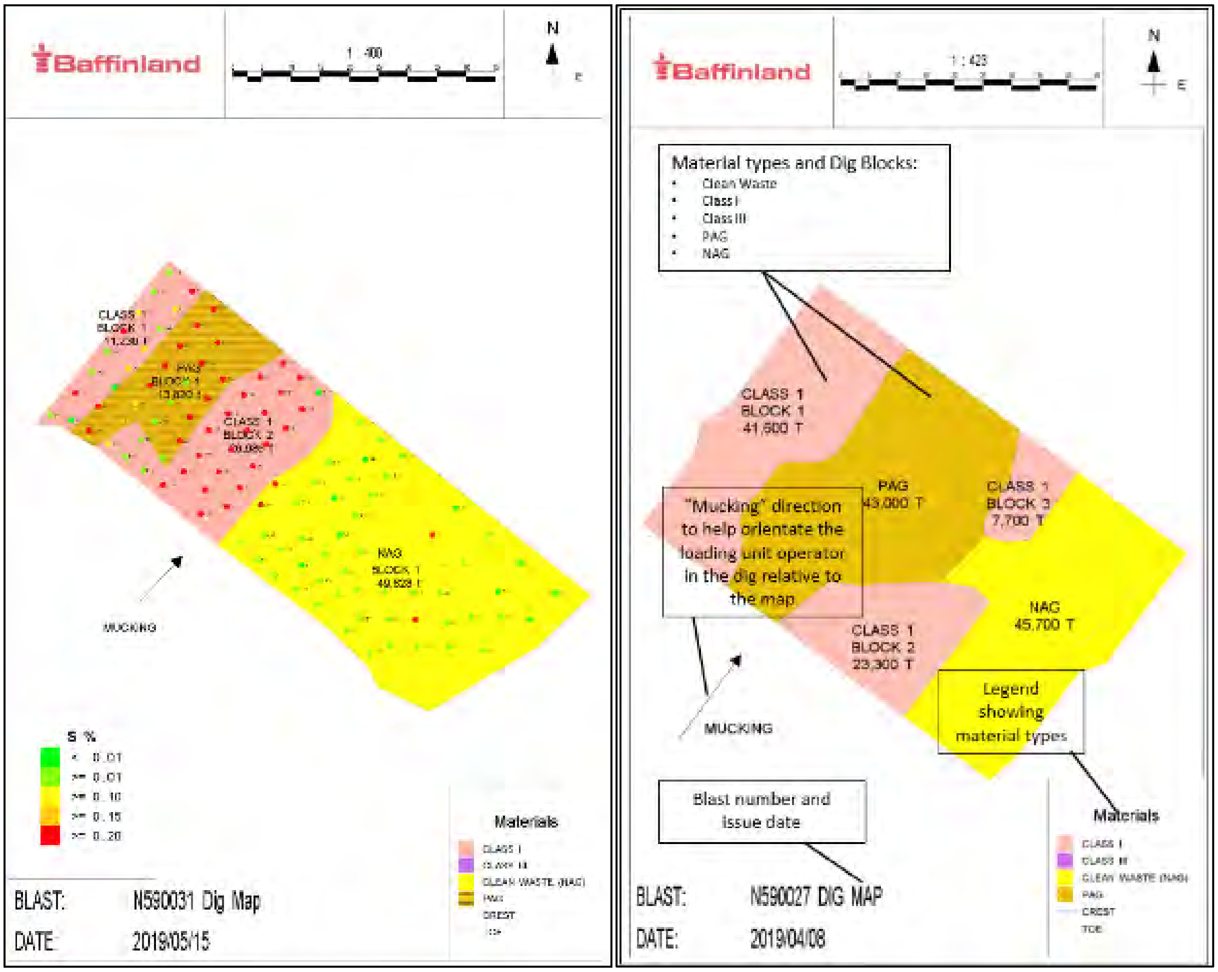


Figure 1: Typical Material "Block Out" within a Actual Blast Pattern from two blast patterns ontaining NAG (NPAG) and PAG

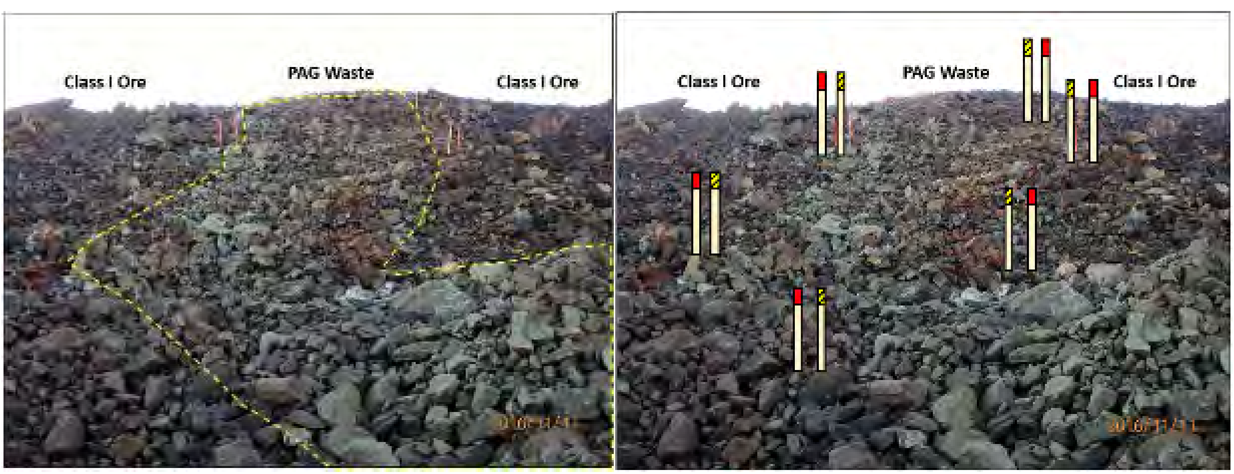


Figure 2: Blast Stake Placement for Material Classification

3. WRF Material Placement Tracking

Survey Component

Prior to waste placement, Survey will delineate areas where PAG can be dumped using survey stakes. This will occur for each dump lift before during and after completion of that lift, the survey includes the following:

- Lift outline (toe and crest)
- Must stake out area to differentiate between PAG and Non-PAG and inform operations of the plan

Daily Dump Plan

On a daily basis the operations team must have a dump plan that differentiates between PAG and Non-PAG dump areas/define general source location and placement location. The material is then dumped according to the issued Daily Dump Plan (Figure 3). The dump plan must include the following:

- Outlines of active PAG suitable dump areas are outline in the issued daily plan and in the field
- Field checks are conducted by the technical team to ensure all limits are defined and refreshed as needed.
- Once a defined area is exhausted for dumping, a new area must be assigned and staked for the deposition of waste materials so that placement tracking can continue

Waste Rock Placement Tracking

Monthly reconciliation of NPAG and PAG materials will occur during dump construction using the site database. This includes but is not limited to the following:

- Reconcile truck tracking to survey data using historic, current, and future survey and truck tracking information to reconcile values.
- Maintaining a database of all survey data and truck counts for the waste dump operations for future modeling and reconciliation purposes.

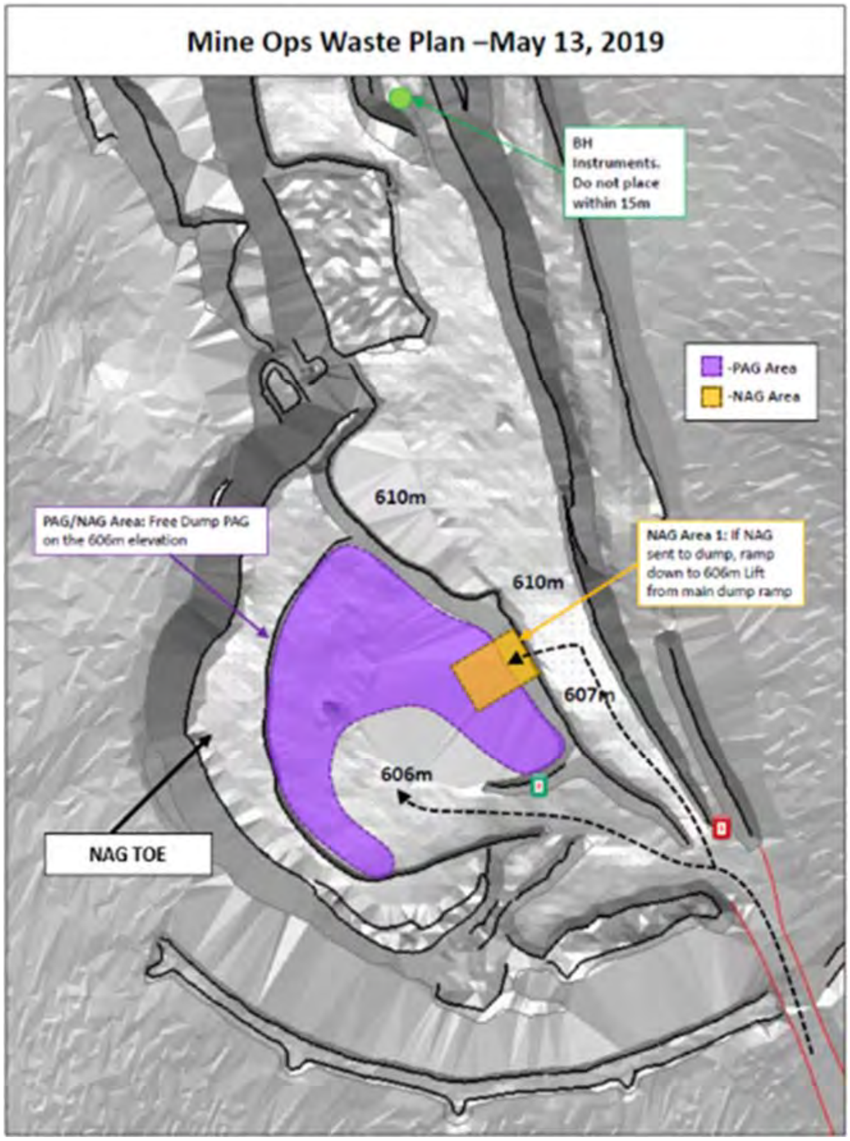


Figure 3: Example of Daily Dump Plan for the WRF

4. Thermal Instrumentation Monitoring: Data Collection, Interpretation and Modeling

Eight thermal monitoring instruments (thermistors) have been installed throughout the WRF along with accompanying barometer, piezometers and oxygen sensors (Figure 4**)**. These instruments continuously collect temperature, oxygen and fluid flow readings from the surface to subsurface of the dump. Data is stored locally on the units and then transferred to a combined database for monitoring, interpretation and modelling (Table 1 & Table 2). This data will indicate the status of the dump i.e., frozen/properly encapsulated, subsurface flowing water, airflow, etc. From the data, thermal model can be calibrated using data generated at each thermistor location. An example of temperature depth profile based upon actual thermistor data can be observed in Section XX.

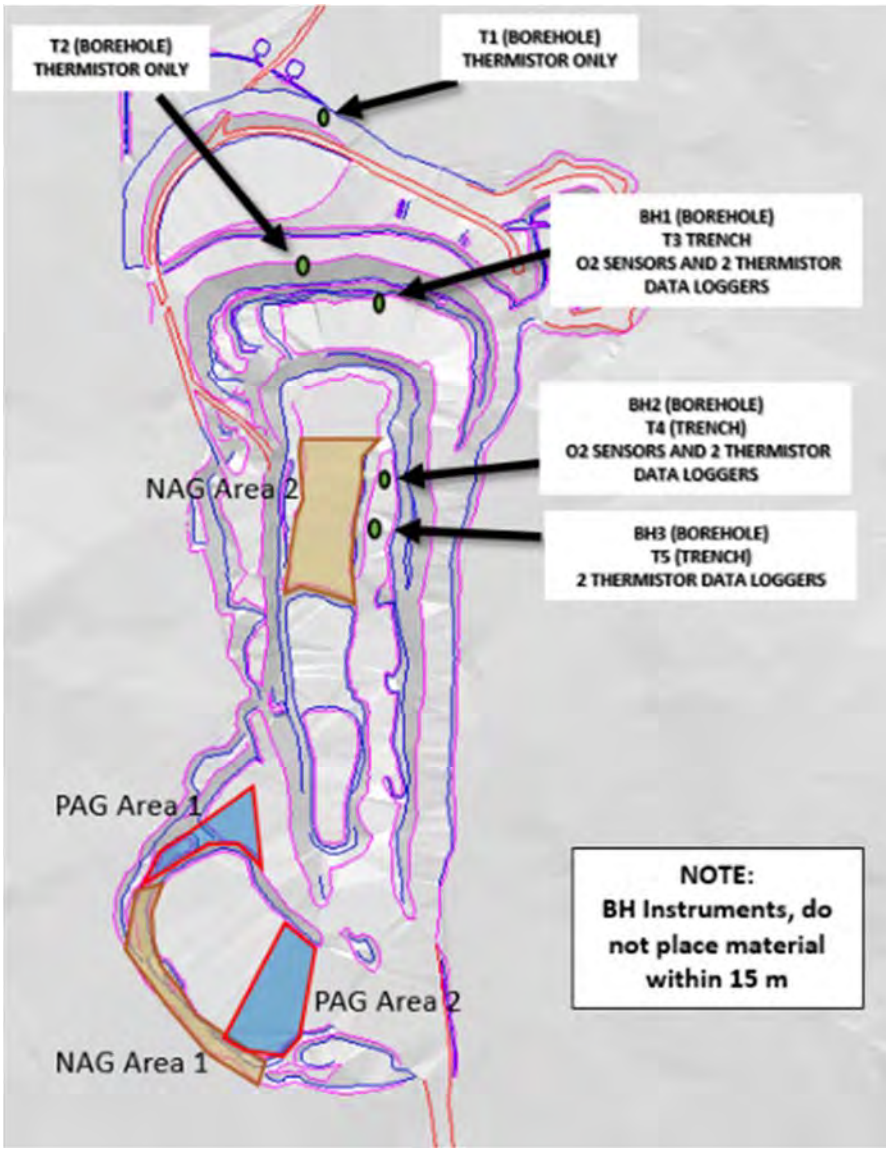


Figure 4: Map of Current Thermistor Locations at the WRF

The following actions are the regular quality control activities associated with the WRF instrumentation monitoring:

Collection of Monitoring Data – Once Per Week

- Monitoring data to be collected based on the instrumentation reporting package

Inspection of Instrumentation – Twice per week

Figure 5 below displays an example of an inspection form for the thermistor condition inspections.

- Instruments inspected
- Battery status
- Damage (cuts, cracking, damage to cabling or housing, other)
- If extension is required

As Required inspections in areas of active deposition, monthly inspections otherwise.

Notification of Change – As Required

Notification to Mine Superintendent and mine management personnel of:

- Instrumentation damage
- Instrumentation extension required

Damage photographs – As Required

Minimum of one (1) photograph of each damaged instrument (highlight damaged area)

Database Maintenance

Update database of:

- Inspection notes
- Damage and extension
- Monitoring data

Baffinland

THERMISTOR INSPECTION LOG

DATE: ______________

LOGGED BY: ______________

THERMISTOR #: ______________

O2 SENSOR #: ______________

1. **TRENCH OR BOREHOLE:** TRENCH BOREHOLE
2. **CABLE INSPECTION:** GOOD DAMAGED
3. **TRIPOD INSPECTION:** GOOD DAMAGED
4. **DATA COLLECTOR:** GOOD DAMAGED
5. **SOLAR PANEL:** GOOD DAMAGED
6. **BATTERY CHECK:** GOOD DEAD

COMMENTS/PHOTO DESCRIPTIONS:

Figure 5: Example of Thermistor Inspection Log

Table 1: Example of Accumulated Thermistor Readings within Combined Thermistor Database

TIMESTAMP	RECORD	BATTERY	Therm 1	Therm 2	Therm 3	Therm 4	Therm 5	Therm 6	Therm 1	Therm 2	Therm 3	Therm 4	Therm 5	Therm 6	LOGGER TEMP
		Volts	deg C	deg C	deg C	deg C	deg C	deg C	Ohms	Ohms	Ohms	Ohms	Ohms	Ohms	deg C
2018-12-07 16:00	1	3.53	2.64	3.01	1.98	1.9	3.34	3.35	8572.62	8414.9	8861.342	8896.398	8276.162	8270.961	1.9
2018-12-08 0:00	2	3.57	1.87	1.7	2.02	2	1.96	2.52	8910.012	8989.932	8844.438	8853.448	8869.244	8622.688	3
2018-12-08 8:00	3	3.56	5.01	5.36	4.74	4.68	5.36	5.59	7616.03	7484.774	7720.008	7742.153	7487.561	7400.81	5
2018-12-08 16:00	4	3.56	4.54	4.82	4.26	3.82	4.7	5.06	7798.314	7689.318	7907.086	8080.085	7736.369	7597.123	4.3
2018-12-09 0:00	5	3.55	4.43	4.85	4.53	3.77	4.73	4.82	7839.27	7676.889	7800.258	8099.348	7724.816	7688.361	4.3
2018-12-09 8:00	6	3.55	4.35	4.74	4.42	3.47	4.64	4.77	7871.621	7720.969	7842.205	8222.241	7759.533	7706.565	4.3
2018-12-09 16:00	7	3.55	5.18	5.58	5.35	4.92	5.5	5.43	7554.772	7403.562	7491.277	7651.148	7432.98	7459.752	5.1
2018-12-10 0:00	8	3.55	3.92	4.17	4.14	3.68	3.88	4.17	8039.703	7939.757	7953.663	8137.013	8056.837	7941.742	3.8
2018-12-10 8:00	9	3.55	1.12	1.58	2.39	0.82	1.56	2.04	9255.106	9041.762	8679.701	9399.119	9049.857	8835.439	1.9
2018-12-10 16:00	10	3.45	-16.21	-13.11	-12.19	-11.25	-10.95	-11.72	23440.68	19690.22	18718.76	17768.93	17480.57	18237.53	-20.8
2018-12-11 0:00	11	3.45	-11.66	-7.16	-5.32	-4.74	-4.45	-4.74	18180.56	14246.74	12915.22	12524.71	12340.6	12526.46	-21.2
2018-12-11 8:00	12	3.45	-11.05	-6.73	-4.83	-4.22	-4.04	-4.23	17576.85	13922.91	12589.85	12187.14	12074.56	12193.91	-20.4
2018-12-11 16:00	13	3.45	-10.83	-6.69	-4.8	-4.15	-3.98	-4.15	17368.29	13892.51	12565.15	12148.34	12036.23	12146.65	-18.9
2018-12-12 0:00	14	3.45	-10.67	-6.72	-4.83	-4.15	-3.97	-4.13	17215.66	13914.79	12588.08	12144.97	12029.58	12134.88	-17.9
2018-12-12 8:00	15	3.45	-10.55	-6.76	-4.88	-4.16	-3.97	-4.13	17103.17	13941.19	12618.16	12155.07	12029.58	12131.52	-17.2
2018-12-12 16:00	16	3.45	-10.45	-6.81	-4.94	-4.18	-3.97	-4.13	17013.42	13979.9	12657.22	12166.88	12034.57	12131.52	-17.1
2018-12-13 0:00	17	3.44	-10.36	-6.85	-4.99	-4.21	-3.99	-4.13	16927.05	14010.57	12696.46	12185.45	12042.89	12134.88	-17.1
2018-12-13 8:00	18	3.43	-10.29	-6.91	-5.05	-4.24	-4	-4.14	16860.03	14055.71	12734.06	12202.37	12051.21	12138.24	-16.9
2018-12-13 16:00	19	3.44	-10.22	-6.96	-5.11	-4.27	-4.01	-4.15	16801.38	14094.87	12777.22	12221.02	12059.54	12143.29	-16.9
2018-12-14 0:00	20	3.44	-10.16	-7	-5.17	-4.3	-4.03	-4.15	16745.66	14119.67	12815.15	12241.41	12069.55	12148.34	-16.4
2018-12-14 8:00	21	3.43	-10.11	-7.04	-5.23	-4.34	-4.05	-4.16	16703.4	14154.92	12856.87	12265.26	12081.24	12153.39	-15.8
2018-12-14 16:00	22	3.44	-10.07	-7.1	-5.29	-4.37	-4.07	-4.17	16666.55	14198.64	12898.77	12285.74	12092.95	12158.44	-15.3
2018-12-15 0:00	23	3.45	-10.05	-7.15	-5.35	-4.4	-4.09	-4.18	16645.55	14236.26	12939.03	12307.99	12104.67	12165.19	-14.9
2018-12-15 8:00	24	3.46	-10	-7.18	-5.41	-4.45	-4.11	-4.19	16601.04	14261.42	12979.46	12335.45	12118.08	12171.94	-14.5
2018-12-15 16:00	25	3.46	-9.97	-7.22	-5.47	-4.48	-4.13	-4.2	16569.73	14288.75	13020.06	12359.54	12131.52	12178.69	-14.2
2018-12-16 0:00	26	3.46	-9.91	-7.26	-5.52	-4.52	-4.15	-4.21	16520.34	14316.15	13057.12	12385.42	12144.97	12185.45	-13.9
2018-12-16 8:00	27	3.45	-9.85	-7.28	-5.58	-4.55	-4.17	-4.23	16468.57	14337.28	13096.19	12406.18	12158.44	12193.91	-13.8
2018-12-16 16:00	28	3.46	-9.8	-7.31	-5.63	-4.59	-4.19	-4.24	16419.62	14360.57	13131.68	12432.2	12173.63	12200.68	-13.7
2018-12-17 0:00	29	3.45	-9.75	-7.34	-5.69	-4.64	-4.22	-4.25	16376	14379.66	13169.18	12460.03	12188.83	12209.15	-13.6
2018-12-17 8:00	30	3.45	-9.7	-7.37	-5.73	-4.68	-4.24	-4.26	16332.54	14400.92	13203.06	12486.19	12202.37	12215.93	-13.6
2018-12-17 16:00	31	3.45	-9.66	-7.39	-5.78	-4.72	-4.26	-4.27	16296.89	14417.96	13233.27	12512.44	12217.63	12224.42	-13.7
2018-12-18 0:00	32	3.45	-9.62	-7.41	-5.83	-4.75	-4.29	-4.29	16263.88	14432.9	13269.27	12535.24	12234.61	12232.91	-13.9

Table 2: Example of Accumulated Oxygen Sensor Readings within Thermistor Database Combined

TOA5	CR1000-2_BH-2_BIM	CR1000X	2943	CR1000X.St	CPU:BH2_v3_2019030	57739	O2_Data						
TIMESTAMP	RECORD	O2_1	Therm_1	O2_2	Therm_2	O2_3	Therm_3	O2_4	Therm	O2_5	Therm_5	Batt_V	Panel_T
TS	RN												
		Smp	Smp	Smp	Smp	Smp	Smp	Smp	Smp	Smp	Smp	Smp	Smp
2019-03-02 0:00	0	51.8479	0.322	51.04998	1.676	50.9502	0.909	50.888	0.68	51.4	0.47	12.55	2.241
2019-03-02 8:00	1	51.61267	0.783	50.83825	2.057	50.7466	1.323	50.6798	1.16	51.2	-0.045	12.55	2.824
2019-03-02 16:00	2	51.63895	0.299	50.63665	1.785	50.7747	0.889	50.6933	0.72	51.3	-0.398	12.54	2.876
2019-03-03 0:00	3	51.30715	-2.016	50.47761	-1.1	50.4778	-1.689	50.4351	-1.82	51	-2.131	12.52	-0.318
2019-03-03 8:00	4	51.22137	-2.402	50.38119	-1.553	50.4056	-2.112	50.3572	-2.22	50.9	-2.471	12.51	-0.836
2019-03-03 16:00	5	51.73809	1.162	50.94516	2.667	50.8441	1.801	50.7936	1.58	51.3	0.213	12.51	3.327
2019-03-04 0:00	6	51.82919	-1.008	51.01131	-0.167	50.9646	-0.691	50.9428	-0.84	51.4	-1.194	12.5	0.463
2019-03-04 8:00	7	51.8333	-2.182	50.98628	-1.587	50.984	-1.999	50.9738	-2.11	51.5	-2.049	12.49	-0.997
2019-03-05 0:00	8	48.90805	-16.59	49.25467	-10.02	50.7623	-5.777	50.1045	-4.24	50.6	2.91	12.32	-25.29
2019-03-05 8:00	9	48.92031	-15.98	49.26712	-8.75	50.1408	-3.907	49.9844	-3.2	50	-2.038	12.27	-26.13
2019-03-05 16:00	10	48.72661	-13.5	49.10737	-8.5	49.7985	-3.523	49.8433	-3.02	49.4	-1.887	12.29	-21.33
2019-03-06 0:00	11	48.87236	-14.56	49.03946	-8.42	49.5445	-3.364	49.7438	-2.94	48.9	-1.837	12.26	-25.65
2019-03-06 8:00	12	48.84439	-15.04	49.09494	-8.37	49.4863	-3.273	49.688	-2.9	48.6	-1.807	12.25	-25.22
2019-03-06 16:00	13	48.85992	-15.3	49.14276	-8.35	49.516	-3.215	49.7502	-2.87	48.5	-1.784	12.27	-22.71
2019-03-07 0:00	14	48.86707	-15.48	49.12527	-8.34	49.5371	-3.182	49.8187	-2.85	48.4	-1.777	12.24	-27.41
2019-03-07 8:00	15	48.68913	-15.6	49.03153	-8.34	49.4817	-3.16	49.8263	-2.83	48.2	-1.772	12.22	-28.22
2019-03-07 16:00	16	48.76896	-15.68	48.99052	-8.34	49.4476	-3.138	49.8018	-2.81	48	-1.753	12.26	-20.81
2019-03-08 0:00	17	48.72372	-15.78	49.05706	-8.35	49.3763	-3.129	49.7474	-2.8	47.8	-1.753	12.24	-26.05
2019-03-08 8:00	18	48.61669	-15.83	48.97954	-8.36	49.3505	-3.126	49.6844	-2.79	47.7	-1.753	12.22	-28.93
2019-03-08 16:00	19	48.48077	-15.87	48.86519	-8.36	49.3279	-3.116	49.7261	-2.78	47.5	-1.737	12.27	-18.58
2019-03-09 0:00	20	48.51405	-15.93	48.97663	-8.38	49.3698	-3.125	49.7571	-2.78	47.5	-1.746	12.22	-28.94
2019-03-09 8:00	21	48.76465	-15.99	49.09833	-8.4	49.5105	-3.131	49.9393	-2.78	47.6	-1.755	12.16	-30.95
2019-03-09 16:00	22	48.93813	-16.02	49.35818	-8.4	49.7912	-3.129	50.1908	-2.76	47.8	-1.742	12.2	-22.4
2019-03-10 0:00	23	49.03669	-16.06	49.46339	-8.41	49.9398	-3.134	50.3272	-2.76	48	-1.741	12.21	-26.11
2019-03-10 8:00	24	49.13993	-16.11	49.58327	-8.43	49.9873	-3.142	50.422	-2.76	48	-1.742	12.19	-27.02
2019-03-10 16:00	25	49.14769	-16.14	49.60706	-8.44	50.0144	-3.143	50.441	-2.75	47.9	-1.732	12.23	-21.44
2019-03-11 0:00	26	49.12251	-16.2	49.47597	-8.46	49.8862	-3.158	50.3342	-2.75	47.7	-1.746	12.16	-30.53
2019-03-11 8:00	27	48.92139	-16.24	49.32945	-8.47	49.7796	-3.169	50.1966	-2.75	47.5	-1.749	12.14	-27.48
2019-03-11 16:00	28	48.88637	-16.27	49.35628	-8.48	49.7406	-3.173	50.124	-2.74	47.4	-1.742	12.16	-24.87

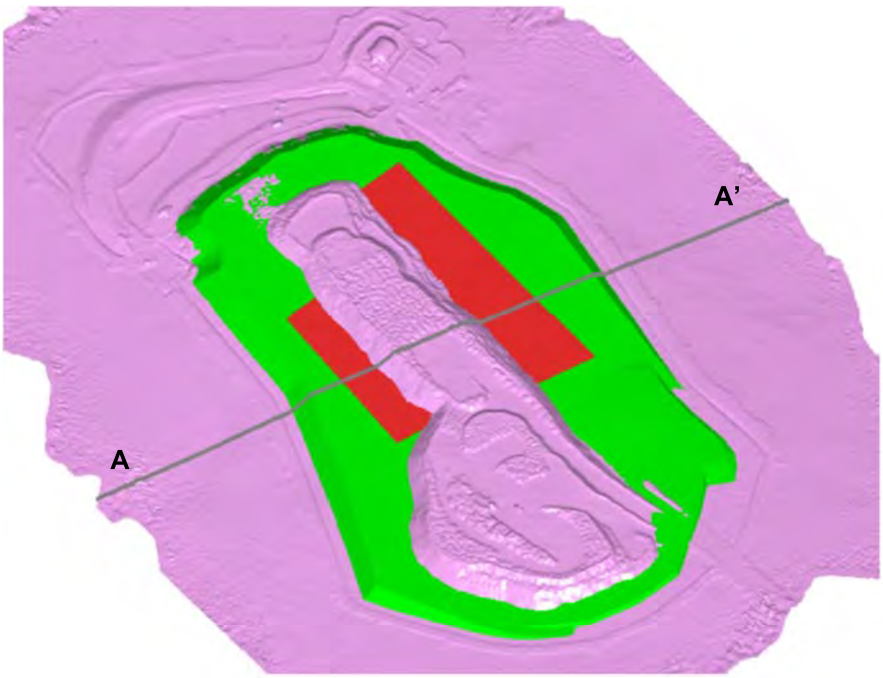
APPENDIX C

Conceptual Waste Rock Deposition Plans

Seasonal and conceptual waste rock deposition plans were developed by Baffinland based on their 2020 – 2021 mining plan and in support of the water balance and water quality modelling. The waste rock deposition plans are presented below. The actual waste rock deposition locations are expected to vary and will be determined by Baffinland during operations.

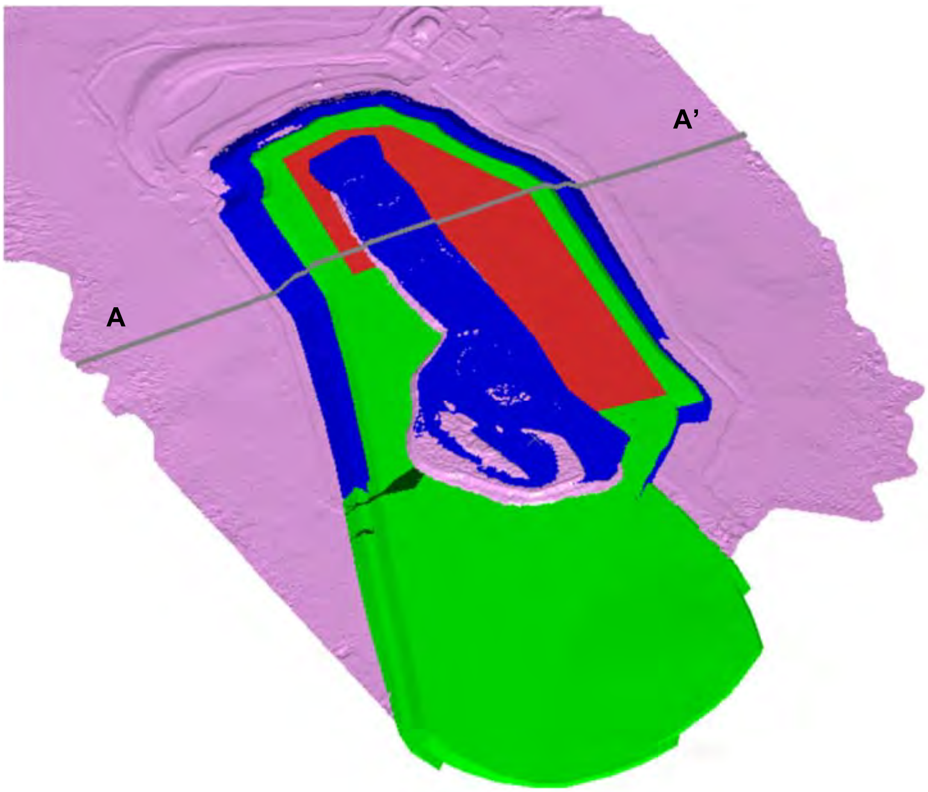
For the images depicting waste rock deposition, green and red areas identify proposed Non-AG and PAG deposition locations, respectively for the placement period being discussed. Blue areas identify waste rock proposed to have been placed during previous periods. The pink area identifies the September 13, 2019 topographic survey.

January 2020 through May 2020

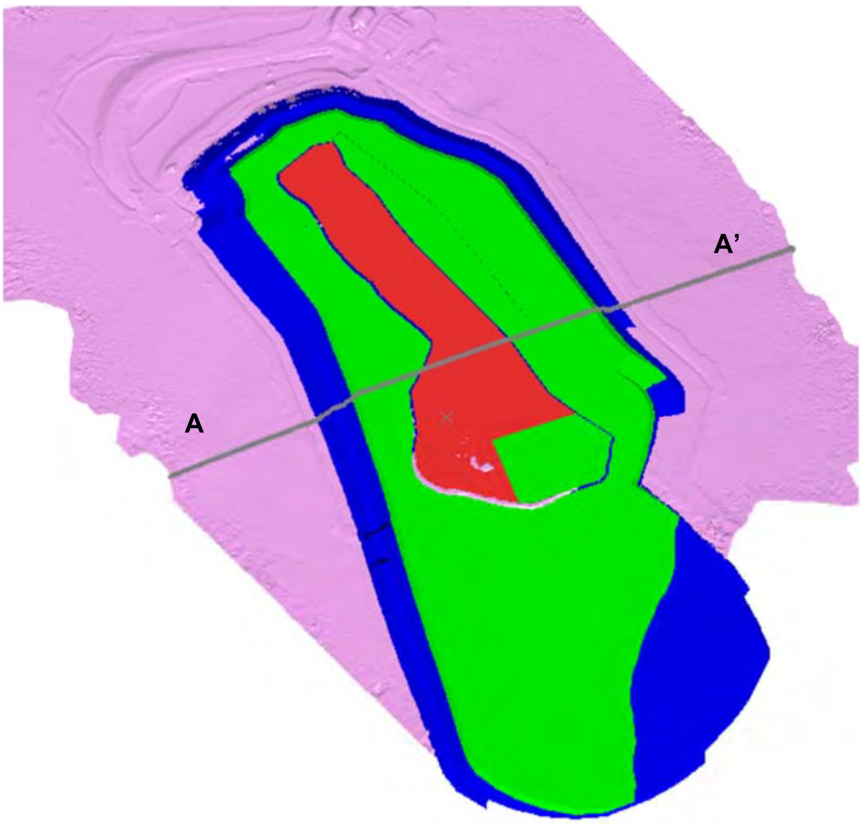


June 2020 through September 2020

October 2020 through May 2021



June 2021 through September 2021



APPENDIX B WATER TREATMENT PLANT OPERATING MANUAL SOP

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Baffinland Iron Mines Corporation

Waste Pond Water Treatment Plant Operations

Rev 1.0

Prepared By: Chet Fong
Department: Mine Operations
Title: Senior Mining Engineer
Date: 17/08/2018
Signature:

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Department: Mine Operations
Title: Mine Manager
Date: 17/08/2018
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DOCUMENT REVISION RECORD

Issue Date MM/DD/YY	Revision	Prepared By	Approved By	Issue Purpose
08/17/18	V1.0	CF		Initial

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1 PURPOSE

This document outlines the basic procedure to safely operate the Water Treatment Plant

2 SCOPE

This document will cover the basic operations of the plant, including start up and shut down, monitoring, treatment, and emergency protocols and procedures for at risk activities at the Water Treatment Plant.

2.1 EXEMPTIONS

This document does not include instructions related to water treatment, which can be found in the plant Operations and Maintenance Manual.

3 RESPONSIBILITES

Any visitor shall request permission to the plant operator prior to entering the work area. In the absence of an operator, permission shall be requested to the mine supervisor.

The Plant operator shall ensure that everyone working in the plant wears the requisite PPE according to the activities being performed (e.g. chemical handling).

4 PROCEDURES

The information in this section is intended as a summary of plant operations. In the case of a discrepancy between this document and the Operations and Maintenance Manual, the latter will take precedence.

For full details on design and plant operation, refer to the operator's manual. In standard operations, the WTP is intended to draw water from the Waste Dump Pond and treat the intake water in 3 steps inside the WTP structure. The water is then discharged to a Geotube Settling Pond, where a fourth treatment step of settlement will occur, before water is either discharged into the environment or, if not compliant, recirculated back to the Waste Dump Pond.

The three steps of treatment involve the injection of chemical into temporary storage tanks.

- Step 1 – Iron Precipitation
- Step 2 – Hydroxide Precipitation and pH Adjustment

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- Step 3 – Flocculation
- Step 4 - Filtration

Steps 1-3 occur inside the WTP structure, with the 4th step taking place in the Geotube Settling Pond.

4.1 PLANT OPERATIONS

Plant operations consists primarily of managing flow, dosage and water levels across the pond, sump, and tanks. Flow is managed with a combination of control panel adjustments and manual valve manipulations.

The plant consists of the following components:

1. Intake Pump – pulls water from the Waste Dump Pond into the WTP
2. Onion tanks – water is stored for treatment prior to discharge. There are two trains, which can be run independently or concurrently.
3. Control panel – use to remotely manage pumps – can be set for automatic and manual operations
4. Dosing pumps – use to inject chemical into onion tanks at a fixed rate
5. Dosing tanks – mixing tanks from which chemicals (Lime, Polymer) is depleted at a configurable rate
6. Transfer pumps – used to take treated water from the plant out to the Geotube Pond
7. Geotube Pond – discharge from the plant is deposited here for particulate settlement prior to final discharge.
8. Discharge pump – used to pull treated water from the Geotube Pond to either be discharged into the environment or recirculated back to the Waste Dump Pond.
9. Blower motors – used to agitate water in onion tanks during treatment to ensure more even dispersion of chemicals.

Once the Plant is operational, the operator will commence with monitoring the measured levels of pH and suspended solids with built in instrumentations and gauges. These readings may be corroborated with manual instrumentations such as a YSI meter.

When readings indicate pH readings at the desired values, the operator shall then initiate discharging of water into the Geotube Pond. This water is allowed to percolate through the Geotube, which catches particulates as a filter. Once in the Sump, where any remaining particulates are then captured and settle into the bottom of the pond.

Water is discharged from this Geotube Pond, either directly into the environment or back into the Waste Dump Pond. The maximum flow rate for these discharging is 1200 gal/min, this limit imposed by the flowmeter installed.

At design capacity, the intake pump(s) should be able to pull water into the WTP for treatment at an equal rate to the discharge pump. The plant effectively runs continuously with dosing in-stream.

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4.2 Plant Start up

The following steps should be undertaken when starting up the WTP.

1. Ensure blower motors are activated.
2. Ensure all the Valves to the Geotube Sump are open.
3. Ensure the transfer pumps are switched to automatic
4. Check that all the intake valves are open
5. Keep valves open between tanks on each train
6. Start up intake pump and adjust pressure accordingly. To do this, adjust the following:
    a. Rpm of the pump
    b. Valve openings
7. Start Ferric Sulphate Dosing system. Ensure intake is in the Ferric Sulphate barrels, and there are no leaks present. Pumps should be activated.
8. Start Lime Dosing system. Dosing pumps should be activated.
9. Start up Polymer Dosing System. Dosing pumps should be activated

Plant operations can now commence.

4.3 Plant Shut Down

Plant shut down can be undertaken when it is to be unmanned for a longer period of time (eg. More than 2 shifts) within the same system (for winter decommissioning, procedure XXX). To run a plant shut down

1. Shut all intake valves
2. Shut all Ferric Sulphate dosing equipment
3. Shut all Lime dosing equipment
4. shut all Polymer dosing equipment
5. Rinse Lime lines (reference other procedure)

Plant can now be shut down. This procedure can be utilized with the onion tanks full. This should also be done before any interruptions in power due to generator maintenance or other causes.

4.4 Discharging

Discharging be undertaken whenever the plant is running. It is most efficient to run the discharge when there is moderate to high water levels in the Geotube Sump. The intake hose for the Geotube Sump should utilize the ring to ensure that drawn water is from the top of the water surface.

Discharging requires the manual operation of the valves to discharge the water either to the environment or back to the Waste Dump Pond. Readings should also be checked and logged on the flowmeter when discharge begins using the totalizer values.

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NOTE: discharge flow rate should be kept below 1200 gal/min, as flow greater than this will not be measureable.

To discharge, the following steps should be undertaken:

1. Ensure enough water to discharge. Water levels should be at least 50 centimetres from the bottom of the sump prior to beginning discharge.
2. Ensure valve on re-circulation line is closed. This will enable the water to discharge into the environment. Where re-circulation is required, close the valve on the discharge line and open the valve on the re-circulation line.
3. If discharging to the environment, check the totalizer reading on the flowmeter prior to discharge. This is not required if re-circulating.
4. On the control panel, Set discharge to "on"
5. While discharging, check discharge pH and Turbidity with sampling tap periodically. Samples can be collected and tested using YSI instrument.
6. When discharging is complete or to be disabled, go to control panel and set discharge to "off"

4.5 Chemical Dosing

Chemical dosing is performed as part of the treatment process. The primary drivers for chemical dosing is:

1. Reduce the pH
2. Reduce the suspended solids

Prior to discharging water back into the environment.

As dosing quantities will vary depending on flow rate and water qualities, refer to user manual for dosing quantities.

Dosing procedures will vary slightly between the stages of treatment. The three stages that require chemical intervention are Ferric Sulphate, Lime, and Polymer.

4.5.1 Ferric Sulphate – Liquid

PPE Required: long chemical resistant gloves, apron, face shield, standard PPE

- Prepare a barrel for dosing by placing the barrel into the duck pond by the ferric sulphate dosing area and removing the top seal.
- Put 2 dosing pumps into 1 barrel (1 per train)
- Switch on dosing pump on the control panel
- On the pump, check frequency and stroke length to ensure dosage is as expected.
- To change barrels, switch off on the dosing pump and change barrel

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4.5.2 Lime – bags

PPE Required: long chemical resistant gloves, respirator, face shield, respirator, standard PPE

- Fill mixing tank with intake water.
- Check filter on accessory intake water line (dedicated line for filling lime and polymer mixing tanks)
- Open valve on AI water line (fill tank). Fill to required water levels
- Ensure mixer is operating
- Add lime to water

4.5.3 Polymer – bags

PPE Required: standard PPE

- Fill mixing tank with intake water.
- Check filter on accessory intake water line (dedicated line for filling lime and polymer mixing tanks)
- Open valve on AI water line (fill tank). Fill to required water levels
- Ensure mixer is operating
- Add polymer to water

4.6 System Automation

For instruction on System Automation, please refer to the Operations and Maintenance Manual.

4.7 Trouble Shooting

For issue identification, please refer to the checklists in the Operations and Maintenance Manual.

4.8 Accident response

As the WTP involves the handling of a number of chemicals that may be harmful, precautions must be taken to ensure all personnel who are in the work area are informed of the hazards and the preventative and treatment measures.

4.8.1 response equipment available

The WTP is equipped with a stationary emergency shower, 2 portable emergency shower stations and eyewash stations (dual purpose), 2 fire extinguishers, and 1 stationary eyewash station.

Additionally, the WTP is equipped with spare PPE, face shields, respirators, chemical resistant gloves, hearing protection, and spill kits.

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There are also patch kits for the onion tanks, hose and fitting replacements, tools, and a base station radio available at the WTP.

In the event that an incident occurs that requires emergency response, same basic steps should be immediately undertaken. The following lists some of the possible situations and a brief of the response steps.

4.8.2 Spills on the Ground

- Retrieve spill pad kit
- use gloves to handle
- dispose in drum
- Label and dispose.

4.8.3 Spills on Person

- Proceed to stationary emergency shower
- Notify secondary operator
- Secondary operator activates pump switch
- Pull handle and rinse for 10 mins
- If unable to proceed to stationary emergency shower, refer to “emergency response procedure”

4.8.4 Lime in Eyes

- If possible, proceed immediately to emergency eyewash station
- Activate emergency eyewash and rinse for 10 mins.
- Repeat if required
- Notify secondary operator
- If unable to proceed to emergency eyewash station, refer to “emergency response procedure”

4.8.5 Lime Spill

- Retrieve spill pad kit
- use gloves to handle
- dispose in drum
- Label and dispose.

4.9 APPENDICIES

Appendix A – Operations and Maintenance Manual for Mary River Mine Waste Rock Pile Water Treatment Plant

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APPENDIX A – OPERATIONS & MAINTENANCE MANUAL FOR MARY RIVER MINE WASTE ROCK PILE WATER TREATMENT PLANT 20180817_v02

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OPERATIONS & MAINTENANCE MANUAL FOR MARY RIVER MINE WASTE ROCK PILE WATER TREATMENT PLANT
20180817_v02

Baffinland Iron Mines Corporation

Prepared by:

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BROWNFIELDS TO GOLD MINES

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Project No. 137-0001

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1.0 INTRODUCTION

This documents outlines the Operations Manual for Baffinland Iron Mine Corporation's (BIM) Mary River Mine Waste Rock Pile water treatment plant (WTP).

2.0 PLANT OVERVIEW

2.1 General Process Description

The WTP employs a process of coagulation, pH adjustment, flocculation, and filtration to treat acid rock surface runoff collected in the pond at the base of the waste rock pile. The objective of the system operation is to treat water to within the parameters outlined in the Metal Mining Effluent Regulations (MMER), as specified to McCue by BIM, and summarized in Table 1.

Table 1: MMER Effluent Limits

Parameter	Unit	Maximum Authorized Monthly Mean Concentration	Maximum Authorized Concentrations in a Composite Sample	Maximum Authorized Concentration in a Grab Sample
Arsenic	mg/L	0.5	0.75	1.00
Copper	mg/L	0.3	0.45	0.60
Cyanide	NTU	1.00	1.50	2.00
Lead	mg/L	0.20	0.30	0.40
Nickel	mg/L	0.50	0.75	1.00
Zinc	mg/L	0.50	0.75	1.00
Total Suspended Solids	mg/L	15.00	22.50	30.00
Radium 226	Bq/L	0.37	0.74	1.11
pH	SU	6-9.5	6-9.5	6-9.5

The treatment steps are described in Section 2.2. Refer to drawings in Appendix A:

2.2 Brief Process Overview

2.2.1 *System Inlet*

Water is collected at an inlet storage pond (P-001) where it is held for treatment. Two diesel powered centrifugal trash pumps (PU-100A/B) are used to transfer water from the storage pond to an equipment enclosure where the WTP is housed.

At the WTP, the flow can be divided into two separate treatment trains (1 and 2), with each train having a flow meter on the inlet line to monitor flow.

Water is directed into two reactor tanks (TA-110 and TA-210) for processing.

2.2.2 *Step 1 – Iron Precipitation*

Ferric sulphate solution is injected into TA-110 and TA-210 to promote coagulation and precipitation of some heavy metals.

As of system commissioning in June 2018, ferric sulphate liquid solution (12% Fe) is used and injected directly into the process. Each process train utilizes an independent chemical pump to introduce chemical into the system.

The WTS also includes a ferric sulphate make down system, including a holding tank and mixer to allow for makeup of solution using dry ferric sulphate.

Each reactor tank includes a pH sensor to provide continuous monitoring of pH.

Each reactor tank is equipped with four air diffusers which supply air to the process and provide continuous mixing so that solids are kept suspended. Each train is supplied air by a dedicated blower.

2.2.3 *Step 2 – Hydroxide Precipitation and pH Adjustment*

Water flows by gravity from TA-110 and TA-210 to TA-120 and TA-220 respectively. Here, hydrated lime is injected into the process to increase pH and aid in further precipitation of some metals through hydroxide precipitation.

Hydrated lime solution is made manually by adding dry hydrated lime and raw influent water to a mixing tank (TA-020). A mixer is run continuously to ensure the hydrated lime slurry does not solidify.

One hydrated lime chemical pump is utilized to dose each reactor tank with chemical. Two motorized valves (MV-120 and MV-220) are used to control the flow of lime to each reactor tank. Each reactor tank includes a pH sensor to provide continuous monitoring of pH.

Each reactor tank is equipped with four air diffusers which supply air to the process and provide continuous mixing so that solids are kept suspended. Each train is supplied air by a dedicated blower.

2.2.4 *Step 3 – Flocculation*

Water flows by gravity from TA-120 and TA-220 to TA-130 and TA-230 respectively. Here, polymer is injected into the process to aid in flocculation of suspended solids prior to filtration.

Polymer solution is made manually by adding dry polymer and raw influent water to a mixing tank (TA-030). A mixer is run continuously to ensure uniformity of the polymer solution.

Two polymer chemical pumps are utilized to provide polymer dosing to each train. Polymer can be dosed directly into each reactor tank, or inline through a static mixer located directly downstream of the reactor tank.

2.2.5 *Step 4 – Filtration*

Water from TA-130 and TA-230 is pumped to a geotube pond via two diesel powered centrifugal trash pumps (PU-200A/B).

Water is directed to a manifold where it can be distributed to two geotube bags for solids filtration. Two additional geotube bags can be deployed in the pond once the currently operating geotube bags have reached capacity. These spare geotubes are currently stored in a warehouse for future use.

Filtered water leaves the geotube bags and is directed to a collection point at the North West corner of the pond. From here, water is pumped via one diesel trash pump (PU-300) to the Mary River discharge point, or recycled back to the inlet pond. A flow meter is installed on the discharge line to Mary River to allow for data logging of flow.

2.3 Major Equipment List

The WTP layout is provided in appendix A. A list of major equipment is provided in Table 2.

Table 2: Major WTP Equipment

Equipment	Description	Qty	Drawing Reference (If Available)
Pond Transfer Pump	Model: Prime Aire PA4A60-404ST Power: Diesel Driven Capacity: 140m3/hr	2	PU-100 A / PU-100 B
Inlet Flow Meter	Model: GF Signet 3-2551-P1-42	2	FT-100 / FT-200
Ferric Reaction Tank	Material: Polyurethane Size: 5.9m W x 1.5 H Capacity: 24,820 Liters	2	TA-110 / TA-210
Lime Reaction Tank	Material: Polyurethane Size: 5.9m W x 1.5 H Capacity: 24,820 Liters	2	TA-120 / TA-220
Polymer Reaction Tank	Material: Polyurethane Size: 5.9m W x 1.5 H Capacity: 24,820 Liters	2	TA-130 / TA-230
Aeration Blowers	Gast R7100A-3 Blower • 208 V / 3 HP / 60 Hz	2	BL-100A / BL-100B
pH Controller and Sensors	Model: Walchem W900 (Controller) Model: Walchem WEL-PHF-NN (Sensors)	1	pH-110/120/210/220
Motorized Ball Valve	Hayward 1" Ball Valve Model: HRSN2	2	MV-120 and MV-220
Level Transmitter	Model: Echosonic 11 LU27	2	LT-130 / LT-230
Bag Filter	Model: FTI830-2P-150-CS-BS-P13-DP Bag Size: 5 Micron	1	FIL-100
Ferric Chemical Pump	Model: Walchem EHE31E1-VC Power: 115 VAC/1hp/60Hz Capacity: 1 LPM @ 105m TDH	2	PU-010A / PU-010B
Lime Chemical Pump	Model: Flowmotion FR25-HR30HR Power: 230V/3hp/60Hz Capacity: 9.5 LPM @ 105 m TDH	1	PU-020
Polymer Chemical Pump	Model: Flowmotion FR25-HR30HR Power: 230V/3hp/60Hz Capacity: 16.5 LPM @ 105 m TDH	2	PU-030A / PU-030B
Ferric Mixing Tank	Material: Polyurethane Size: Ø 1.2m x 1.3m Height	1	TA-010
Lime Mixing Tank	Material: Polyurethane Size: Ø 1.8m x 1.7m Height	1	TA-020
Polymer Mixing Tank	Material: Polyurethane Size: Ø 1.6m x 1.6m Height	1	TA-030
Coarse Bubble Diffusers	Model: Maxair 24" SS	24	-

2.4 System Automation

The system is automated through a main control panel located in the system enclosure. The system P&ID is provided in Appendix A. Operation is outlined in Table 3.

Table 3: Control Panel Automation

Equipment ID	Equipment Description	Control Logic	PID Control Reference	Controls	Panel Indication
PU – 100 A/B	Inlet Pond Pump	Units can be controlled in Hand or in Auto. Pump will turn on in Hand in Auto or in Hand.	-	-	Pump icon will indicate run status
		Pump will turn off if high level is measured in TA-110 or TA-210	LSH-110 / LSH-210	Auto	High level alarm at panel
		Pump will turn off if high level measured in TA-130 or TA-230	LIT-130 / LIT-230	Auto - High level settable at panel	High level alarm at panel
BL-100 A/B	Blower	Units can be controlled in Hand or in Auto Blower will turn on in Auto or in Hand	-	-	Blower icon will indicate run status
		BL-100 A will turn off if low level is measured by LIT-130	LIT-130	Auto – Low level settable at panel	Low level alarm
		BL-100 B will turn off if low level is measured by LIT-230	LIT-230	Auto – Low level settable at panel	Low level alarm
pH-110	pH Sensor	Continuous monitoring of pH	-	-	Display pH on PLC
pH-210	pH Sensor	Continuous monitoring of pH	-	-	Display pH on PLC

pH-210	pH Sensor	If pH>9.5, close MV-120 - Alarm	MV-120	Auto – pH set point settable at panel	Display pH on PLC
pH-220	pH Dosage	If pH>9, close MV-220 - Alarm	MV-220	Auto – pH set point settable at panel	Display pH on PLC
PU-010A	Ferric Pump	Units can be controlled in Hand or in Auto	-	-	Pump icon will indicate run status
		If FIT-100 measures flow, PU-010A energizes.	FIT-100	Auto	Display run status on PLC
PU-010B	Ferric Pump	Units can be controlled in Hand or in Auto	-	-	Pump icon will indicate run status
		If FIT-200 measures flow, PU-010B energizes.	FIT-100	Auto	Display run status on PLC
PU-020	Lime Pump	Units can be controlled in Hand or in Auto	-	-	Pump icon will indicate run status
		Speed Control (1 train only) If pH-120> 8.5, PU-020 will reduce speed. If pH < 8, pump will increase pump speed. If pH is between 8 to 8.5, pump will maintain pump speed.	pH-110 / pH-120	Auto – pH set point adjustable at panel	Display run status on PLC
		Speed Control Disabled If flow is detected by both trains, speed control is disabled.	FIT-100 / FIT-200	Auto	Display run status on PLC
PU-030 A	Polymer Pump	Units can be controlled in Hand or in Auto	-	-	Pump icon will indicate run status

		Polymer pump energizes if PU-200 A is on	PU-200A	-	Display run status on PLC
PU-030 B	Polymer Pump	Units can be controlled in Hand or in Auto	-	-	Pump icon will indicate run status
		Polymer pump energizes if PU-200 B is on	PU-200B	-	Display run status on PLC
PU-200 A	Transfer Pump	Units can be controlled in Hand or in Auto	-	-	Pump icon will indicate run status
		If LT-130 measures < 3’, PU-200A off. If LT-130 measures >3’, PU-200A on.	LT-130	Auto – Set points adjustable at panel	Pump icon will indicate run status
		If LT-130 measures >4.5’, PU-200A off. If LT-130<4.5’, PU-200A on.	LT-130	Auto – Set points adjustable at panel	Pump icon will indicate run status
PU-200 B	Transfer Pump	Units can be controlled in Hand or in Auto	-	-	Pump icon will indicate run status
		If LT-230 measures < 3’, PU-200B off. If LT-230 measures >3’, PU-200B on.	LT-130	Auto – Set points adjustable at panel	Pump icon will indicate run status
		If LT-230 measures >4.5’, PU-200B off. If LT-230<4.5’, PU-200B on.	LT-130	Auto – Set points adjustable at panel	Pump icon will indicate run status
PU-300	Discharge Pump	Units can be controlled in Hand or in Auto	-	-	Pump icon will indicate run status
		Pump off at LSL-200	LSL-200	-	Level indicator on panel

		Pump on at LSH-200	LSH-200	-	Level indicator on panel
		High Level Alarm at LSHH-200	LSHH-200	-	High Level Alarm
MX-010 /020/030	Mixer	Units can be controlled on/off manually	-	-	-

3.0 GENERAL STARTUP PROCEDURE

3.1 After Dormancy Pre-start-up Procedures

The following steps shall be taken after extended periods of dormancy, prior to general startup of the WTP.

Task	Check
Perform a visual inspection of the system enclosure for signs of water/snow ingress.	☐
Inspect hose and pipe for signs of leaks, abrasion, or other physical damage.	☐
Inspect Reactor tanks as follows: • Signs of leaks, abrasion, or other physical damage. • Tank connections for signs of strain or stress. • Make sure that valves at the inlet and outlet are opened.	☐
Inspect Blowers as follows: • Signs of abrasion, or other physical damage on all external accessories such as relief valves, gauges and filters. • Make sure that valves at the inlet and outlet are opened.	☐
Inspect Diesel Pumps as follows: • Signs of leaks, abrasion, or other physical damage. • Check for and tighten loose attaching hardware. • Make sure that valves at the inlet and outlet are opened. • Check oil levels and lubricate as necessary.	☐
Inspect Ferric Sulphate pump as follows • Signs of leaks, abrasion, or other physical damage. • Make sure that valves at the inlet and outlet are opened.	☐
Inspect Hydrated Lime pumps as follows • Signs of leaks, abrasion, or other physical damage. • Inspect condition of internal pump hose. • Make sure that valves at the inlet and outlet are opened.	☐
Inspect Polymer pump as follows: • Signs of leaks, abrasion, or other physical damage. • Inspect condition of internal pump hose. • Make sure that valves at the inlet and outlet are opened.	☐
Inspect Level Transmitter as follows: • Monitor debris and ensure the sensor is level and mounted perpendicular to water level. • Check and roughly compare measurement on the PLC with the real on the field.	☐
Inspect pH sensors as follows: • Monitor debris and deposition of scaling on the transmitter. Perform a cleaning of the sensors as necessary.	☐

-

Insect Bag Filter vessel as follows: • Signs of leaks, abrasion, or other physical damage. • Inspect filter bag and replace as necessary	☐
Inspect Inlet Flow Meter as follows: • Signs of leaks, abrasion, or other physical damage. • Inspect flow sensor for scaling. Clean as necessary.	☐
Inspect Geotube Bag as follows: • Ensure inlet connection points are securely attached. • Ensure height of bag does not exceed recommended limits. If so, decommission geotube bag. • Clean geotube surface of sediment and scaling to prevent fouling using a push broom, or gentle pressure washing.	☐

3.2 Commissioning

After pre-start-up procedures are completed, the system can be energized. The following procedure reflects a high level overview of equipment checks to be performed. Detailed instructions can be found in the product specific manuals. Before any mechanical intervention, disconnect the electrical supply.

3.2.1 *Hydrated Lime Pump / Polymer Pump*

Task	Check
Ensure that all protections (cover, cover window, ventilator hood, coupling protection) are in place before operating the pump.	☐
Check the direction of rotation of the pump.	☐
Make sure that valves at the inlet and outlet are opened.	☐
Start the pump by checking its direction of rotation through the cover window.	☐
Check the flow and discharge pressure and adjust rollers if these figures don't match the pump specifications.	☐

IMPORTANT: Ensure lime pump valves remains open during operation. Should valves be left in the closed position, the process line can over pressurize, leading to a rupture of the chemical hose.

3.2.2 *Blowers*

Task	Check
Ensure impeller rotation is correct.	☐
Check filters and inspect for signs of fouling. Replace if necessary.	☐

Ambient temperature – Check room and discharge air temperatures. Exhaust air should not exceed 135ºC.	☐
Working pressure and vacuum values – Adjust relief valve pressure or vacuum setting, if needed.	☐
Motor current – Check that the supply current matches recommended current rating on product nameplate.	☐
Electrical overload cutout – Check that the current matches the rating on product nameplate.	☐

3.2.3 *Ferric Pump*

Task	Check
Ensure pump is energized.	☐
Make sure that valves at the inlet and outlet are opened.	☐
Start the pump manually, in order to prime and adjust dosing rates.	☐
Prime the pump. See manual for details.	☐
Adjust dosing according to inlet water flow rate. See below.	☐
Check dosing rate with calibration cylinder.	☐

3.2.4 *Motorized Valve*

Task	Check
Ensure valve is energized.	☐
Ensure valve opens/closes reliably in manual mode:	☐

3.2.5 *Diesel Pumps*

Task	Check
Check fuel level and oil levels in the engine, air compressor, pump bearings and seal housing.	☐
Consult engine operations manual before attempting to start the unit.	☐
Allow pump to prime.	☐
Adjust engine speed to desired output.	☐

3.2.6 *pH Sensors*

Task	Check
Ensure sensor is calibrated.	☐
Ensure the pH reading displayed locally at the Walchem panel is transmitted correctly to PLC.	☐

3.2.7 *Geotube*

Task	Check
Ensure surface is clean of sediment and debris.	☐
Ensure all inlet valve are open.	☐
Ensure height of geotube does not exceed manufacturer recommended limit.	☐

4.0 OPERATION

4.1 General Operating Instructions

Operation of the WTP will consist of ensuring major equipment (blowers, dosing pumps, motorized valves, level transmitters) is running correctly, and ensuring influent/effluent monitoring and sampling are conducted on schedule.

The drivers for pH adjustment and TSS treatment are operation of the Ferric Sulfate, Hydrated Lime and Polymer Pump, along with the proper performance of the aeration blowers and diffusers equipment.

The unit will run manually. During short term dormancy, the unit can be operated in a "Sleep Mode" where the system is run in a re-cycle status using two submersible pumps inside TA-130 and TA-230 to recirculate water from the end of each train to the beginning of each train. Chemical injection is disabled during dormancy, however, the lime mixer should remain on to maintain suspension of the hydrated lime slurry. Blowers will also remain on to ensure suspension of solids within the reactor tanks.

Parameters to be measured and recorded daily include temperature, pH (typical values are between 6.5 and 9), and TSS. The system must be monitored regularly to ensure pH does not drop below the low level set point or raise above the level set point.

The pH reading should be recorded daily. The pH should be cross referenced regularly with a hand held device. Should the pH differ from the hand held reading, the operator should clean the pH electrodes using a 2-5% solution of hydrochloric acid.

System data can be recorded in the spreadsheet provided in Appendix B. Regular daily monitoring of parameters such as pH, temperature, TSS, and Geotube height must be recorded to ensure proper operation.

4.2 Operating Procedure

The following section will outline the step-by-step procedures for operating the treatment system.

4.2.1 *Standard Operation*

Inlet

The inlet pond level should be checked and recorded prior to start up. Two pond pumps can be utilized to transfer raw water to the treatment system. Usage will depend on the volume of treatment required. At low pond levels, one pond pump and one process train can be utilized. At high levels, both pumps can be utilized to increase the treatment volume.

All pump discharge valves must be opened. The pumps (PU-100 A/B) shall be placed in “Hand” at the PLC. This will energize the pumps and begin transfer of water to the treatment system. The pumps will only turn on if a high level is measured by LSH-110/210 or LT-130/230.

Operators must ensure the inlet pond level is monitored, as the pumps do not include a low level shut off.

Ferric Pumps (PU-010 A/B)

Water is transferred from the inlet pond to two reactor tanks (TA-110 and TA-210) where ferric sulphate is injected. The dosage rate of the ferric pumps is determined by the inlet quality of the raw water and can range from 0 to 20 mg/l. The dosage rate is to be determined by the operator.

The dosage rate must be set manually at the pump. Once set, the pump can be set to “Auto” at the control panel. The ferric pumps, PU-010 A and PU-010 B, will energize when flow is detected by FIT-100 and FIT-200 respectively.

Before starting the pumps, all discharge valves must be opened.

Lime Pump (PU-020)

After coagulant addition, water flows by gravity to TA-120 and TA-220 where hydrated lime is injected into the process. The dosage rate of the Lime pump is determined by the inlet quality of raw water and the pH required, and can range from 0 to 300 mg/l. The dosage rate is to be determined by the operator.

In manual mode, the speed of the pump can be set at the pump VFD, located on the lime pump stand.

Pump speed will be dependent on the pH measured by pH-120, and the pH set point entered into the panel (adjustable by an operator). At a setpoint of 8.5, the pump will increase speed if pH-120 measures a pH below 8. If pH-120 measures a pH above 9, pump speed will decrease. If pH is measured between 8 to 8.5, the dosage rate will remain the same.

-

At a pH above 9.5, MV-120 and MV-220 will close.

The lime pump will operate continuously, with chemical consistently recirculated to the lime mixing tank (TA-020). This is done to ensure the lime slurry does not settle and solidify in the piping system. At the end of every shift, clean water must be flushed through the piping in order to prevent fouling. Flushing may be required more frequently depending on operational conditions.

Due to the possibility of fouling, the lime pump system must be monitored for pressure consistently.

Lime Solution Make Up

Hydrated lime solution is made manually, with the solution concentration ranging from 5-10% depending on volume of raw water to be treated. A concentration of 5% is recommended to minimize line fouling caused by the lime slurry. Higher concentrations can be made, but more frequent line flushing will be required.

The lime tank mixer is operated from the panel, and should be operated continuously to prevent the slurry from solidifying.

Polymer Pumps (PU-030 A/B)

The dosage rate of the ferric pumps is determined by the inlet quality and can range from 0 to 3 mg/l.

The dosage rate must be set manually at the pump. Once set, the pump can be set to “Auto” at the control panel. The polymer pumps, PU-020 A and PU-020 B, will energize when the transfer pumps, PU-200 A and PU-200 B are energized.

Before starting the pumps, all discharge valves must be opened.

Polymer Solution Make Up

Polymer solution is made manually, with concentration ranging from 0.1 to 0.25% depending on volume to be treated.

The polymer tank mixer is operated from the panel, and should be kept on at all times to maintain uniformity of the solution.

Blowers

The blowers are operated from the panel, and should be energized at all times when raw water is being processed in the reactor tanks.

Both blowers (BL-100A and BL-100B) can be set in “Auto” at the panel, at which point they will run continuously until the water level in TA-130 and TA-230 is measured to be less than 6”. This level is settable at the panel.

Raw Water Bag Filter

The bag filter provides filtration of water required for chemical makeup. The filter bags should be replaced periodically when differential pressure across the filter exceeds approximately 20 psi.

Geotube Bags

Water is transferred from the final reactor tanks (TA-130 and TA-230) by diesel generated trash pumps (PU-200 A and PU-200 B) to the geotube pond. The transfer pumps, PU-200A and PU-200B are operated based on the level measured by the reactor tank level transmitters, LT-130 and LT-230 respectively. These set points are adjustable at the panel.

The height of the geotube bags must be monitored regularly.

4.3 Daily Operator Checklist

The following steps outline day-to-day operational procedures for the WTS.

Standard Operation

Task	Check
Check inlet pond and record water level	☐
Check lime and polymer solutions, make up additional solution as required.	☐
Place PU-100 A (and PU-100 B if necessary) in Hand mode at the control panel.	☐
Set Ferric Sulphate pump (PU-010 A / B) dose rate and place pump in Auto at control panel. Ensure pump energizes when flow is detected by FIT-100 or FIT-200.	☐
Turn on hydrated lime pump (PU-020 A) manually. Adjust dose rate based on flow measured by inlet flow meters.	☐
Monitor hydrated lime pump pressure gauge. If pressure gauge is showing a pressure greater than 15 psi, flush line with water.	☐
Set polymer pump dose rate at panel. Set in “remote” mode. Set pump to auto at panel. Pump will turn on when PU-200A/B energize.	☐
Set Blowers (BL-100 A / BL-100B) to Hand.	☐
Once onion tanks are full, set PU-200A/B to Auto (if using both trains). Ensure downstream valves to geotube bags are open.	☐

Observe reactor tank water levels to ensure inlet and outlet flows are balanced.	☐
Observe and record height of geotube bags. Height must not exceed 6 feet.	☐
Set PU-300 to auto in the panel. Once the water in the pond reaches the operating float switch, the pump will be energized.	☐
Discharge vales must be set manually to allow for discharge to the creek, or recycle back to the inlet pond. Set valves in correct position.	☐

Daily Shutdown

Task	**Check**
Set inlet pump to Off position	
Allow reactor tanks to be pumped down to ¼ volume.	☐
Turn off chemical pumps.	☐
Flush lime line with water	☐
Keep lime mixer (Mix-020) on to ensure hydrated lime slurry remains in liquid form.	☐
If tanks are lowered, blowers can be turned off. If tanks are kept full, energize recirculation pumps.	☐
Check lime and polymer solutions, make up additional solution if required.	☐
Turn transfer pumps (PU-200 A/B) and discharge diesel pump (PU-300) off.	☐

APPENDIX A –DRAWINGS

NOTES:

PU-200A/B- Transfer Pump
PU-300- Discharge Pump
FT-300- Flow Meter
LS- Level Switch
-LSHH 200
-LSH 200
-LSL 200

Process lines
Instrumentation lines

Process based on conceptual desgin by Golder Associates

REVISION TABLE

No.	DESCRIPTION	DATE
0	Original Issue	2018/04/30
1	Record Drawing	2018/07/31

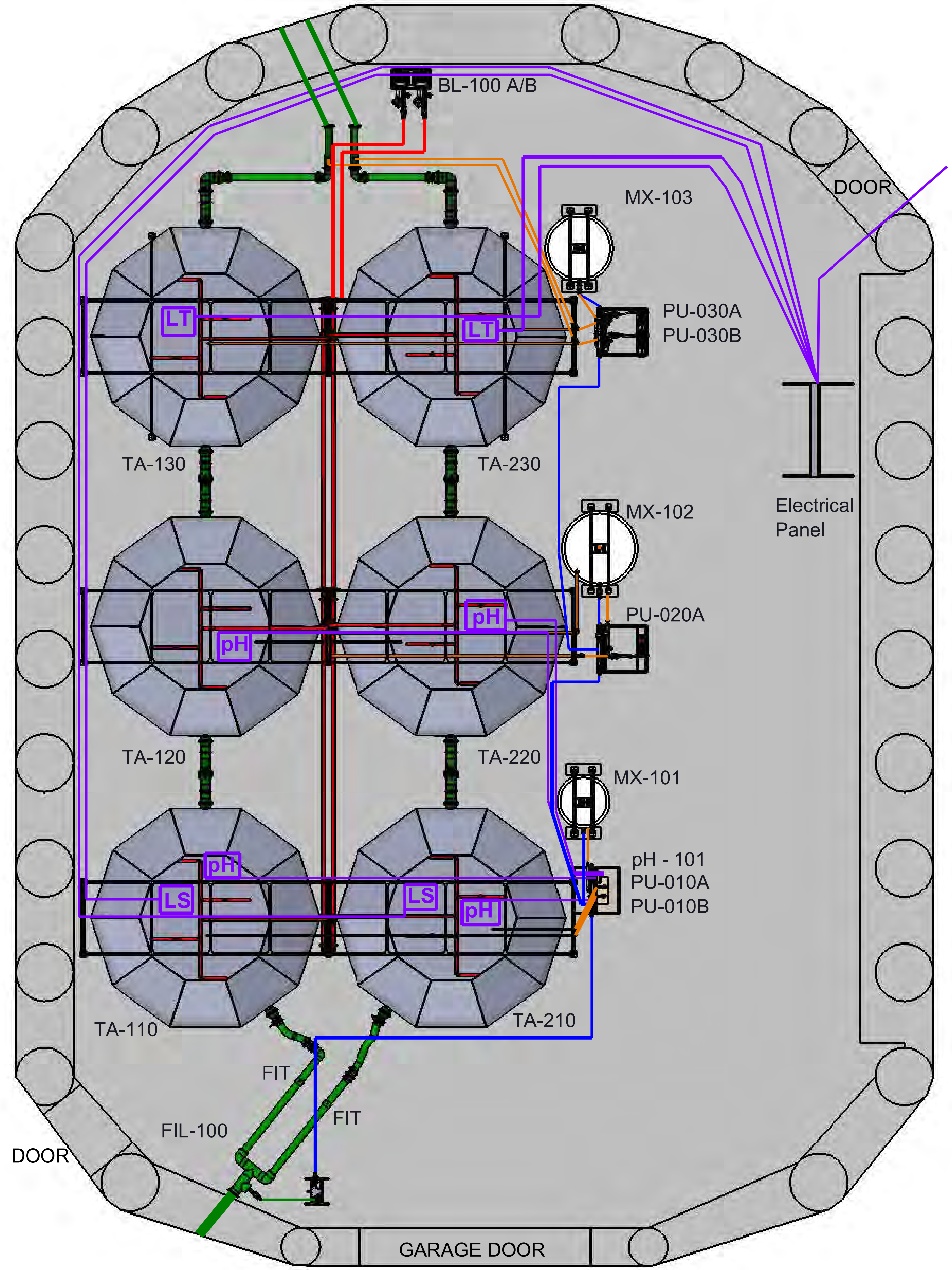
McCUE ENGINEERING CONTRACTORS

CLIENT:

BAFFINLAND IRON MINES CORPORATION

FULL SITE LAYOUT
GENERAL ARRANGEMENT DRAWING
Waste Rock Pile Water Treatment Plant

DATE: July 31, 2018	SCALE: NTS
DATA BY: R.B.	MCCUE JOB NO. 137-0001
DRAWN BY: L.S	FIG: GA-001



LEGEND

BL-100 A/B - Blower
FIL-100 - Bag Filter
MX-101 - Ferric Mixing Station
MX-102 - Lime Mixing Station
MX-103 - Polymer Mixing Station
PU-010 A/B - Ferric Pump
PU-020 - Lime Pump
PU-030 A/B - Polymer Pump
TA-110 - Ferric Process Tank (Train 1)
TA-210 - Ferric Process Tank (Train 2)
TA-120 - Lime Process Tank (Train 1)
TA-220 - Lime Process Tank (Train 2)
TA-130 - Polymer Process Tank (Train 1)
TA-230 - Polymer Process Tank (Train 2)
pH-101 - pH Controller
FIT - Flow Meter
pH - pH Sensor
LS - Level Switch
LT - Level Transmiter

Notes:

- Process Lines
- Water Make-up Lines
- Chemical Lines
- Air Lines
- Instrumentation Line

Process based on conceptual design by Golder Associates

REVISION TABLE

No.	DESCRIPTION	DATE
0	Original Issue	2018/05/01
1	Record Drawing	2018/08/17

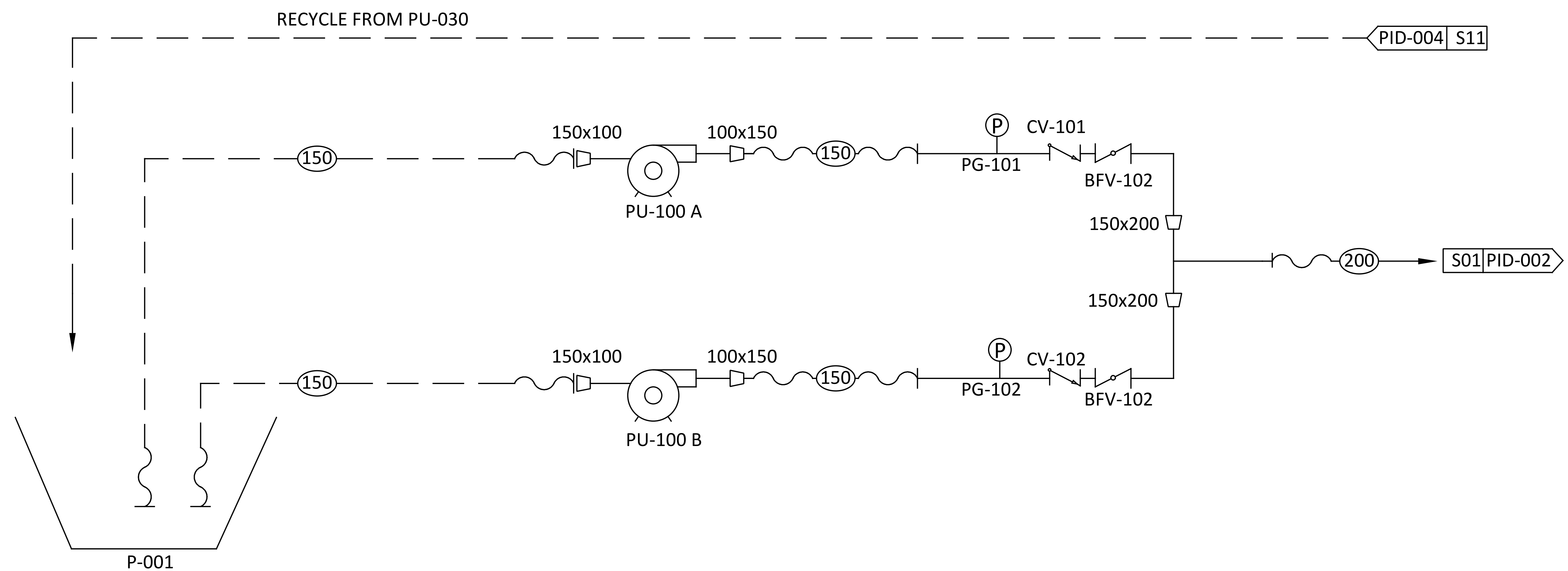
McCUE ENGINEERING CONTRATORS

CLIENT:

BAFFINLAND IRON MINES CORPORATION

BUILDING LAYOUT
GENERAL ARRANGEMENT DRAWING
Waste Rock Pile Water Treatment Plant

DATE: August 17, 2018	SCALE: AS SHOWN
DATA BY: R.B	JOB NO: 137-0001
DRAWN BY: L.S	FIG: GA-002



P-001
Inlet Storage Pond

PU-100 A/B
Pond Transfer Pump
Model: Prime Aire PA4A60-404ST
Power: Diesel Driven
Capacity: 140m³/hr

LEGEND :

- Hose
- Sch. 80 PVC Pipe
- Butterfly Valve
- Check Valve
- Reducer
- Pressure Gauge

Process based on conceptual design by Golder Associates

NO.	REVISION TABLE	DATE
0	Original Issue	April 30, 2018
1	Record Drawing	July 31, 2018

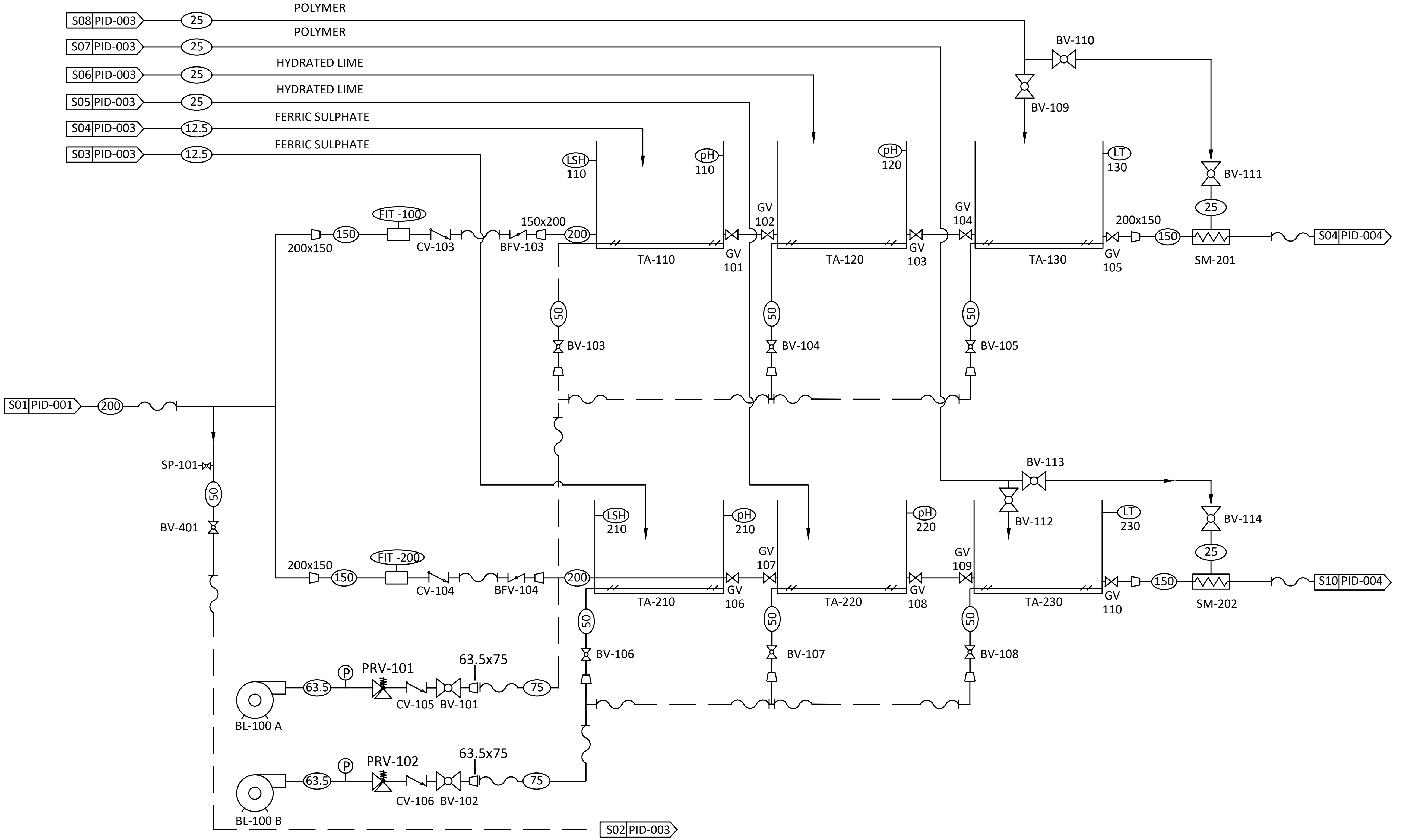
McCUE ENGINEERING CONTRACTORS

CLIENT:

BAFFINLAND IRON MINES CORPORATION

Waste Rock Water Storage Pond
PROCESS & INSTRUMENTATION DIAGRAM
Waste Rock Pile Treatment Plant

DATE: July 31, 2018	SCALE: NTS
DATA BY: R.B.	MCCUE JOB NO: 137-0001
DRAWN BY: M.T.	FIG: PID-0001



BL-100 A/B
Blower
Model: Gast R7100A-3
Power: 208V/3hp/60Hz
Capacity: 500m³/hr @ 1.9m TDH

TA-110/210
Ferric Reaction Tank
Material: Polyurethane
Size: 5.9m W x 1.5 H
Capacity: 24,820 Liters

TA-120/220
Lime Reaction Tank
Material: Polyurethane
Size: 5.9m W x 1.5 H
Capacity: 24,820 Liters

TA-130/230
Polymer Reaction Tank
Material: Polyurethane
Size: 5.9m W x 1.5 H
Capacity: 24,820 Liters

FT-100/200
Influent Flow Meter
Model: GF Signet 3-2551-P1-41

LT-130/230
Level Transmitter
Model: Echosonic 11 LU27

pH-110/120/210/220
pH Meter
Model: Walchem WEL-PHF-NN

LEGEND:

- Hose
- Sch. 80 PVC Pipe
- Butterfly Valve
- Check Valve
- Reducer
- Pressure Gauge
- Static Mixer
- Gate Valve
- Pressure Relief Valve
- Ball Valve
- Sample Port
- Flow Meter
- Level Switch
- pH Sensor
- Level Transmitter

Process based on conceptual design by Golder Associates

NO.	REVISION TABLE	DATE
0	Original Issue	April 30, 2018
1	Record Drawing	July 31, 2018

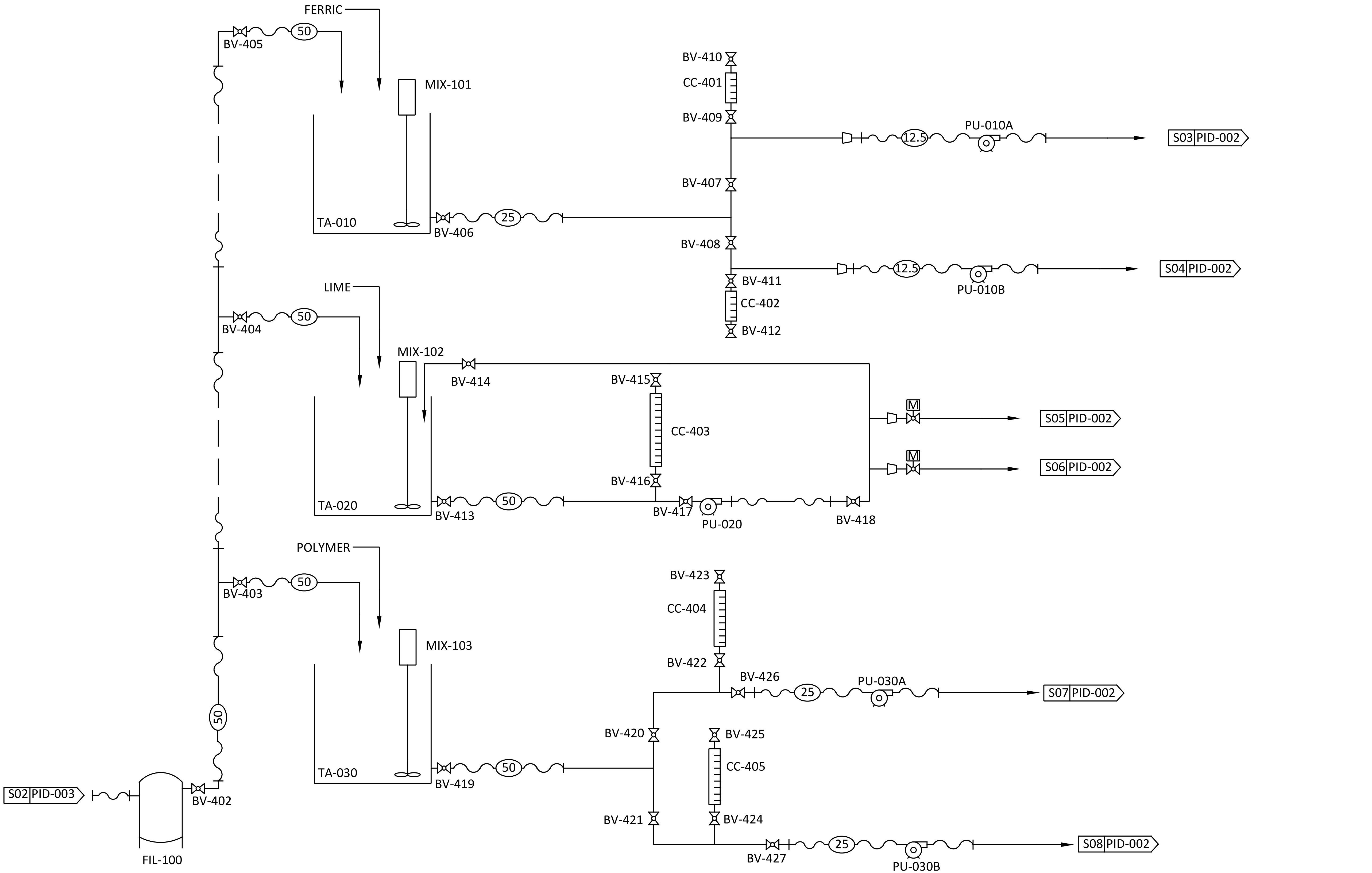
McCUE ENGINEERING CONTRACTORS

CLIENT:

BAFFINLAND IRON MINES CORPORATION

REACTION TANKS
PROCESS & INSTRUMENTATION DIAGRAM
Waste Rock Pile Water Treatment Plant

DATE: July 31, 2018	SCALE: NTS
DATA BY: R.B.	MCCUE JOB NO: 137-0001
DRAWN BY: M.T.	FIG: PID-0002



FIL-100
Bag Filter
Model: FTI 830-2P-150-CS-BS-P13-DP
Bag Size: 5 Micron

PU-010A/B
Ferric Chemical Pump
Model: Welchmen EHE31E1-VC
Power: 115 VAC/1hp/60Hz
Capacity: 21 LPM @ 106m TDH

PU-020
Lime Chemical Pump
Model: Flowmotion FR25-HR30HR
Power: 230V/3hp/60Hz
Capacity: 570 LPM @ 42m TDH

PU-030
Polymer Chemical Pump
Model: Flowmotion FR25-HR30HR
Power: 230V/3hp/60Hz
Capacity: 990 LPM @ 42m TDH

MIX-101
Ferric Mixer
Model: Dynamix DMX-5505K-1
Power: 0.5 HP, 230V/1Ph/60Hz
Shaft: 1" Diameter x 41" Long

MIX-102
Lime Mixer
Model: Dynamix DMX-5505K-2
Power: 0.5 HP, 230V/1Ph/60Hz
Shaft: 1" Diameter x 52" Long

MIX-103
Polymer Mixer
Model: Dynamix DMX-5505K-1
Power: 0.5 HP, 230V/1Ph/60Hz
Shaft: 1" Diameter x 49" Long

TA-010
Ferric Mixing Tank
Material: Polyurethane
Size: Ø 1.2m x 1.3m Height

TA-020
Lime Mixing Tank
Material: Polyurethane
Size: Ø 1.8m x 1.7m Height

TA-030
Polymer Mixing Tank
Material: Polyurethane
Size: Ø 1.6m x 1.6m Height

CC-401/402/403/404/405
Calibration Column

LEGEND:

Hose

Sch. 80 PVC Pipe

Ball Valve

Reducer

Motorized Ball Valve

Process based on conceptual design by Golder Associates

NO.	REVISION TABLE	DATE
0	Original Issue	April 30, 2018
1	Record Drawing	July 31, 2018

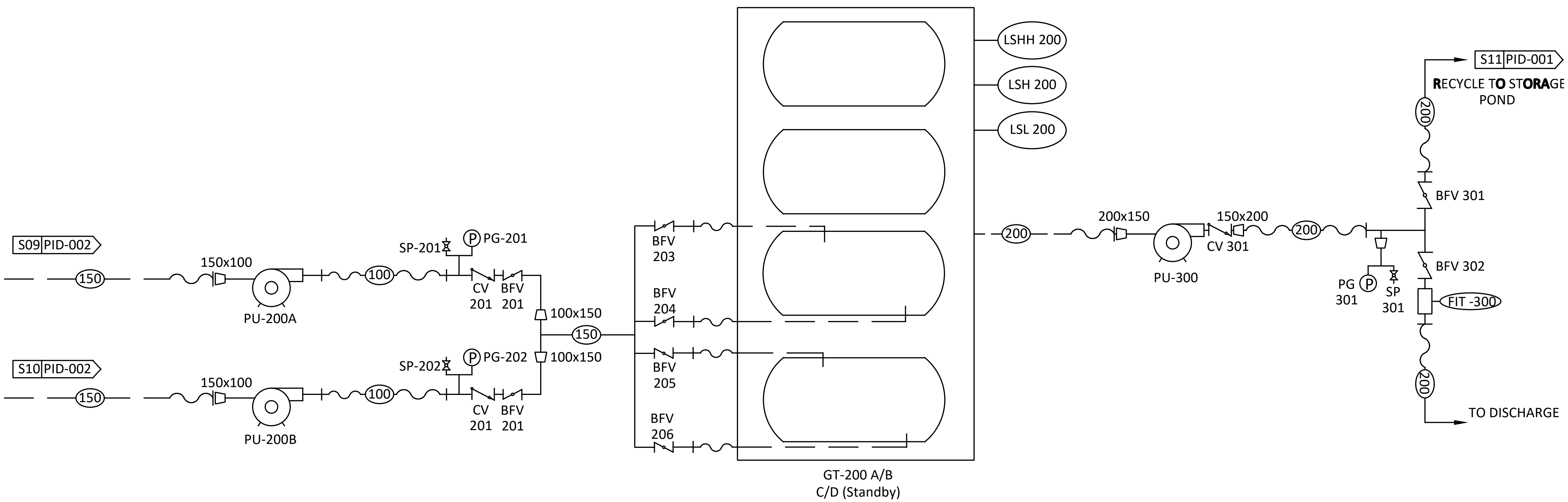
McCUE ENGINEERING CONTRACTORS

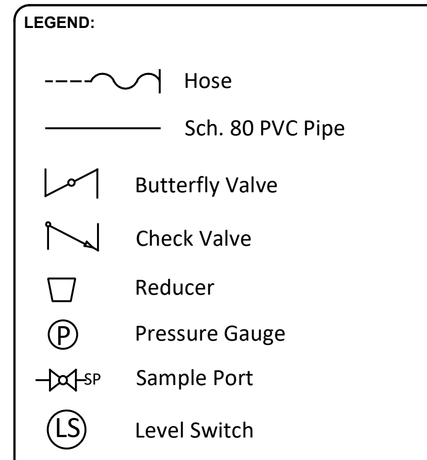
CLIENT:

BAFFINLAND IRON MINES CORPORATION

CHEMICAL MAKEUP
PROCESS & INSTRUMENTATION DIAGRAM
Waste Rock Pile Water Treatment Plant

DATE: July 31, 2018	SCALE: NTS
DATA BY: R.B.	MCCUE JOB NO: 137-0001
DRAWN BY: M.T.	FIG: PID-003





<u>PU-200A/B</u>
Transfer Pump
Model: Prime Aire PA4A60-404ST
Power: Diesel Driven
Capacity: 140m³/hr

<u>GT-200 A/B/C/D</u>
Geotube
Model: Tencare GT500
Dimensions: 60' Circumference x 100' Long

<u>PU-300</u>
Discharge Pump
Model: Prime Aire PA4A60-404ST
Power: Diesel Driven
Capacity: 280m³/hr

<u>FT-300</u>
Flow Meter
Model: Toshiba GFG32

Process based on conceptual design by Golder Associates

NO.	REVISION TABLE	DATE
0	Original Issue	April 30, 2018
1	Record Drawing	July 31, 2018

McCUE ENGINEERING CONTRACTORS

CLIENT:

BAFFINLAND IRON MINES CORPORATION

GEOTUBE FIELD
PROCESS & INSTRUMENTATION DIAGRAM
Waste Rock Pile Water Treatment Plant

DATE: July 31, 2018	SCALE: NTS
DATA BY: R.B.	MCCUE JOB NO: 137-0001
DRAWN BY: M.T.	FIG: PID-004

APPENDIX B - MONITORING

BROWNFIELDS TO GOLD MINES

Monitoring Spreadsheet

Project Name: BaffinLand Iron Mine
Waste Pile Water Treatment

			Inlet Quality			Train 1						Train 2						Discharge							
Date	Time	OP	Temp ºC	Inlet pH	Inlet TSS mg/L	FIT-100 (L/s)	pH-110	pH-120	Ferric Dosage Stroke/Speed	Lime Dosage Hz	Polymer Dosage Hz	FIT-200 (L/s)	pH-210	pH-220	Ferric Dosage Stroke/Speed	Lime Dosage Hz	Polymer Dosage Hz	FIT-300 (gpm)	FIT-300 Totalizer (gpm)	Geotube Pond pH	Geobag 1 Height (m)	Geobag 2 Height (m)	Discharge pH	Discharge Turbidity NTU	Discharge TSS (mg/L)

Observations

Chemical Availability	Week #1 Date:	Week #2 Date:	Week #3 Date:	Week #4 Date:
Ferric Sulphate				
Hydrated Lime				
Polymer				

APPENDIX C WASTE ROCK FACILITY QAQC PROGRAM PLAN

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Baffinland Iron Mines Corporation

Waste Rock Facility QAQC Monitoring Plan

BAF-PH1-340-P16-0004

Rev 0

Prepared By: Lenny Tokar / Daniel Janusauskas
Department: Mine Operations
Title: Technical Services Superintendent
Date: December 31, 2019
Signature:

Approved By: Sylvain Proulx
Department: Operations
Title: Chief Operating Officer
Date: December 31, 2019
Signature:

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DOCUMENT REVISION RECORD

Issue Date MM/DD/YYYY	Revision	Prepared By	Approved By	Issue Purpose
12/31/2019	0	LT/DJ	SP	For Use

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1 INTRODUCTION

The monitoring of waste material placement at the Deposit 1 Waste Rock Facility (WRF) is critical to ensure compliance with Baffinland's Waste Rock Management Plan (WRMP) at the Mary River Mine. Waste rock material speciation within Deposit 1 consists of two broad material types, Potential Acid Generating waste (PAG) and Non Acid Generating waste (Non-AG). To mitigate the risk for ARD at the WRF, a broad quality control (QC) and quality assurance (QA) program is required. Material classification, placement plans, placement tracking and survey information is collected as part of this program to ensure compliance with the WRMP.

2 RESPONSIBILITIES

2.1 MINE MANAGER

The Mine Manager or designate is responsible for implementing the Plan within their department and area of operation. They must ensure that their personnel understand the contents of this Plan and follow its requirements. They are responsible for auditing the WRF QAQC program and ensuring implementation of corrective actions in the event of identified non-compliances, non-conformances, and/or issues of concern.

2.2 MINE OPERATIONS SUPERINTENDENT

The Mine Operations Superintendent is responsible for the following:

- The health and safety of all persons while managing and directing activities associated with the equipment operating and labour tasks within the WRF and vicinity.
- Ensuring all activities are executed as per the plan set in place by the Technical Services Superintendent.
- Ensuring all supervisors and operators receive the proper training and understand the plan to be executed.

2.3 TECHNICAL SERVICES SUPERINTENDENT

The Technical Services Superintendent is responsible for the following:

- The health and safety of all persons while managing and directing activities associated with the technical services related to placement of waste rock and WRF stability monitoring.
- Ensuring all engineers, geologists, technicians and surveyors are properly trained and understand this Plan
- Designate responsible persons for implementing the Plan within their department and area of expertise
- Responsible for implementing an inspection program to ensure that the Plan is being fully implemented.

2.4 MINE DEVELOPMENT SUPERVISOR

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The Mine Development Supervisor, in conjunction with the Load and Haul Supervisor, is responsible for the following:

- The health and safety of all persons while managing and directing activities associated with the hauling and placement of waste rock
- Ensuring all workers and operators are trained and understand this Plan
- Inspections of the WRF and reporting of all non-conformances
- In the event that a push unit is not available to direct the dumping activities, the supervisor shall ensure the placement of used tires to indicate the dumping limits of waste material

2.5 Haul Truck Operator

Haul truck operators are responsible for the safe operation of their haul truck as outlined in the Haul Truck Operation Procedure (BAF-PH1-340-PRO-0006) and the following responsibilities:

- Carry out all pre-operation and shut down inspections as specified in Baffinland policies
- Observe all speed limits and adjust driving for the conditions during bad weather
- Follow closely all directional signs when operating at the waste rock facility
- Reporting all spills and/ or non-conformances to their supervisor
- Contacting their supervisor if uncertain about any of the tasks

2.6 Push Unit Operator

Operators are responsible for the safe operation of their equipment as outlined in the Loader Operation Procedure (BAF-PH1-300-PRO-0010) and Dozer Operation Procedure (BAF-PH1-300-PRO-0011) and the following responsibilities:

- Reading and understanding the Working Near Slopes: Pit Walls, Dumps, and Stockpiles Procedure (BAF-PH1-340-PRO-0033)
- Carry out all pre-operation and shut down inspections as per Baffinland policy
- Maintain safe conditions for haul truck dumping at the edges of the stockpile lift and at the dumping location
- Give clear communication and signals to the haul truck operator
- Ensuring material is dumped and/or pushed in such a way as to minimize material segregation and respects designated lift height
- Reporting all spills and/ or non-compliances to their supervisor
- Contacting their supervisor if uncertain about any of the tasks

2.7 Mine Engineer

Mine Engineers are responsible for the following responsibilities:

- Reading and understanding the Working Near Slopes: Pit Walls, Dumps, and Stockpiles Procedure (BAF-PH1-340-PRO-0033)

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- Short and Long Term Scheduling of placement PAG and Non-AG materials at the WRF within the guidelines of the WRMP
- Scheduling Non-AG and PAG lifts sequence
- Design ultimate WRF for existing footprint
- Ensuring WRF slopes are maintained according to original design
- Frequent WRF field visits and monitoring

2.8 Mine Geologist

Mine Geologists are responsible for the following responsibilities:

- Reading and understanding the Working Near Slopes: Pit Walls, Dumps, and Stockpiles Procedure (BAF-PH1-340-PRO-0033)
- Monitoring PAG and Non-AG placement on the WRF
- Collecting samples of PAG and Non-AG to ensure proper placement of materials
- WRF temperature monitoring by retrieving data from thermistors

2.9 Mine Surveyor

Mine Surveyors are responsible for the following responsibilities:

- Reading and understanding the Working Near Slopes: Pit Walls, Dumps, and Stockpiles Procedure (BAF-PH1-340-PRO-0033)
- Survey pick up of WRF construction development as required
- Monitoring of lift thickness to meet design requirements

3 Quality Control Program

Monitoring and collecting data associated with waste rock deposition, specifically:

1. In-Pit Material Identification
2. WRF Foundation Preparation and Tracking
3. WRF Material Placement Tracking
4. WRF Dump Thermal Modeling
5. WRF Instrumentation Monitoring

3.1 In-Pit Material Identification

In-pit waste, PAG & Non-AG, materials are classified and delineated by the Mine Geologist based upon the following parameters:

- Determination of material classification through assessment of geochemical analyses and spatial relationships within dig blocks (Figure 1) based on the criteria outlined in the WRMP (Golder 2019).

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- Areas of Non-AG and PAG rock within mining advances are flagged and staked according to material type present for ease of operator differentiation when mining (Figure 2).
- The Mine Geologist monitors the advances daily to ensure the PAG materials are being properly separated and sent to the right destination in the WRF. Truck loads are tracked in Baffinland's internal database and audited by Mine Geologists to ensure correct material type and destinations.

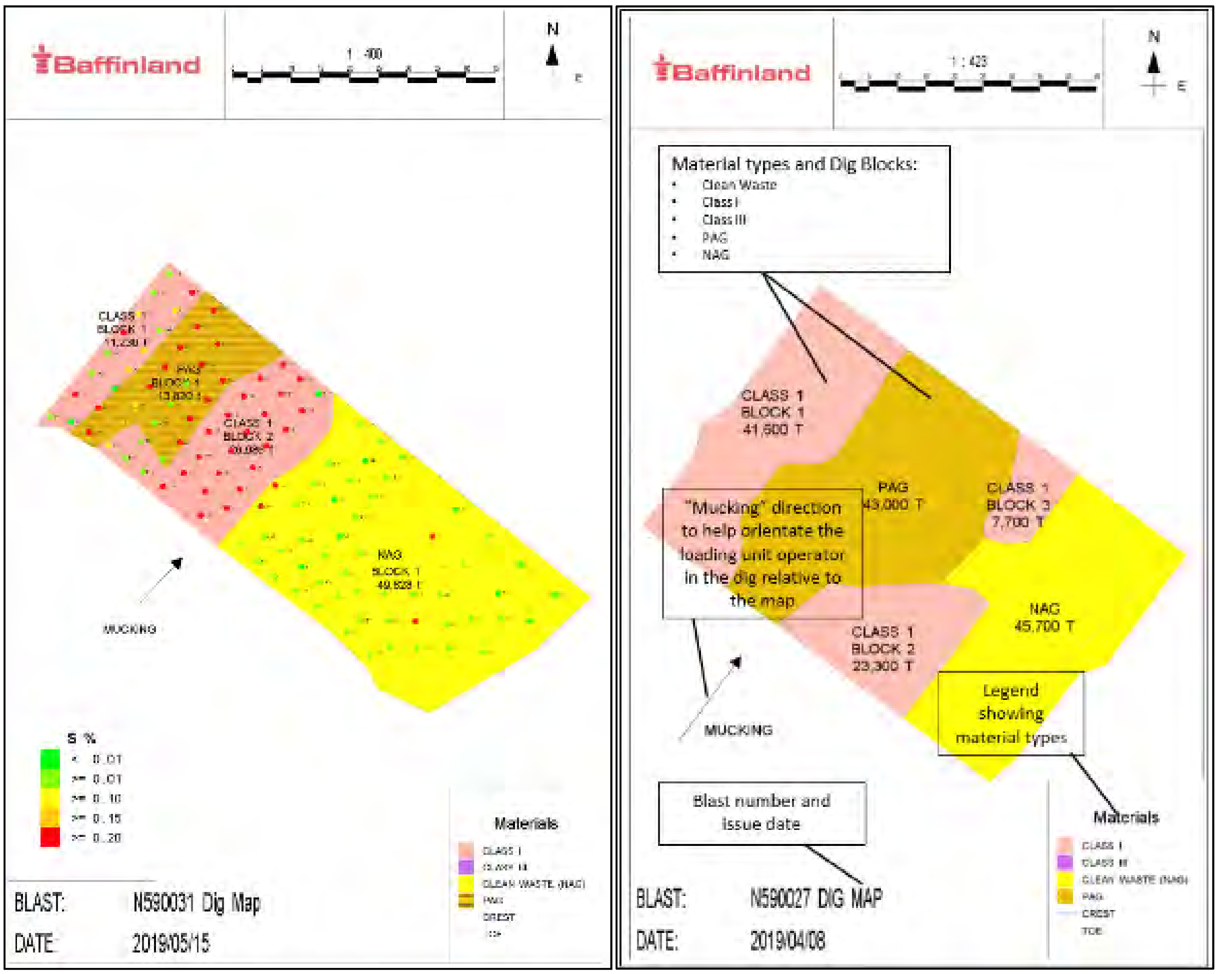

FIGURE 1: TYPICAL MATERIAL "BLOCK OUT" WITHIN A ACTUAL BLAST PATTERN FROM TWO BLAST PATTERNS CONTAINING NON-AG AND PAG

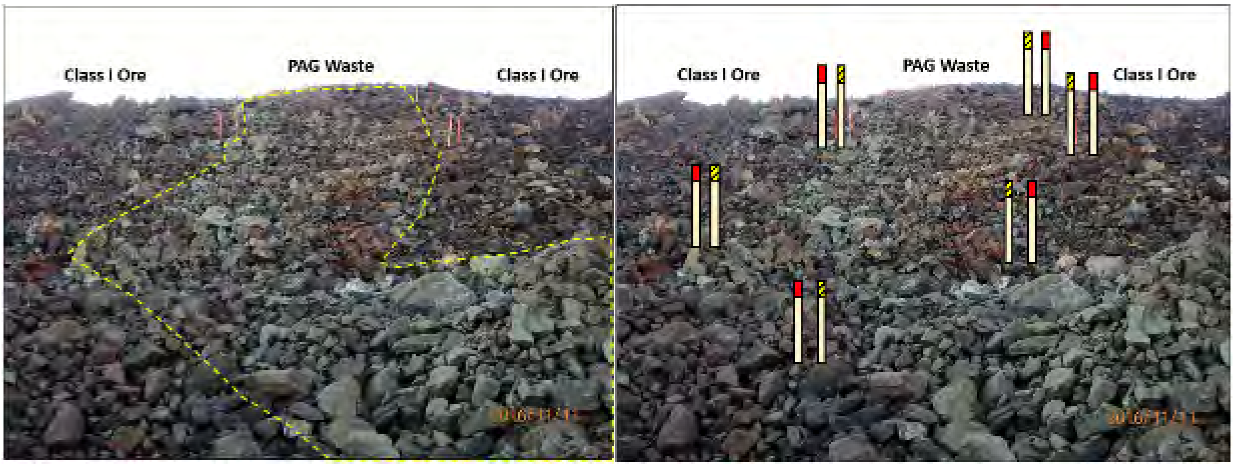

FIGURE 2: BLAST STAKE PLACEMENT FOR MATERIAL CLASSIFICATION

3.2 WRF Foundation Preparation and Tracking

Before any PAG waste materials can be deposited, a minimum 3 m base layer of Non-AG must be placed on the existing ground, preferably in the colder months of the year. The winter foundation placement ensures that an insulated frozen barrier of Non-AG rock exists between the PAG and the existing tundra.

Tracking the placement of this foundation at the WRF will consist of the following actions:

- Survey of prepared foundation extents
    - Once prior to placement of footprint expansion
    - Survey required following preparation of foundation
- Foundation construction material confirmation
    - Once prior to placement of footprint expansion
    - Identify Non-AG source within the pit for use in construction of the foundation through geochemical evaluation

3.3 WRF Material Placement Tracking

Survey Component

Prior to waste placement, Survey will delineate areas where PAG can be dumped using survey stakes. This will occur for each dump lift before during and after completion of that lift, the survey includes the following:

- Lift outline (toe and crest)
- Must stake out area to differentiate between PAG and Non-AG and inform operations of the plan

Daily Dump Plan

On a daily basis the operations team must have a dump plan that differentiates between PAG suitable and Non-AG dump areas/define general source location and placement location. The material is then dumped according to the issued Daily Dump Plan (Figure 3). The dump plan must include the following:

- Outlines of active PAG suitable dump areas are outlined in the issued daily plan and in the field
- Field checks are conducted by the technical team to ensure all limits are defined and refreshed as needed.
- Once a defined area is exhausted for dumping, a new area must be assigned and staked for the deposition of waste materials so that placement tracking can continue

Waste Rock Placement Tracking

Monthly reconciliation of Non-AG and PAG materials will occur during dump construction using the site database. This includes but is not limited to the following:

- Reconcile truck tracking to survey data using historic, current, and future survey and truck tracking information to reconcile values.
- Maintaining a database of all survey data and truck counts for the waste dump operations for future modeling and reconciliation purposes.
- Survey information and material transaction database will be stored in a centralized location on the Baffinland network.

Annual confirmatory grab sampling will be completed to validate the material placement and geochemical classification. A minimum of 10 samples from different areas and material classifications will be taken for analysis.

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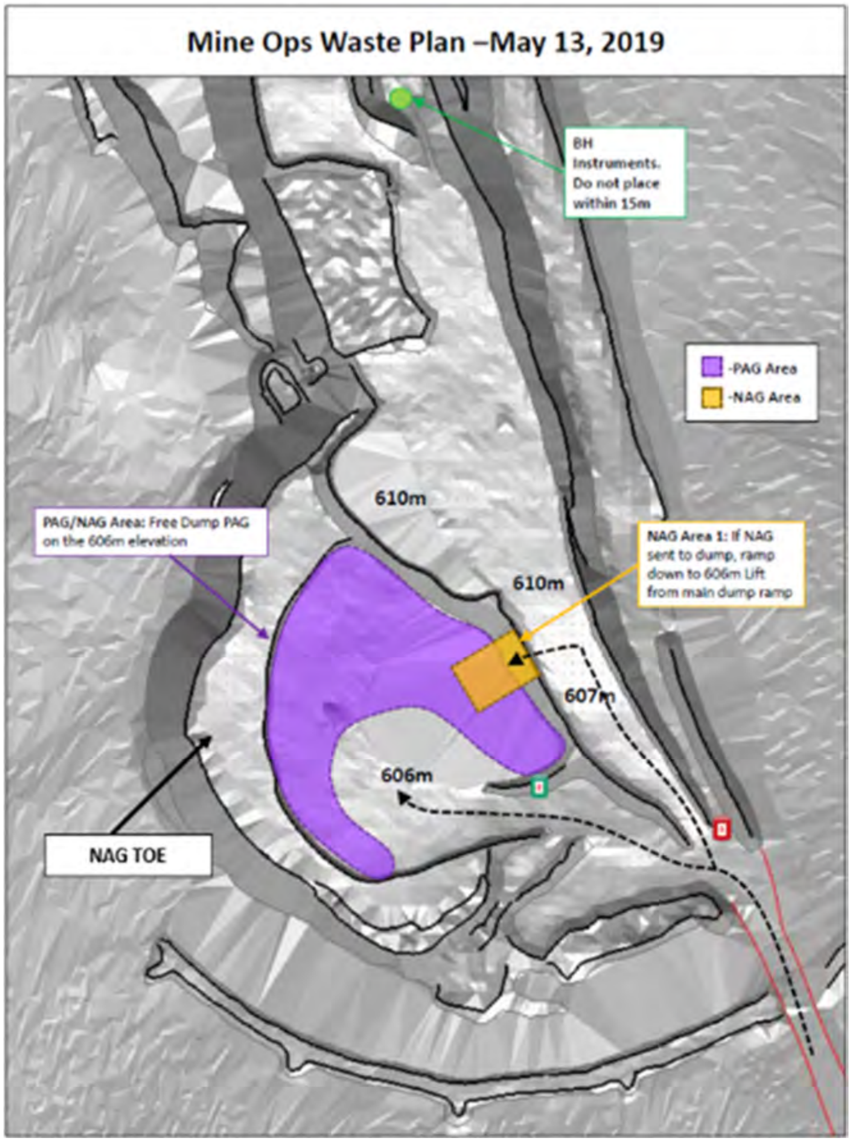

FIGURE 3: EXAMPLE OF DAILY DUMP PLAN FOR THE WRF

3.4 Thermal Instrumentation Monitoring: Data Collection

Eight thermal monitoring instruments (thermistors) have been installed throughout the WRF along with accompanying barometer, piezometers and oxygen sensors (Figure 4**)**. These instruments continuously collect temperature, oxygen and fluid flow readings from the surface to subsurface of the dump. Data is stored locally on the units and then transferred to a combined database for monitoring, interpretation and modelling (Table 1 & Table 2). This data will indicate the status of the dump i.e., frozen/properly encapsulated, subsurface flowing water, airflow, etc. An example of temperature depth profile based upon actual thermistor data can be observed in in WRMP (Golder 2019).

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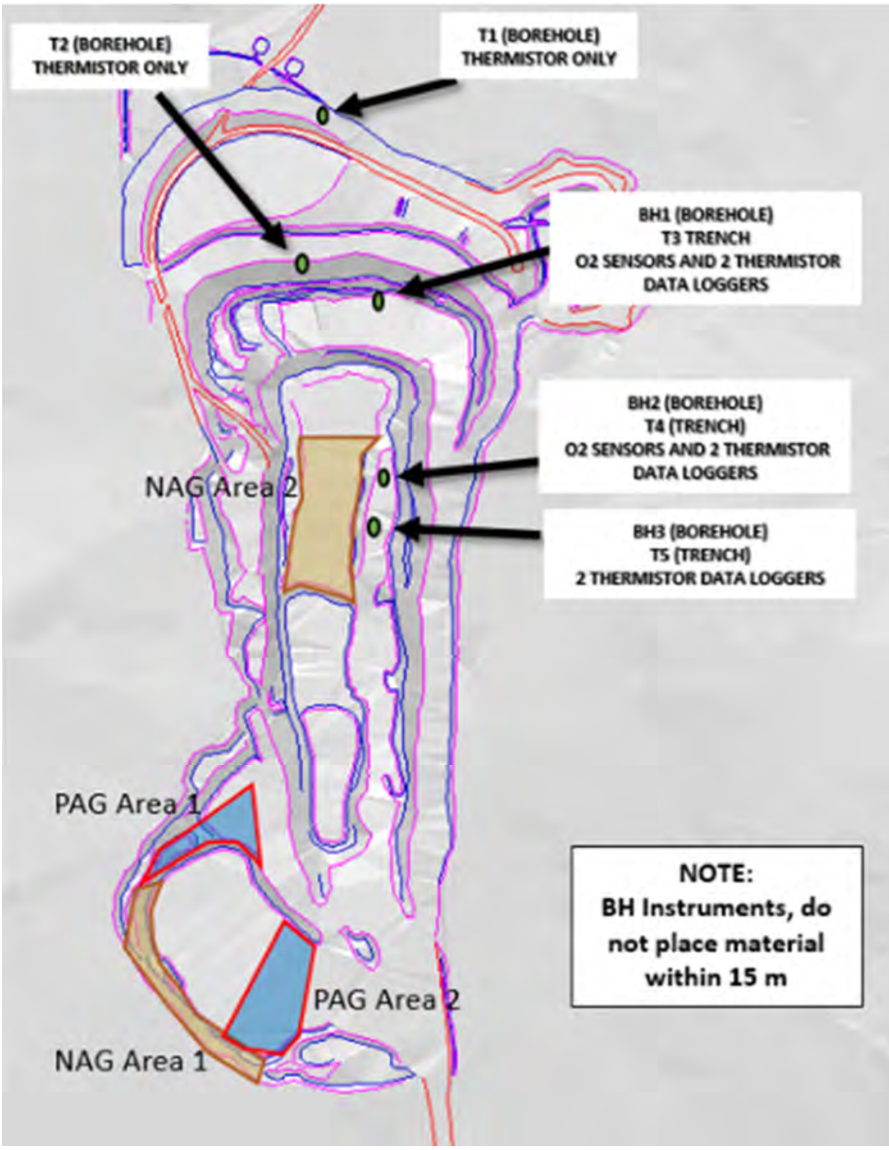

FIGURE 4: MAP OF CURRENT THERMISTOR LOCATIONS AT THE WRF

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TABLE 1: EXAMPLE OF ACCUMULATED THERMISTOR READINGS WITHIN COMBINED THERMISTOR DATABASE

TIMESTAMP	RECORD	BATTERY	Therm 1	Therm 2	Therm 3	Therm 4	Therm 5	Therm 6	Therm 1	Therm 2	Therm 3	Therm 4	Therm 5	Therm 6	LOGGER TEMP
		Volts	deg C	deg C	deg C	deg C	deg C	deg C	Ohms	Ohms	Ohms	Ohms	Ohms	Ohms	deg C
2018-12-07 16:00	1	3.53	2.64	3.01	1.98	1.9	3.34	3.35	8572.62	8414.9	8861.342	8896.398	8276.162	8270.961	1.9
2018-12-08 0:00	2	3.57	1.87	1.7	2.02	2	1.96	2.52	8910.012	8989.932	8844.438	8853.448	8869.244	8622.688	3
2018-12-08 8:00	3	3.56	5.01	5.36	4.74	4.68	5.36	5.59	7616.03	7484.774	7720.008	7742.153	7487.561	7400.81	5
2018-12-08 16:00	4	3.56	4.54	4.82	4.26	3.82	4.7	5.06	7798.314	7689.318	7907.086	8080.085	7736.369	7597.123	4.3
2018-12-09 0:00	5	3.55	4.43	4.85	4.53	3.77	4.73	4.82	7839.27	7676.889	7800.258	8099.348	7724.816	7688.361	4.3
2018-12-09 8:00	6	3.55	4.35	4.74	4.42	3.47	4.64	4.77	7871.621	7720.969	7842.205	8222.241	7759.533	7706.565	4.3
2018-12-09 16:00	7	3.55	5.18	5.58	5.35	4.92	5.5	5.43	7554.772	7403.562	7491.277	7651.148	7432.98	7459.752	5.1
2018-12-10 0:00	8	3.55	3.92	4.17	4.14	3.68	3.88	4.17	8039.703	7939.757	7953.663	8137.013	8056.837	7941.742	3.8
2018-12-10 8:00	9	3.55	1.12	1.58	2.39	0.82	1.56	2.04	9255.106	9041.762	8679.701	9399.119	9049.857	8835.439	1.9
2018-12-10 16:00	10	3.45	-16.21	-13.11	-12.19	-11.25	-10.95	-11.72	23440.68	19690.22	18718.76	17768.93	17480.57	18237.53	-20.8
2018-12-11 0:00	11	3.45	-11.66	-7.16	-5.32	-4.74	-4.45	-4.74	18180.56	14246.74	12915.22	12524.71	12340.6	12526.46	-21.2
2018-12-11 8:00	12	3.45	-11.05	-6.73	-4.83	-4.22	-4.04	-4.23	17576.85	13922.91	12589.85	12187.14	12074.56	12193.91	-20.4
2018-12-11 16:00	13	3.45	-10.83	-6.69	-4.8	-4.15	-3.98	-4.15	17368.29	13892.51	12565.15	12148.34	12036.23	12146.65	-18.9
2018-12-12 0:00	14	3.45	-10.67	-6.72	-4.83	-4.15	-3.97	-4.13	17215.66	13914.79	12588.08	12144.97	12029.58	12134.88	-17.9
2018-12-12 8:00	15	3.45	-10.55	-6.76	-4.88	-4.16	-3.97	-4.13	17103.17	13941.19	12618.16	12155.07	12029.58	12131.52	-17.2
2018-12-12 16:00	16	3.45	-10.45	-6.81	-4.94	-4.18	-3.97	-4.13	17013.42	13979.9	12657.22	12166.88	12034.57	12131.52	-17.1
2018-12-13 0:00	17	3.44	-10.36	-6.85	-4.99	-4.21	-3.99	-4.13	16927.05	14010.57	12696.46	12185.45	12042.89	12134.88	-17.1
2018-12-13 8:00	18	3.43	-10.29	-6.91	-5.05	-4.24	-4	-4.14	16860.03	14055.71	12734.06	12202.37	12051.21	12138.24	-16.9
2018-12-13 16:00	19	3.44	-10.22	-6.96	-5.11	-4.27	-4.01	-4.15	16801.38	14094.87	12777.22	12221.02	12059.54	12143.29	-16.9
2018-12-14 0:00	20	3.44	-10.16	-7	-5.17	-4.3	-4.03	-4.15	16745.66	14119.67	12815.15	12241.41	12069.55	12148.34	-16.4
2018-12-14 8:00	21	3.43	-10.11	-7.04	-5.23	-4.34	-4.05	-4.16	16703.4	14154.92	12856.87	12265.26	12081.24	12153.39	-15.8
2018-12-14 16:00	22	3.44	-10.07	-7.1	-5.29	-4.37	-4.07	-4.17	16666.55	14198.64	12898.77	12285.74	12092.95	12158.44	-15.3
2018-12-15 0:00	23	3.45	-10.05	-7.15	-5.35	-4.4	-4.09	-4.18	16645.55	14236.26	12939.03	12307.99	12104.67	12165.19	-14.9
2018-12-15 8:00	24	3.46	-10	-7.18	-5.41	-4.45	-4.11	-4.19	16601.04	14261.42	12979.46	12335.45	12118.08	12171.94	-14.5
2018-12-15 16:00	25	3.46	-9.97	-7.22	-5.47	-4.48	-4.13	-4.2	16569.73	14288.75	13020.06	12359.54	12131.52	12178.69	-14.2
2018-12-16 0:00	26	3.46	-9.91	-7.26	-5.52	-4.52	-4.15	-4.21	16520.34	14316.15	13057.12	12385.42	12144.97	12185.45	-13.9
2018-12-16 8:00	27	3.45	-9.85	-7.28	-5.58	-4.55	-4.17	-4.23	16468.57	14337.28	13096.19	12406.18	12158.44	12193.91	-13.8
2018-12-16 16:00	28	3.46	-9.8	-7.31	-5.63	-4.59	-4.19	-4.24	16419.62	14360.57	13131.68	12432.2	12173.63	12200.68	-13.7
2018-12-17 0:00	29	3.45	-9.75	-7.34	-5.69	-4.64	-4.22	-4.25	16376	14379.66	13169.18	12460.03	12188.83	12209.15	-13.6
2018-12-17 8:00	30	3.45	-9.7	-7.37	-5.73	-4.68	-4.24	-4.26	16332.54	14400.92	13203.06	12486.19	12202.37	12215.93	-13.6
2018-12-17 16:00	31	3.45	-9.66	-7.39	-5.78	-4.72	-4.26	-4.27	16296.89	14417.96	13233.27	12512.44	12217.63	12224.42	-13.7
2018-12-18 0:00	32	3.45	-9.62	-7.41	-5.83	-4.75	-4.29	-4.29	16263.88	14432.9	13269.27	12535.24	12234.61	12232.91	-13.9

TABLE 2: EXAMPLE OF ACCUMULATED OXYGEN SENSOR READINGS WITHIN THERMISTOR DATABASE COMBINED

TOA5	CR1000-2_BH-2_BIM	CR1000X	2943	CR1000X.St	CPU:BH2_v3_2019030	57738	O2_Data						
TIMESTAMP	RECORD	O2_1	Therm_1	O2_2	Therm_2	O2_3	Therm_3	O2_4	Therm	O2_5	Therm_5	Batt_V	Panel_T
TS	RN												
		Smp	Smp	Smp	Smp	Smp	Smp	Smp	Smp	Smp	Smp	Smp	Smp
2019-03-02 0:00	0	51.8479	0.322	51.04998	1.676	50.9502	0.909	50.888	0.68	51.4	-0.47	12.55	2.241
2019-03-02 8:00	1	51.61267	0.783	50.83825	2.057	50.7466	1.323	50.6798	1.16	51.2	-0.045	12.55	2.824
2019-03-02 16:00	2	51.63895	0.299	50.83665	1.785	50.7747	0.889	50.6933	0.72	51.3	-0.398	12.54	2.876
2019-03-03 0:00	3	51.30715	-2.016	50.47761	-1.1	50.4778	-1.689	50.4351	-1.82	51	-2.131	12.52	-0.318
2019-03-03 8:00	4	51.22137	-2.402	50.38119	-1.553	50.4056	-2.112	50.3572	-2.22	50.9	-2.471	12.51	-0.836
2019-03-03 16:00	5	51.73809	1.162	50.94516	2.667	50.8441	1.801	50.7936	1.58	51.3	0.213	12.51	3.327
2019-03-04 0:00	6	51.82919	-1.008	51.01131	-0.167	50.9646	-0.691	50.9428	-0.84	51.4	-1.194	12.5	0.463
2019-03-04 8:00	7	51.8333	-2.182	50.98628	-1.587	50.984	-1.999	50.9738	-2.11	51.5	-2.049	12.49	-0.997
2019-03-05 0:00	8	48.90805	-16.59	49.25462	-10.02	50.7623	-5.777	50.1045	-4.24	50.6	-2.91	12.32	-25.29
2019-03-05 8:00	9	48.92031	-15.98	49.26712	-8.75	50.1408	-3.907	49.9844	-3.2	50	-2.038	12.27	-26.13
2019-03-05 16:00	10	48.72661	-13.5	49.10737	-8.5	49.7985	-3.523	49.8433	-3.02	49.4	-1.887	12.29	-21.33
2019-03-06 0:00	11	48.87236	-14.56	49.03946	-8.42	49.5445	-3.364	49.7438	-2.94	48.9	-1.837	12.26	-25.65
2019-03-06 8:00	12	48.84439	-15.04	49.09494	-8.37	49.4863	-3.273	49.688	-2.9	48.6	-1.807	12.25	-25.22
2019-03-06 16:00	13	48.85992	-15.3	49.14276	-8.35	49.516	-3.215	49.7502	-2.87	48.5	-1.784	12.27	-22.71
2019-03-07 0:00	14	48.86707	-15.48	49.12527	-8.34	49.5371	-3.182	49.8187	-2.85	48.4	-1.777	12.24	-27.41
2019-03-07 8:00	15	48.68913	-15.6	49.03153	-8.34	49.4817	-3.16	49.8263	-2.83	48.2	-1.772	12.22	-28.22
2019-03-07 16:00	16	48.76896	-15.68	48.99052	-8.34	49.4476	-3.138	49.8018	-2.81	48	-1.753	12.26	-20.81
2019-03-08 0:00	17	48.72372	-15.76	49.05706	-8.35	49.3763	-3.129	49.7474	-2.8	47.8	-1.753	12.24	-26.05
2019-03-08 8:00	18	48.61669	-15.83	48.97954	-8.36	49.3505	-3.126	49.6844	-2.79	47.7	-1.753	12.22	-28.93
2019-03-08 16:00	19	48.48077	-15.87	48.86519	-8.36	49.3279	-3.116	49.7261	-2.78	47.5	-1.737	12.27	-18.58
2019-03-09 0:00	20	48.51405	-15.93	48.97663	-8.38	49.3698	-3.125	49.7571	-2.78	47.5	-1.746	12.22	-28.94
2019-03-09 8:00	21	48.76465	-15.99	49.09833	-8.4	49.5105	-3.131	49.9393	-2.78	47.6	-1.755	12.16	-30.95
2019-03-09 16:00	22	48.93813	-16.02	49.35818	-8.4	49.7912	-3.129	50.1908	-2.76	47.8	-1.742	12.2	-22.4
2019-03-10 0:00	23	49.03669	-16.06	49.46339	-8.41	49.9398	-3.134	50.3272	-2.76	48	-1.741	12.21	-26.11
2019-03-10 8:00	24	49.13993	-16.11	49.58327	-8.43	49.9873	-3.142	50.422	-2.76	48	-1.742	12.19	-27.02
2019-03-10 16:00	25	49.14769	-16.14	49.60706	-8.44	50.0144	-3.143	50.441	-2.75	47.9	-1.732	12.23	-21.44
2019-03-11 0:00	26	49.12251	-16.2	49.47597	-8.46	49.8862	-3.158	50.3342	-2.75	47.7	-1.746	12.16	-30.53
2019-03-11 8:00	27	48.92139	-16.24	49.32945	-8.47	49.7796	-3.169	50.1966	-2.75	47.5	-1.749	12.14	-27.48
2019-03-11 16:00	28	48.88637	-16.27	49.35628	-8.48	49.7406	-3.173	50.124	-2.74	47.4	-1.742	12.16	-24.87

The following outlines regular quality control activities associated with the WRF instrumentation monitoring:

Collection of Monitoring Data – Once Per Week

- Monitoring data to be collected based on the instrumentation reporting package

Inspection of Instrumentation – Twice per week

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Figure 5 below displays an example of an inspection form for the thermistor condition inspections.

- Instruments inspected
- Battery status
- Damage (cuts, cracking, damage to cabling or housing, other)
- If extension is required

As Required inspections in areas of active deposition, monthly inspections otherwise.

Notification of Change – As Required

Notification to Mine/Technical Services Superintendent and mine management personnel of:

- Instrumentation damage
- Instrumentation extension required

Damage photographs – As Required

Minimum of one (1) photograph of each damaged instrument (highlight damaged area)

Database Maintenance

Update database of:

- Inspection notes
- Damage and extension
- Monitoring data

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Baffinland

THERMISTOR INSPECTION LOG **DATE:** ____________

LOGGED BY: ____________

THERMISTOR #: ____________

O2 SENSOR #: ____________

1. **TRENCH OR BOREHOLE:** TRENCH BOREHOLE
2. **CABLE INSPECTION:** GOOD DAMAGED
3. **TRIPOD INSPECTION:** GOOD DAMAGED
4. **DATA COLLECTOR:** GOOD DAMAGED
5. **SOLAR PANEL:** GOOD DAMAGED
6. **BATTERY CHECK:** GOOD DEAD

COMMENTS/PHOTO DESCRIPTIONS:

FIGURE 5: EXAMPLE OF THERMISTOR INSPECTION LOG

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