# Appendix D.3

Fifteen Mile Stream Project Tailings Management Plan for Environmental Impact Statement Submission,

Knight Piésold Ltd

Prepared for
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**VA101-708/4-3**

# FIFTEEN MILE STREAM PROJECT

# TAILINGS MANAGEMENT PLAN FOR ENVIRONMENTAL IMPACT STATEMENT SUBMISSION

| Rev | Description | Date |
|---|---|---|
| 0 | Issued in Final for EIS Submission | September 30, 2019 |
| 1 | Issued with Revisions to Water Management Infrastructure | June 16, 2020 |

Knight Piésold
CONSULTING

# EXECUTIVE SUMMARY

The Tailings Management Plan outlines Atlantic Mining NS Corp.'s strategies to responsibly manage tailings produced by the Fifteen Mile Stream Project. The Project will generate tailings that will be stored in a Tailings Management Facility, located to the east of the Open Pit, adjacent to the Plant Site.

The primary objectives of this plan include ensuring the long-term physical and chemical stability of the tailings and preventing contamination of groundwater and surface waters proximal to the TMF.

This plan outlines the:

- Applicable legislation and guidelines
- The design basis and operating requirements of the TMF
- Environmental protection measures to be implemented
- Proposed monitoring to confirm the effectiveness of the mitigation strategies
- The responsibilities of AMNS and its contractors

The plan applies to the construction and operational phases of the Project. At closure, the TMF will be reclaimed as described in the Project Description of the EIS (Chapter 2).

The Tailings Management Plan is a discipline-specific biophysical management plan that forms part of AMNS's overall Environmental Management Plan (EMP) developed for The Project. AMNS will update this as part of the Industrial Approval (IA) application process and prior to construction to reflect relevant design changes during detailed engineering, and through the life of the Project based on the outcome of management reviews, incident investigations, regulatory changes, or other Project-related changes.

Related environmental management plans are presented in the Environmental Management System Framework document provided in the appendices to the EIS.

This plan has been prepared to comply with existing regulations and follow the available guidelines provided by the federal and provincial governments.

The proposed Process Plant throughput is approximately 5,500 tonnes per day (tpd). Tailings will be produced at a slurry solids content of approximately 38% solids by weight before being pumped to the TMF. The tailings will be conveyed in a single overland pipeline and discharged from the TMF embankment via spigotted offtakes.

A total of 13.4 million tonnes (Mt) of tailings will be discharged to the TMF over the 7-year mine life. The estimated average settled dry density of the tailings is approximately 1.3 tonnes per cubic metre ($t/m^3$).

During the Construction Phase, a starter dam will be constructed using material generated from pre-stripping of the Open Pit and from excavation of a local till borrow source and will provide approximately 12 months of tailings storage. An embankment raise is scheduled to take place during the first year of operations. The TMF embankments will be progressively expanded at scheduled intervals during operations, utilizing the downstream method of construction.

Materials from the Open Pit (non-acid generating (NAG) waste rock) and borrow pits (low-permeability till) will be used to construct the expansions. The embankment will include an upstream liner system with the liner extending from the upstream toe of the embankment into the TMF basin to control seepage gradients prior to the development of the tailings beaches.

Measures will be taken to:

- Minimize exposure of the tailings to the atmosphere, to reduce ML/ARD, and also reduce potential dusting
- Prevent runoff and seepage from interacting with surface or groundwater
- Stabilize the TMF embankments
- Prevent harm to wildlife

Adaptive management may be required if environmental performance monitoring indicates results that differ from those predicted. The need for any corrective actions to on-site management of the TMF or installation of additional control measures will be determined on a case-by-case basis, based on monitoring conducted as described above.

Guidelines for monitoring, inspection and reporting on the performance of the TMF are outlined in the Canadian Dam Association Dam Safety Guidelines and the CDA Technical Bulletin on the Application of the Dam Safety Guidelines to Mining Dams.

These documents provide requirements for dam safety inspections and reviews, and the development of an Operations, Maintenance, and Surveillance (OMS) Manual as well as an Emergency Preparedness and Response Plan (EPRP) specific to the TMF. The OMS Manual and EPRP will be prepared as part of an Industrial Approval Application and will be reviewed and revised annually and as each staged TMF expansion is constructed.

Geotechnical instrumentation will be installed in the TMF embankments and foundation during construction, and will be utilized during the Operation, Closure and Reclamation, and Post-Closure Phases of the Project.

AMNS will submit annual reports as required by the Nova Scotia Department of the Environment (NSE) and as outlined in the IA.

Roles and responsibilities with respect to tailings management will be developed and assigned as part of the preparation of the OMS Manual. Prior to conducting any work on the mine site, AMNS will designate a Mill Operations Manager who must be present onsite regularly, and who is ultimately responsible for application of all requirements on the site. As such the Mill Operations Manager is ultimately responsible for the safety of the TMF.

The Mill Operations Manager or designate will conduct regular evaluations of the monitoring activities as needed. This Plan may be updated if additional methods for monitoring are found to be more appropriate.

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# ABBREVIATIONS

AEMP ........ aquatic effects management plan
AMNS ........ Atlantic Mining NS Corp.
AQDMP ........ air quality and dust management plan
ARD ........ acid rock drainage
CDA ........ Canadian Dam Association
EDF ........ environmental design flood
EDGM ........ earthquake design ground motion
EIS ........ environmental impact statement
EMP ........ environmental management plan
EoR ........ Engineer of Record
EPRP ........ emergency preparedness and response plan
ERP ........ emergency response plan
ESCP ........ erosion and sediment control plan
FMS ........ Fifteen Mile Stream
IDF ........ inflow design flood
ITRB ........ independent tailings review board
KP ........ Knight Piésold Ltd.
MAC ........ Mining Association of Canada
MDE ........ maximum design earthquake
MDMER ........ Metal and Diamond Mine Effluent Regulations
ML ........ metal leaching
mm ........ millimetres
Mt ........ million tonnes
NPAG ........ non-potentially acid generating
NSE ........ Nova Scotia Department of Environment
OBE ........ operating basis earthquake
OMS ........ operating, maintenance and surveillance
PAG ........ potentially acid generating
PGA ........ peak ground acceleration
PMF ........ probable maximum flood
Project, the ........ Fifteen Mile Stream Project, the
QA/QC ........ quality assurance/quality control
QPO ........ quantitative performance objective
SOP ........ standard operating procedure
SWMP ........ site water management plan
SWMS ........ surplus water management system
$t/m^3$ ........ tonnes per cubic metre
TMF ........ tailings management facility
TMP ........ tailings management plan
tpd ........ tonnes per day
TSS ........ total suspended solids
WTP ........ water treatment plant

# 1.0 GENERAL

## 1.1 PURPOSE

The Tailings Management Plan (TMP) outlines Atlantic Mining NS Corporation's (AMNS) strategies to responsibly manage tailings generated at the Project. The Project will generate tailings that will be stored in a Tailings Management Facility (TMF) located to the east of the Open Pit (Figure 1.1).

The TMP is a discipline-specific biophysical management plan that forms part of the Project's Environmental Management System (EMS). AMNS will update this plan prior to construction to reflect relevant design changes resulting from detailed engineering. It will also be refined throughout the life of the Project based on the outcome of management reviews, incident investigations, regulatory changes, or other Project-related changes.

Related environmental management plans are presented in the Environmental Management System Framework document provided in the appendices to the EIS.

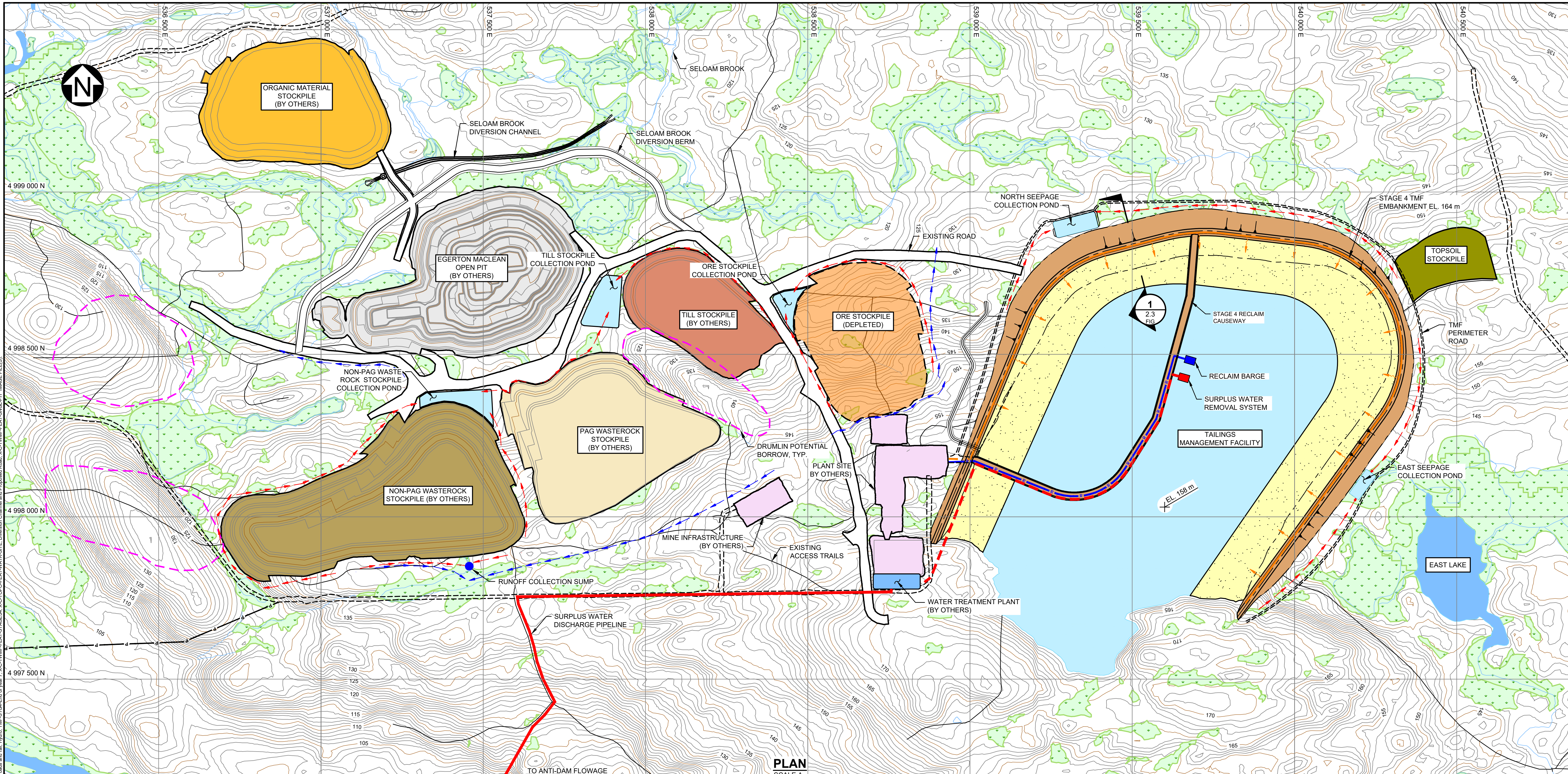
## 1.2 SCOPE AND OBJECTIVES

The primary objectives of tailings management activities are to ensure the long-term physical and chemical stability of the tailings and prevent contamination of groundwater and surface waters proximal to the TMF.

This plan outlines:

- Applicable legislation and guidelines
- Design basis and operating requirements of the TMF
- Environmental protection measures to be implemented
- Proposed monitoring to confirm the effectiveness of the mitigation strategies
- Responsibilities of AMNS

This plan applies to the Construction and Operation Phases of the Project. At closure, the TMF will be reclaimed as described in Project Description of the EIS (Chapter 2).




**LEGEND:**

- MINE WATER
- FRESH WATER
- TAILINGS
- EMBANKMENT FILL
- WETLAND
- OPEN PIT (BY OTHERS)
- ORE STOCKPILE (DEPLETED)
- PAG STOCKPILE (BY OTHERS)
- NON-PAG STOCKPILE (BY OTHERS)
- TILL STOCKPILE (BY OTHERS)
- ORGANIC MATERIAL STOCKPILE (BY OTHERS)
- PLANT SITE (BY OTHERS)
- TOPSOIL PILE (BY OTHERS)
- RECLAIM PUMPS
- SURPLUS WATER REMOVAL SYSTEM
- WATER MANAGEMENT POND
- STREAM
- EXISTING ROAD
- PROPOSED ROAD
- SEEPAGE COLLECTION DITCH
- NON-CONTACT WATER DITCH
- POWERLINE
- RECLAIM WATER PIPE
- SURPLUS WATER PIPELINE
- SURPLUS WATER DISCHARGE PIPELINE
- TAILINGS DISCHARGE PIPE
- TAILINGS DEPOSIT

**NOTES:**

1. COORDINATE GRID IS NAD83, ZONE 20 T.
2. CONTOURS BASED ON 2014 LIDAR OBTAINED FROM GEONOVA, REPRODUCED AND DISTRIBUTED WITH THE PERMISSION OF INTERNAL SERVICES. CONTOURS HAVE BEEN PRODUCED BY KNIGHT PIESOLD LTD. AND INCLUDES DATA PROVIDED BY INTERNAL SERVICES. THE INCORPORATION OF DATA SOURCED FROM INTERNAL SERVICES WITHIN THIS PRODUCT SHALL NOT BE CONSTRUED AS CONSTITUTING AN ENDORSEMENT BY INTERNAL SERVICES OF OUR PRODUCT.
3. WETLAND AND WATER COURSE MAPPING PROVIDED BY McCALLUM ENVIRONMENTAL LTD. SEPTEMBER 06, 2018. DATA PROVIDED IN DRAFT WITH NO IMPLIED WARRANTIES AND SHALL BE CONSIDERED PRELIMINARY.
4. DIMENSIONS AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.

**FOR INFORMATION ONLY**

SCALE A 100 50 0 100 200 300 400 500 600 m

ATLANTIC MINING NS CORP.

FIFTEEN MILE STREAM PROJECT

**PROJECT OVERVIEW**

Knight Piésold CONSULTING

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| FIGURE 1.1 | REV 1 |
|---|---|

| REV | DATE | DESCRIPTION | DESIGNED | DRAWN | REVIEWED |
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SAVED: M:\1\01\00708\04\A\Acad\FIGS\B36, 6/12/2020 3:07:25 PM , SCAMMAYO PRINTED: 6/15/2020 11:02:43 AM, FIG 1.1, SCAMMAYO ACAD VERSION: 23.0S (LMS TECH)

## 1.3 CORPORATE GOVERNANCE

AMNS is committed to developing an Environmental Management System (EMS) based on environmental risk; as a due diligence procedure from the perspectives of fiscal, legal, social and environmental responsibility. Development and implementation of the EMS, with associated procedures to be detailed in an Environmental Protection Plan (EPP), will include all phases of the TMF from construction to operation, maintenance, monitoring and ultimately closure, as well as integrate other aspects such as documentation. It is intended that the EMS and associated procedural level EPP will integrate systems, plans and processes across the Fifteen Mile Stream Project, including the Best Applicable Practices (BAPs) for tailings management.

## 1.4 APPLICABLE LEGISLATION AND GUIDELINES

This plan has been prepared to comply with existing regulations and follow the available guidelines provided by the federal and provincial governments. The following guidelines and regulations have been considered in the development of the tailings management plan:

- Canadian Dam Association, 2013. 2007 Dam Safety Guidelines – 2013 Revision.
- Canadian Dam Association, 2014. Technical Bulletin – Application of Dam Safety Guidelines to Mining Dams.
- Government of Canada, 2016. *Fisheries Act, 1995.* R.S.C., 1985, c. F-14. Amended 2016.
- Government of Canada, 2018. *Canadian Environmental Protection Act, 1999.* S.C. 1999, c.33. Amended 2018.
- Government of Canada, 2018. *Metal and Diamond Mining Effluent Regulations*. SOR/2002-222. Amended 2018.
- Environment and Climate Change Canada, 2009. *Environmental Code of Practice for Metal Mines*.
- Government of Nova Scotia, 2017. Nova Scotia *Environment Act,* Chapter 1 of the Acts of 1994-95 (Amended 2017).
- Government of Nova Scotia, 2018. Nova Scotia *Mineral Resources Act*, Chapter 3 of the Acts of 2016 (Amended 2018).
- Government of Nova Scotia, 2016. Nova Scotia *Occupational Health and Safety Act*, Chapter 7 of the Acts of 1996 (Amended 2016).
- Government of Nova Scotia, 1995. Nova Scotia *Water Act,* Chapter 500 of the Revised Statutes, 1989 (Amended 1995).
- Government of Nova Scotia, 2000. Nova Scotia *Water Resources Protection Act,* Chapter 10 of the Acts of 2000.
- Mining Association of Canada (MAC), 2017. *A Guide to the Management of Tailings Facilities.* Third Edition.
- Mining Association of Canada (MAC), 2019. *Developing an Operation, Maintenance and Surveillance Manual for Tailings and Water Management Facilities*. Second Edition.

## 1.5 STAKEHOLDER ENGAGEMENT AND COLLABORATION

AMNS will develop or continue existing procedures for collaborative engagement with all stakeholders and the Mi’kmaq of Nova Scotia in the areas impacted by tailings or dam activities to improve overall tailings and watershed stewardship. Evidence demonstrating stakeholder and Mi’kmaq engagement on tailings issues will be reviewed on an ongoing basis. All tailings related complaints from stakeholders or the Mi'kmaq within the geographic setting will be summarized as part of Complaints Response Procedure and reviewed at least annually.

Regulatory liaison on all phases of tailing management is of mutual benefit to AMNS and regulatory bodies. Development of BAPs for tailings management is intended to be a collaborative process. While inputs from broader stakeholder and Mi'kmaq engagement will support this, AMNS intends to directly collaborate with staff of Nova Scotia Environment (NSE) and Department of Natural Resources (DNR) on all aspects of its tailings management strategy from design through to construction, operation, maintenance, monitoring and ultimately closure of the TMF.

AMNS is committed to providing summaries of comments and documents from the IE and ITRB on an ongoing periodic basis. In the event that the IE or ITRB identify conditions that demonstrate the potential for non-compliant conditions, these findings will be conveyed to regulators immediately with together with an appropriate corrective action plan.

# 2.0 RELEVANT PROJECT ACTIVITIES

## 2.1 TAILINGS PRODUCTION

The proposed Process Plant throughput is approximately 5,500 tonnes per day (tpd). Tailings will be produced at a slurry solids content of approximately 38% solids by weight before being pumped to the TMF. The tailings will be conveyed in a single overland pipeline and discharged from the TMF embankment via spigotted offtakes.

A total of 13.4 million tonnes (Mt) of tailings will be discharged to the TMF over the 7-year mine life. The estimated average settled density of the tailings is approximately 1.3 tonnes per cubic metre ($t/m^3$).

## 2.2 TAILINGS GEOCHEMISTRY

The geochemistry of the FMS tailings are presented in a separate report provided in the appendices of the EIS (Lorax Environmental Services Ltd. (Lorax), 2019).

## 2.3 TAILINGS MANAGEMENT FACILITY

The TMF will contain tailings for the life of the Project. While this plan describes the TMF, supporting information is provided in the report *Preliminary Waste and Water Management Design for Submission of the Environmental Impact Statement* (Knight Piésold Ltd., 2019), included as an appendix to the EIS.

### 2.3.1 TMF BEST APPLICABLE PRACTICES

Key aspects for tailings management include:

- Identifying issues and concerns
- Managing liabilities
- Identifying opportunities for cost and operational efficiency
- Providing input into design, construction, operation and closure and rehabilitation
- Providing input into the monitoring, surveillance and associated record keeping
- Educating operators and the Mi’kmaq and external stakeholders alike
- Improving data management
- Providing a standardized review process to ensure implementation of BAPs

AMNS’s corporate governance supports development of Best Applicable Practices (BAPs) specific to the FMS TMF. BAPs will be adhered to in all phases of construction, operation, and closure and reclamation of the TMF. BAPs will be developed based on industry definition and relevant guidelines and legislation, including CDA Dam Safety Guidelines (CDA 2013 & 2014), and the MAC guidelines on *Developing an Operation, Maintenance and Surveillance Manual for Tailings and Water Management Facilities* (MAC, 2019).

BAPs will be adhered to through the development of Quantitative Performance Objectives (QPOs) to be incorporated into the standard operating procedure for the TMF. These will include measuring and reporting on tailings beach lengths, calibration of TMF filling schedule during operations, water balance audits, construction material availability, and scheduling to ultimate TMF embankment heights. QPOs will be developed as part of the Operation, Maintenance and Surveillance (OMS) Manual that will be prepared for the TMF.

### 2.3.2 GENERAL DESCRIPTION AND FILLING SCHEDULE

The general arrangement of the TMF is presented in Figure 2.1, and its location is at UTM 539,045 E and 4,998,615 N (Zone 20T NAD 83). The TMF will utilize natural topographical containment provided to the south of the facility to minimize embankment construction requirements. The TMF has one rock/earthfill embankment that impounds the TMF to the west, north, and east. The embankment is approx. 3,000 m long at its centreline with a maximum height of approx. 28 m. The embankment will include an upstream liner system with the liner extending from the upstream toe of the embankment into the TMF basin to control seepage gradients prior to the development of the tailings beaches.

The TMF will be constructed in four stages, as shown with the TMF filling curve on Figure 2.2. The first stage during the Construction Phase will involve constructing a starter dam using non-potentially acid generating (NPAG) material generated from pre-stripping of the Open Pit and from excavation of a local till borrow source and will provide approximately 12 months of tailings storage. Embankment raises will be undertaken during the first year of operations and subsequently in year 3 and year 6 of operations, all utilizing the downstream method of construction. Non-potentially acid generating (NPAG) waste rock from the Open Pit and low-permeability till from borrow pits will be used to construct the expansions.

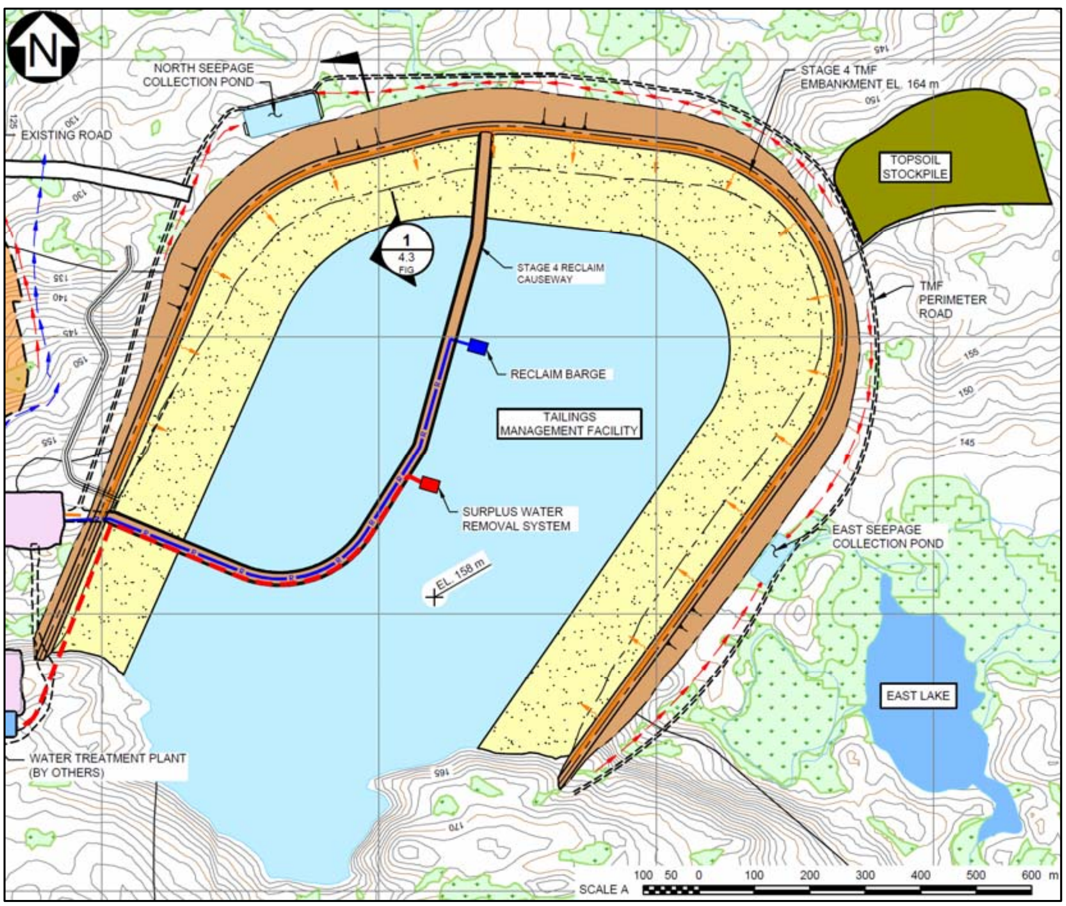
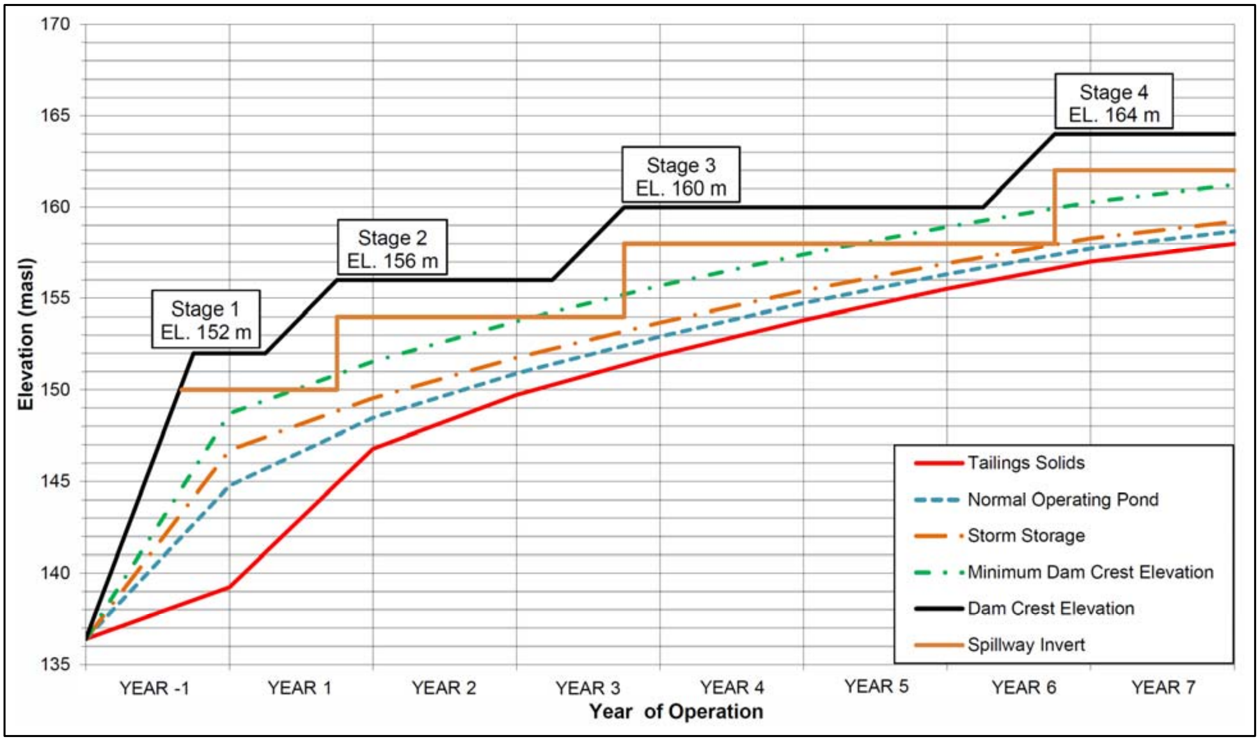



**Figure 2.1 TMF General Arrangement**




**NOTES:**

1. TAILINGS TONNAGE AND MILL RAMPUP SCHEDULE BASED ON JUNE 2019 PRODUCTION SCHEDULE.
2. AVERAGE SETTLED TAILINGS DENSITY ASSUMED TO BE 1.3 TONNES PER $M^3$ DURING OPERATIONS.
3. MINIMUM DAM CREST ELEVATION ASSUMED 2 METRES ABOVE REQUIRED ELEVATION FOR STORM STORAGE (INCLUDES ALLOWANCE FOR SPILLWAY DEPTH).

**Figure 2.2 TMF Filling Schedule**

### 2.3.3 DESIGN BASIS AND OPERATING CRITERIA

The design of the TMF has considered the following requirements:

- Permanent, secure, and total confinement of all solid waste materials within an engineered disposal facility
- Control, collection, and removal of free draining liquids from the tailings during the Operation Phase for recycling as process water to the maximum practical extent
- The inclusion of monitoring features for all aspects of the facility to ensure performance goals are achieved and design criteria and assumptions are met

The following factors have been considered in the design of the TMF:

- Assumed physical and chemical characteristics of the tailings material, including metal leaching and acidic drainage potential as well as the potential for liquefaction
- Hydrology and hydrogeology, including local climatic conditions and extreme weather events (including projections of climate variability)
- Availability and characteristics of construction materials
- Topography of the TMF footprint and adjacent areas

The TMF will store runoff from an Environmental Design Flood (EDF) as per Canadian Dam Association (CDA) Dam Safety Guidelines (CDA, 2013 & 2014). The EDF for the facility is equivalent to the total precipitation from a 1-in-200 year 24-hour precipitation event in addition to the estimated maximum monthly precipitation across the entire TMF catchment. Flood events exceeding the EDF, up to a Probable Maximum Flood (PMF) event will be safely conveyed from the TMF through an emergency discharge spillway, located in the southwestern abutment of the TMF embankment.

Non-contact water will be diverted around site facilities to the maximum practicable extent to minimize the impact to local water courses and the unnecessary collection of fresh water. Diversion channels will collect and divert runoff from undisturbed catchment areas for precipitation events up to a 1-in-200-year precipitation event.

Contact water from site facilities will be collected in a system of ditches that convey collected flows to water management ponds. The ponds were designed to store catchment runoff for the 1-in-10 year 24-hour storm event (conveyed by systems of collection ditches) plus direct precipitation for the 1 in 200-year 24-hour storm event on the surface of the ponds.

### 2.3.4 DAM CLASSIFICATION

The design, construction, operation, and monitoring of dams, including tailings embankments, must be completed in accordance with appropriate provincial and federal regulations and industry best practices. The primary guidance documents for dam classification are the Dam Safety Guidelines published by the Canadian Dam Association (CDA, 2013), and the CDA Technical Bulletin on the Application of the Dam Safety Guidelines to Mining Dams (CDA, 2014).

A key component of these guidelines involves assigning the dam into a classification category (Low, Significant, High, Very High, or Extreme) using the following criteria:

- Population at risk
- Loss of life
- Environmental and cultural values
- Infrastructure and economics

The overall dam classification is defined by the criterion with the highest (i.e., most severe) rating. The dam classification helps to identify appropriate geotechnical and hydrotechnical design criteria. It is important to note that the classification refers to the downstream consequences in the inundation zone of a dam breach.

The Fifteen Mile Stream Project TMF embankments have been assigned a dam classification of **HIGH**. The potential incremental losses are as follows:

- **Population at Risk:** The population at risk was determined based on the likelihood of people being in the potential inundation zone. There is no permanent population downstream of the TMF. Temporary population will be present in the form of mine workers, and users of nearby roads. Therefore, the risk to population was determined to be **Significant**.
- **Loss of Life:** The loss of life factor considers the most probable size of the population at risk if failure occurs. For the Project site, this includes mine workers and users of nearby roads, and is estimated to be fewer than 10 people at any one time. The potential loss of life was therefore determined to be **HIGH**.

- **Environmental and Cultural Values:**
  - Environmental loss considers the potential loss or deterioration of fish and wildlife habitat in the affected area. In the event of a breach of the TMF embankment, tailings and supernatant water will flow north into Seloam Brook and subsequently into the Open Pit. While Seloam Brook has evidence of brown trout and dolly varden populations, it is not critical fish habitat. Therefore, the impact on wildlife was classified as **HIGH**.
  - Cultural losses are based on the potential impact to areas of cultural significance in the inundation zone. No considerable impact on culturally sensitive areas is predicted, therefore potential loss of cultural values was determined to be **Low**.
- **Infrastructure and Economics:** Infrastructure and economic losses consider potential damage to transportation routes, commercial and recreational facilities, other infrastructure, services, and storage facilities. Minor highways and seasonal roads are located downstream of the TMF along potential breach flow paths to the south or the northeast. Therefore, the infrastructure and economic losses were determined to be **Significant**.

### 2.3.5 INFLOW DESIGN FLOOD

The Canadian Dam Association Dam Safety Guidelines (CDA, 2013 & 2014) states that for tailings dams of a 'HIGH' dam classification, the minimum target design criteria for design flood events corresponds to the following return period events:

- Construction and Operations Phase: 1/3 between the 1/1,000-year return period event and the Probable Maximum Flood (PMF)
- Post-Closure Phase: 2/3 between the 1/1,000-year return period event and the PMF

### 2.3.6 SEISMICITY

The Canadian Dam Association Dam Safety Guidelines (CDA, 2013 & 2014) states that for tailings dams of a 'HIGH' dam classification, the minimum target design criteria for seismic loading corresponds to the following return period events:

- Construction and Operations Phase: the 1/2,475-year return period seismic event
- Post-Closure Phase: 1/2 between the 1/2,475 year and the 1/10,000-year (or MCE) return period seismic events

The Earthquake Design Ground Motion (EDGM) for the Construction and Operations Phases is the Operating Basis Earthquake (OBE). The OBE is the earthquake that a structure must safely withstand no damage and has a reasonable probability of occurring during the life of the structure.

The EDGM for the Post Closure Phase is the Maximum Design Earthquake (MDE) for the life of the TMF. The MDE is the earthquake that would generate the most critical ground motions for evaluation of the seismic performance of a structure among those loadings to which the structure might be exposed.

### 2.3.7 TMF EMBANKMENTS

A typical embankment cross-section is shown on Figure 2.3. The main design features of the TMF embankments are as follows:

- Starter dam sized to provide approximately 12 months of tailings and supernatant water storage; starter dam crest elevation of 152 m
- Progressive embankment raises throughout operations using downstream expansion methods
- Low-permeability till (Zone S) liner on upstream TMF embankment face and partial coverage of TMF basin
- Filter (Zone F) and Transition Zone (Zone T) zones on upstream face of embankment to minimize migration of fines using processed NPAG waste rock from Open Pit mining
- Shell zone (Zone C) consisting of NPAG waste rock from Open Pit mining activities

The ponds and ditches downstream of the TMF embankment will also be sized to collect and manage seepage flows through the TMF embankments in addition to runoff and precipitation. The seepage collection ponds were sized to collect flows up to a 1 in 10-year precipitation event falling on the contributing catchment area. Collected flows will be pumped back to the TMF supernatant pond over a 10-day drawdown period.

### 2.3.8 WATER MANAGEMENT

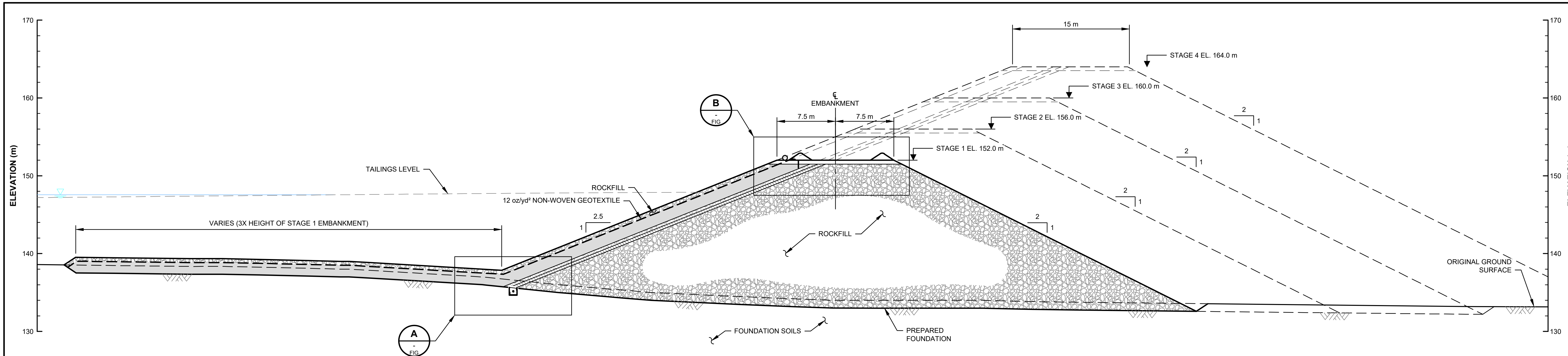
Site water management planning considers the management of surface water at the Project site during the construction, operations, closure, and post-closure phases of the Project. Surface water will be managed by constructing systems of ditches, ponds, berms, and pump and pipeline systems, and by selective grading disturbed surfaces. Two types of surface water are considered in the water management strategy.

- Contact water, which is water impacted by mine workings or disturbed areas (open pit dewatering flows; TMF seepage; runoff from the waste rock stockpile, ore stockpile, till stockpile, topsoil stockpiles, TMF embankments, etc.)
- Non-contact water, which is runoff from undisturbed areas

The water management plan forms the basis of a site wide water balance, which has been developed on a monthly basis and considers a range of climatic conditions consistent with historic variability in the project area. The primary goal of the water balance model is to estimate the anticipated volume of surplus water that must be released from the mine site on an annual basis to manage the inventory of water stored in the TMF within a target range consistent with the design basis of the impoundment.

The following water management components are associated with the TMF:

- Flood events will be managed through a combination of embankment freeboard (to contain the EDF event) and an emergency discharge spillway located in the southwestern abutment of the TMF embankment for larger flood events that exceed the EDF (up to the PMF).
- Seepage collection ponds located downstream of the embankment will collect seepage from the TMF embankment and collected seepage will be pumped back to the TMF.
- Tailings supernatant water will be reclaimed using a floating pump/barge and a single overland pipeline to the Process Plant.
- A process water tank located at the Process Plant will store reclaim water from the TMF for processing.
- A Surplus Water Management System (SWMS) will remove surplus water from the TMF supernatant pond.

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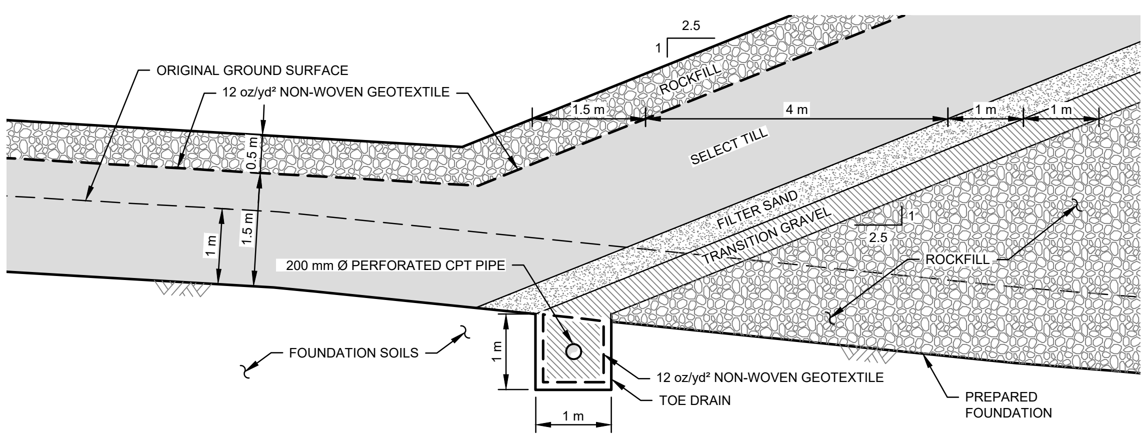
1.1
FIG

## SECTION
**TYPICAL EMBANKMENT DESIGN SECTION**
SCALE A




A
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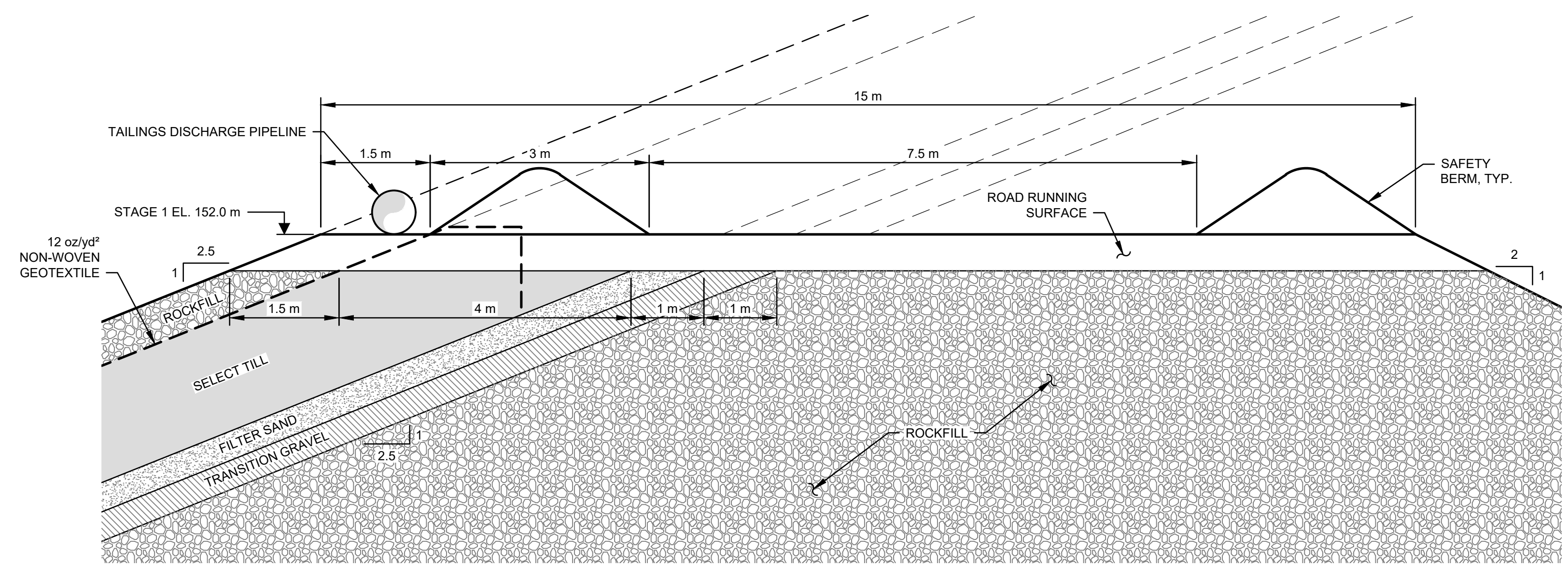
FIG

## DETAIL
**TOE DRAIN**
SCALE B




B
-
FIG

## DETAIL
**STAGE 1 CREST**
SCALE B

**FOR INFORMATION ONLY**

SCALE A: 5 2.5 0 5 10 15 20 25 m
SCALE B: 1 0.5 0 1 2 3 4 5 m

**LEGEND:**

- ROCKFILL
- SELECT TILL
- FILTER SAND
- TRANSITION GRAVEL

**NOTES:**

1. DIMENSIONS AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.

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FIFTEEN MILE STREAM PROJECT

**TMF EMBANKMENT**
**SECTION AND DETAILS**

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**FIGURE 2.3** REV 1

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The water balance developed for the TMF has indicated that the TMF will operate in a net positive surplus throughout operations for all climatic conditions during the Construction and Operation Phases (Figure 2.4). The Surplus Water Management System (SWMS) allows for the removal of excess water from the TMF supernatant pond during operations to maintain target operating pond volumes, tailings beach length, and minimum freeboard requirements. Surplus water will be removed by pumping water to a Water Treatment Plant (WTP) located near the Plant Site, if required to meet discharge criteria, before being released to Anti-Dam Flowage. The Site Water Management Plan (SWMP) will describe the water management strategies as well as effluent monitoring that will be undertaken.

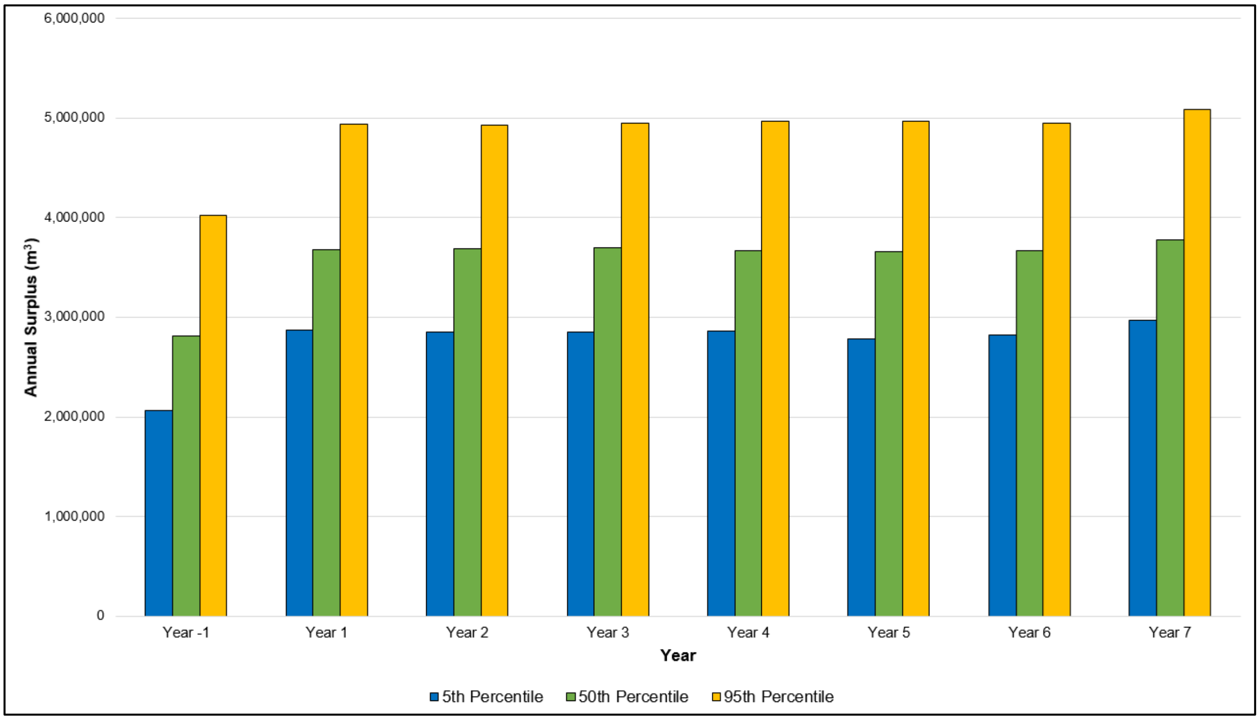


**Figure 2.4 TMF Annual Surplus - Operations**

# 3.0 ENVIRONMENTAL PROTECTION MEASURES

Measures will be taken to:

- Minimize exposure of the tailings to the atmosphere, to reduce ML/ARD, and also reduce potential dusting
- Prevent runoff and seepage from interacting with surface or groundwater
- Stabilize the TMF embankments
- Prevent harm to wildlife

These measures are described in more detail below.

## 3.1 MINIMIZE ML/ARD GENERATION

The potential for the tailings within the TMF to leach metals and generate acid will be minimized by reducing exposure of the tailings to atmospheric conditions. This will be accomplished by strategically depositing new tailings over the existing tailings and by maintaining a supernatant pond to maintain a degree of saturation within tailings stored in the TMF.

## 3.2 RUNOFF MANAGEMENT

Non-contact water will be diverted around the project site to the maximum practical extent. All non-contact water diversion structures are designed to divert runoff from a 1-in-200 year 24-hr precipitation event.

All direct precipitation on the TMF footprint, up to a volume from the EDF event, will be stored within the TMF. Flood events exceeding the EDF (up to the IDF) will be conveyed through an emergency discharge spillway in the southwest abutment of the TMF embankment.

Site contact water (including open pit dewatering flows) will be managed in a system of collection ditches and management ponds. Contact water collected in the management ponds will be pumped to the TMF supernatant pond.

## 3.3 SEEPAGE MANAGEMENT

Potential seepage from the TMF will be largely controlled by the low-permeability till liner and low permeability tailings mass. Two seepage collection ponds, the North Seepage Collection Pond, and the East Seepage Collection Pond, will be constructed at topographic low points downstream of the TMF embankment (Figure 2.1).

Seepage collected in the Seepage Collection Ditches, constructed along the toe of the embankment, will convey collected seepage and embankment runoff to the respective ponds. Water collected in the ponds will be continuously monitored and returned to the TMF to ensure it does not adversely affect the receiving environment.

## 3.4 DUST CONTROL

Selective tailings deposition and management of the operational supernatant pond volume will ensure that the beaches are saturated, thus reducing the potential for dust generation.

Dust generation at closure will be managed be encapsulating the consolidated tailings with an earth and rockfill closure cover, appropriately graded to shed runoff from the TMF.

## 3.5 SEDIMENT AND EROSION CONTROL

Sediment and erosion control will be a focus during construction of the TMF and subsequent embankment raises. The measures identified in the Sediment and Erosion Control Plan will be applied to facility construction and will minimize erosion and prevent sediment releases into the receiving environment.

## 3.6 SURPLUS WATER MANAGEMENT

The Surplus Water Management System (SWMS) allows for the removal of excess water from the TMF supernatant pond during operations to maintain target operating pond volumes, tailings beach length, and minimum freeboard requirements. Surplus water will be removed by pumping water to a Water Treatment Plant (WTP) located near the Plant Site, if required to meet discharge criteria. Water will be discharged to Anti-Dam Flowage from the WTP via a gravity discharge pipeline.

Monitoring plans will be implemented to monitor TMF supernatant water quality to determine if water treatment will be required to be acceptable for discharge to the receiving environment at Anti-Dam Flowage.

## 3.7 TMF CLOSURE

TMF closure and rehabilitation will be carried out progressively during the Operation Phase (where possible) and primarily at the end of economically viable mining. Closure and reclamation activities for the TMF are summarized below and are also discussed in Section 2 of the Project Description.

Opportunities for progressive reclamation of the TMF include reclaiming the downstream faces of the TMF embankments with topsoil cover and revegetation once the final Stage 4 embankments are constructed.

Closure and reclamation of the TMF will involve:

- Removal of supernatant pond water from the TMF to the open pit at closure to aid in the establishment of a pit lake.
- Containing and isolating the tailings and converting the TMF into a physically stable landform by constructing a revegetated closure cover on top of the consolidated tailings (after the pond has been removed) and establishing a permanent spillway and outlet channel to facilitate shedding of runoff from the surface of the reclaimed TMF to the open pit.

The following reclamation activities will be completed during TMF closure:

- Prior to closure, tailings will be selectively deposited around the TMF to establish a final tailings beach that will facilitate construction of the final closure cover.
- Tailings supernatant pond water will be removed and pumped to the open pit.
- Tailings and reclaim delivery systems and all pipelines, structures, and equipment not required beyond mine closure will be dismantled and removed.
- A permanent spillway will be developed by constructing a breach through the southwest abutment of the TMF embankment and establishing an outlet channel to the open pit.
- A combined rock and soil cover will be placed over the consolidated tailings mass in a manner that conveys runoff to the permanent spillway.

- All access roads, ponds, ditches, and borrow areas associated with the TMF that are not required beyond TMF closure will be removed and the areas re-graded.
- Disturbed areas will be revegetated consistent with the re-vegetation strategy.

The TMF embankment slopes are designed at 2H:1V downstream slopes, which are expected to be stable following closure and will not require further modification at closure other than surface preparation with topsoil and revegetation (may be completed concurrently during operations) unless monitoring information indicates otherwise.

Final reclamation of the TMF will be completed after the reclamation activities described above have been completed. The seepage collection system will continue to operate for several additional years past this point until seepage has diminished to negligible quantities and/or is suitable for direct discharge to the environment. The seepage collection systems will be dismantled and removed, and the seepage collection ponds regraded and reclaimed once this has been achieved.

# 4.0 MONITORING PROGRAM

## 4.1 MONITORING

Guidelines for monitoring, inspection and reporting on the performance of the TMF are outlined in the Canadian Dam Safety Guidelines (CDA, 2013) and the CDA Technical Bulletin on the Application of the Dam Safety Guidelines to Mining Dams (CDA, 2014).

These documents provide requirements for dam safety inspections and reviews, and the development of an Operations, Maintenance, and Surveillance (OMS) Manual as well as an Emergency Preparedness and Response Plan (EPRP) specific to the TMF. The OMS Manual and EPRP will be prepared as part of an Industrial Approval Application and will be reviewed and revised annually, and as each staged TMF expansion is constructed. Quantitative Performance Objectives (QPOs) for the management and operation of the TMF will be developed and summarized in the OMS Manual.

Geotechnical instrumentation will be installed in the TMF embankments and foundation during construction, and will be utilized during the Operation, Closure and Reclamation, and Post-Closure Phases of the Project.

Instrumentation will be provided during construction, operations, and closure to monitor the TMF and may include:

- Pond level indicator in TMF supernatant pond
- Water management pond inflow weirs
- Vibrating wire piezometers in the TMF embankment
- Survey and surface movement monitoring monuments
- Flow monitoring for seepage collection ditches

Groundwater monitoring wells and select geotechnical instrumentation will be retained post-closure for use as long-term dam safety and downstream groundwater quality monitoring devices. Post-closure monitoring will also include annual inspection of the former TMF and ongoing evaluation of water quality, flow rates, and instrumentation records to confirm design objective for closure have been met.

The instrumentation will be used to monitor and assess embankment performance and to identify any conditions different to those assumed during design and analysis. Amendments to the ongoing design and/or remediation work can be implemented to respond to the changed conditions, should the need arise. Key control and monitoring subject areas will include:

- Construction controls, including the use of a construction management program.
- Performance monitoring inspections of the TMF, including instability indicators, stability monitoring, tailings deposition, supernatant pond levels, water management and control, and quality of effluent.
- Monitoring of the flow rates and water quality in the Seepage Collection System.
- Monitoring of the flow rates and water quality in the Reclaim Water and Surplus Water Management Systems.
- Monitoring of water quality in the Water Treatment Plant (if required) and Surplus Water Discharge System.
- Monitoring of downstream groundwater quality including aquatic effects monitoring on the receiving environment.

- The adequacy of the supernatant pond and tailings deposition strategy as a dust control to minimize onset of ML/ARD, should the tailings be characterized as PAG.
- Quality assurance and quality control (QA/QC) measures for ongoing monitoring and inspections.

The future OMS Manual will clearly document the procedures for operating, maintaining, monitoring, and inspecting the TMF along with the roles and responsibilities of relevant staff. Inspections will include:

- Daily inspections by the Mine Supervisor
- Weekly, or after a major storm event, or change, by the Mine Supervisor
- Annual dam safety inspections will be undertaken by the Engineer of Record (EoR)

Environmental monitoring will consist of regular monitoring of the quality of tailings supernatant, collected seepage, and downstream groundwater as described in the SWMP. The downstream aquatic environment will also be monitored as described in the AEMRP.

## 4.2 ADAPTIVE MANAGEMENT

Adaptive management may be required if environmental performance monitoring indicates that adverse conditions are prevalent in the ongoing results. Examples of inspections or monitoring that may trigger adaptive monitoring programs to be implemented include:

- Adaptive Geotechnical Stability Management – If annual geotechnical inspections identify stability concerns with the facility.
- Adaptive Seepage Management – If groundwater monitoring suggests that seepage collection measures are inadequate (i.e., seepage flows exceeding design flows).
- Adaptive Reclaim Water / Surplus Water Discharge Quality Management – If monitoring as described in the Site Water Management Plan indicates that supernatant water quality or TSS exceed what is acceptable for recycling to the Process Plant.
- Adaptive Downstream Water Quality Management – If monitoring as part of the Aquatic Effects Management and Response Plan identifies aquatic effects that require further investigation.
- Adaptive Sediment and Erosion Control Management – If regular visual monitoring identifies sediment and erosion control or other issues.

The need for any corrective actions to on-site management of the TMF or installation of additional control measures will be determined on a case-by-case basis, based on monitoring conducted as described above.

## 4.3 REPORTING

Table 4.1 presents a proposed reporting schedule for relevant reports. The final schedule of reports will be outlined in the IA for the project.

**Table 4.1 Reporting Requirements for Tailings Management**

| Project Phase | Monitoring, Inspection and Reporting Requirement | Frequency |
|---|---|---|
| Pre-Development | Dam Classification Study and Dam Break Inundation Study for Significant or higher consequence TMFs. | Prior to Construction |
| Construction | As-Built Reports | Within 90 days of completion of construction |
| Operation | As-Built Reports (embankment raises) | Within 90 days of completion of construction for each staged embankment expansion |
| | Annual Report (includes updates to the TMF Register, if applicable) | Annually |
| | Dam Safety Inspection Report | Semi-annually |
| | Independent Tailings Review Board (ITRB) Report | Annually |
| | OMS Manual Update | Annually |
| | EPRP Update and Testing | Annually |
| | Dam Safety Review including Dam Classification Review and Update | Min. 2 over LOM, or every 5 years |
| Closure | Closure Management Manual | Prior to end of operations |
| | OMS Manual Update | Annually |
| | EPRP Update and Testing | Annually |
| Post-Closure | Annual Report | Annually |
| | Dam Safety Inspection Report | Annually |
| | Dam Safety Review including Dam Classification Review and Update | Every 5 years |

# 5.0 ROLES AND RESPONSIBILITIES

Roles and responsibilities with respect to tailings management will be developed and assigned as part of the preparation of the OMS Manual. Prior to conducting any work on the mine site, AMNS will designate a Mill Operations Manager who must be present onsite daily, and who is ultimately responsible for application of all requirements on the site. As such the Mill Operations Manager is ultimately responsible for the safety of the TMF. A proposed organizational structure proposed for the implementation of this Plan is presented in Table 5.1

**Table 5.1 Roles and Responsibilities Organizational Chart**

| Position | Responsibilities |
|---|---|
| **CEO/COO** | The CEO or COO, as the lead representative of a Mine Owner, will designate a Mill Operations Manager who must be present onsite daily and who is ultimately responsible for application of all requirements of the Plan on the site. The CEO retains overall accountability for tailings management; responsible for putting an appropriate management structure in place, and for providing assurance to the Company and Communities of Interest that tailings are managed appropriately. |
| **Manager Environment & Community** | Responsible for the development and ongoing updates of this Plan, and for ensuring its implementation. The VP Environment and Community, with help from the Mill Operations Manager, will prepare and maintain the OMS Manual. He/she is also responsible for communication with government and community, including Aboriginal Groups, and for ensuring that the Plan reflects the results of these communications. |
| **Mill Operations Manager** | The Mill Operations Manager is the individual ultimately responsible for the mine, including the following aspects:<br>• Accountable for all aspects of the performance and management of tailings and water retaining structures<br>• Responsible for compliance with regulatory requirements and relevant guidelines<br>• Responsible to submit all compliance reports to the required regulatory agencies by the due dates<br>• Defines site roles and responsibilities, authority, and accountability<br>• Allocates required human and financial resources<br>• Reports dangerous occurrences including significant TMF or dam safety incidents to NSE<br>The Mill Operations Manager is therefore accountable for the proper implementation and success of this Plan and the OMS Manual at the project site. The Mill Operations Manager will be also responsible for approving monitoring programs and SOPs with support from the Mine supervisor. All compliance reporting with respect to tailings management will be submitted to the Mill Operations Manager. |
| **Engineer of Record (EoR)** | An EoR will be designated once construction of the TMF is underway. The EoR must be an individual (not a firm) who is a qualified and competent engineer with experience commensurate with the consequence classification and complexity of the facility. The EoR will:<br>• Hold the professional responsibility for the facility design, and is responsible for evaluating the adequacy of the as-built facility relative to the design as well as applicable standards, criteria, and guidelines<br>• Report on annual Dam Safety Inspections<br>• Participate in Dam Safety Reviews<br>• Participate in risk assessments |

| Position | Responsibilities |
|---|---|
| | • Participate in ongoing construction quality assurance in accordance with AMNS's Quality Management Plan (QMP)<br>• Provide QPOs and monitoring frequencies required to ensure the facility is functioning as designed for inclusion in the OMS<br>• Participate in the implementation of a succession plan in the event of a change in the EoR |
| **Independent Tailings Review Board (ITRB)** | An ITRB will be established comprised of independent subject matter experts not currently involved in or responsible for the design, operation, or construction of the TMF. The size and make-up of the ITRB will be based on complexity of the tailings system in terms of risk, consequence, and disciplines of substance. AMNS's ITRB will be established to:<br>• Provide an independent assessment to senior mine management and regulators whether the TMF is designed, constructed, and operated appropriately, safely and effectively<br>• Provide the site team with practical guidance, perspective, experiences, and standard/best practices from other operations<br>• Review and comment on the planning and design process, monitoring programs, data analysis methodology and work performed by site team and/or contract consultants<br>• Provide non-binding advice and guidance<br>The ITRB will not direct the work or perform the role of the Engineer of Record. |
| **Mine Supervisor** | The Mine Supervisor will have functional responsibility for the implementation of this Plan under the direction of the Mill Operations Manager. This includes communicating with relevant on-site personnel to ensure compliance with the Plan. |
| **Environmental Superintendent** | The Environmental Superintendent will direct personnel on site to fulfill environmental management responsibilities and tasks, and audit contractors for compliance with Plan requirements. |
| **Environmental Monitors** | Environmental monitor(s) will be responsible for implementing the monitoring measures for this Plan. This includes completing daily tasks such as sample collection, performance monitoring, and reporting. |
| **Inspectorate** | An independent inspector, external to AMNS, will review applications and compliance monitoring for completeness and technical reasonableness, and conduct mine inspections to assess and enforce the compliance with plan requirements.<br>The inspectorate will be designated by NSE. |

Refinement and confirmation of the organizational structure will continue as the permitting process progresses and AMNS eventually staffs the Project. Any changes to the above will be consistent with the requirements of relevant federal and provincial guidelines.

# 6.0 REVIEW OF PLAN EFFECTIVENESS

The Mill Operations Manager or designate will conduct regular evaluations of the monitoring activities as needed. This Plan may be updated if additional methods for monitoring are found to be more appropriate.

The QA/QC for relevant monitoring programs will include the preparation of a SOP for each of the activities within the tailings management system, and auditing operations against this plan and any relevant SOPs.

# 7.0 REFERENCES

Canadian Dam Association (CDA), 2013. *2007 Dam Safety Guidelines – 2013 Revision*.

Canadian Dam Association (CDA), 2014. *Technical Bulletin – Application of Dam Safety Guidelines to Mining Dams*.

Lorax Environmental Services Ltd. (Lorax), 2019. *Fifteen Mile Stream Project – ML/ARD Assessment Report.* Report prepared for AMNS. August 2019.

Knight Piésold Ltd. (KP), 2019. *Fifteen Mile Stream Project – Preliminary Waste and Water Management Design for Submission of the Environmental Impact Statement.* Rev.0. Report prepared for AMNS. September 9, 2019.

Mining Association of Canada (MAC), 2017. *A Guide to the Management of Tailings Facilities.* 3rd Edition.

Mining Association of Canada (MAC), 2019. *Developing an Operation, Maintenance, and Surveillance Manual for Tailings and Water Management Facilities*. 2nd Edition.

Nova Scotia Department of Environment (NSE), 2018. Approval No. 2012-084244-05 under Province of Nova Scotia Environment Act, S.N.S. 1994-95, c.1 s.1. July 18, 2018.

Stantec Consulting Ltd. (Stantec), 2018. *Operations, Maintenance and Surveillance Manual – Touqouy Gold Project – Tailings Management Facility.* Revision 2.

# 8.0 CERTIFICATION

This report was prepared and reviewed by the undersigned.

Prepared:

Jim Fogarty, P.Eng.
Senior Engineer

REGISTERED PROFESSIONAL ENGINEER
DATE
2020-06-19
D. D. Fontaine
11856
PROVINCE OF NOVA SCOTIA

Reviewed:

Daniel Fontaine, P.Eng.
Specialist Engineer | Associate

Reviewed:

Richard Cook, P.Geo. (Ltd.)
Specialist Environmental Scientist | Associate



Approval that this document adheres to the Knight Piésold Quality System: DDF

# Appendix D.4

Seloam Brook Diversion Channel Technical Response,

Knight Piésold Ltd

**April 14, 2020**

**Knight Piésold Ltd.**
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Mr. James (Jim) Millard
Manager Environment and Permitting
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Canada, B0N 1X0

Dear James,

## RE: Seloam Brook Diversion Channel Design

Knight Piésold Ltd. (KP) has completed a feasibility level design for the Seloam Brook Diversion (Diversion) in support of the Environmental Impact Statement (EIS) submission for the Fifteen Mile Stream Project (Project). This letter describes the design of the Seloam Brook Diversion, including the Seloam Diversion Berm (Diversion Berm), Seloam Brook Diversion Channel (Diversion Channel), haul road from the Open Pit to the Organics Waste Dump, the associated culvert at the road crossing, and relevant fish features. The natural environment upstream and downstream of the Seloam Brook Diversion including potential change in stream stability along with the associated mitigation measures is under investigation by others.

## 1.0 DESIGN BASIS

The Diversion is required to provide conveyance of flood flows and prevent flooding of the Open Pit while enabling low flow conductivity around the Diversion Berm. The Diversion Channel incorporates fish habitat features and will provide fish passage under normal and low flow conditions. The Diversion Channel is sized to pass a flow of 6 $m^3/s$ with a 0.3 m freeboard, with a maximum channel capacity equivalent to a 10-year flood event (Q10). The channel is also required to remain stable throughout the operational life of the Project and in the long-term following closure.

The haul road crossing the Diversion provides access from the Open Pit area to the Organics Waste Dump. The road is required to provide single lane traffic for approximately 5 m wide haul trucks, including appropriately sized safety berms on either side of the road.

The culvert design is based on the requirement to pass the 1 in 200 year flood event (Q200) without overtopping the haul road or the Diversion Berm. The probability of a 200 year flood occurring during the seven-year mine life is 3.4%, or 0.5% in any year of operations. The culvert will also provide fish passage under normal and low flow conditions. Additional considerations for the culvert include a requirement for an energy dissipation pool at the outlet (Nova Scotia 2015), and sufficient clearance to allow construction crews to work inside the culvert to construct any required fish friendly features.

Six species of fish are noted to be present within the Fifteen Mile Stream (FMS) project area; Brook Trout, White Sucker, Lake Chub, Brown Bullhead, Banded Killfish, and Ninespine Stickleback. The design of the Diversion Channel and culvert is not intended to target a specific fish species or specific life stage habitat, but rather to provide fish friendly features that will enable passage for different species and provide refuge from high velocities during high flow periods and adequate depths during low flow periods.

# 2.0 DIVERSION CHANNEL AND CULVERT DESIGN

## 2.1 SELOAM BROOK DIVERSION CHANNEL DESIGN CAPACITY

The minimum dimensions for the Diversion Channel required to satisfy the design flow requirements and maintain the appropriate freeboard are summarized in Table 2.1. The channel plan view is shown on Drawing FM-C1000, and the channel profile and a typical cross-section are shown on Drawing FM-C1001. The drawings include the proposed liner and riprap armoring specifications. The specified riprap size is larger than the minimum required for normal operating flow conditions in the Diversion Channel in order to satisfy the requirement for the channel to remain stable over the life of mine and in the long term.

**Table 2.1 Seloam Brook Diversion Channel Sizing**

| | |
|---|---|
| **Channel Slope (%)** | 0.5 |
| **Minimum Channel Depth (m)** | 1.5 |
| **Freeboard (m)** | 0.3 |
| **Channel bottom width (m)** | 1.0 |
| **Channel Side Slopes (H:V)** | 2:1 |
| **Riprap Size D50 (mm)** | 75 |

Two inlet structures are planned to convey water from the Seloam Reservoir and Trafalgar Creek tributaries into the Diversion Channel. In addition, an energy dissipation pool will be constructed at the outlet of the culvert, along with an outlet structure located downstream of the haul road crossing that will convey water to the natural environment.

The inlets, outlet, and energy dissipation pool will include riprap armor to protect against erosion during high flow events. The locations for these structures are shown on Drawing FM-C1000, and additional concept details are shown on Drawings FM-C1001, and FM-C1003.

## 2.2 HAUL ROAD AND CULVERT DESIGN

The haul road between the Open Pit and the Organics Waste Dump was designed for single lane haul traffic with a road width of 20 m, including 1.8 m high safety berms on either side, and 2H:1V side slopes, consistent with the design of other haul roads within the mine property. The road is designed with an approximate 0.8% grade from the Organics Waste Dump to the Diversion Berm, and an approximate -2.5% grade from the Diversion Berm to the Open Pit area. The road surface also includes a 2% lateral slope on either side of the centerline to help promote drainage during rain events. The haul road design is presented on Drawing FM-C1002.

The culvert selected for under the haul road is a single Corrugated Steel Pipe (CSP) culvert that will contain a similar bed material to the bed material of the Diversion Channel. The primary design consideration for the culvert was to pass the Q200 without overtopping the haul road or the Diversion Berm. Consideration was also given to the size required to allow access for the construction crew, and to enable construction of applicable fish features within the culvert as necessary.

An energy dissipation pool will be constructed at the outlet of the culvert in order to reduce the exit velocity of the diverted flow and to help prevent erosion of the downstream environment. In accordance with the Watercourse Alteration Standards for Nova Scotia (Nova Scotia 2015); at least 70% of the riprap must be between 0.3 m and 0.45 m based on the expected flow velocities out of the culvert. In addition, a minimum of three 1.0 m boulders will be placed in the pool in a triangular pattern to create resting areas for fish.

The dimensions for the culvert and energy dissipation pool that satisfy the design requirements are summarized in Table 2.2 and are shown on Drawing FM-C1003.

**Table 2.2 Haul Road Crossing Culvert and Energy Dissipation Pool**

| **Culvert Sizing** | |
|---|---|
| Culvert Slope (%) | 0.5 |
| Culvert Type | CSP |
| Culvert Diameter (m) | 3.0 |
| Embedded material depth (mm) | 750 |
| Minimum cover required (mm) | 1,500 |
| Steel Thickness (mm) | 2.8 |
| **Energy Dissipation Pool Sizing** | |
| Bottom width (m) | 6.0 |
| Bottom length (m) | 9.0 |
| Depth below culvert outlet (m) | 1.0 |
| Side Slope (H:V) | 2:1 |

## 3.0 FLOW MODELLING

The Seloam Brook Diversion design was an iterative process that included flow modelling used to confirm or modify the sizing of the Diversion Channel, haul road culvert, required riprap, and heights for the Diversion Berm and the haul road.

### 3.1 GENERAL

A two-dimensional (2D) flow model was developed for the Diversion Channel, road crossing, culvert, and surrounding area to support the design. The model was developed using the HEC-RAS 2D modelling software (Version 5.0.7).

The 2D mesh in HEC-RAS 2D was set to a 10 x 10 m grid within the floodplains, a 5 x 5 m grid within the natural channels, and a 2 x 2 m grid within the Diversion Channel. A four second computational timestep was used to calculate the results. The applied 2D mesh is shown on Figure 3.1, along with inflow locations for various tributaries. Modelling of the downstream environment and the impact assessment on stream stability and mitigation requirements is under investigation by others and is not part of this scope.

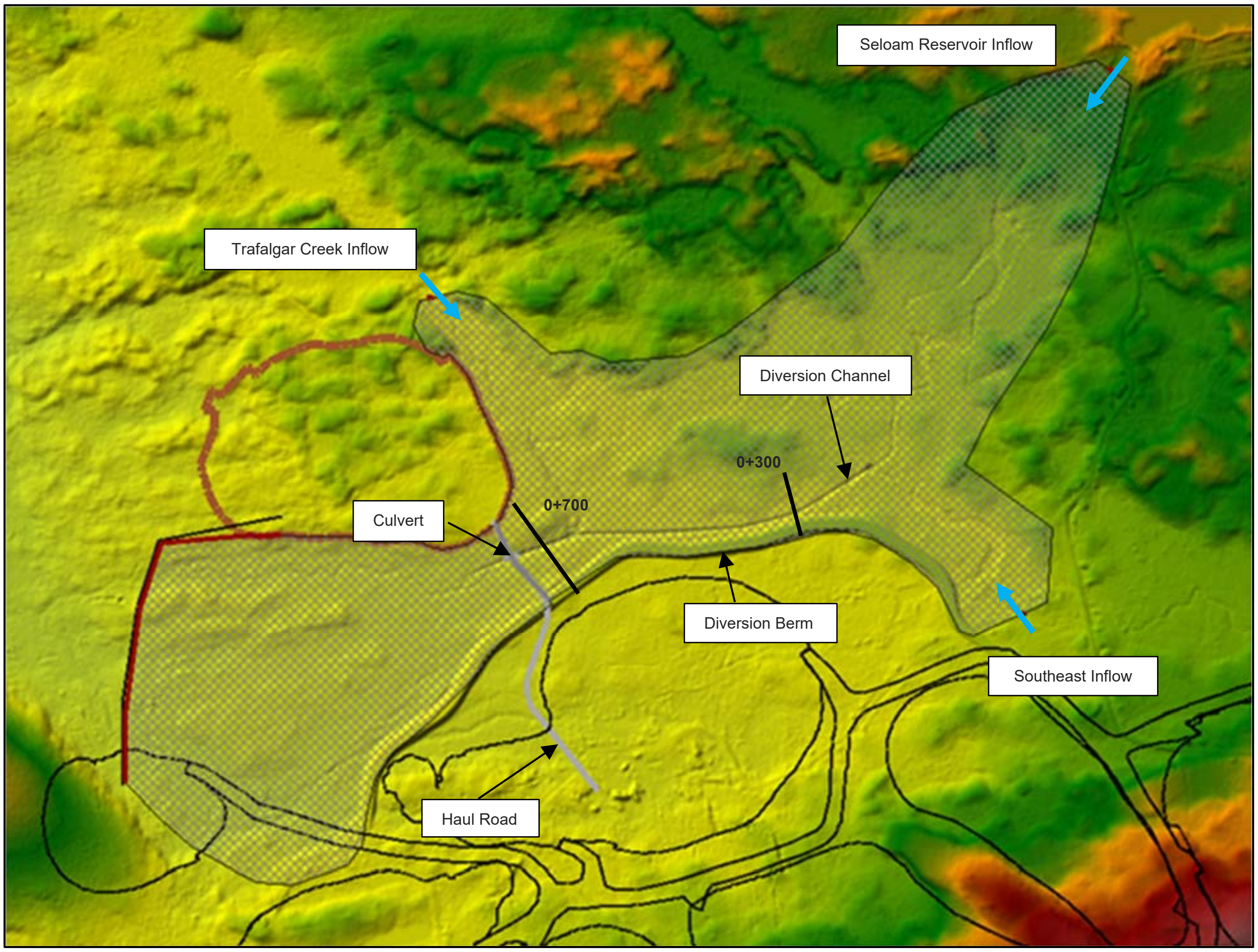



**Figure 3.1 HEC-RAS 2D Model Boundary and Computational Mesh**

## 3.2 MODELLING SCENARIOS

Four flow scenarios were modelled to assess the functionality of the Seloam Brook Diversion.

- 1 in 20 year Annual Dry condition: Modelled to confirm flow conveyance is achieved under low flow conditions.
- Mean Annual Discharge (MAD): Modelled to confirm flow conveyance is achieved under normal operating conditions.
- Q10 (1 in 10 year flood event): Modelled to confirm the channel design provides sufficient flow capacity under 10 year flood conditions.
- Q200 (1 in 200 year flood event): Modelled to assess the inundation around the Diversion Berm and the haul road, evaluate whether overtopping would occur, and support the riprap sizing for the channel to remain stable under these flood conditions.

## 3.3 MODEL INPUTS

Model inputs include data representing the terrain, roughness or resistance to flow, and hydrology (inflows).

#### 3.3.1 TERRAIN

A Digital Elevation Model (DEM) was generated from the terrain data based on Light Detection and Ranging (LiDAR), sourced from the provincial database. Typically, LiDAR data do not provide sufficient information for defining the bed elevations for stream channels and other water bodies (e.g. lakes, wetlands), as the data cannot be collected below the water surface. In order to model the incoming tributaries and other waterbodies, a channel bed was manually cut into the terrain approximating the natural systems based on Google Earth imagery of the area.

#### 3.3.2 RESISTANCE TO FLOW (ROUGHNESS COEFFICIENT)

The Manning's n roughness coefficient was assumed to be 0.06 within the natural channels that contribute flows to the Diversion Channel, and 0.1 within the overbank areas. This was considered to be a reasonable approximation based on available photos of the stream channels and surrounding area (see Photos 5.1 and 5.2 in Section 5 of this letter).

Manning's n for the Seloam Brook Diversion Channel was estimated to be 0.035 based on the modified channel method (Chow, 1959), using the following equation:

$$n = (n_0 + n_1 + n_2 + n_3 + n_4) * m$$

where

$n_0$ is a base value of n based on the channel surface (assumed 0.026 for a gravel channel)

$n_1$ is a correction factor for the effect of surface irregularities (assumed 0, as this is a constructed riprap channel, that will prevent bed and bank erosion)

$n_2$ is a correction factor for variations in the shape and size of cross-sections (assumed 0.003, as several pools will be implemented within the channel, which will vary the channel cross-section)

$n_3$ is a correction factor for the effect of obstructions (assumed 0.006 for obstructions like logs of boulders occupying between 5% and 15% of the channel cross-section area)

$n_4$ is a correction factor for the effect of vegetation (assumed 0 as instream or overbank vegetation are not expected in a riprapped channel)

$m$ is a correction factor for the effect of the meandering of the channel (assumed 1.00 as the channel does not meander much)

#### 3.3.3 HYDROLOGY

The modelled inflows were determined by scaling the regional return period unit runoffs developed for the Project, as presented in the Preliminary Engineering Hydrometeorology Report (KP, 2018), along with flood estimates generated with a rainfall runoff model developed using the HydroCAD stormwater modelling software. Flows in Seloam Brook represent the outflows from the Seloam Reservoir that are regulated by the Seloam Reservoir Dam. The mean annual discharge developed for the Seloam Reservoir outflows is within the range of observed Seloam Reservoir outflows from 2007 to 2018 as provided by Nova Scotia Power (NSP 2018).

The available information regarding the Seloam Reservoir operations was used for flood flow modelling in this study (NSP 2009). The spillway outflows from the reservoir for various return period flood events were estimated in the developed HydroCAD model, which accounts for the reservoir and spillway characteristics

(NSP 2009) and includes the estimated attenuation of the lake. A 15% climate change factor was also applied to the peak flow estimates in order to account for potential future increases in storm intensity as a result of climate change, as recommended in the Preliminary Engineering Hydrometeorology report (KP 2018).

The resulting discharge inputs are summarized in Table 3.1. The Seloam Reservoir inflow node includes the flow from the reservoir outlet and the incremental inflow that is estimated to contribute to the Diversion Channel between the Seloam Reservoir inflow node and the Trafalgar Creek inflow node.

**Table 3.1 Seloam Brook Diversion Inflows for 2D Modelling Scenarios**

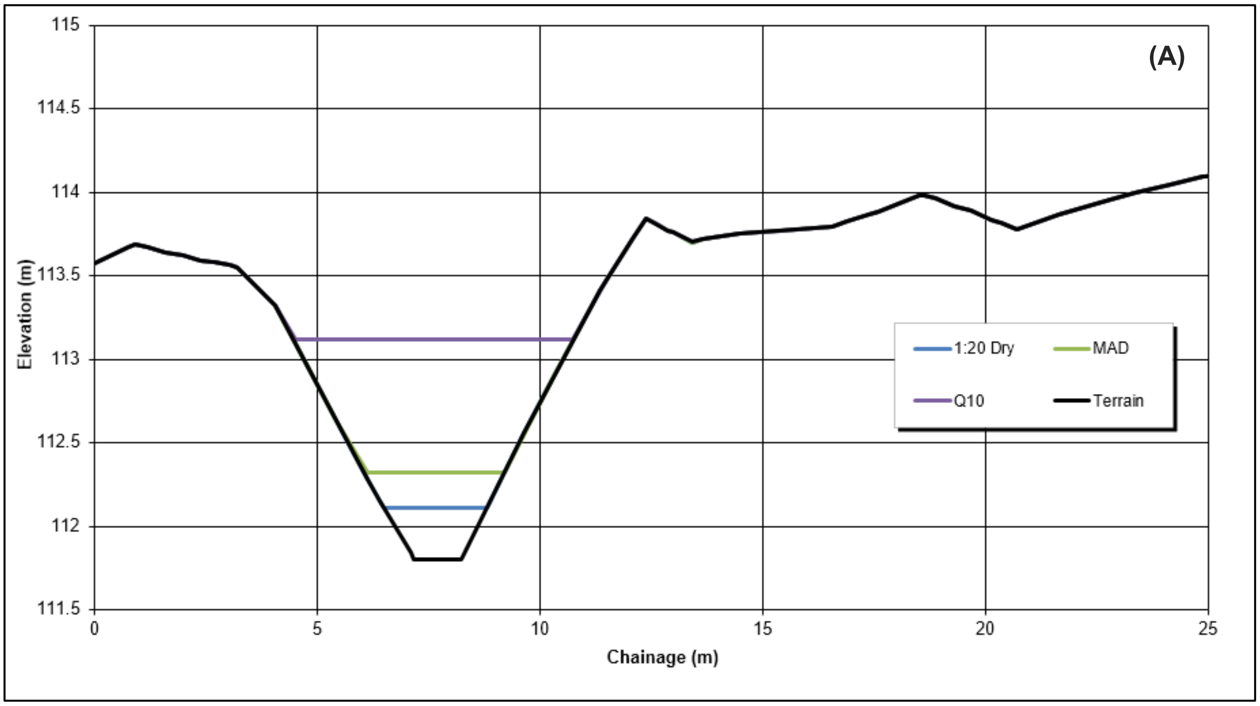
| Scenario Modelled | Inflow Node | Discharge Input ($m^3/s$) |
|---|---|---|
| 1 in 20 Year Annual Dry | Seloam Reservoir | 0.22 |
| | Southeast Inflow | 0.02 |
| | Trafalgar Creek | 0.04 |
| MAD | Seloam Reservoir | 0.64 |
| | Southeast Inflow | 0.07 |
| | Trafalgar Creek | 0.11 |
| Q10 | Seloam Reservoir | 4.8 |
| | Southeast Inflow | 2.5 |
| | Trafalgar Creek | 3.8 |
| Q200 | Seloam Reservoir | 11.2 |
| | Southeast Inflow | 4.4 |
| | Trafalgar Creek | 6.6 |

# 4.0 FLOW MODELLING RESULTS

## 4.1 Q10, MAD, AND 1 IN 20 YEAR DRY FLOW SCENARIOS

The results of modelling the Q10 flood flow scenario confirm that the Diversion Channel is capable of passing the design flow from the upstream environment through the channel and culvert without overtopping. The results for MAD and the 1 in 20 year dry flows confirm that the channel design is sufficient to convey average and low flows, providing sufficient depth for fish passage. The resulting water depths in the Diversion Channel for Q10, MAD, and the 1 in 20 year dry flow scenarios are presented on Figure 4.1. Chainage 0+700 m represents a typical cross section of the channel with a minimum depth of 1.5 m, noting that the channel is deeper than the minimum required depth in many areas due to the natural topography, as shown for chainage 0+300 m. The average water depths for each flow condition are summarized below:

- 1 in 10 year flood event (Q10) = 1.27 m
- MAD = 0.44 m
- 1 in 20 year Annual Dry = 0.24 m



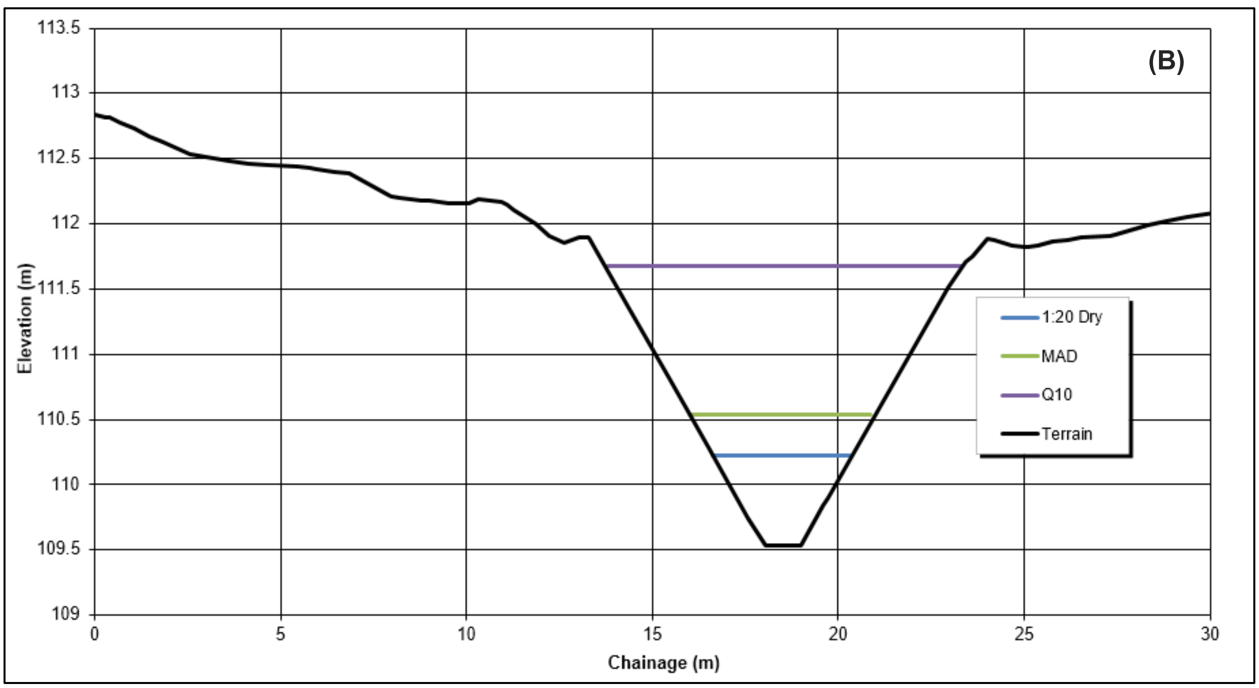
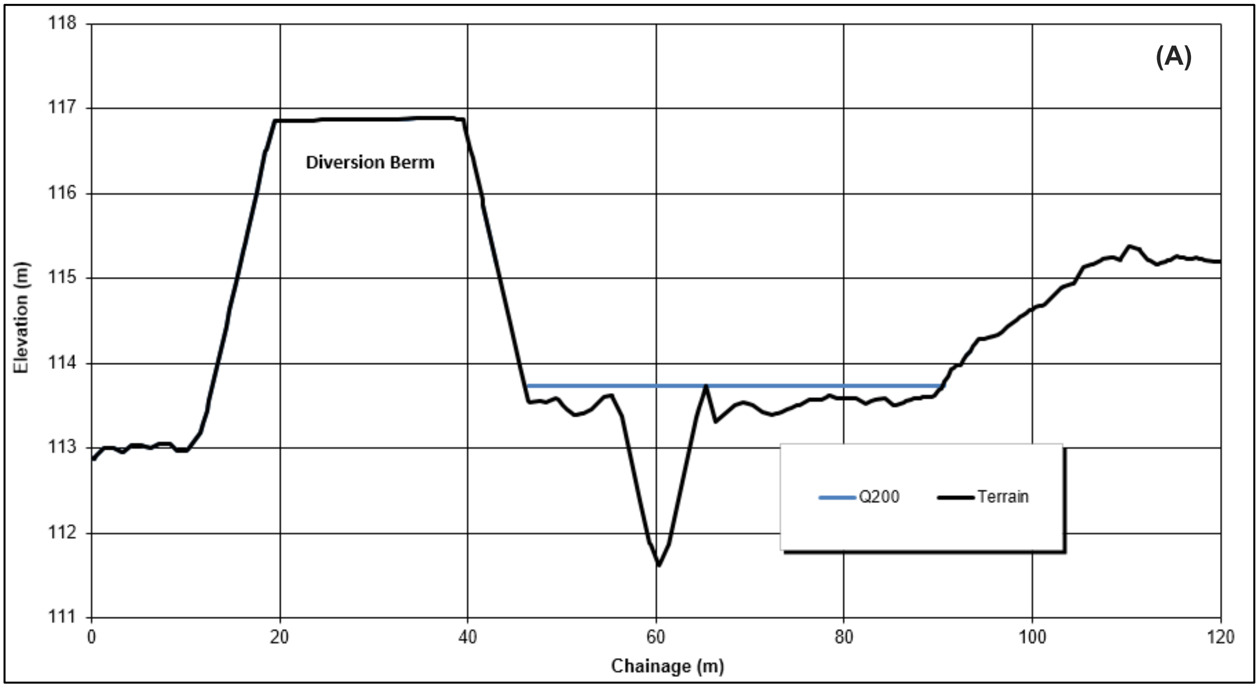




**Figure 4.1 Diversion Channel Water Depths – (A) Chainage 0+300 and (B) Chainage 0+700**

### 4.2 Q200 FLOOD FLOW SCENARIO

The results of the Q200 flood flow scenario indicate that there is sufficient freeboard along the haul road and the Diversion Berm such that neither is overtopped during the modeled peak flood event. Figure 4.2 shows the estimated water depth at the approximate chainage of 0+300 m and 0+700 m.



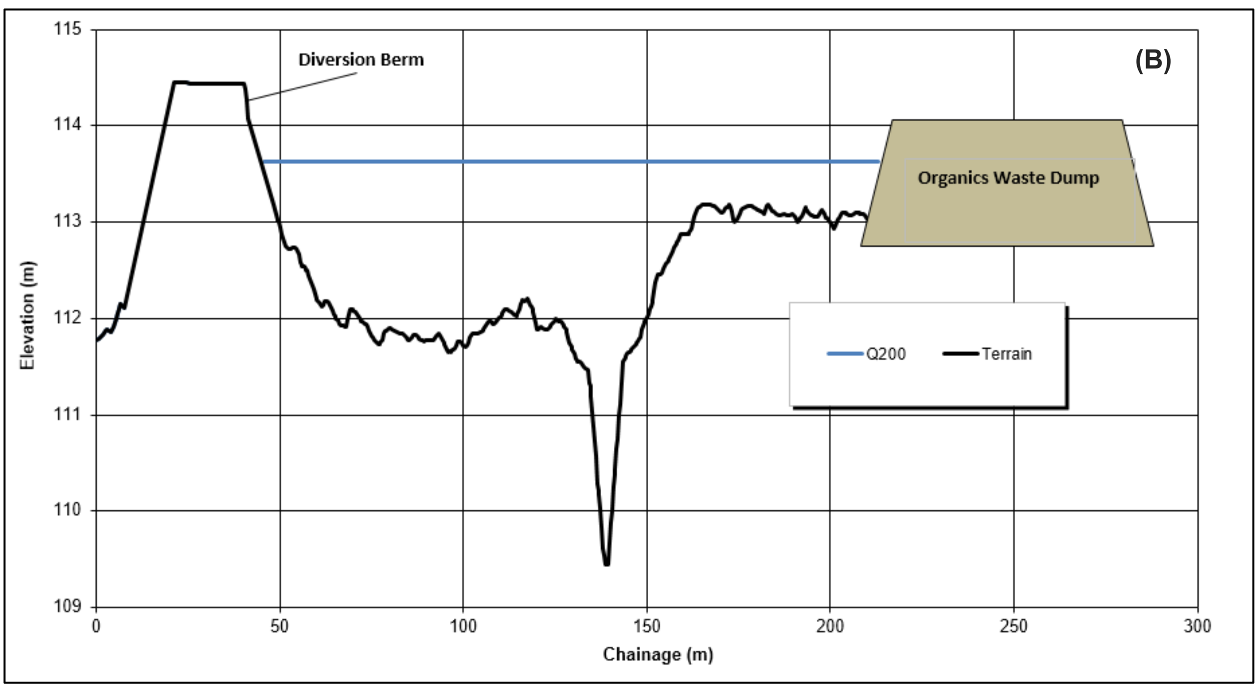




**Figure 4.2 Diversion Flooding Depths for Q200 – (A) Chainage 0+300 and (B) Chainage 0+700**

In addition to the water depths, shear stress was calculated to estimate the size of material that would mobilize under the peak flow scenario. The calculated shear stresses were then used to confirm that the specified riprap size within the channel that would remain stable under the design flood conditions.

Shear stress is defined as follows:

$$\tau = \gamma_w R S$$

where:

- $\tau$ - shear stress (units of force per unit area)
- $\gamma_w$ – unit weight of water (units of force per unit volume)
- R – hydraulic radius or wetted cross-sectional area / wetted perimeter (units of length)
- S – channel slope (dimensionless, units of length / length)
- The critical shear stress required to mobilize bed material of a given size can be estimated using the Shields equation:

$$\tau_c = \tau^* (\rho_s - \rho_w) g D$$

where:

- $\tau_c$ – critical shear stress (units of force per unit area)
- $\tau^*$ - non-dimensional critical shear stress (selected representative values range from 0.03 to 0.06)
- $\rho_s$, $\rho_w$ – density of bed material and water (units of mass per unit volume)
- g – gravitational acceleration (units of length per unit time squared)
- D – characteristic bed material grain size (units of length)

Riprap armor with a $D_{50}$ = 75 mm is specified within the Diversion Channel (Drawing FM-C1001), in consideration of modelled shear stresses that indicate material between 2 mm and 64 mm in diameter may be mobilized. As a result, it is expected that the specified riprap is sufficiently large to withstand the shear stresses expected during the Q200 flood event, with potential for minimal channel repair required following such an event.

## 5.0 SELOAM BROOK DIVERSION CHANNEL DESIGN FOR FISH PASSAGE

In order to design the Seloam Brook Diversion Channel such that it would provide adequate fish passage, it is proposed that the Diversion Channel and culvert mimic existing conditions in the surrounding watercourses to the extent practical.

Photo 5.1 shows the channel characteristics at the SW2 hydrometric monitoring station, located downstream of the Seloam Reservoir. Photo 5.2 shows the channel characteristics at the SW5 hydrometric station, located roughly 1,200 m downstream of the Seloam Brook Diversion.

**Photo 5.1 Channel Morphology at SW2 (August 22, 2017)**

**Photo 5.2 Channel Morphology at SW5 (June 18, 2018)**

Although the site photos provide a general overview of the channel morphology, a field study is recommended in order to obtain more detailed information with respect to the contributing watercourses around the Seloam Brook Diversion Channel prior to the detailed design.

In order to approximate the natural conditions, several fish friendly features are proposed to be implemented throughout the Diversion Channel. The proposed fish friendly features are presented on Drawing FM-C1004 and include:

- Deflector Logs – Typically used to force the stream into a more meandering pattern and to create pools. By partially blocking flow, a deflector causes water to backup to some extent which results in increased water depths upstream of the log and faster velocities around the log. In natural systems, a deflector log will cause a pool to form downstream and opposite of the log as a result of the faster velocities; however, as the Diversion Channel would be riprap lined, a pool would not form naturally through erosion, but could be created during construction. In this application, the primary purpose of deflector logs would be to create zones of slower moving water providing areas of refuge for fish.
- Rock Weirs – Used to create pools within a channel and provide resting and refuge areas for fish. Pools are typically designed to work in conjunction with food producing areas such as riffles.
- Riffles – Used to provide higher energy sections in a creek system that tend to be shallower than other portions of the system, which help support a variety of aquatic life. Water flowing over a riffle will add oxygen to the system. Insects and plants can often be found in and around riffles, providing areas where fish can find food.
- In-Line or Off-Channel Ponds – Provide fish with refuge from fast moving flow, refuge during extreme low flow conditions, and hiding places from predators. In addition, ponds provide areas for a variety of food sources to grow.

We trust that the information provided in this letter is sufficient for your needs at this time. If you have any questions or comments, please contact the undersigned.

Yours truly,
**Knight Piésold Ltd.**

2020-04-14

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
B. T. S. WORRALL
# 45441

| | |
|---|---|
| Prepared: Brendan Worrall, P.Eng.<br>Project Engineer | Reviewed: Violeta Martin<br>Violeta Martin, Ph.D., P.Eng.<br>Specialist Hydrotechnical Engineer<br>Associate |

Approval that this document adheres to the Knight Piésold Quality System: V.M.

**Attachments:**

| | |
|---|---|
| Drawing FM-C1000 Rev B | Seloam Brook Diversion Plan |
| Drawing FM-C1001 Rev B | Seloam Brook Diversion Channel Profile and Section and Inlet/Outlet Concept |
| Drawing FM-C1002 Rev B | Seloam Brook Diversion Haul Road Profile and Section |
| Drawing FM-C1003 Rev B | Seloam Brook Diversion Haul Road Culvert and Dissipation Pool Sections |
| Drawing FM-C1004 Rev B | Seloam Brook Diversion Typical Fish Habitat Details |

**References:**

Chow, V.T. 1959 (Chow 1959). Open-Channel Hydraulics. McGraw-Hill Kogakusha, Ltd.

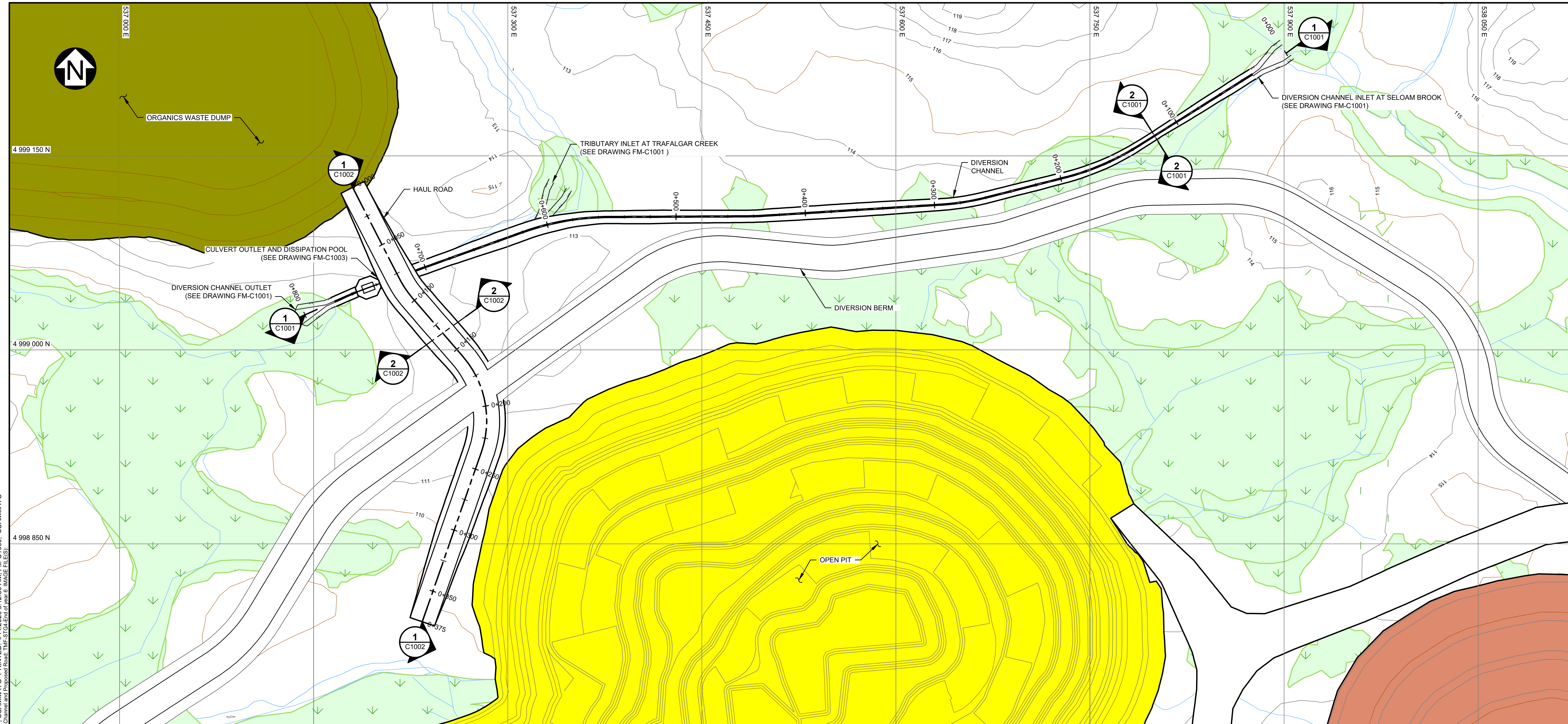
Knight Piésold Ltd. 2018 (KP 2018) Moose River Consolidated Phase II Preliminary Engineering Hydrometeorology Report, Report No. VA101-00708/4-1 Rev 0.

Nova Scotia Environment (Nova Scotia 2015). 2015 Nova Scotia Watercourse Alterations Standard. Version 2, June 1, 2015.

Nova Scotia Power, An Emera Company. 2009 (NSP 2009). East River Sheet Harbour Hydro System. Relicensing Report. Author: Environmental Services. Version: Two. Date: February 16, 2009.

Nova Scotia Power. 2018 (NSP 2018). Excel Spreadsheet summarizing reservoir elevations, gate openings and low level outlet discharges for the period June 11, 2007 to Oct 15, 2018.

/bw




## PLAN
**DIVERSION CHANNEL AND PROPOSED ROAD DESIGN**
SCALE A

**FOR INFORMATION ONLY**

30 15 0 50 100 150 m
SCALE A

### NOTES:

1. COORDINATE GRID IS NAD83, ZONE 20 N.
2. CONTOURS BASED ON 2014 LIDAR OBTAINED FROM GEONOVA, REPRODUCED AND DISTRIBUTED WITH THE PERMISSION OF INTERNAL SERVICES. CONTOURS HAVE BEEN PRODUCED BY KNIGHT PIESOLD LTD. AND INCLUDE DATA PROVIDED BY INTERNAL SERVICES. THE INCORPORATION OF DATA SOURCED FROM INTERNAL SERVICES WITHIN THIS PRODUCT SHALL NOT BE CONSTRUED AS CONSTITUTING AN ENDORSEMENT BY INTERNAL SERVICES OF OUR PRODUCT.
3. WETLAND AND WATER COURSE MAPPING PROVIDED BY McCALLUM ENVIRONMENTAL LTD. SEPTEMBER 06, 2018. DATA PROVIDED IN DRAFT WITH NO IMPLIED WARRANTIES AND SHALL BE CONSIDERED PRELIMINARY.
4. DIMENSIONS AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.



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**FIFTEEN MILE STREAM PROJECT**

**SELOAM BROOK DIVERSION PLAN**

| P/A NO. | DRAWING NO. | REVISION |
|---|---|---|
| VA101-708/4 | FM-C1000 | B |

| DRG. NO. | DESCRIPTION |
|---|---|
| C1001 | SELOAM BROOK DIVERSION CHANNEL - PROFILE AND SECTION, AND INLET/OUTLET CONCEPTS |
| C1002 | SELOAM BROOK DIVERSION - HAUL ROAD - PROFILE AND SECTION |

REFERENCE DRAWINGS

| REV | DATE | DESCRIPTION | DESIGNED | DRAWN | REVIEWED | APPROVED |
|---|---|---|---|---|---|---|

REVISIONS

| REV | DATE | DESCRIPTION | DESIGNED | DRAWN | REVIEWED | APPROVED |
|---|---|---|---|---|---|---|
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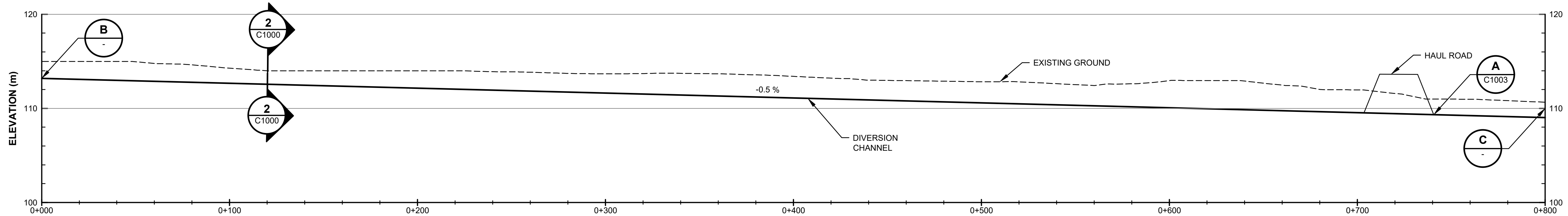
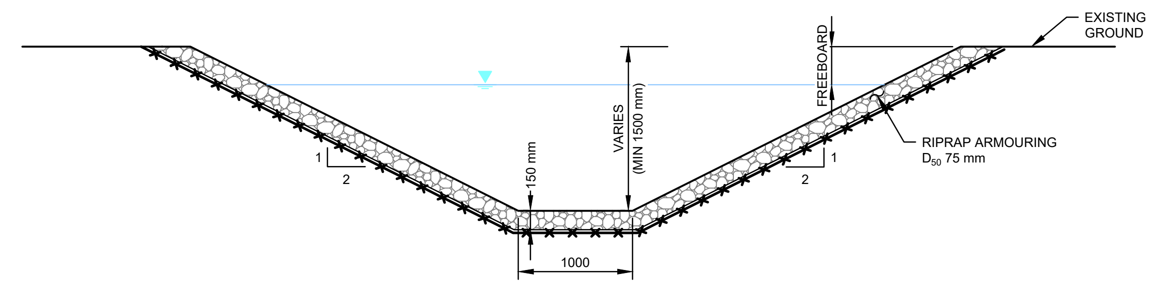
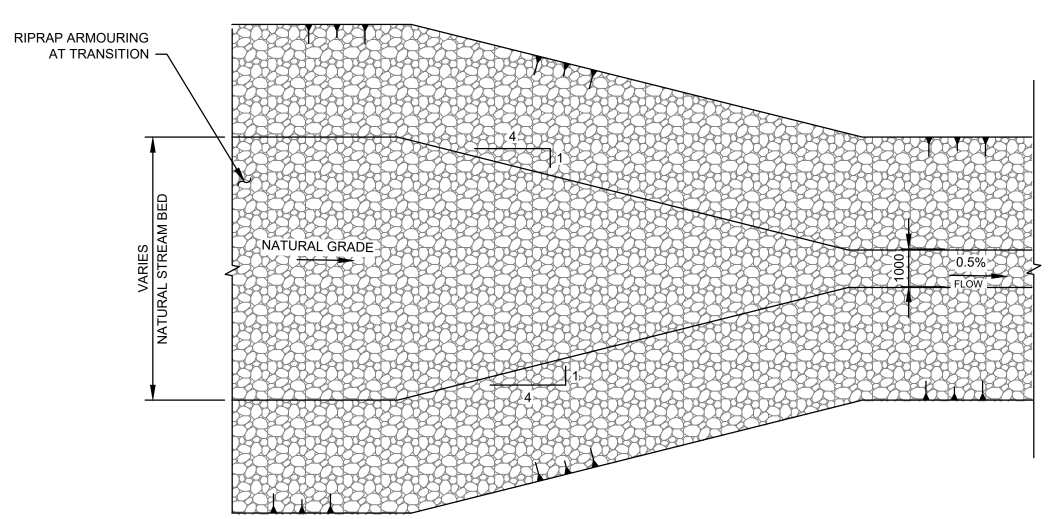
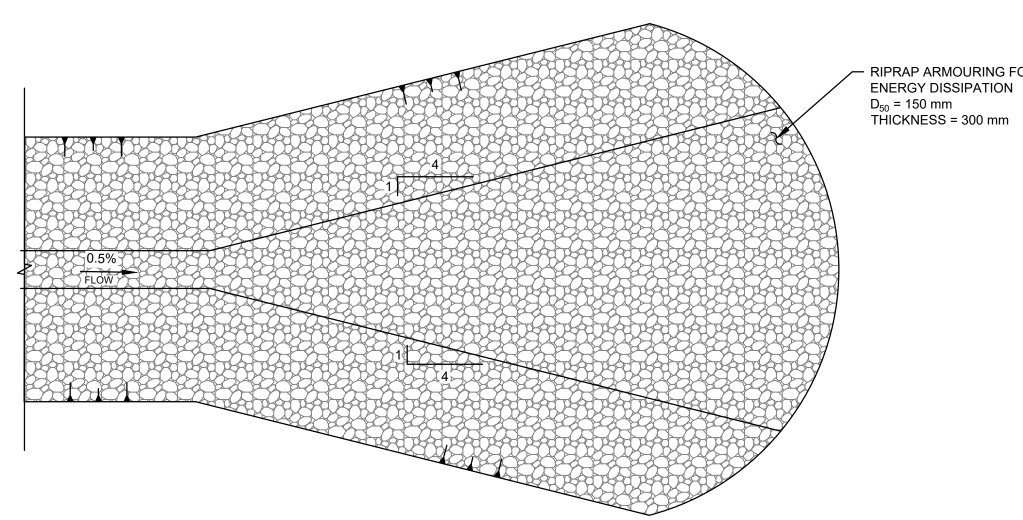



1 / C1000 **PROFILE**
**DIVERSION CHANNEL**
HORIZONTAL: SCALE A
VERTICAL: SCALE B




2 / C1000 **CROSS SECTION**
**DIVERSION CHANNEL**
SCALE C




B / - **DIVERSION CHANNEL INLET CONCEPT - PLAN**
NTS

C / - **DIVERSION CHANNEL OUTLET CONCEPT - PLAN**
NTS

**LEGEND:**
- WEARING COURSE
- COMPACTED SUITABLE FILL MATERIAL
- BEDDING MATERIAL
- WELL GRADED BASE COURSE
- RIPRAP ARMOURING
- NON-WOVEN GEOTEXTILE
- WATER SURFACE

**NOTES:**
1. DIMENSIONS ARE IN MILLIMETERS, UNLESS NOTED OTHERWISE.
2. DESIGN FLOW = 6.0 m³/s.
3. FREEBOARD = 300 mm.

SCALE A: 25 12.5 0 25 50 75 100 125 m
SCALE B: 5 2.5 0 5 10 15 20 25 m
SCALE C: 0.6 0.3 0 1 2 3 m

**FOR INFORMATION ONLY**



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**SELOAM BROOK DIVERSION CHANNEL PROFILE AND SECTION, AND INLET/OUTLET CONCEPTS**

| P/A NO. | DRAWING NO. | REVISION |
|---|---|---|
| VA101-708/4 | FM-C1001 | B |

REFERENCE DRAWINGS

| DRG. NO. | DESCRIPTION |
|---|---|
| C1000 | SELOAM BROOK DIVERSION - PLAN |
| C1003 | SELOAM BROOK DIVERSION - HAUL ROAD CULVERT AND DISSIPATION POOL SECTIONS |

REVISIONS

| REV | DATE | DESCRIPTION | DESIGNED | DRAWN | REVIEWED | APPROVED |
|---|---|---|---|---|---|---|

REVISIONS

| REV | DATE | DESCRIPTION | DESIGNED | DRAWN | REVIEWED | APPROVED |
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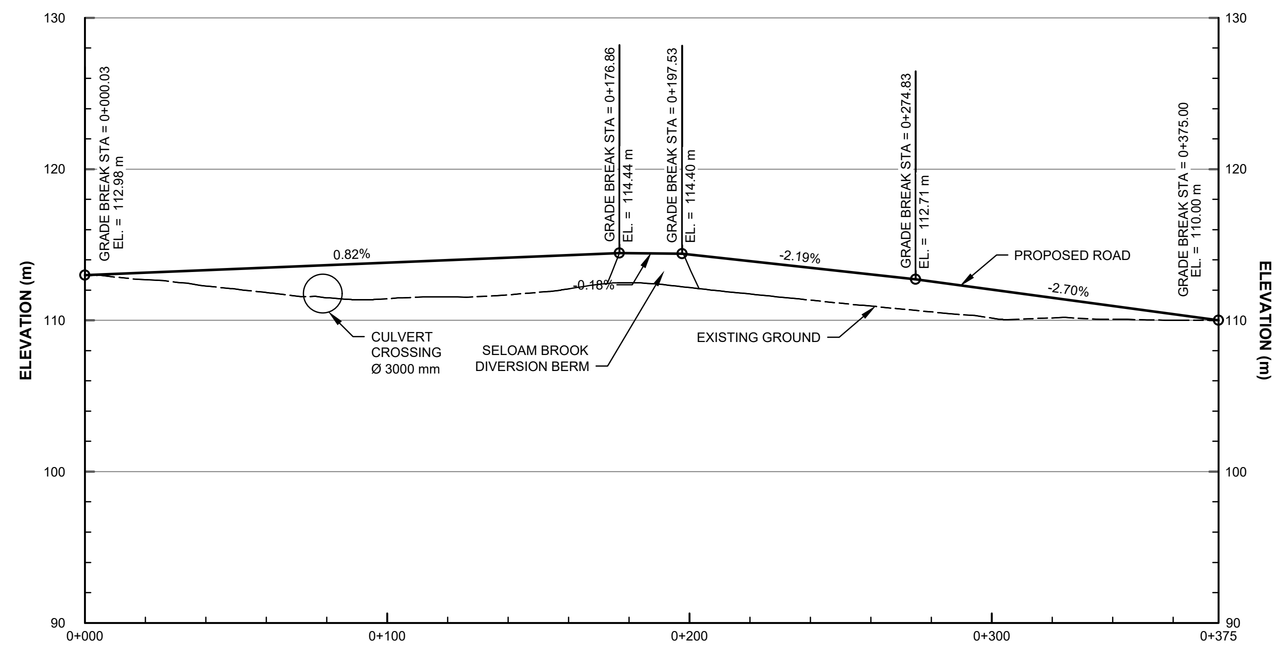
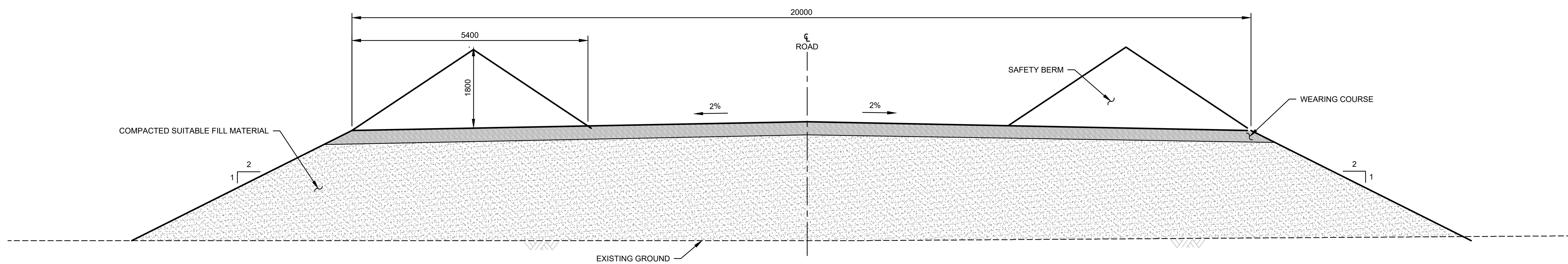



**1 / C1000 PROFILE**
**HAUL ROAD**
HORIZONTAL: SCALE A
VERTICAL: SCALE B




**2 / C1000 TYPICAL SECTION**
**HAUL ROAD**
SCALE C

SCALE C: 1 0.5 0 1 2 3 4 5 m
SCALE B: 5 2.5 0 5 10 15 20 25 m
SCALE A: 25 12.5 0 25 50 75 100 125 m

**LEGEND:**

- WEARING COURSE
- COMPACTED SUITABLE FILL MATERIAL

**NOTES:**

1. DIMENSIONS ARE IN MILLIMETERS, UNLESS NOTED OTHERWISE.

**FOR INFORMATION ONLY**



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FIFTEEN MILE STREAM PROJECT

**SELOAM BROOK DIVERSION**
**HAUL ROAD**
**PROFILE AND SECTION**

| P/A NO. | DRAWING NO. | REVISION |
|---|---|---|
| VA101-708/4 | FM-C1002 | B |

REFERENCE DRAWINGS

| DRG. NO. | DESCRIPTION |
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REVISIONS

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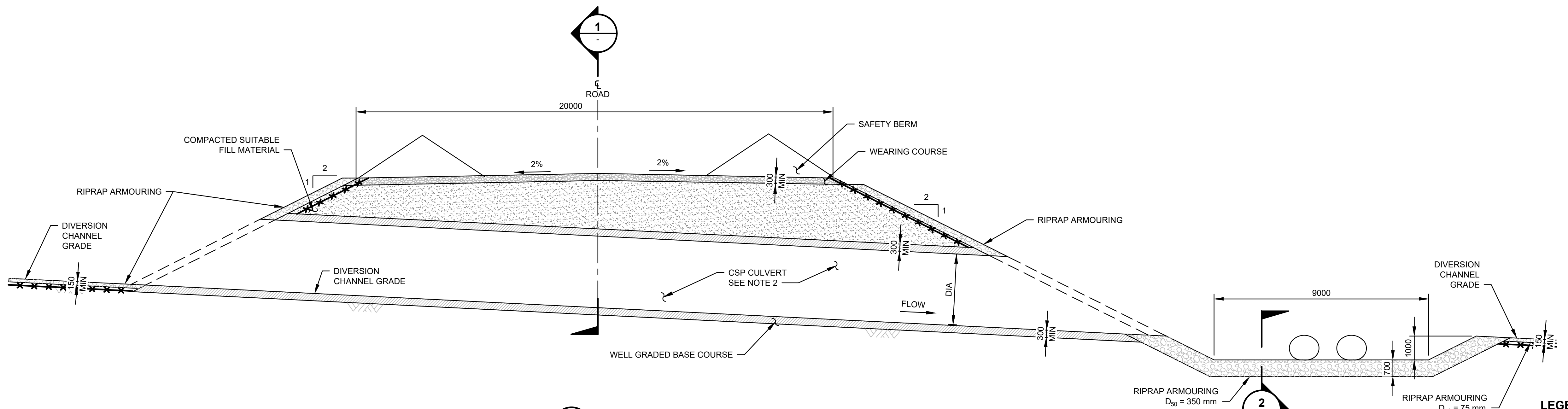
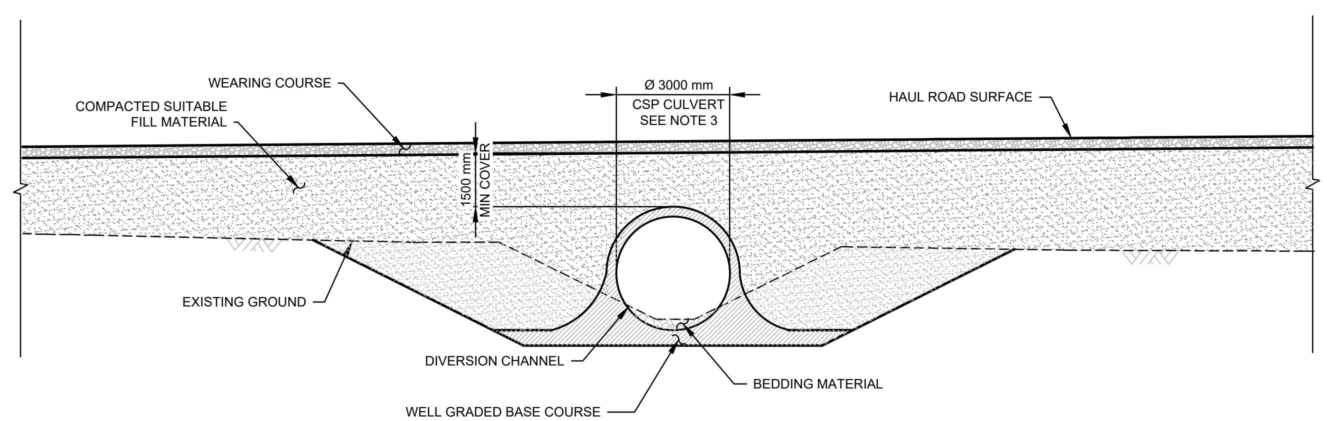


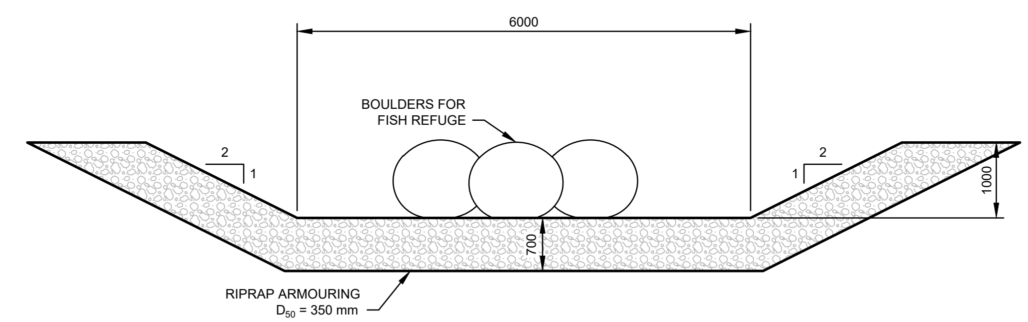

**A / C1001 HAUL ROAD SECTION - CULVERT PROFILE**
NTS

**LEGEND:**

- WEARING COURSE
- COMPACTED SUITABLE FILL MATERIAL
- BEDDING MATERIAL
- WELL GRADED BASE COURSE
- RIPRAP ARMOURING




**1 CULVERT SECTION**
NTS




**2 DISSIPATION POOL SECTION**
SCALE A

**NOTES:**

1. ALL DIMENSIONS ARE IN MILLIMETRES AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.
2. CULVERT TO BE INSTALLED AT SAME SLOPE OF DIVERSION / COLLECTION DITCHES.
3. CORRUGATED STEEL PIPE SPECIFICATION :
   - 3.1. CORRUGATED STEEL PIPE SPECIFICATION 76 X 25 .
   - 3.2. CULVERT WALL THICKNESS OF 2.8 mm.
4. DISSIPATION POOL TO CONTAIN AT MINIMUM THREE 1.0 m BOULDERS ARRANGED IN A TRIANGLE PATTERN TO CREATE RESTING AREAS FOR FISH.
5. 70% OF THE RIP RAP IN THE DISSIPATION POOL MUST BE BETWEEN 0.3 m 0.45 m.

**FOR INFORMATION ONLY**

SCALE A 1 0.5 0 1 2 3 4 5 m



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FIFTEEN MILE STREAM PROJECT

**SELOAM BROOK DIVERSION**
**HAUL ROAD CULVERT AND DISSIPATION POOL SECTIONS**

| P/A NO. | DRAWING NO. | REVISION |
|---|---|---|
| VA101-708/4 | FM-C1003 | B |

| DRG. NO. | DESCRIPTION |
|---|---|
| C1001 | SELOAM BROOK DIVERSION CHANNEL - PROFILE AND SECTION, AND INLET/OUTLET CONCEPTS |

REFERENCE DRAWINGS

| REV | DATE | DESCRIPTION | DESIGNED | DRAWN | REVIEWED | APPROVED |
|---|---|---|---|---|---|---|

REVISIONS

| REV | DATE | DESCRIPTION | DESIGNED | DRAWN | REVIEWED | APPROVED |
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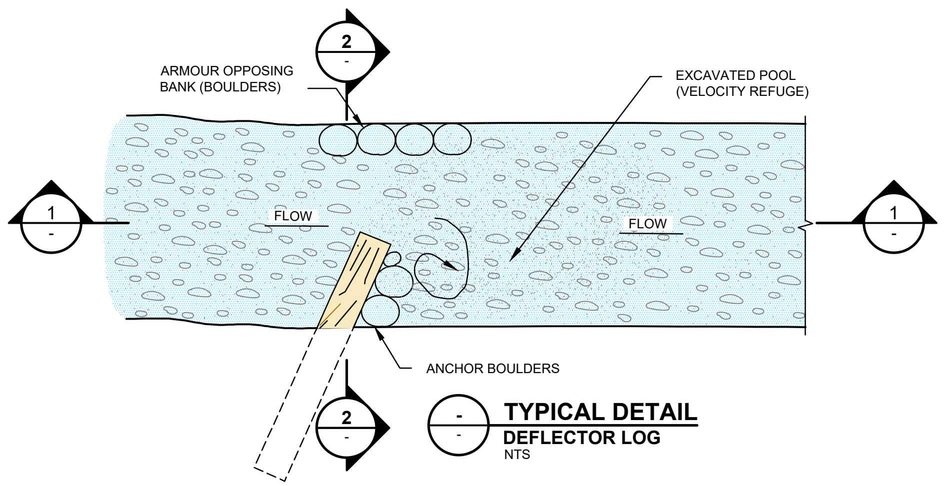
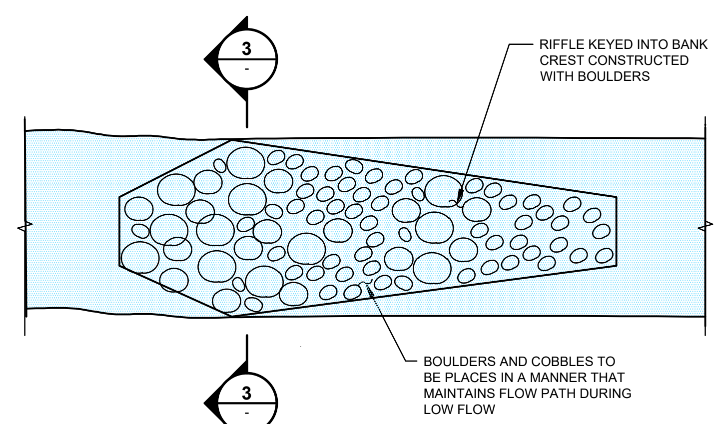
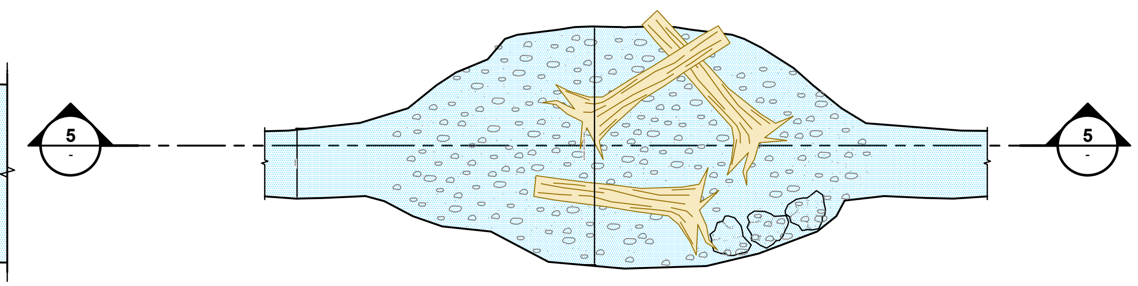


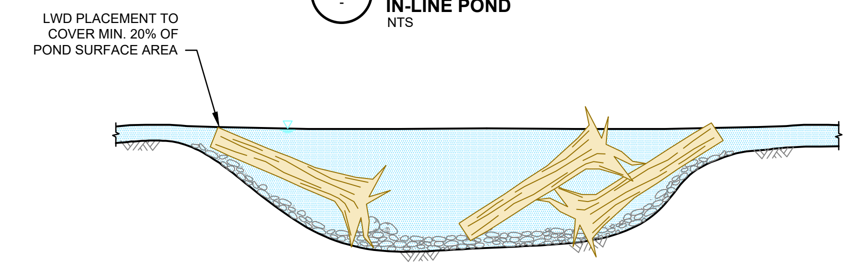

**TYPICAL DETAIL**
**DEFLECTOR LOG**
NTS



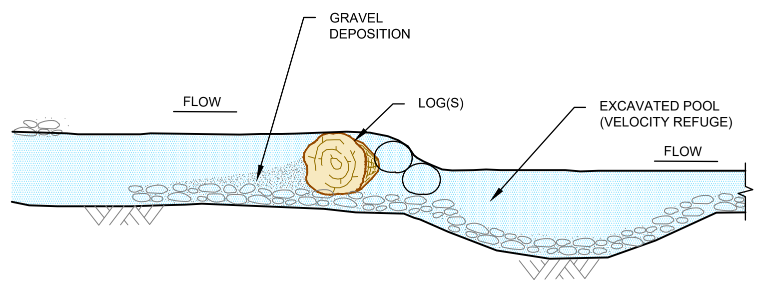

**TYPICAL DETAIL**
**RIFFLE**
NTS



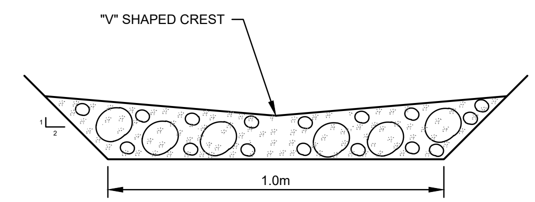

**TYPICAL PLAN**
**IN-LINE POND**
NTS



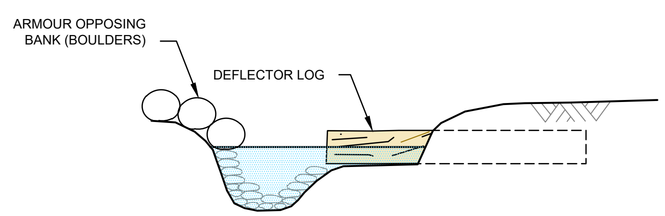

**5 TYPICAL SECTION**
**IN-LINE POND**
NTS



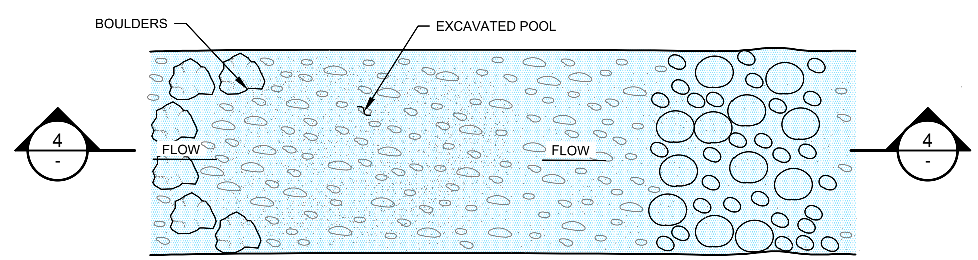

**1 TYPICAL PROFILE**
**DEFLECTOR LOG**
NTS




**3 SECTION**
**RIFFLE**
NTS




**2 TYPICAL SECTION**
**DEFLECTOR LOG**
NTS




**TYPICAL DETAIL**
**ROCK WEIR CONSTRUCTION**
NTS

**NOTES:**

1. LWD (LARGE WOODY DEBRIS) SHOULD RETAIN ROOTWADS AND LIMBS IF POSSIBLE.
2. CABLING OF LWD MAY NOT BE REQUIRED IF THE STEMS CAN BE PINNED UNDER BOULDER COMPLEXES.
3. ALL ON-SITE SWD (SMALL WOODY DEBRIS) IS TO BE INCORPORATED INTO THE POOL OR CHANNEL MARGINS WHERE APPLICABLE. OVERSIZED OR UNDERSIZED BOULDERS MAY ALSO BE INCORPORATED INTO THE CHANNEL DESIGN.
4. BOULDERS TO BE EMBEDDED A MINIMUM DEPTH OF 20 % OF THEIR DIAMETER.
5. DEFLECTOR LOGS TO BE EMBEDDED IN BANK FOR MINIMUM 50%OF LWD LENGTH. IN STREAM LWD LENGTH NOT TO EXCEED 30% OF THE CHANNEL WIDTH.

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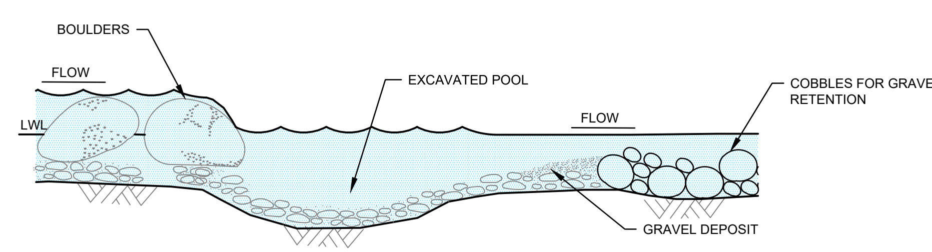


**4 TYPICAL SECTION**
**ROCK WEIR CONSTRUCTION**
NTS



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FIFTEEN MILE STREAM PROJECT

SELOAM BROOK DIVERSION
TYPICAL FISH HABITAT DETAILS

| P/A NO. | DRAWING NO. | REVISION |
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| VA101-708/4 | FM-C1004 | B |

REFERENCE DRAWINGS

| DRG. NO. | DESCRIPTION |
|---|---|
| - | - |

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|---|---|---|---|---|---|---|

REVISIONS

| REV | DATE | DESCRIPTION | DESIGNED | DRAWN | REVIEWED | APPROVED |
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# AppendixE.1

Economic Impact Assessment of the Fifteen Mile Stream Mining Project, KPMG LLP

ATLANTIC GOLD CORPORATION

# Economic Impact Assessment of the Fifteen Mile Stream Mining Project

Preliminary Report

March 2019

kpmg.ca

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# Disclaimer

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# Executive Summary

Atlantic Gold Corporation (AGB) has retained the services of KPMG to evaluate the economic benefits stemming from its Fifteen Mile Stream (FMS) mining project in Nova Scotia and, more precisely, from its exploration, construction and operation activities. The Fifteen Mile Stream project is a gold mine with a projected production over the life of mine (LOM) of 390,800[1] ounces. Mine operations are expected to start in 2021 after a one (1) year construction period and five (5) years of exploration. The mine is expected to stay in operation for six (6) years.

Between 2014 and 2018, $14.6M has been spent on exploration, while the initial or capital investment (CAPEX) currently being considered by AGB is estimated at $123.4M and average annual operating costs (OPEX) at $39.0M. Based on the financial data provided by AGB, KPMG calculated the direct and indirect economic impacts of exploration, construction and operating activities using the Statistics Canada Input-Output (I-O) model. This model is the benchmark model for analyzing economic benefits in the Canadian economy. The table below summarizes the economic impact on Canada and Nova Scotia stemming from exploration, construction and operating spend of AGB for the FMS project.

The exploration phase as a whole generated $10.6M in value added in Nova Scotia over a five-year period, while supporting 93 jobs. The construction phase would generate $81.4M in value added for Nova Scotia economy, support 778 jobs and generate $4.4M and $2.4M in provincial and municipal government revenues, respectively. Finally, operating activities would generate $18.6M in value added annually, support 289 jobs in the province and provide $13.0M and $0.9M in provincial and municipal government revenues.

Impacts on the Canadian economy as a whole will be higher as some of the subcontractors working on site would come from other Canadian provinces. For exploration, construction and operation activities, the impacts on the Canadian economy would be 18%, 14% and 27%, respectively, higher than provincial impacts (based on value added).

**Table 1: Summary of the Economic Impact (direct and indirect) on Canada and Nova Scotia Stemming from Exploration, Construction and Operation Activities for the FMS mining project**
*2020-2026, in millions of dollars*

| | Canada | | | Nova Scotia | | |
|---|---|---|---|---|---|---|
| In millions of dollars | Exploration (5 years) | Construction (1 year) | Operation (Per year) | Exploration (5 years) | Construction (1 year) | Operation (Per year) |
| Value added | 12.5 | 93.1 | 23.7 | 10.6 | 81.4 | 18.6 |
| Government revenues | 0.9 *(federal only)* | 4.3 *(federal only)* | 8.6 *(federal only)* | 0.9 *(provincial only)* 1.3 *(municipal only)* | 4.4 *(provincial only)* 2.4 *(municipal only)* | 13.0 *(provincial only)* 0.9 *(municipal only)* |
| In person-year (FTE equivalent) | | | | | | |
| Jobs created | 105 | 915 | 323 | 93 | 778 | 289 |

[1] Refer to the recovered quantity considering an average ore grade of 1.24 g/t Au and an average recovery rate of 90.6% as based on information provided by AGB.

It should be noted that this report does not explore dynamic economic impacts on the Nova Scotia economy, such as:

– Additional investments in Nova Scotia resulting from the increased activity stimulated by the project;
– Reinforcement of Nova Scotia's mining sector;
– Spillover effect resulting from the expertise of professional firms and contractors from other provinces;
– Improvement of living conditions in certain communities as salary in the mining sector is significantly higher in the mining sector;
– Reduction of worker migration to other provinces.

# 1. Introduction

## 1.1 Mandate overview

Atlantic Gold Corporation, and hereby designated as “AGB”, has retained the services of KPMG to evaluate the economic benefits stemming from the development of the **Fifteen Mile Stream** (FMS) mining project and, more precisely, from exploration, construction and operating activities related to the project.

This evaluation was carried out based on the information available as of January 2019. The information primarily came from the technical report carried out by Ausenco technical services and published in January 2018[2]. Additional data and information were provided by AGB where more detail was required for the purposes of the analysis.

### 1.1.1 Objectives

The objective of the mandate is to evaluate the economic contribution of the investments and overall activities related to the FMS mining project. The economic impact is based on the total capital expenditures (CAPEX) and the operational expenditures (OPEX) over the life of mine (LOM). The economic impacts are measured in terms of:

- jobs directly sustained by AGB in Nova Scotia and Canada;
- jobs indirectly sustained in Nova Scotia and Canada by all of AGB’s expenditures;
- value added or wealth created in Nova Scotia and Canada (from exploration, capital and operation expenditures);
- taxes paid directly or indirectly (property taxes, income taxes, corporate taxes, taxes on products and royalties), at the municipal, provincial and federal levels.

## 1.2 Methodological Framework

### 1.2.1 Static Economic Impacts

This study presents the static economic impacts, which are the multiplying effects of the initial spending that AGB plans to spend on the project in Nova Scotia. In short, these impacts measure the cascading effects that are produced by an injection of cash in a given territory. The more integrated the economy, or the more initial spending engages sectors of activity already in the region, the greater the economic benefits.

The cascading economic benefits are divided into two main groups – the direct and indirect effects of intended spending:

- The **direct effects** are the revenues directly attributable to the spending involved in the project. These revenues are generated by the principals authorizing the expansion project (meaning AGB and its general contractors). These are the salaries paid to AGB’s or prime contractors staff and other revenues generated (profits, amortization);
- The **indirect effects** are the income effects stemming from a demand for goods and services generated by the project activities in other industrial sectors. We are referring here to the impacts on the suppliers selling their goods and services to the principals investing in the project. For example, these include professional and engineering services, specialized technical services (surveying, drilling, etc.), mechanical, energy, machinery and equipment services and the like. Indirect

[2] Moose River Consolidated Project, Nova Scotia, Canada, NI 43-101 Technical Report on Moose River Consolidated Phase 1 and Phase 2 Expansion

impacts therefore also include salaries paid to employees of the various suppliers as well as other revenues generated by these suppliers (profits, amortization).

The direct and indirect economic impacts were calculated using Statistics Canada Input-Output (I-O) model. This model is designed to simulate the activity of a project, a company or an industry (based on the number of jobs, production volume, expenditures or sales) and measure its direct and indirect effects on the national and provincial economies.

This study does not include an assessment of the dynamic impacts of FMS project operations or its investments. Dynamic economic impacts occur when a project contributes, in addition to its effect of spending on the territory's economy, to increase the overall economic performance of firms, a region or an industrial sector. This improvement in performance can take various forms, such as improving worker productivity, developing new skills, reducing production costs or increasing exports. The scope of these impacts is generally much broader than the project under study, and the benefits generated can be felt in many companies, including customers and suppliers.

## 1.3 Basic Assumptions Underlying This Evaluation

The evaluation of the economic benefits stemming from the FMS mining project is based on numerous assumptions, the most important ones being as follows:

– The analysis is based on the project costs that were provided to KPMG by AGB. The information mainly comes from the technical report published in January 2018, but some figures were refined based on further information sent by AGB to KPMG. Benefits could vary upwards or downwards depending on whether the final project costs are eventually higher or lower;

– The analysis is based on the project cost distribution provided by AGB. The benefits could vary if the distribution among the components were to change;

– The analysis is based on 2014 Input-Output (I-O) model from Statistics Canada, which is, as of February 2019, the most recent model available and representative structure of the Nova Scotia and Canadian economies. All results are denominated in 2018 Canadian dollars. Where possible, adjustments were performed to update certain parameters of the model[3]. The benefits could vary if the average structure of the Canadian economy changed. Furthermore, the input-output model is based on the assumption of fixed technological coefficients. It does not take into account economies of scale, constraint capacities, technological change, externalities, or price changes. This makes impact analysis less accurate for long-term and large impacts as firms adjust their production technology and the IO technological coefficients become outdated. Assuming that firms adjust their production technology over time to become more efficient implies that the impact of a change in final demand will tend to be overestimated;

– The benefits include contingency impacts. Such impacts could vary as contingency margins are increased or decreased.

– KPMG preferred to be careful about any additional assumptions that could be made such that the results remain conservative.

[3] In particular, employment numbers were adjusted to take into account wage increases over the 2014-2018 period. When possible, fiscal data was also updated to take into account changes in fiscal policy. While the analysis is based on the 2014 tax structure for taxes on products and production (tax rate, available credit, contribution rate, etc.), 2016 personal effective income tax rates were used to estimate both direct and indirect personal revenue income taxes generated. The 2018 corporate tax rates and royalty regime were used to assess the direct fiscal contribution of AGB. These latter figures were provided by AGB.

## 1.4 Document Structure

This document is divided into four main blocks:

– The first section provides an outline of the **project's scope**;

– The second section presents the economic benefits stemming from the **exploration** activities;

– The third section displays the economic benefits stemming from the **construction** activities;

– The fourth section assesses the economic benefits stemming from **operations**.

# 2. Project Scope

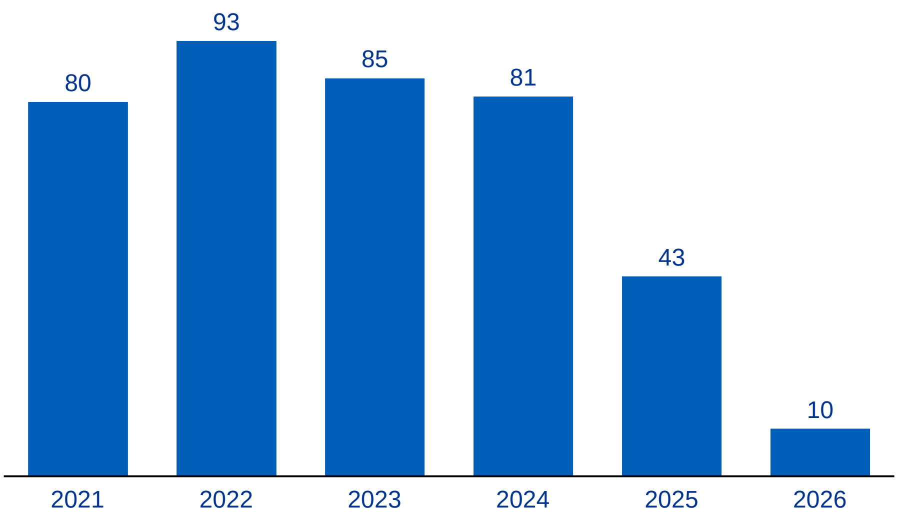
This first section presents the main characteristics of the FMS mining project.

## 2.1 Project Overview

AGB is currently focused on the development of its portfolio of advanced gold development properties located in Nova Scotia. AGB currently holds four gold development projects in the province (Touquoy, Beaver Dam, Cochrane Hill and Fifteen Mile Stream). The FMS project is still at its early stage of development and has historical resources in place.

The FMS Gold Deposit is located approximately 57 km northeast of the central processing facility at the Moose River Consolidated Gold Mine. According to the Feasibility Study, the mine will be in operation in 2021 after one (1) year of site preparation (construction) and five (5) years of exploration. It is expected that the mine will be in operation for six (6) years (from 2021 to 2026) and will produce a total of 390,800 ounces of gold over the LOM at grade ranging from 1.57 to 0.39 grams per tonne and an average recovery grade of 90.6%.

**Figure 1: Fifteen Mile Stream LOM Production Schedule**
*2020-2026, gold produced in '000 ounces*




Source: AGB, 2018. KPMG analysis

## 2.2 Spending and Investment Needs throughout LOM

A project like the one considered by **AGB is subject to important investments and spending whether for the stages of construction or for the operation of the mine. AGB plans to spend $399.4 million in Nova Scotia over the 2014 to 2026 period.**

**Table 2: Distribution of Spending: FMS Project**
*2014-2026, over the entire life of the project*

| Spending category | In M$ | As a % of the total |
|---|---|---|
| 1. Exploration (2014-2018) | 14.6 | 3.7% |
| 2. Construction (2020) | 123.4 | 30.9% |
| 3. Operation (2021-2026) | 234.0 | 58.6% |
| 4. Sustaining capital (2021-2026) | 27.4 | 6.9% |
| **Total (2020-2026)** | **399.4** | **100.0%** |

Source: AGB, 2018. KPMG analysis

The **exploration phase** (2014-2018) includes all the activities related to the search of minerals such as prospecting, mapping, digging and the production of geophysical surveys.

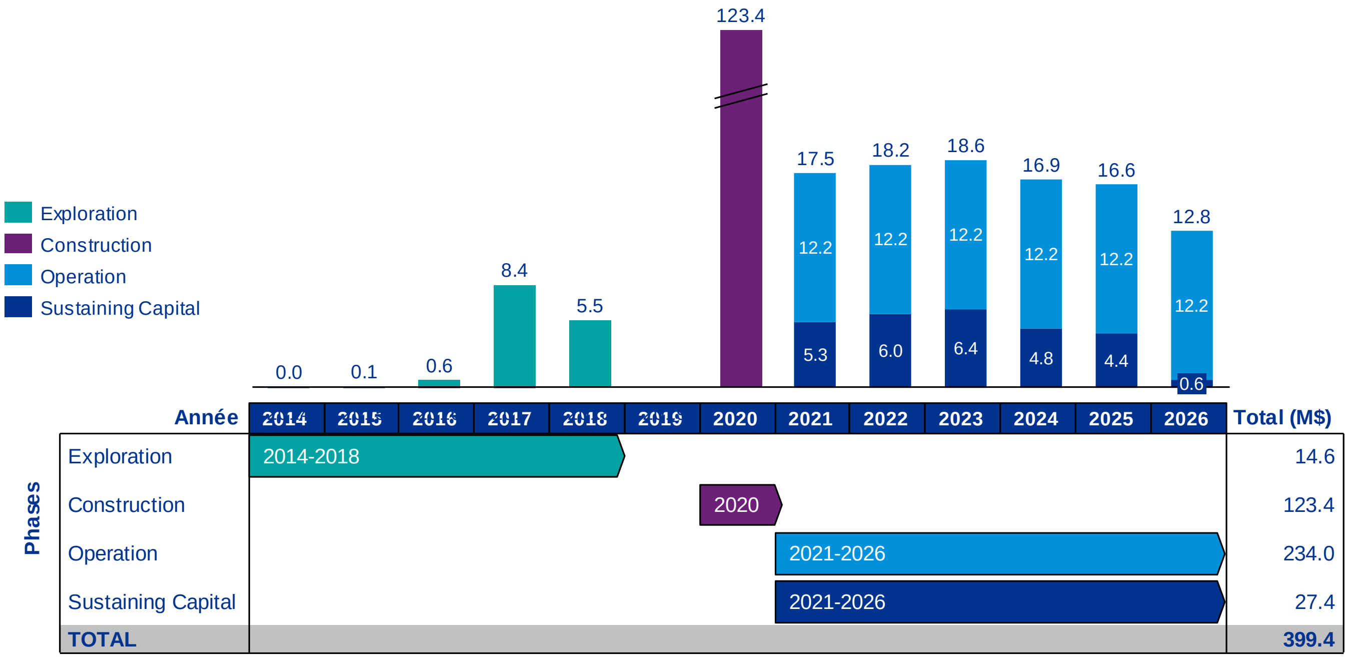
The **construction phase** (2020) includes the expenditure required to start up a business to a standard where it is ready for initial production. This phase would start with mine site development activities including forest clearing, soil preparation and road constructions. Following this step, AGB would go forward with the construction of the site's infrastructure such as of the electrical infrastructure, water and sewage treatment plants. Investments at this stage would also include permanent equipment, materials and labour associated with the physical construction of the process facility, infrastructure, utilities, buildings, etc. Contractor's costs are also considered.

The **operation phase** (2021-2026) of the mine would begin in 2021 and extend for six (6) years, according to documents provided by AGB. Life of mine unit operation costs were estimated at $19.2/t milled for FMS[4]. They include material costs and payroll for all mine activities, including, for example, drilling, extraction, conveying and transportation of ore. The operating phase also includes the costs of the ore processing plant (e.g. chemicals, electricity, consumables, fuel), tailings management and water management (e.g. environmental services, waste management residues) and the general administration of operations (e.g. management of site administration, human resources, technical services, electronic equipment, office supplies). In addition, all capital investments required to maintain infrastructure or spending related to the preservation of the environment (i.e. wetland restauration) occurring during the operation phase will be considered as operation costs.

Figure 2 illustrates the schedule of the spending throughout the LOM.

[4] Average annual cost excludes final year of stockpile rehandle.

**Figure 2: Total Spending by AGB on the FMS Mining Project**
*2024-2026, in $M*




Source: AGB, 2018. KPMG analysis

# 3. Economic Benefits Stemming from Exploration Activities

This second section presents the direct and indirect economic benefits stemming from exploration expenditures at FMS. The nature and scope of the expenditures made are first analyzed, then the resulting economic benefits for the province of Nova Scotia and for Canada are presented.

## 3.1 Exploration Expenditures

Mining exploration refers to the search for mineral that appears in high enough concentration and amounts to be extracted and processed for profit. This phase includes activities such as prospecting, mapping, digging and production of geophysical surveys, but also the acquisition of permits, leases and licenses that are required. These generate further economic activity, support well-paid jobs and play a key role in ensuring the long-term viability of the province's mining industry.

### 3.1.1 Broad Spending Components

AGB has conducted exploration activities at the FMS site between 2014 and 2018 for a total spending of $14.6M. Exploration costs can be divided into eight (8) broad components:

– Permits and claims;

– Drilling and fieldwork;

– Scientific services including analysis by third party to assess drill results, metallurgical recoveries and chemistry of the core;

– Drilling and fieldwork;

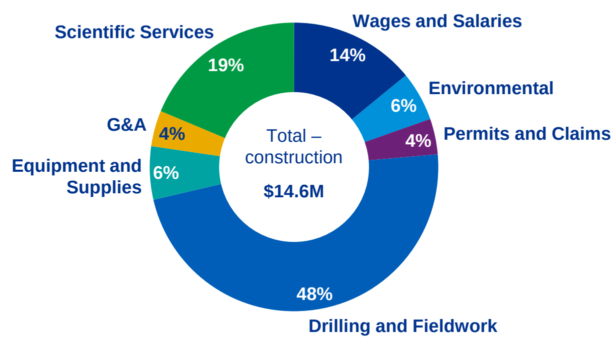
– Environmental related activities, among which permits acquisition, wetland alternation plans, field studies, environmental auditing of drill programs;

– Equipment and supplies;

– Wages and salaries;

– General and administration, including travel and accommodation, and office material.

**Figure 3: Breakdown of the FMS Mining Project Exploration Spending by Broad Component**
*2014-2018, exploration phase*




Note: Due to rounding, the sum of items may not add up to the total.
Source: Data from AGB, KPMG analysis.

## 3.2 Economic Impacts of Exploration Activities

The economic spinoffs of exploration spending at FMS are estimated at $10.6M in Nova Scotia. This total corresponds to the value added of exploration expenditures in Nova Scotia, or, in other words, the true wealth creation effect on the Nova Scotia economy. Pre-tax wages represent 65% of this added value, or $6.9M. These activities supported 93 jobs (in person-year) over the 5-year exploration period.

The following table shows the distribution of direct and indirect effects on value added and employment over the whole exploration period.

**Table 3 : Economic Impact on Nova Scotia Stemming from the Exploration Activities – FMS Mining Project**
*Total from 2014-2018, in millions of dollars and in person-years*

| Nova Scotia | Direct Effects | Indirect Effects | Total |
|---|---|---|---|
| **In millions of dollars** | | | |
| Total value added, of which | 3.6 | 7.0 | 10.6 |
| Salaries and wages before income taxes | 2.1 | 4.8 | 6.9 |
| Other revenues before income taxes | 1.5 | 2.2 | 3.7 |
| **In person-year (FTE equivalent)** | | | |
| Jobs in person-years | 30 | 63 | 93 |

Note : Due to rounding, the sum of items may not add up to the total.
Source : Simulations of Statistics Canada based on data from AGB, KPMG analysis

For Canada as a whole, the impacts arising from exploration activities in terms of wealth are slightly higher – less than 20% higher. Impacts are estimated at $12.5M in value added across Canada and 105 jobs supported (including AGB suppliers; these are full-time equivalent jobs over the duration of the exploration phase).

**Table 4 : Economic Impact on Canada Stemming from the Exploration Activties – FMS Mining Project**
*Total from 2014-2018, in millions of dollars and in person-years*

| Canada | Direct Effects | Indirect Effects | Total |
|---|---|---|---|
| **In millions of dollars** | | | |
| Total value added, of which | 3.6 | 8.9 | 12.5 |
| Salaries and wages before income taxes | 2.1 | 5.9 | 8.0 |
| Other revenues before income taxes | 1.5 | 3.0 | 4.5 |
| **In person-year (FTE equivalent)** | | | |
| Jobs in person-years | 30 | 75 | 105 |

Note : Due to rounding, the sum of items may not add up to the total.
Source : Simulations of Statistics Canada based on data from AGB, KPMG analysis

The exploration phase also has an impact on government revenues, whether through taxes on personal incomes, taxes on products and taxes on production. Total tax revenues are estimated at $0.9M for the Nova Scotia Government, $1.0M for the Federal Government and $1.3M for municipal governments as the result of the acquisition of permits and claims.

**Table 5: Direct and Indirect Municipal, Provincial (Nova Scotia) and Federal Government Revenues Stemming from Exploration Activities – FMS Mining Project**

*2020, in millions of dollars*

| Detail tax revenues | Personal income tax[1] | Taxes on products[2] | Taxes on production[2] | Total |
|---|---|---|---|---|
| | | | | |
| Municipal | -- | 0.0 | 1.3 | 1.3 |
| Nova Scotia (Provincial) | 0.6 | 0.0 | 0.3 | 0.9 |
| Canada (Federal) | 0.6 | 0.0 | 0.4 | 1.0 |

Note : Due to rounding, the sum of items may not add up to the total.
1.Personal income taxes have been estimates based on 2016 effective tax rate in Nova Scotia and Canada (from Statistics Canada).
2.Direct and indirect taxes, based on Statistics Canada Input-Output model.
Source : Statistics Canada, AGB, KPMG analysis

# 4. Economic Benefits Stemming from Construction Activities

This third section presents the direct and indirect economic benefits of the investment expenditures of the FMS Project. The nature and scope of the expenditures are first analyzed, then the resulting economic benefits for the province of Nova Scotia and for Canada are presented.

## 4.1 Construction Activities

### 4.1.1 Broad Spending Components

According to the data provided by AGB, total costs for the construction of the Fifteen Mile Stream mine are estimated at $123.4M including right of way and land acquisition of $1.8M[5] and contingency. These costs consist of four (4) broad components:

– Construction and commissioning of the processing plant (60% of the total spending);

– Construction of the mine including site preparation and pit water (19% of total spending);

– On-site infrastructure such as laboratory and sewage treatment plant (14% of the total spending);

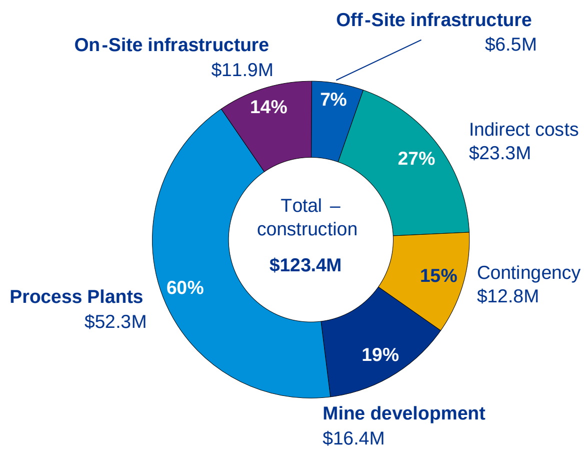
– Off-site infrastructure like roads and power supply (7% of total spending);

Are also included:

– Indirect costs which include all costs associated with implementation of the plant and incurred by the owner, engineer or consultants in the design, procurement, construction, and commissioning of the project (27% of the total spending);

– Contingency is a cost element to accommodate unknown items that are expected to occur within the defined scope of the project, but which cannot be properly defined at the current stage of the project (15% of the total spending).

**Figure 4: Breakdown of FMS Mining Project Construction Spending by Broad Component**
*2020, construction phase*

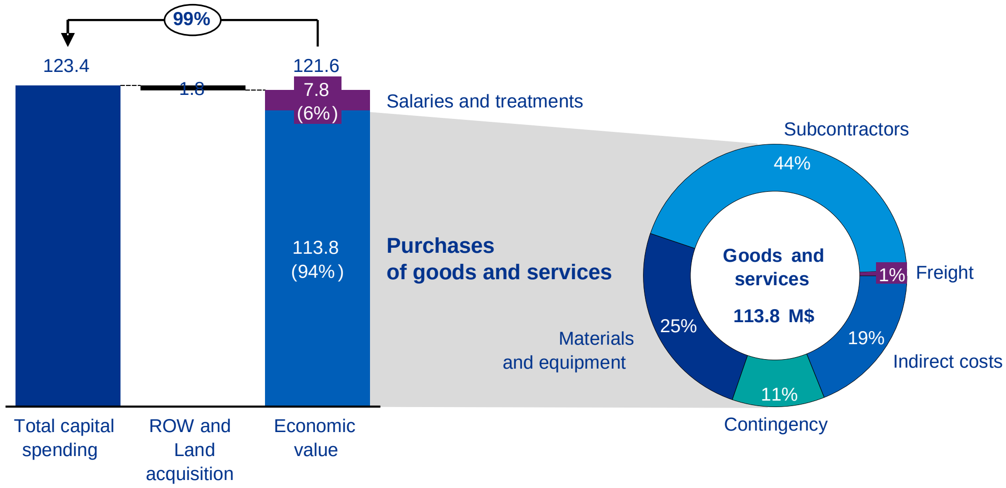



Note : Due to rounding, the sum of items may not add up to the total. .
Source :Data from AGB, KPMG analysis.

The construction phase is characterized by a large volume of purchases of goods and services, notably to subcontractors (44%) as well as towards the purchase of materials and specialized equipment (25%). The following figure shows the breakdown by type of expenditure.

[5] Since the purchase of land and rights of way is not planned to create value in the economy, this portion of the capital expenditures will be excluded from the economic impact analysis.

**Figure 5: Distribution of FMS Project Construction Expenses by Category of Goods and Services**
*2020, in millions of dollars and breakdown in %*




Source: Data from AGB, KPMG analysis.
Note: For the purposes of this economic impact analysis, all cost related to ROW and land acquisition has been removed from the input's simulation as they are considered to generate no economic value.

## 4.2 Economic Impacts of Construction Activities

For 2020, the economic spinoffs of the projected investments stemming from the construction of the FMS mine are estimated at $81.4 million in Nova Scotia. This total corresponds to the value added of the project in Nova Scotia, or, in other words, the true wealth creation effect on the Nova Scotia economy. Pre-tax wages represent 77% of this added value, or $63.1M. The investment activities would support 778 jobs (in person-years) over the entire duration of the work. These would consist of 666 direct jobs, to which would be added 112 indirect jobs among Nova Scotia suppliers.

The following table shows the distribution of direct and indirect effects on value added and employment. It is important to emphasize that those benefits are not recurring yearly and reflect the impact of one-off expenditures during the construction work.

**Table 6 : Economic Impact on Nova Scotia Stemming from the Construction – FMS Mining Project**
*2020, in millions of dollars and in person-years*

| Nova Scotia | Direct Effects | Indirect Effects | Total |
|---|---|---|---|
| **In millions of dollars** | | | |
| Total value added, of which | 68.8 | 12.6 | 81.4 |
| Salaries and wages before income taxes | 55.4 | 7.7 | 63.1 |
| Other revenues before income taxes | 13.5 | 4.9 | 18.3 |
| **In person-year (FTE equivalent)** | | | |
| Jobs in person-years | 666 | 112 | 778 |

Note: Due to rounding, the sum of items may not add up to the total.
Source: Simulations of Statistics Canada based on data from AGB, KPMG analysis

For Canada as a whole, the impact arising from the construction activities of FMS mining project in terms of wealth is estimated at $93.1M and would support 915 additional jobs (including AGB suppliers). These are full-time equivalent jobs over the duration of the construction phase (1 year).

**Table 7 : Economic Impact on Canada Stemming from the Construction – FMS Mining Project**
*2020, in millions of dollars and in person-years*

| Canada | Direct Effects | Indirect Effects | Total |
|---|---|---|---|
| **In millions of dollars** | | | |
| Total value added, of which | 71.7 | 21.4 | 93.1 |
| Salaries and wages before income taxes | 57.4 | 13.2 | 70.5 |
| Other revenues before income taxes | 14.3 | 8.2 | 22.6 |
| **In person-year (FTE equivalent)** | | | |
| Jobs in person-years | 726 | 189 | 915 |

Note: Due to rounding, the sum of items may not add up to the total.
Source: Simulations of Statistics Canada based on data from AGB, KPMG analysis

The development of the mine would also have a significant impact on government revenues, whether through taxes on personal incomes, taxes on products and taxes on production. Total expected tax revenues stemming from the construction phase amount to $4.4M for the Nova Scotia Government, $4.3M for the Federal Government and $2.4M for municipal governments.

**Table 8: Direct and Indirect Municipal, Provincial (Nova Scotia) and Federal Government Revenues Stemming from the Construction – FMS Mining Project**
*2020, in millions of dollars*

| Detail tax revenues | Personal income tax[1] | Taxes on products[2] | Taxes on production[2] | Total |
|---|---|---|---|---|
| | | | | |
| Municipal | -- | 0.0 | 2.4 | 2.4 |
| Nova Scotia (Provincial) | 3.6 | 0.4 | 0.4 | 4.4 |
| Canada (Federal) | 4.0 | 0.3 | 0.0 | 4.3 |

Note: Due to rounding, the sum of items may not add up to the total.
1.Personal income taxes have been estimates based on 2016 effective tax rate in Nova Scotia and Canada (from Statistics Canada).
2.Direct and indirect taxes, based on Statistics Canada Input-Output model.
Source: Statistics Canada, AGB, KPMG analysis

# 5. Economic Benefits Stemming from Operations

This last section presents the economic benefits stemming from mining and processing activities at FMS, for both Nova Scotia and Canada.

## 5.1 FMS Operating Expenditures

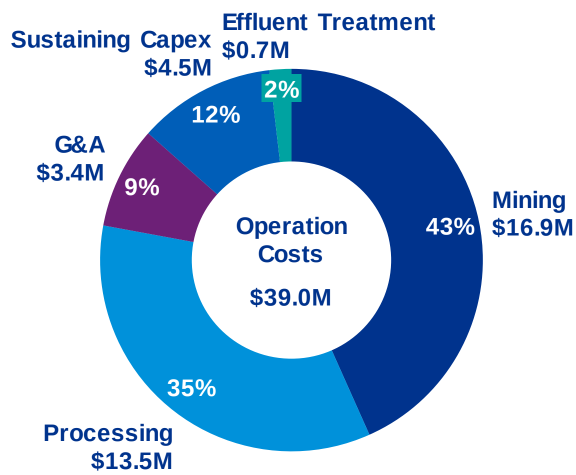
### 5.1.1 Broad Spending Components

Operating expenditures represent an important part of the FMS's contribution to the economy. Over its lifetime – which is assumed to be of six (6) years – OPEX are estimated at $234.0M, which is equivalent to an average yearly spending of $39.0M.

The breakdown of the yearly average operating costs for the FMS mine is illustrated in figure five (5) and falls into six (6) broad components:

- Mining cost including labor, materials, specialized equipment, etc. (43% of total spending);
- Processing cost such as labour, chemicals, electricity, fuel, etc. (35% of total spending);
- Sustaining Capex including materials and spare parts, owner costs and environmental services (12% of total spending);
- General and administration (electronic equipment, office supplies, etc.)  (9% of total spending);
- Effluent Treatment (6% of total spending).

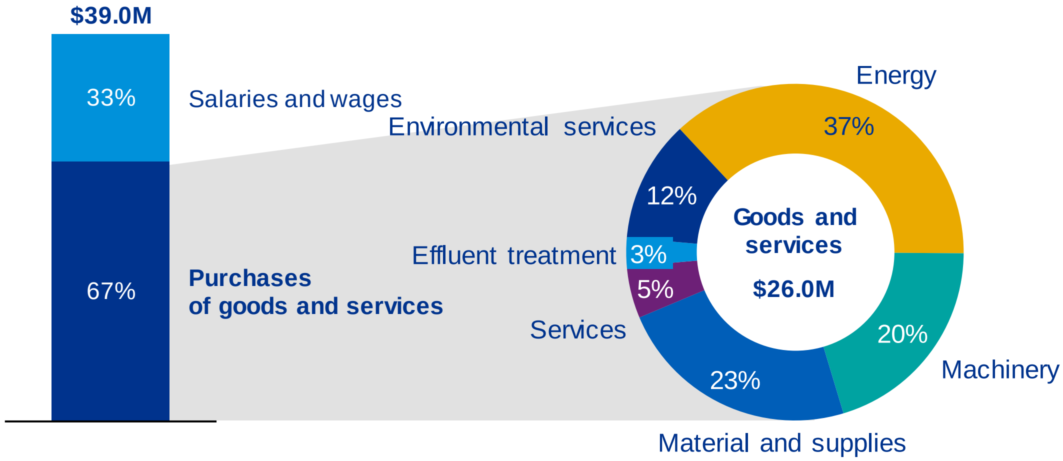
**Figure 6: Breakdown of Average Annual Mine Operating Expenditures by Broad Component**
*2021,2026 operation phase*




Source : AGB, KPMG analysis.

As illustrated in figure 5, for the purposes of the economic impact analysis, sustaining CAPEX has been included in operating expenditures in order to reflect their specific nature. Sustaining capital costs include the costs for raising the tailings dam (as required over the life of the mine), plant and infrastructure spending and reclamation costs.

**Table 9: Distribution of Mine Operating Expenses by Category of Goods and Services**




Source : AGB, KPMG analysis.

## 5.2 Economic Benefits of Operations

Operating expenses would contribute to increase value added in Nova Scotia by $18.6M per year on average, or $111.4M over the entire operating phase (2021-2026). Pre-tax wages would represent 87% of this added value, or more than $16.0M per year. The planned activities would support the equivalent of 298 full-time equivalent workers per year. These jobs would consist of 235 direct jobs, plus 54 indirect jobs with AGB's leading suppliers. The following table shows the distribution of direct and indirect benefits to value added and employment.

**Table 10: Economic Impacts in Nova Scotia Stemming from Operations – FMS Mining Project**
*Typical year, in millions of dollars and in person-years*

| Nova Scotia Province | Direct Effects | Indirect Effects | Total |
|---|---|---|---|
| **In millions of dollars** | | | |
| Total value added, of which | 12.9 | 5.6 | 18.6 |
| Salaries and wages before income taxes | 12.8 | 3.3 | 16.2 |
| Other revenues before income taxes | 0.1 | 2.3 | 2.4 |
| **In person-year (FTE equivalent)** | | | |
| Jobs in person-years | 235 | 54 | 289 |

Note: Due to rounding, the sum of items may not add up to the total.
Source: Simulations of Statistics Canada based on data from AGB, KPMG analysis

The following table presents the economic benefits arising across Canada from the projected OPEX. Average yearly value added for Canada amounts to $23.7M and operations would support 323 jobs across the country.

**Table 11: Economic Impacts on Canada Stemming from Operations – FMS Mining Project**
*Typical year, in millions of dollars and in person-years*

| Canada | Direct Effects | Indirect Effects | Total |
|---|---|---|---|
| **In millions of dollars** | | | |
| Total value added, of which | 12.9 | 10.7 | 23.7 |
| Salaries and wages before income taxes | 12.8 | 5.8 | 18.6 |
| Other revenues before income taxes | 0.1 | 4.9 | 5.1 |
| **In person-year (FTE equivalent)** | | | |
| Jobs in person-years | 235 | 88 | 323 |

Note: Due to rounding, the sum of items may not add up to the total.
Source: Simulations of Statistics Canada based on data from AGB, KPMG analysis

The operation of the mine would generate additional government revenues in terms of labor income taxes, indirect taxes, corporate taxes and mining royalties. Total tax revenues for the Nova Scotia, Canadian and municipal governments would reach nearly $22.8M a year. These represent conservative estimates as, for example, corporate income taxes paid by suppliers cannot be estimated.

**Table 12: Municipal, Provincial and Federal Direct and Indirect Tax Revenues Stemming from Operations – FMS Mining Project**
*Typical year, in millions of dollars*

| Detail tax revenues | Corporate income tax and royalties[1] | Personal income tax[2] | Taxes on products[3] | Taxes on production[3] | Total |
|---|---|---|---|---|---|
| | | | | | |
| Municipal | -- | -- | 0.0 | 0.9 | 0.9 |
| Nova Scotia (provincial) | 9.9 | 1.1 | 1.9 | 0.1 | 13.0 |
| Canada (federal) | 7.2 | 0.8 | 0.9 | 0.0 | 8.9 |

Note: Due to rounding, the sum of items may not add up to the total.
1. Direct income taxes and royalties are estimated by AGB; figures exclude corporate income taxes paid by AGB suppliers.
2. Personal income taxes have been estimates based on 2016 effective tax rate in Nova Scotia and Canada (from Statistics Canada).
3. Direct and indirect taxes, based on Statistics Canada Input-Output model.
Source: Statistics Canada, AGB, KPMG analysis

# 6. Conclusion

The FMS mining project that AGB is currently developing in Nova Scotia would benefit the province's economy. The project under review represents more than $372M of spending over the 2014-2026 period, including $14.6M in exploration activities, $123.4M in capital expenditures and $234.0M in operating expenditures ($39.0M in yearly OPEX).

As previously shown, the exploration phase has generated $10.6M in value added across the province during the five (5) years these activities were conducted. The initial investment leading to the construction of the mine would generate $81.4M in value added in Nova Scotia, support 778 full-time equivalent jobs and generate $11.1M in revenues for the three levels of government, while the operating and recurrent spending would generate $18.6M in value added annually, support 289 jobs and provide $22.8M per year in government revenues.

Impacts on the Canadian economy as a whole will be higher as some of the subcontractors working on site would come from other Canadian provinces. For exploration, construction and operation activities, the impacts on the Canadian economy would be 18%, 14% and 27%, respectively, higher than provincial impacts (based on value added).

**Table 13: Summary of the Economic Impact (direct and indirect) on Canada and Nova Scotia Stemming from Exploration, Construction and Operation Activities for the FMS Mining Project**
*2020-2026, in millions of dollars*

| | Canada | | | Nova Scotia | | |
|---|---|---|---|---|---|---|
| In millions of dollars | Exploration (5 years) | Construction (1 year) | Operation (Per year) | Exploration (5 years) | Construction (1 year) | Operation (Per year) |
| Value added | 12.5 | 93.1 | 23.7 | 10.6 | 81.4 | 18.6 |
| Government revenues | 0.9 *(federal only)* | 4.3 *(federal only)* | 8.9 *(federal only)* | 0.9 *(provincial only)* 1.3 *(municipal only)* | 4.4 *(provincial only)* 2.4 *(municipal only)* | 13.0 *(provincial only)* 0.9 *(municipal only)* |
| In person-year (FTE equivalent) | | | | | | |
| Jobs created | 105 | 915 | 323 | 93 | 778 | 289 |

This report did not explore dynamic economic impacts on the Nova Scotia economy. Dynamic impacts could stem from:

– Additional investments in Nova Scotia resulting from the increased activity stimulated by the project;

– Reinforcement of Nova Scotia's mining sector;

– Spillover effect resulting from the expertise of professional firms and contractors from other provinces;

– Improvement of living conditions in certain communities as salary in the mining sector is significantly higher in the mining sector ;

– Reduction of worker migration to other provinces.

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Atlantic Gold

# Appendix F.1

## Fifteen Mile Stream Project: Geochemical Source Term Predictions, Lorax Environmental Services Ltd.

# *Fifteen Mile Stream Project: Geochemical Source Term Predictions*

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**Project No. A490-6**

**September 18, 2019**

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# 1. Introduction

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

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

- Mineralogy and geochemistry of the exposed material;
- Reactive surface area;
- Water-to-rock ratio;
- Depositional environment (*e.g.*, saturated versus unsaturated conditions); and
- Temperature.

The prediction of both the elemental concentrations in contact water from the Waste Rock Storage Areas (WRSAs), overburden and ore stockpiles, pit walls, and the Tailings Management Facility (TMF) was conducted using a combination of kinetic test results as well as site monitoring and analogue data from the operational Touquoy Mine. Table 1-1 provides an overview of all facilities for which geochemical source terms were derived as well as the respective model approach. Where predictions relied on upscaling of kinetic test results, a number of calibration work stages were implemented.

Blasting of waste and ore rock will result in the coating of particle surfaces with N species (ammonia, nitrite, nitrate) from explosives by-products. In waste rock and ore storage facilities, this process is generally responsible for the release of these species into the receiving environment. A source term model in consideration of the explosives type, water/rock ratios was generated separately in order to predict drainage chemistry specific to nitrogen. The following sections discuss the background and rationale for the various considerations built into the geochemical source term model.

**Table 1-1:**
**Overview of Source Term Locations and Modelling Approach Used (Excluding N Source Terms)**

| Mine Component | Contaminant Source | Approach |
|---|---|---|
| Process water | Mill | Tailings supernatant |
| Tailings Beach | Mill; Tailings | Shake Flask Extraction tests |
| Porewater/seepage | Mill; Tailings | Saturated columns |
| Pit Walls | Waste rock & Ore | Upscaling of kinetic tests |
| NAG WRSA | Waste rock | Upscaling of kinetic tests |
| PAG WRSA | Waste rock | Upscaling of kinetic tests |
| TMF Embankment | Waste rock | Upscaling of kinetic tests |
| Low-Grade Ore SP | Ore | Upscaling of kinetic tests |
| Topsoil SP | Soil | Shake Flask Extraction tests |
| Till SP | Till/Overburden | Shake Flask Extraction tests |

**Notes:** PAG = Potentially Acid Generating; NAG= Non-Acid Generating; WRSA = Waste Rock Storage Area, SP = Stockpile; TMF = Tailings Management Facility.

# 2. Source Term Derivation Approach

## 2.1 Waste Rock and Ore Upscaling

A flow chart of the work stages comprising the scale-up of kinetic tests results, which was applied to model the contact water chemistry for the WRSAs, low-grade ore stockpile and pit walls, is given in Figure 2-1. Each of these work stages is described in detail below. Importantly, scaling factors used in this exercise were generally derived via inverse modelling of available Touquoy site monitoring data. Note that source terms relating to the TMF (process and porewater, beach runoff), TMF embankments, as well as the till and topsoil stockpiles do not rely on the upscaling approach presented in this chapter and are discussed in detail in Sections 2.2 through 2.4. Further, nitrogen source terms considering the use of explosives were developed using a different scaling approach and are discussed separately in Section 3.

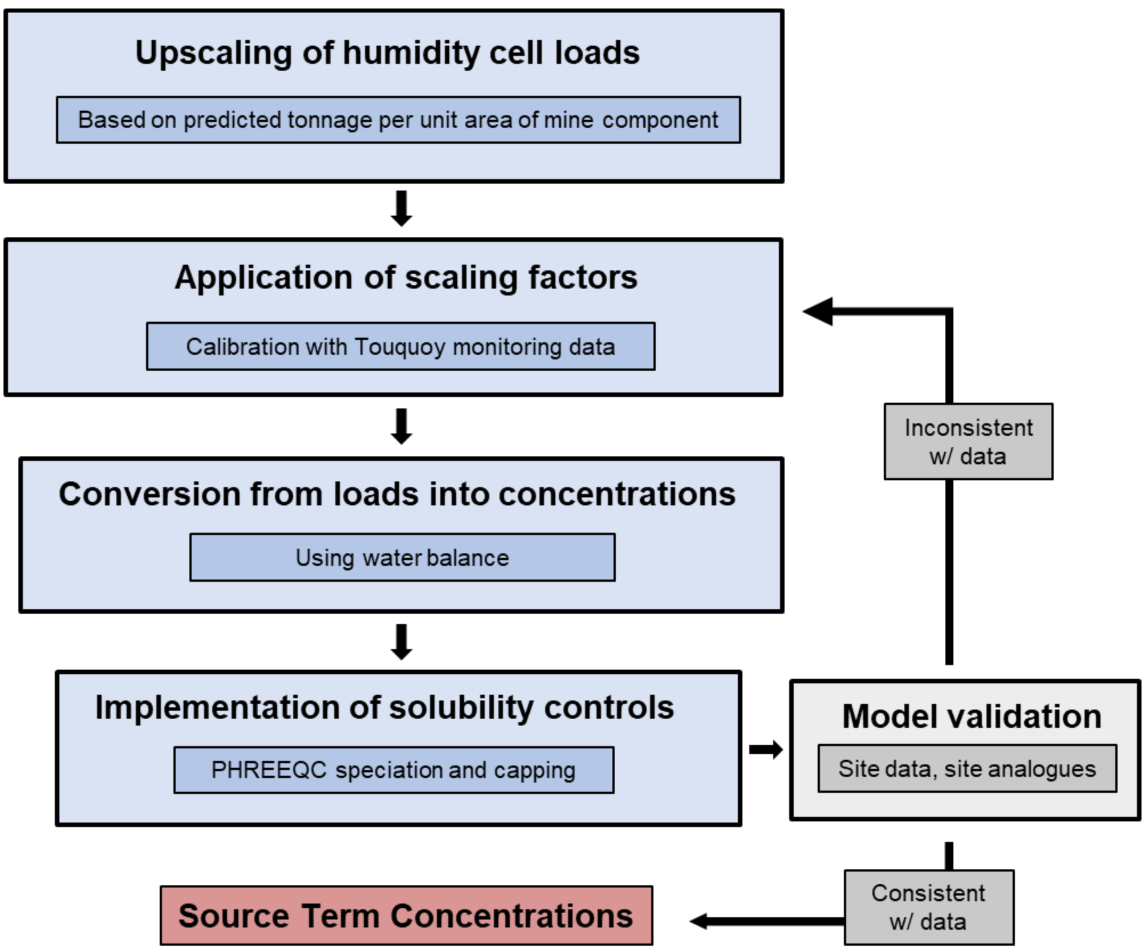


**Figure 2-1: Work stages involved in the scaling of geochemical source terms.**

### 2.1.1 Derivation of Humidity Cell Loading Rates

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

#### *2.1.1.1 Neutral Loading Rates*

Loading rates are herein defined as the mass of a solute released per kg of rock material over one week of humidity cell testing (mg/kg/wk). Two mine phases, End of Mining (EOM) and Post-Closure (PC), were modelled using loading rates from different humidity cell cycles. For each of these mine phases, a Base Case and an Upper Case scenario were implemented. An overview of the scenarios modelled and humidity cells used for the FMS source term predictions is presented in Table 2-1. Conceptually, it was assumed that potentially acid-generating (PAG) materials would remain neutral during operations up until the end of mining. Input loading rates were derived from four humidity cells representing the four major waste rock types and one humidity cell representing low-grade ore to be stored on site. The waste rock loading rates were grouped into the following categories to allow for the reconciliation with the units presented in the waste rock production schedule:

- *Argillite* (HC 1 = **AR** = Argillite w/ <5% Greywacke interbeds and HC 2 = **AG** = Argillite w/ 5- 49% Greywacke interbeds) and
- *Greywacke* (HC 3 = **GA** = Greywacke w/ 20-50% Argillite interbeds and HC 4 = **GW** = Greywacke w/ < 20% Argillite interbeds**).**

To derive a neutral model input, humidity cell data were proportioned to be representative of the static test populations’ sulphide sulphur content. Specifically, the sulphide sulphur content for each cell was put into context by calculating the percentile of the corresponding static test population within each modelled geologic mine unit. The weighting of the two humidity cells to derive the loading rate for each unit was then determined based on this statistical value. An overview of how the different tests were accounted for is given in Table 2-2.

#### *2.1.1.2 Acidic Loading Rates*

None of the FMS humidity cells had turned acidic during their laboratory runtime such that assumptions had to be made with respect to the long-term (PC) drainage chemistry of the FMS potentially-acid generating (PAG) rock under acidic conditions. Using a humidity cell from Cochrane Hill which produced neutral as well as acidic drainage, “acid factors” (AF) were calculated for each species that relates the neutral and acidic water chemistry as follows:

$$AF_i = L_{Ai}/L_{Ni}$$

where $L_{Ai}$ is the loading rate of species i under acidic conditions in HC7 (cycles 33-37) and $L_{Ni}$ is the loading rate of species i in neutral HCs (cycles 33-37). This value was then multiplied with the FMS neutral source term in question to derive loading rates that are representative of acidic conditions. Importantly, these loading rates were only applied proportional to the percentage of PAG materials in the PC scenario of the modelled location. It should be noted that this approach is considered preliminary and geochemical source term model outputs will be updated for the PC scenario once acidic drainage from at least one of the FMS humidity cells is observed. Neutral and acidic loading rates that were used as model input for both the EOM and PC mine phases are summarized in Table 2-3 through Table 2-5.

**Table 2-1:**
**Laboratory Tests and Scenarios Used to Derive Neutral Input Loading Rates**

| Facility | Laboratory test used | Phase | Scenario | Cycles Used |
|---|---|---|---|---|
| **Waste Storage Facilities** | FMS HC 1 through HC 4 | Operational | Base Case | median of cycles 5-15 |
| | | (End of Mine) | Upper Case | 90th percentile of cycles 5-15 |
| | | Long-Term | Base Case | median of cycles 33-37 |
| | | (Post-Closure) | Upper Case | 90th percentile of cycles 33-37 |
| **Pit Walls** | FMS HC 1 through HC 4 | Operational | Base Case | median of cycles 5-15 |
| | | (End of Mine) | Upper Case | 90th percentile of cycles 5-15 |
| | | Long-Term | Base Case | median of cycles 33-37 |
| | | (Post-Closure) | Upper Case | 90th percentile of cycles 33-37 |
| **Low-Grade Ore Stockpile** | FMS HC 5 | Operational | Base Case | median of cycles 5-15 |
| | | (End of Mine) | Upper Case | 90th percentile of cycles 5-15 |
| | | Long-Term | Base Case | median of cycles 33-37 |
| | | (Post-Closure) | Upper Case | 90th percentile of cycles 33-37 |

**Notes:** HC = Humidity Cell; TMF = Tailings Management Facility

**Table 2-2:**
**Weighting of Humidity Cells to Derive Neutral Input Loading Rates**

| Sample ID | Lithology Code | Sulphide S (%) | Percentile of population | Weighting |
|---|---|---|---|---|
| Argillite | | | | |
| HC1 | AG | 0.345 | 54% | 72% |
| HC2 | AR | 0.565 | 90% | 28% |
| Greywacke | | | | |
| HC3 | GA | 0.49 | 96% | 26% |
| HC4 | GW | 0.22 | 53% | 74% |

**Notes:** HC = Humidity Cell

**Table 2-3:**
**Neutral Short-Term Loading (EOM) Rates Used as Input for the FMS Source Term Model**

| Parameter | Unit | Argillite | | Greywacke | | Ore | |
|---|---|---|---|---|---|---|---|
| | | Base Case | Upper Case | Base Case | Upper Case | Base Case | Upper Case |
| Sulphate | mg/kg/wk | 12 | 14 | 8.5 | 11 | 7.1 | 13 |
| Al | mg/kg/wk | 0.039 | 0.076 | 0.054 | 0.074 | 0.066 | 0.072 |
| Ag | mg/kg/wk | 0.000012 | 0.000012 | 0.000011 | 0.000011 | 0.000011 | 0.000011 |
| As | mg/kg/wk | 0.0050 | 0.0055 | 0.017 | 0.038 | 0.0055 | 0.013 |
| Ca | mg/kg/wk | 5.7 | 6.6 | 5.8 | 6.3 | 5.2 | 6.7 |
| Cd | mg/kg/wk | 0.0000012 | 0.0000033 | 0.0000013 | 0.0000033 | 0.00000066 | 0.0000022 |
| Co | mg/kg/wk | 0.000021 | 0.000040 | 0.0000081 | 0.000026 | 0.0000068 | 0.000025 |
| Cr | mg/kg/wk | 0.0000070 | 0.000034 | 0.0000089 | 0.000043 | 0.0000067 | 0.000039 |
| Cu | mg/kg/wk | 0.00031 | 0.0010 | 0.00021 | 0.00064 | 0.00019 | 0.0028 |
| Fe | mg/kg/wk | 0.0016 | 0.0059 | 0.0016 | 0.0053 | 0.0016 | 0.0054 |
| Hg | mg/kg/wk | 0.0023 | 0.011 | 0.0022 | 0.0028 | 0.0022 | 0.0023 |
| Mn | mg/kg/wk | 0.0017 | 0.0048 | 0.013 | 0.015 | 0.0089 | 0.0099 |
| Mo | mg/kg/wk | 0.00014 | 0.00047 | 0.000084 | 0.00013 | 0.000066 | 0.00012 |
| Ni | mg/kg/wk | 0.000077 | 0.00017 | 0.000088 | 0.00021 | 0.000090 | 0.00015 |
| Pb | mg/kg/wk | 0.0000051 | 0.000012 | 0.0000047 | 0.000017 | 0.0000089 | 0.000023 |
| Sb | mg/kg/wk | 0.000064 | 0.00013 | 0.000057 | 0.00016 | 0.000044 | 0.000059 |
| Se | mg/kg/wk | 0.0000094 | 0.000029 | 0.0000088 | 0.000012 | 0.000029 | 0.000042 |
| Tl | mg/kg/wk | 0.0000012 | 0.0000036 | 0.0000011 | 0.0000020 | 0.0000011 | 0.0000014 |
| U | mg/kg/wk | 0.00018 | 0.00028 | 0.00042 | 0.00056 | 0.00012 | 0.00015 |
| Zn | mg/kg/wk | 0.00046 | 0.00047 | 0.00044 | 0.00045 | 0.00044 | 0.00045 |

**Table 2-4:**
**Neutral Long-Term (PC) Loading Rates Used for NAG material as Input for the FMS Source Term Model**

| Parameter | Unit | Argillite | | Greywacke | | Ore | |
|---|---|---|---|---|---|---|---|
| | | Base Case | Upper Case | Base Case | Upper Case | Base Case | Upper Case |
| Sulphate | mg/kg/wk | 9.8 | 11 | 6.7 | 9.1 | 15 | 17 |
| Al | mg/kg/wk | 0.023 | 0.023 | 0.040 | 0.044 | 0.025 | 0.036 |
| Ag | mg/kg/wk | 0.000011 | 0.000012 | 0.000011 | 0.000012 | 0.000011 | 0.000012 |
| As | mg/kg/wk | 0.0037 | 0.0038 | 0.0092 | 0.0095 | 0.0052 | 0.0080 |
| Ca | mg/kg/wk | 5.3 | 5.7 | 5.6 | 6.5 | 7.7 | 8.4 |
| Cd | mg/kg/wk | 0.0000035 | 0.0000046 | 0.00000068 | 0.0000023 | 0.0000013 | 0.0000020 |
| Co | mg/kg/wk | 0.000028 | 0.000041 | 0.000011 | 0.000013 | 0.000034 | 0.000053 |
| Cr | mg/kg/wk | 0.000018 | 0.000019 | 0.000018 | 0.000019 | 0.000017 | 0.000019 |
| Cu | mg/kg/wk | 0.00072 | 0.0014 | 0.00034 | 0.00053 | 0.00029 | 0.00033 |
| Fe | mg/kg/wk | 0.0017 | 0.0099 | 0.0017 | 0.0042 | 0.0017 | 0.0027 |
| Hg | mg/kg/wk | 0.0023 | 0.0024 | 0.0022 | 0.0024 | 0.0022 | 0.0024 |
| Mn | mg/kg/wk | 0.0013 | 0.0022 | 0.010 | 0.012 | 0.0088 | 0.014 |
| Mo | mg/kg/wk | 0.00032 | 0.00072 | 0.000096 | 0.00010 | 0.000067 | 0.000079 |
| Ni | mg/kg/wk | 0.000042 | 0.000071 | 0.000024 | 0.000036 | 0.00030 | 0.00044 |
| Pb | mg/kg/wk | 0.0000056 | 0.000036 | 0.0000072 | 0.000013 | 0.0000022 | 0.0000024 |
| Sb | mg/kg/wk | 0.00021 | 0.00022 | 0.00020 | 0.00021 | 0.00019 | 0.00021 |
| Se | mg/kg/wk | 0.0000092 | 0.0000096 | 0.0000089 | 0.0000095 | 0.000017 | 0.000021 |
| Tl | mg/kg/wk | 0.0000035 | 0.0000040 | 0.0000020 | 0.0000026 | 0.0000026 | 0.0000028 |
| U | mg/kg/wk | 0.000066 | 0.00011 | 0.00022 | 0.00033 | 0.000064 | 0.00011 |
| Zn | mg/kg/wk | 0.00046 | 0.00048 | 0.00045 | 0.00048 | 0.00043 | 0.00047 |

**Table 2-5:**
**Acid Factors and Acidic Long-Term (PC) Loading Rates Used for PAG material in the FMS Source Term Model**

| Parameter | Unit | Argillite | | Greywacke | | Ore | | *Acid Factor (unitless)* |
|---|---|---|---|---|---|---|---|---|
| | | Base Case | Upper Case | Base Case | Upper Case | Base Case | Upper Case | |
| Sulphate | mg/kg/wk | 22 | 25 | 15 | 21 | 33 | 39 | 2.3 |
| Al | mg/kg/wk | 0.13 | 0.14 | 0.24 | 0.26 | 0.15 | 0.21 | 5.9 |
| Ag | mg/kg/wk | 0.000011 | 0.000011 | 0.000011 | 0.000011 | 0.000010 | 0.000011 | 0.95 |
| As | mg/kg/wk | 0.020 | 0.020 | 0.048 | 0.050 | 0.027 | 0.042 | 5.3 |
| Ca | mg/kg/wk | 1.1 | 1.2 | 1.1 | 1.3 | 1.6 | 1.7 | 0.20 |
| Cd | mg/kg/wk | 0.00095 | 0.0013 | 0.00019 | 0.00063 | 0.00035 | 0.00054 | 273 |
| Co | mg/kg/wk | 0.0066 | 0.0094 | 0.0025 | 0.0030 | 0.0080 | 0.012 | 232 |
| Cr | mg/kg/wk | 0.000017 | 0.000018 | 0.000017 | 0.000018 | 0.000016 | 0.000018 | 0.95 |
| Cu | mg/kg/wk | 0.010 | 0.020 | 0.0047 | 0.0075 | 0.0040 | 0.0046 | 14 |
| Fe | mg/kg/wk | 2.7 | 16 | 2.7 | 6.8 | 2.7 | 4.4 | 1618 |
| Hg | mg/kg/wk | 0.0022 | 0.0023 | 0.0021 | 0.0023 | 0.0020 | 0.0022 | 0.95 |
| Mn | mg/kg/wk | 0.012 | 0.019 | 0.091 | 0.11 | 0.077 | 0.12 | 8.8 |
| Mo | mg/kg/wk | 0.000024 | 0.000054 | 0.0000071 | 0.0000076 | 0.0000050 | 0.0000058 | 0.074 |
| Ni | mg/kg/wk | 0.013 | 0.021 | 0.0071 | 0.011 | 0.090 | 0.13 | 301 |
| Pb | mg/kg/wk | 0.0014 | 0.0090 | 0.0018 | 0.0032 | 0.00054 | 0.00060 | 253 |
| Sb | mg/kg/wk | 0.00019 | 0.00020 | 0.00019 | 0.00020 | 0.00018 | 0.00020 | 0.95 |
| Se | mg/kg/wk | 0.000068 | 0.000071 | 0.000066 | 0.000071 | 0.00013 | 0.00015 | 7.4 |
| Tl | mg/kg/wk | 0.000022 | 0.000025 | 0.000012 | 0.000016 | 0.000016 | 0.000018 | 6.2 |
| U | mg/kg/wk | 0.00053 | 0.00089 | 0.0018 | 0.0027 | 0.00052 | 0.00086 | 8.1 |
| Zn | mg/kg/wk | 0.37 | 0.38 | 0.36 | 0.38 | 0.34 | 0.38 | 799 |

### 2.1.2 Scaling of Geochemical Loads

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

$$ML_i = r_i * m * t$$

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

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

$$SL_i = ML_i * SF_a * SF_b * \ldots * SF_x$$

where $SL_i$ is the scaled load for species i (in mg) and SF is the scaling factor for a given parameter to be scaled (a, b, x). In the absence of site monitoring data, such parameters typically include grain size, water/rock ratio, and, temperature. The following describes in detail the derivation of the individual scaling factors employed in the FMS source terms model.

#### *2.1.2.1 Particle Size*

Before representative material is placed into laboratory kinetic test cells, rock samples are crushed to a nominal grain size of <1/4" to allow for better comparability of reaction rates across different experiments containing different geological materials. The particle size distribution of the mine rock stockpiles, and other facilities influences the degree of water-rock interaction by controlling the exposed surface area; surface area increases exponentially as the particle size decreases. Therefore, the largest relative surface area per mass is associated with the finest particles which may comprise a relatively small quantity of the WRSA. Strömberg and Banwart (1999) observed a large difference in weathering rates between fine particles and larger waste rock at the Aitik mine in northern Sweden.

Particles with diameters smaller than 25 mm were shown to account for 80% of the sulphide and silicate weathering. The same study determined the <25 mm fraction to be only about 27% of the total waste rock mass. Similar conclusions have been drawn in other studies that have examined the effect of particle size on geochemical release rates (*e.g.*, Fines *et al.* 2003; Frostad *et al.*, 2005; and Neuner *et al.*, 2009).

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

#### *2.1.2.2 Contact Water*

Laboratory experiments are conducted using high water-rock ratios (0.5L:1kg) that allow for the flushing of virtually all material surfaces placed into the reactor cell. The hydrogeology of unsaturated waste rock facilities has been subject to much research and most studies suggest that only a portion of the rock mass contained in these facilities is contacted by infiltrating water (Marcoline *et al*., 2006; Andrina *et al.*, 2009, Neuner *et al.*, 2009). The larger the mine storage facility for a given infiltration rate, the more rock material will be physically shielded from water contact as preferential flow paths develop and water is diverted along higher permeability layers. Furthermore, low water-rock ratios within a mine rock or tailings facility are more likely to result in the development of geochemical equilibrium conditions (Morin, 2013). Therefore, after a certain mass of rock material has been flushed, further physical contact may not necessarily lead to an increase in concentrations as kinetic or thermodynamic limitations are reached (*e.g.,* Kirchner & Mattson, 2015).

Correcting for different water/rock ratios (i.e., contact water) in humidity cells versus full-scale mine facilities may be one of the largest uncertainties associated with a source term model if not calibrated. To increase the confidence in the scaling factor applied to correct for this parameter, humidity cell, geological, mine plan, and surface water monitoring data from the Touquoy minesite were utilized to develop an inverse model from which empirical scaling factors could be constrained. Specifically, scaled loading rates from argillite and greywacke humidity cell were upscaled to the tonnage (or surface area for pit walls) of the respective mine facility and, under consideration of the known water balance, compared to site monitoring data. Since the humidity cell data were already grain-size corrected, and monitoring data were preferentially collected during months in which a temperature correction would not apply, the resulting discrepancy between the predicted concentrations and the observed water monitoring values effectively represents the empirical contact water factor. Besides the fact that the Touquoy site presents an excellent site analogue with respect to geology, this approach also has the advantage that it generates element-specific scaling factors. This is important as it has been shown that major and minor/trace metals cannot generally be predicted accurately using the same scaling factors (e.g. Kirchner & Mattson, 2015). Table 2-6 provides a more detailed description of the Touquoy parameters used in this calibration model. Several qualifiers need to be introduced in the context of the use of data from water monitoring stations:

- Median concentrations from the respective water monitoring stations were used;
- Concentrations measured at the waste rock ponds (SW-WRSP1 and -WRSP2) were artificially increased in the calibration model to account for 50% dilution along the flow path from the WRSA toe to the monitoring stations;
- The flow assumed for the open pit (450,000 m3/yr) was derived from current pumping rates at site provided by AMNS. This value encompasses both pit wall runoff as well as groundwater flow. Groundwater geochemistry data from monitoring wells surrounding the open pit were used to estimate a geochemical loading contribution which was accounted for in order to derive a calibrated scaling factor for pit wall runoff only.

The calibrated scaling factors that resulted from this model were vetted and it was found that the direct application of the Touquoy WRSA calibration model values would likely lead to an overestimation of the predicted geochemical loads in the FMS WRSA and ore stockpile. The reason for this is that the water/rock ratio in these facilities in the EOM scenario is almost an order of magnitude lower than that estimated for the relatively small, operational Touquoy WRSA. As mentioned above, after a certain WRSA thickness is reached, equilibrium conditions are expected to be attained under neutral conditions for most species, especially for minor and trace elements. This means that increasing the tonnage (or thickness) of a waste facility with the same material type would not necessarily result in an increase in pore-water concentrations. Since humidity cell leachates would be upscaled to a larger mass however, lower scaling factors would need to be applied to arrive at the same concentrations. In accordance with this theory, the empirical contact water scaling factors derived from the Touquoy site data were adjusted to account for the different water/rock ratios and thicknesses of the Touquoy WRSA in comparison to the EOM configuration expected for the FMS facilities. The ultimately applied contact water scaling factor was calculated as follows:

$$\text{Contact Water } SF_i = \text{Calibrated } SF_i * WR_{FMS}/WR_{TQ}$$

where $SF_i$ = Scaling factor for species i and $WR_{FMS}$ and $WR_{TQ}$ are the water/rock ratios for FMS and Touquoy facilities, respectively. Water/rock ratios are calculated as the estimated annual net infiltration volume divided by the total tonnage of rock contained in the mine component. Final contact water scaling factors for FMS source term locations are listed in Table 2-7.

The considerable range in scaling factor values across the presented parameters is evidence of the difference in geochemical mobility, where species with a lower scaling factors are attenuated more strongly on larger scales relative to the loading rates seen in humidity cells.

#### *2.1.2.3 Temperature*

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

Due to the fact that the empirical scaling factors described in the previous section rely on Touquoy water quality monitoring data collected throughout the year; it is assumed that any temperature-related trends on drainage chemistry would be captured by these data. Therefore, no additional scaling factor was applied to correct for lower temperatures at site conditions.

**Table 2-6:**
**Parameters from The Touquoy Site Used in the Calibration Exercise to Derive Scaling Factors for the FMS Source Term model**

| | Unit | Pit Walls | WRSA |
|---|---|---|---|
| HCs Used | Argillite | 06-017, 06-012, 06-006, 06-049, 06-079 | |
| | Greywacke | 06-039, 06-06 | |
| Facility Dimensions (Current) | Total | Footprint: 200,000 m2 | Tonnage: 3.72 Mt |
| | Argillite | Footprint: 96,612 m2 | Tonnage: 2.01 Mt |
| | Greywacke | Footprint: 103,388 m2 | Tonnage: 1.71 Mt |
| Contact Water | - | 450,000 $m^3$/yr | 372,000 $m^3$/yr |
| Water Monitoring Station | - | SW-OP (Pit sump) | SW-WRSP1, SW-WRSP2 (Waste rock ponds) |

**Notes:** HC = Humidity Cell; WRSA = Waste Rock Storage Area

**Table 2-7:**
**Parameter-Specific Contact Water Scaling Factors Derived from the Touquoy Site and Applied to the FMS Source Term Model**

| Parameter | Pit walls | PAG WRSA | NAG WRSA | LG Ore Stockpile |
|---|---|---|---|---|
| | ***kg/m2*** | ***unitless*** | ***unitless*** | ***unitless*** |
| Sulphate | 19638 | 1.9 | 0.59 | 0.75 |
| Al | 56 | 0.014 | 0.0043 | 0.0055 |
| Ag | 1209 | 0.086 | 0.026 | 0.033 |
| As | 198 | 0.0095 | 0.0029 | 0.0037 |
| Ca | 4886 | 0.48 | 0.14 | 0.18 |
| Cd | 1341 | 0.32 | 0.096 | 0.12 |
| Co | 15291 | 1.2 | 0.35 | 0.45 |
| Cr | 21903 | 1.6 | 0.48 | 0.61 |
| Cu | 3441 | 0.24 | 0.074 | 0.094 |
| Fe | 1806 | 0.13 | 0.039 | 0.050 |
| Hg | 956 | 0.068 | 0.020 | 0.026 |
| Mn | 1936 | 0.27 | 0.083 | 0.11 |
| Mo | 15345 | 0.21 | 0.064 | 0.081 |
| Ni | 83712 | 3.6 | 1.1 | 1.4 |
| Pb | 16904 | 1.2 | 0.36 | 0.46 |
| Sb | 479 | 0.022 | 0.0066 | 0.0084 |
| Se | 18335 | 1.3 | 0.39 | 0.50 |
| Tl | 14636 | 1.0 | 0.31 | 0.40 |
| U | 11265 | 0.29 | 0.088 | 0.11 |
| Zn | 1802 | 0.13 | 0.039 | 0.050 |

**Notes:** PAG = Potentially Acid Generating; NAG = Non-Acid Generating; WRSA = Waste Rock Storage Area; LG = Low-Grade

### 2.1.3 Conversion of Loads into Concentrations

Average annual drainage and runoff concentrations for the two scenarios (EOM and PC) were calculated by dividing the final scaled geochemical loads (in mg) by the volume of water predicted to infiltrate into the facility of interest in a given year. These assumed infiltration values were provided by Knight Piésold (Jackson, pers. comm., 2018) and are summarized in Table 2-8 for the different facilities. Note that the pit wall hydrology is based on runoff rates.

During Post-Closure, a soil cover will be placed on the WRSA in order to limit infiltration and oxygen flow. A cover efficiency of around 60% was estimated, thereby reducing the contact water volume to less than half of the EOM infiltration rates. No detail regarding cover placement or material was provided to Lorax and it was assumed that the reduction in flow will result in a proportional reduction in contact water. Therefore, the contact water scaling factor was set to 40% of the EOM contact water scaling factor for the PC WRSA scenario which effectively produces the same source term concentrations as would be expected for an uncovered PC configuration.

**Table 2-8:**
**Overview of Contact Water for the FMS Mine Facilities Modelled by Upscaling of Kinetic Tests**

| Location | Scenario | Infiltration | Runoff | Footprint | Contact water |
|---|---|---|---|---|---|
| | | *% MAP* | *% MAP* | *$m^2$* | *L* |
| Pit Walls | EOM/PC | - | 90% | 1 | 1,296 |
| PAG WRSA | EOM | 85% | - | 244,280 | 298,998,720 |
| | PC | 34% | - | | 119,599,488 |
| NAG WRSA | EOM | 85% | - | 305,820 | 374,323,680 |
| | PC | 34% | - | | 149,729,472 |
| Low-Grade Ore SP | EOM | 85% | - | 81,444 | 184,383,360 |
| | PC | 34% | - | | 73,753,344 |

**Notes:** PAG = Potentially Acid Generating; NAG = Non-Acid Generating; WRSA = Waste Rock Storage Area; MAP = Mean Annual Precipitation = 1440 mm; EOM = End of Mining; PC = Post-Closure.

### 2.1.4 Model Validation and Capping

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

During the scaling exercise it was noted that several species commonly fall below the detection limit in humidity cell leachates and/or the site analogue databases and are therefore not expected to be a concern due to their low solubility, at least under neutral conditions. In these cases (Ag, Cr, Cu, Hg, Tl, V), the respective detection limit and half the detection limit value were chosen as the solubility caps for the Upper Case and Base Case scenarios, respectively. No caps were applied to the PC scenario to maintain conservatism.

Due to the relatively well-constrained mineralogical fate of Fe, Al, and sulphate in mining environments, caps for these species were derived using the geochemical speciation code PHREEQC, which contains an extensive thermodynamic database (Parkhurst and Appelo, 1999). Table 2-9 provides an overview of the caps implemented and the concentration-limiting mineral phase for PHREEQC-modelled species.

**Table 2-9:**
**Mineral Phases Considered in the Application of the PHREEQC Speciation Model**

| Parameter | Unit | EOM | | PC | | Data Source |
|---|---|---|---|---|---|---|
| | | Base Case | Upper Case | Base Case | Upper Case | |
| $SO_4$ | mg/L | Gypsum equilibrium | | Gypsum equilibrium | | PHREEQC-Gypsum |
| Ag | mg/L | 0.00005 | 0.0001 | - | - | Field and HC Data |
| Al | mg/L | Gibbsite equilibrium | | Gibbsite equilibrium | | PHREEQC-Gypsum |
| Cr | mg/L | 0.0005 | 0.001 | - | - | Field and HC Data |
| Cu | mg/L | 0.001 | 0.002 | - | - | Field and HC Data |
| Fe | mg/L | $Fe(OH)_3$ equilibrium | | $Fe(OH)_3$ equilibrium | | PHREEQC-$Fe(OH)_3$ |
| Hg | mg/L | 0.0000065 | 0.000013 | - | - | Field and HC Data |
| Tl | mg/L | 0.00005 | 0.0001 | - | - | Field and HC Data |
| V | mg/L | 0.001 | 0.002 | - | - | Field and HC Data |

**Notes:** EOM = End of Mining; PC = Post-Closure.

### 2.1.5 Example Calculation

To allow the reader a better understanding of the various steps taken to derive geochemical source term predictions, a step-by-step sample calculation is provided below:

**Derivation of As-source term concentration for the FMS pit walls**

**(EOM; base case scenario)**

As outlined in the previous sections, the following steps formed the basis for the prediction of pit wall drainage chemistry.

1) Conversion of median weekly load to grain-size corrected annual load for each unit exposed in the pit walls:

*Median load * grain size factor * (weeks/year) = Grain-size corrected As-load*

Argillite: 0.0050 mg/kg/wk * 20% * 52 wk/yr = 0.052 mg/kg/yr

Greywacke: 0.017 mg/kg/wk * 10% * 52 wk/yr = 0.088 mg/kg/yr

Ore: 0.0055 mg/kg/wk * 15% * 52 wk/yr = 0.043 mg/kg/yr

2) Conversion of grain-size corrected annual load to proportioned load considering pit wall proportions at EOM:

*∑(Grain-size corrected As-load * pit wall proportion) = Proportioned load*

0.052 mg/kg/yr * 16% + 0.088 mg/kg/yr * 58% + 0.043 mg/kg/yr * 25% = 0.070 mg/kg/yr

3) Apply empirical contact water scaling factors to account for hydrogeological pathways:

*Proportioned load * contact scaling factor = Annual load from 1m$^2$ of pit wall exposure*

0.070 mg/kg/yr * 198 kg/m$^2$ = 13.9 mg/yr

4) Convert into scaled annual loads into base case As concentrations:

*Annual pit wall load (per 1m$^2$) / annual pit wall runoff per 1m$^2$*

13.9 mg/yr / 1,296 L/yr = 0.011 mg/L

5) Apply secondary mineral controls and concentration caps

Arsenic was not capped and was not considered during geochemical speciation in PHREEQC. Therefore, this model step did not affect the final As source term concentrations.

## 2.2 Specific Waste Rock and Ore Model Assumptions

### 2.2.1 Prediction of pH

The pH of mine drainage is governed by a sensitive and complex acid-base balance which, in turn, is controlled by rock storage regime, solute speciation, water-rock ratios and the availability and type of acid-generating and acid-buffering solid phases. The upscaling approach described for waste rock and ore in this chapter focusses primarily on the relationship of metal release in a laboratory-scale versus mine-scale environment. Due to the uncertainties related to the prediction of pH through geochemical modelling and upscaling of humidity cell tests, pH values were predicted based on the knowledge gained from the FMS static and kinetic test programs in combination regional water quality data. It can be said with some certainty that the during the EOM scenario all mine facilities will yield circum-neutral conditions due to the neutralization potential afforded by the waste rock and ore. During Post-Closure, around 12.5% of waste rock and 70% of ore materials (if not processed) are estimated to be PAG and therefore become depleted in neutralization potential leading to the development of ARD. Waste rock PAG proportion estimates were based on the integration of NPR values into the geological block model to gain a spatial representation of environmental parameters. This exercise was not done for ore materials such that the prediction of PAG proportions within the ore shell relied on the relative amounts of PAG ore samples in the static test database.

There is currently no direct evidence from the FMS or Touquoy site of the pH range that will be produced from waste rock after carbonate mineral depletion. A survey of standing water in 50 slate quarries in the Meguma Formation throughout Nova Scotia found an average pH of 3.78 (Manchester, 1986). Furthermore, Kereks *et al.,* (1984) found mean pH of 3.6 and 4.0 in two lakes north of Halifax. These results are consistent with ARD being buffered by hydrous ferric oxide (HFO) at approximately pH 3.5 (Blowes *et al.*, 2003). Given the relatively low overall sulphide contents in FMS rock, it can reasonably be expected that the pH in the PAG materials will be buffered at a similar range as in these other Meguma Formation sites with pH between 3.6 and 4.0. Hence, pH values for the PAG WRSA were set to 4 and 3.5 in the Base and Upper Case scenarios, respectively. By design, the NAG WRSA will continue produce circum-neutral pH in the long-term.

For the low-grade ore stockpile, the confluence of acidic drainage from PAG rock with alkaline contact water from NAG materials in post-closure was modelled, using PHREEQC, to yield a mixed pH of 4 to 5 (*i.e.*, buffered by Al-hydroxide) which is considered an adequate estimate for long-term drainage from this facility. A pH of 4.5 could therefore reasonably be expected as the best estimate for the Base Case scenario, while a pH of 4 is predicted for the more conservative Upper Case scenario.

### 2.2.2 WRSAs

Two geochemically distinct WRSAs will be built in order to facilitate the management of drainage from these facilities. One WRSA will be made up entirely of PAG waste rock while the second one will only contain NAG materials.

The PAG WRSA is composed of 3.14 Mt of waste material of which 26% represent argillite-rich rock (lithological codes AR and AG) while the remaining 74% are greywacke (lithological codes GW and GA). These proportions are equivalent in the EOM and PC scenarios. To calculate the tonnage of PAG waste rock to be produced during the life of mine, a geologic block model was generated using the Leapfrog$^{TM}$ software. This modelling exercise considers both the geometry of the geological units and the spatial distribution of the samples to produce an interpolated grade shell at the NPR = 2 to discriminate between PAG and NAG zones. While sufficient neutralization potential is contained in these rocks to initially buffer the waste rock seepage at circum-neutral pH, it is likely that, owing to the depletion of NP in the PAG material, the pH will decrease to acidic conditions in the long-term. This reduced pH will have a direct effect on mineral solubility, metal leachability, and hence drainage chemistry, when comparing the End of Mine and the Post-Closure scenarios.

Material designated as NAG will be used for the construction of site infrastructure (*e.g.*, TMF embankments, roads, *etc.*) with excess material being destined for the NAG WRSA for permanent storage. Under consideration of the NAG waste rock being used for site infrastructure, the NAG WRSA will have a capacity of around 13 Mt, 60% of which is greywacke with the remaining 40% being classified as argillite.

### 2.2.3 Low-Grade Ore Stockpile

By definition, the low-grade ore stockpile is a temporary site feature that is expected to be processed at the End of Mining. Nevertheless, to account for the possibility that fluctuating gold prices will affect the mine plan rendering the low-grade or stockpile unprofitable, both EOM and PC scenarios were modelled. The ore tonnage assumed for the source term model was set at 5 Mt which represents the maximum amount of low-grade ore stored on site during operations. For the Post-Closure scenario, a PAG rock proportion of 70% was employed consistent with the static test database (Lorax, 2019).

### 2.2.4 Pit Walls

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

As for the model assumptions used in the development of WRSA source terms, humidity cell units were grouped to represent argillite (AR and AG) and greywacke (GW and GA), as only these two units were resolved in the estimation of pit wall surface areas. The rock and environmental units exposed in the FMS pit are listed in Table 2-10. This table shows the estimated relative proportions of wall rock exposures in the FMS pit at EOM and in PC when the mine pit is fully flooded to the spillway elevation. The geologic block model yielded that, at this time, virtually no PAG rock will be exposed above the final pit lake elevation. This demonstrates the risk for development of ARD is, to some extent, tied to depth within open pit and proximity to the mineralized zone. A small portion of the FMS pit wall rock is not defined in the geologic block model. This ‘undefined’ unit is assumed to be 50% argillite and 50% greywacke for the purpose of source term calculation.

**Table 2-10:**
**Pit Wall Rock Exposed in the FMS Pit for the EOM and PC Scenarios**

| | EOM | PC |
|---|---|---|
| **Argillite** | 16% | 19% |
| **Greywacke** | 58% | 70% |
| **Ore** | 25% | 11% |

**Notes:** No potentially acid generating (PAG) material is expected to be exposed in the pit walls after pit lake formation; EOM = End of Mining; PC = Post-Closure; wall rock present above spillway elevation

## *2.3 Specific Tailings Model Assumptions*

Ore processing at the FMS site will employ a conventional floatation circuit producing a gold concentrate which will then be hauled to the Touquoy mill for the final gold extraction steps via cyanidation. The tailings produced during initial ore processing steps, comprising a conventional rougher and cleaner flotation, will be stored in a TMF on the FMS property. This TMF will comprise a surface impoundment in which tailings are partially submerged by a water cover with tailings beaches developing along the dammed perimeter.

The geochemical behaviour of saturated (water-covered) tailings is known to differ distinctly from that of unsaturated (beached) tailings with the availability of oxygen, and thereby redox conditions, being the main driver with respect to material leaching characteristics. In the submerged portion of the TMF, potential contaminant sources include (i) those contained in the tailings process water (supernatant) as well as (ii) those associated with post-depositional processes, including the reductive dissolution of metal-bearing tailings phases in submerged tailings materials.

Tailings materials exposed in the beach portions of the TMF will be subject to oxidative weathering where sulphide oxidation and neutralization processes are expected to control contact water chemistry. In contrast to the waste rock, the fine grain size of tailings is expected to limit oxygen ingress into the tailings beach. Therefore, the thickness of the tailings package affected by aerobic weathering processes and releasing pore water and runoff into the tailings pond is expected to be less than 2 m after years of exposure (Holmström *et al.*, 2001).

Two samples of tailings solids generated during metallurgical testing in 2018 were characterized through acid-base-accounting (ABA), metals analysis and shake flask extraction (SFE) tests in order to understand the short-term leaching behaviour of these materials. These two tailings samples represent the waste products of a split circuit (Test 6) and a conventional flotation circuit (Test 10) that were evaluated during the 2018 metallurgical test program (Lorax, 2019) where the conventional circuit has since been identified as the preferred ore processing method for FMS. The corresponding tailings sample has an NPR of 2.0 and was therefore classified as NAG. As such, one key assumption that will be carried forward in the prediction of TMF-related source terms is that contact waters in this facility (unsaturated and saturated) will remain pH-neutral in the long-term.

### 2.3.1 Tailings Supernatant (End of Mining)

Tailings supernatant represents the process water that is discharged to the TMF as part of the tailings slurry. While tailings are being discharged during operations phase, it can be assumed that the supernatant chemistry will dominate the aqueous chemistry in the tailings pond and pore water. Supernatant from the Test 10 (conventional circuit) tailings slurry was decanted and underwent extensive geochemical analysis. This supernatant water was used directly as a proxy for the process water that will be discharged into the FMS TMF during operations. Since only one representative tailings supernatant sample was available at the time of source term development, only one scenario (Base Case) was provided for this model iteration.

### 2.3.2 Tailings Beach

Tailings slurries will be discharged from spigot along the perimeter of the TMF with process water (supernatant) and beach runoff collecting in the topographic lows of the facility. This will lead to the exposure of tailings beaches which, depending on the slurry disposal rates, may be exposed to the atmosphere in some areas for extended periods of time before being covered by fresh tailings layers. The oxidative weathering of these tailings beaches will contribute a geochemical load to the tailings pond in Post-Closure.

SFE tests were conducted on both FMS tailings samples obtained during metallurgical testwork conducted in 2018. For the purpose of the source terms presented herein, these samples are used as the basis for the prediction of beach runoff chemistry. This was done simply by using the average and maximum SFE leachate concentrations to represent the Base and Upper Case scenarios, respectively. Since the SFE method agitates tailings samples for 24 hours, it is assumed that the resulting concentrations are a conservative proxy for the tailings beach runoff.

### 2.3.3 Tailings Porewater

Following cessation of the tailing discharge, post-depositional processes will become increasingly important over time in the saturated tailings. Depending on the mineralogy of the tailings materials and the aqueous regime, these post-depositional processes may attenuate or release contaminants within the TMF pore water. The potential for chemical instability of tailings in the saturated portions of the TMF in the long-term is in response to contrasting redox conditions in the mill (basic pH, oxidizing redox potentials) and TMF environments (circum-neutral pH, low redox potential). In this regard, both redox- and pH-dependent mechanisms may promote the dissolution of tailings phases.

A saturated tailings column containing Test 10 FMS tailings solids was initiated in March 2019. The purpose of this column experiment is to mimic long-term, suboxic conditions that can be expected in the FMS tailings pore water and seepage (Lorax, 2019). At the time of preparation of the geochemical source terms, only eight weeks of data leachate were available from this experiment and leaching conditions that would be expected in post-closure had not yet been reached. However, saturated column data from a much longer kinetic test runtime (>1 year) is available for Touquoy tailings showing relatively stable leachate, suboxic leachate chemistry. These data were used to calculate conversion factors correlating short- and long-term leachate data internally for the Touquoy kinetic test cells. These factors were then applied to the FMS saturated column in order to predict the long-term leaching behaviour on the basis of the available short-term data. The conversion factors (CF) were calculated using Touquoy kinetic test data as follows:

$$CF = C_{li} / C_{si}$$

where $C_{li}$ is the concentration of species i in the last three available sampling cycles (week 50-58) and $C_{si}$ is the concentration of species i in week 8 of the saturated column experiment. Median and 90$^{th}$ percentile concentrations were used to calculate $C_{li}$ for the Base and Upper Case scenarios, respectively. An overview of the different CF values used for the development of the FMS tailings pore water source terms is given in Table

**Table 2-11:**
**Conversion Factors derived from Touquoy Saturated Column Data to Model Long-Term FMS Tailings Porewater Chemistry**

| | | **Conversion Factor** | |
|---|---|---|---|
| | | **Base Case** | **Upper Case** |
| Sulphate | mg/L | 1.1 | 1.1 |
| Al* | mg/L | 0.42 | 0.79 |
| Ag | mg/L | 1.0 | 1.0 |
| As | mg/L | 2.1 | 4.3 |
| Ca | mg/L | 1.4 | 1.5 |
| Cd | mg/L | 0.71 | 1.5 |
| Co | mg/L | 0.59 | 0.79 |
| Cr | mg/L | 1.0 | 1.0 |
| Cu | mg/L | 1.6 | 2.9 |
| Fe* | mg/L | 0.14 | 0.26 |
| Hg | mg/L | 1.0 | 1.0 |
| Mn | mg/L | 2.9 | 5.1 |
| Mo | mg/L | 0.63 | 0.88 |
| Ni | mg/L | 2.5 | 4.2 |
| Pb | mg/L | 0.65 | 0.96 |
| Sb | mg/L | 0.37 | 0.56 |
| Se | mg/L | 0.91 | 1.7 |
| Tl | mg/L | 2.0 | 3.1 |
| U | mg/L | 0.90 | 0.96 |
| Zn | mg/L | 0.21 | 0.28 |

### 2.3.4 TMF Embankments

The TMF embankment at the FMS site will be built with waste rock material that is suitable for construction purposes which is expected to primarily represent greywacke rock sourced from the open pit. The Touquoy surface water monitoring network includes water quality stations at the toe of the TMF embankments and it can reasonably be assumed that, at least initially, embankment runoff contributes the main water source to these stations before the TMF seepage breakthrough has occurred. Since the Touquoy TMF is also built primarily with locally sourced greywacke material, these embankment monitoring stations provide an excellent site analogue that can be used in the prediction of FMS TMF embankment chemistry.

Since the TMF embankment will be built with NAG waste rock only, ARD will not be an issue. With this in mind, the prediction of the drainage chemistry from the FMS TMF was based on the median (Base Case) and $90^{th}$ percentile (Upper Case) concentrations measured in four Touquoy TMF embankment monitoring stations (SCP1 through SCP4) before April 2018. This date marks the breakthrough of conservative geochemical tracers from TMF porewater (Na, Cl, $SO_4$) and may no longer be representative of the greywacke geochemical signature. Due to the nature of the analogue dataset, no long-term TMF source terms were developed specifically and it is conservatively assumed that the derived EOM source terms would also apply in the PC scenario.

## *2.4 Specific Overburden Assumptions*

### 2.4.1 Till and Topsoil Stockpiles

Overburden will be stripped from the surface before mine development and stockpiled in a till and a topsoil stockpile. This material will later be used for reclamation purposes. Due to its deposition/formation environment and heavily weathered nature, overburden material is generally low in or devoid of sulphide minerals. As a result, the disturbance and relocation of these types of materials is not expected to have the same long-term effects on water quality as ore and waste rock drainage. Nevertheless, exposure of overburden in stockpiles with increased surface area will still cause contact water to adopt a geochemical signature, requiring the consideration of the till and topsoil stockpiles in the FMS water quality models.

Till material from within the FMS mine footprint was recovered during a drilling program led by Golder Associates (Golder, 2018). A total of five till samples were recovered during this program and the drill logs and geochemical test results were provided to Lorax. In addition, eight samples were collected from two existing Touquoy till piles during a Lorax site visit in October 2018. All samples were characterized via acid-base accounting (ABA), metal content after aqua-regia digestion, and shake flask extractions (SFE) to gain insight into the short-term leachability of this material type. SFE data from of FMS and Touquoy till samples were used directly for the generation of geochemical source terms for the till stockpile.

During the 2018 Lorax site visit, five topsoil samples were retrieved from the Beaver Dam mine footprint via shallow test pitting. Although this material is from a different location, it is assumed that the soil characteristics between Beaver Dam and FMS are sufficiently similar to warrant the use of these topsoil samples as a proxy for the FMS source terms.

The till and topsoil materials were generally found to be devoid of or low in sulphide minerals (<0.02% to 0.12 %), and hence SFE tests are considered an adequate, conservative method to predict the quality of water coming in contact with these stockpiles. While the topsoil samples are generally also depleted in carbonate (<0.05%), several till samples show detectable inorganic carbon in the range of 0.05 % to 2.79% with a median of 0.065%. As such, it can be expected that the pH of drainage from the till stockpile will be higher than that in contact with topsoil.

Geochemical source terms for the two material types were derived as the median and 90$^{th}$ percentile SFE leachate values from the corresponding database for the Base and Upper Case scenarios, respectively.

# 3. Nitrogen Source Term Approach

Nitrogen (N) based blasting reagents have been identified by Pommen (1983) as a source of N compounds in pit walls and WRSA at surface mining operations. The nitrogen compounds ammonium ($NH_4^+$) and nitrate ($NO_3^-$) are the primary constituents of ammonium nitrate (AN) based explosives, while nitrite ($NO_2^-$) is typically formed during and after blasting. Under ideal blasting conditions the explosion reaction consumes all ammonium and nitrate in the explosives to form nitrogen gas. However, in practice ideal blasting conditions are not achieved and small proportions of the explosives remain as residue on blasted surfaces.

For surface mining operations the export of N to the receiving environment has been observed to be predominantly in the form of nitrate, and to a lesser extent, nitrite and ammonia (Ferguson and Leask, 1988). The N containing residues on pit walls and exposed blasted rock surfaces are rapidly flushed by contact water (Revey, 1996; Forsyth *et al.*, 1996; Cameron *et al.*, 2007; Mueller *et al.*, 2015). However, in unsaturated waste rock piles preferential and capillary flow paths develop that can lead to variable and delayed flushing of the pile (Fala *et al.*, 2003; Smith and Beckie, 2003; Stockwell *et al.*, 2006; Marcoline *et al*., 2006; Fretz *et al.*, 2011). A delay in blast-related N release from waste rock piles has been observed at various surface mines and has been documented at Diavik (Baily *et al.*, 2013). The N available for leaching is limited to the wetted areas of the pile and the type of flow paths that develop, therefore N release from a large rock pile can persist for years after rock placement.

Sections 3.1 and 3.2 summarize the approach used in the development of nitrogen species source terms for the EOM scenario. The derivation of nitrogen depletion rates to be used in the Post-Closure scenario is described in Section 3.3.

## 3.1 WRSA Nitrogen Loading Model Approach (EOM)

While Touquoy site monitoring data was available for drainage, at the time of source term development, this database only captured around 6 months of WRSA drainage chemistry. As described above, significant delay can be expected in the transport of the nitrogen signature from the source to downstream receivers. Furthermore, the release of stored nitrogen loads from waste rock piles is generally mass-dependent which does not make the still relatively small Touquoy WRSA a reliable proxy for the purpose of nitrogen concentration predictions. Therefore, a nitrogen loading model using the FMS WRSA dimensions and hydrogeological was generated and calibrated with site analogue data. The N loading model is based on an empirically derived approach for surface coal mines

(Ferguson and Leask, 1988) that estimates N loads based on the mining schedule and planned explosives use, and accounts for delayed release of N loads observed in waste rock piles. The derived N loads and WRSA infiltration rate at EOM were used to estimate Base Case and Upper Case concentrations for ammonia, nitrate and nitrite.

**Note**: The nitrogen source terms presented herein were originally derived for one larger WRSA (15.4 Mt) in which both PAG and NAG waste rock are co-deposited. Since the revision of the mine plan, nitrogen predictions were not re-modelled and the source terms presented in the following are applied to both the PAG and the NAG WRSA. Since nitrogen loads are strongly tied to the total mass of waste rock stored in a facility, this approach is considered conservative, especially for the smaller PAG WRSA.

The N loading model considers the planned explosives use rate and the waste rock placement schedule to calculate N loads stored in the last year of operations. The concentrations of ammonia, nitrite and nitrate at EOM are derived from the WRSA infiltration rate at EOM and an assumed N species distribution from literature values. Key model assumptions are summarized below:

- Mining, explosive use, waste rock production and placement will proceed as per the mine plan;
- The explosives product is TITAN® XL 1000, a bulk AN-based emulsion product manufactured by Dyno Nobel. The exact nitrogen content in TITAN® XL 1000, is proprietary therefore it is assumed to contain 25% N, similar to the N content typically found in AN-based emulsion explosives;
- The explosives usage per tonne of blasted rock, also known as the powder factor (PF), is 0.2 kg/t;
- Best explosive use and blasting practices will be implemented to maximize explosive consumption during blasting (*i.e.,* to minimize explosives residue on waste rock surfaces);
- Empirical observations of N loading to waste rock piles by Ferguson and Leask (1988) are a reasonable proxy for N loading from the WRSA.
- The EOM infiltration value for the WRSA provided by Knight Piésold (Jackson, pers. comm., 2018) is 1,296 mm;
- The N release and decay observations at the Diavik Diamond Mines (Baily *et al.*, 2013) and British Columbia surface coal mine waste rock studies (Lorax *et al.*, 2017) are a reasonable proxy for N release from the WRSA;

- Nitrogen is exported to the aqueous downstream receiving environment in N species proportions that are similar to average distributions observed by Ferguson and Leask (1988), with nitrate, ammonia and nitrite respectively representing 87%, 11% and 2% of the N load released; and,
- For the purpose of N source term derivation, the background levels for ammonia, nitrite and nitrite are assumed to be zero.

### 3.1.1 N Loading to the WRSA

The procedures described by Ferguson and Leask (1988) were used to estimate the N loads added to the WRSA in the year of deposition. Ferguson and Leask (1988) studied coal mines discharges in southeastern British Columbia and described an empirical method for estimating the N loads added to WRSA based on the amount and type of explosive used annually. For surface mines that use more than 20% emulsion the following N loading equation was derived:

$$N_{Load\ (k)} = 0.94\% \times E_{An(k)} + 5.1\% \times E_{Em(k)}$$

Where, $N_{Load\ (k)}$ is the annual nitrogen load (kg N) in year $k$ of mine operation; $E_{An(k)}$ is the annual ANFO explosive use (kg N) in year $k$ of mine operation; and, $E_{Em(k)}$ is the annual emulsion explosive use (kg N) in year $k$ mine operation.

Ferguson and Leask (1988) observed that emulsion explosives were generally used in challenging blasting conditions where ammonium nitrate fuel oil (ANFO) explosives were unlikely to be efficiently consumed (*e.g.,* typically where water was in contact with non-detonated explosives). Although emulsion explosives are designed to detonate in the presence of water, challenging conditions are inferred to reduce the emulsion explosives consumption efficiency and therefore contribute higher N loads to rock surfaces as indicated in the emulsion term of the loading equation. It is reasonable to expect that emulsion explosives used in good blasting conditions will be efficiently consumed and contribute N loads similar to the rate indicated in the ANFO term (0.94%) in the loading equation. However, for the N loading model the ANFO term in the loading equation is set to zero and 100% of the emulsion explosives are conservatively assumed to contribute N at the higher rate (5.1%) indicated in the emulsion term of the N loading equation.

The planned explosive use and waste rock placement tonnages, and N loading calculation results are summarized in Table 3-1.

**Table 3-1:**
**Estimated Annual Nitrogen (N) Loading to the Waste Rock Storage Area (WRSA)**

| Mine Year | Y1 [A] | Y2 | Y3 | Y4 | Y5 | Y6 |
|---|---|---|---|---|---|---|
| Quantity of waste rock placed (kt) | 3,829 | 5,191 | 4,221 | 1,900 | 295 | 0 |
| Explosives usage (kg) | 765,724 | 1,038,205 | 844,185 | 380,008 | 58,942 | 0 |
| Explosives N content (kg-N) | 191,431 | 259,551 | 211,046 | 95,002 | 14,735 | 0 |
| N load added to WRSA (kg-N) | 9,763 | 13,237 | 10,763 | 4,845 | 752 | 0 |

[A] Rock placed in the WRSA in year PP (40 kt) is included in this total.

### 3.1.2 Annual N Release from the WRSA

The release rate of N loads from the WRSA was derived from observations at Diavik reported by Baily *et al* (2013) that were scaled to FMS using the WRSA infiltration rate at Closure. The observations of test rock piles at Diavik indicate the release of significant nitrogen levels in waste rock test piles commenced with the third freshet (*i.e.*, the third year) after rock deposition. Further an average 8.2% of the total nitrogen load was released in the first three years after waste rock placement.

Increases in precipitation are expected to lead to increased infiltration and N release to WRSA infiltration water. The mean annual precipitation (MAP) observed at Diavik is 280 mm (Fretz *et al.*, 2011). The MAP at FMS is 1,440 mm, significantly higher than precipitation levels observed at Diavik mine. To estimate N release from the WRSA the Diavik N release rate was scaled-up based on precipitation and infiltration values. As described previously, preferential and capillary flow paths are likely to develop in the WRSA leading to variable release of N from the WRSA. To be consistent with the approach used for geochemical source terms, an infiltration rate of 90% of the MAP (1,296 mm) was used to proportionately scale-up the Diavik N load release using the equation below with the results shown in Table 3-2. An annual 35.8% N release was derived for the WRSA according to the following equation:

$$r_{FMS} = \frac{I_{FMS}}{P_D} \times r_D$$

where, $r_{FMS}$ is the N release estimated for FMS; $r_D$ is the N release observed at Diavik; $I_{FMS}$ is infiltration (mm/yr) at FMS; and, $P_D$ is the mean annul precipitation (mm/yr) at Diavik.

**Table 3-2:**
**Derivation of the Annual N Load Release from the WRSA**

| Term | Value |
|---|---|
| Diavik MAP (mm) ($P_D$) | 280 |
| WRSA Infiltration (90% MAP) (mm) ($P_{EG}$) | 1296 |
| Diavik N release (2007-2010) ($r_D$) | 8.2% |
| WRSA N release ($r_{EG}$) | 36% |

### 3.1.3 N Loads Released from the WRSA at End of Mine

The N loads released from the WRSA at EOM were derived by estimating the stored N load and applying the release factor to that load. For the Base Case scenario, the stored N load is adjusted for N release from the WRSA that is expected to occur annually during mining, whereas the Upper Case scenario assumes the entire N load added to the WRSA annually is stored in the WRSA and that all N is released in the last year of operations.

#### *3.1.3.1 Base Case*

For each annual waste rock quantity placed in the WRSA the N load released annually was calculated using the N release rate and the stored N load. Accelerated wetting of the WRSA is expected relative to observations at Diavik due to the overall warmer conditions and elevated precipitation at FMS. Therefore, the N release was modelled to commence the second year after waste rock placement, rather than the three year lag time observed at Diavik. The N release during the year of rock placement and the following year is assumed to be zero in both years. The N loads released from the WRSA was calculated using the following formula:

$$N_{Release} = r_{FMS} \times N_{Stored}$$

where, $N_{Release}$ is the N released (kg-N) from the annual waste rock quantity; $r_{FMS}$ is the annual N release (%) estimated for FMS; and, $N_{Stored}$ is the N stored (kg-N) in the annual waste rock quantity.

The amount of N stored in each annual waste rock quantity is the difference between the N load stored in year of placement, and the amount N released subsequent to placement. Nitrogen release the year of rock placement and the first year after rock placement is assumed to be zero in both years; from second year onwards, the N stored is reduced by the annual N release as represented by the following equation:

$$N_{Stored\ (i)} = N_{Load\ (i=0)} - \sum_{a=2}^{i,i\geq 2} N_{Released\ (a)}$$

where, $N_{Stored\ (i)}$ is N stored in waste rock year *i* after placement; $N_{Load\ (i=0)}$ is the N load (kg N) the year of placement; and, $N_{Released\ (a)}$ is the N released (kg-N) year *a* after placement.

The amount of N stored in the WRSA at the end of each year was calculated by summing the nitrogen stored in each annual waste rock quantity placed:

$$N_{Stored,WRSF\ (k)} = \sum_{i=0}^{n} N_{Stored\ (i,k)}$$

where, $N_{Stored,WRSF\ (k)}$ is N stored (kg N) in the WRSA at the end of year *k*; and, $N_{Stored\ (i,k)}$ is N stored (kg N) in annual rock quantity *i* in at the end of year *k*, where *n* equals the number of annual waste quantities placed to the end of year *k*.

The annual N release from the WRSA was calculated by summing the nitrogen release from each annual waste rock quantity placed:

$$N_{Released,WRSF\ (k)} = \sum_{i=0}^{n} N_{Release\ (i,k)}$$

where, $N_{Released,WRSF\ (k)}$ is total nitrogen released (kg N) from the waste rock pile in year *k*; and, $N_{Released\ (i,k)}$ is the N released (kg N) from annual waste rock quantity *i* in year *k*, where *n* equals the number of annual waste quantities placed to the end of year *k*.

The results of the Base Case N storage and release calculations are presented in Table 3-3 and Figure 3-1. The N load released in Y6 (7,089 kg-N) was used to model the Base Case N load from the WRSA at EOM.

**Table 3-3:**
**Derivation of the Base Case N Loads Release at End of Mine (Y6)**

| **N Load, Storage and Release (WRSA)** | **Nitrogen (kg-N)** | | | | | |
|---|---|---|---|---|---|---|
| Year of Mine Operation | Y1 | Y2 | Y3 | Y4 | Y5 | Y6 |
| N Load Added in the Year of Waste Deposition | 9,763 | 13,237 | 10,763 | 4,845 | 752 | 0 |
| WRSA N Stored, Cumulative | 9,763 | 23,000 | 30,264 | 28,119 | 20,528 | 13,439 |
| WRSA N Release, Annual | 0 | 0 | 3,500 | 6,990 | 8,343 | 7,089 |
| Y1 Waste Annual N Release | | | 3,500 | 2,245 | 1,440 | 924 |
| Y2 Waste Annual N Release | | | | 4,745 | 3,044 | 1,953 |
| Y3 Waste Annual N Release | | | | | 3,858 | 2,475 |
| Y4 Waste Annual N Release | | | | | | 1,737 |

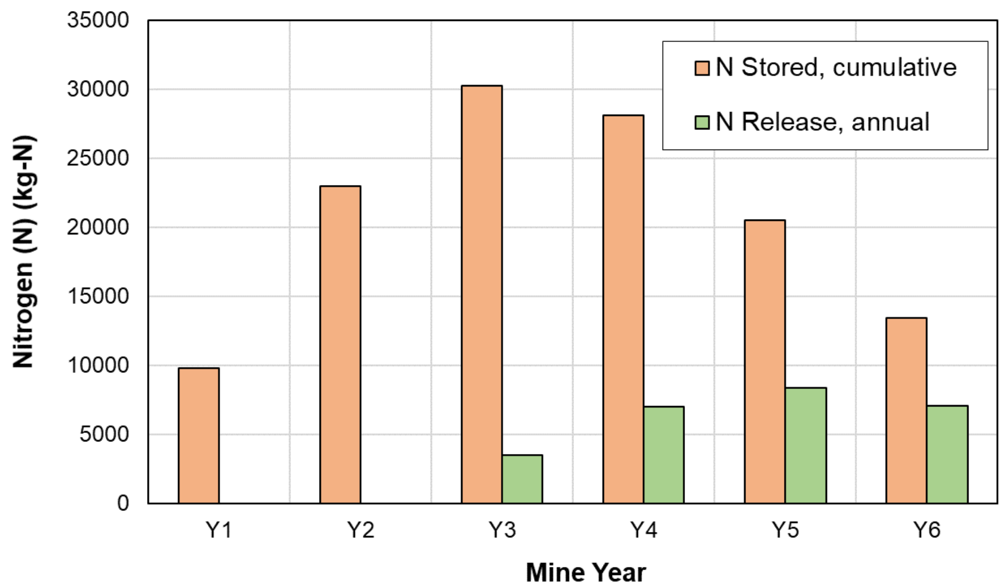


**Figure 3-1: Predicted Annual N Loads Stored and Released from the WRSA to End of Mine (Y6)**

#### *3.1.3.2 Upper Case*

In contrast to the Base Case scenario, the Upper Case scenario conservatively assumes N loads accumulate in the WRSA and are not released until End of Mine. The methodologies described in the previous sections were used to calculate the N stored and released from the WRSA at EOM. The Ferguson and Leask (1988) equation for mines using more than 20% emulsion was used calculate the N stored in WRSA and the N release rate was applied to this total to derive the Upper Case N release of 14,109 kg-N from the WRSA at EOM. The calculations are summarized in Table 3-4 below.

**Table 3-4:**
**WRSA Upper Case N Load Derivation**

| | |
|---|---|
| WRSA Tonnage at Closure (t): | 15,435,453 |
| Explosives Used (kg) | 3,087,091 |
| N in Explosives Used (kg-N) | 771,773 |
| N Stored in WRSA (F&L, > 20% emulsion) | 39,360 |
| N Release Rate (%) | 35.80% |
| N Released at End of Mine (kg-N) | 14,109 |

### 3.1.4 Conversion of N Loads into Concentration

Average annual WRSA drainage N species concentrations were calculated by dividing the N loads released at EOM by the volume of water predicted to infiltrate into the WRSA at

EOM, and proportionately distributing the N load as specific nitrogen species. The assumed EOM infiltration value for the WRSA was provided by Knight Piésold (Jackson, pers. comm., 2018) and is summarized in Table 2-8. The N loads were distributed among the nitrogen species (ammonia, nitrite and nitrate) according to observations by Ferguson and Leask (1988) with most of the load exported as nitrate (87%) and the balance as ammonia (11%) and nitrite (2%). These calculations were conducted according to the following equation:

$$C_{N\ Species} = \frac{N_{Released} \times p_{N\ Species} \times 1000}{F}$$

where, $C_{N\ Species}$ is the N species source term (mg/L); $N_{Released}$ is the total N release (kg-N) from the WRSA at EOM; $p_{N\ Species}$ is proportion of N as ammonia, nitrite or nitrate; and, F is WRSA infiltration volume ($m^3$) at EOM.

## *3.2 Tailings Embankment & Pit Wall Source Term Model Approach (EOM)*

Operational monitoring data from the Touquoy site are available for the open pit and TMF embankments and were used directly in the EOM prediction of nitrogen concentrations for the same mine components at FMS. The direct use of Touquoy operational monitoring data was selected based on the following rationale:

- The reactive rock mass that is available to leach residual nitrogen from blasting activities is much smaller in the TMF embankment and pit walls versus the WRSA. Therefore, the delay in the transport of stored nitrogen loads is expected to be much shorter from these facilities;
- Lithologies and physical rock properties making up these mine components are considered sufficiently similar between Touquoy and FMS. While nitrogen loading rates are not necessarily dependent on the geochemistry of the rock, the physical properties defining a material's behaviour during blasting will likely affect the retention of nitrogen on particle surfaces.

The Touquoy water quality monitoring stations utilized for the prediction of nitrogen source terms are as follows:

- Pit walls: SWOP
- TMF embankments: SWSCP1 through SWSCP4, SW16, SW17

Median and $90^{th}$ percentile values were used to derive a Base Case and an Upper Case EOM source term for these facilities, respectively. The monitoring time frame used for these predictions are from August 2017 - October 2018 and November 2017 - October 2018, for the pit walls and the TMF embankments, respectively.

### 3.3 Post-Closure N Source Term Derivation

It is known that, unlike species associated with the oxidation of sulphide minerals, N species concentrations will decrease once the addition of blasted material to a facility has ceased (*e.g.*, Pommen, 1983). The N depletion rates depend on a variety of factors including the amount of reactive rock surfaces as well as flushing rates that are difficult to model. Long-term monitoring of waste rock drainage at the Roman-Trend Mine has shown that N depletion is not linear but rather is expressed as a decay curve (Figure 3-2) with the highest absolute N reduction observed in the early years after closure (Lorax, 2017). It was found that, in the Post-Closure period, nitrogen concentrations were reduced annually by >10% of the previous year's concentration after correction for seasonal variability. However, the tonnage of the waste rock facility at the Trend-Roman Mine as well as its flushing rates differ markedly from those expected for the FMS WRSA. Therefore, a conservative annual N depletion rate of 10% was scaled to FMS conditions as follows:

$$DR_{FMS} = DR_{TR} \times \frac{h_{TR}}{h_{FMS}} \times \frac{MAP_{FMS}}{MAP_{TR}}$$

where $DR_{FMS}$ and $DR_{TR}$ are the annual nitrogen depletion rates for FMS and the Trend-Roman Mine, respectively; $h_{FMS}$ and $h_{TR}$ are the thicknesses of the respective waste rock facilities; and $MAP_{FMS}$ and $MAP_{TR}$ are the mean annual precipitation at FMS and the Trend-Roman Mine, respectively. The input values used for this scaling exercise are given in Table 3-5. Note that the FMS WRSA height chosen for this scaling model conservatively represents the maximum value as provide by AMNS (pers. comm., 2019). The resulting scaled N depletion rate was $DR_{FMS}$ was calculated to be 25% (Table 3-6) using these parameters. Note that it is herein assumed that nitrite and ammonia are depleted at the same rates as nitrate.

For the TMF embankment and the pit walls, the depletion of nitrogen species is expected to occur significantly faster than in the WRSA due to the smaller size and higher water/rock ratios in these mine components. The N depletion rate of TMF embankment was scaled in the same manner as the WRSA where a thickness of around 17 m was assumed (Table 3-5). Since the water/rock ratio in the pit walls that are influenced by blasting are expected to be relatively high, the use data from two field bins constructed with freshly blasted Touquoy material (argillite and greywacke) was considered appropriate to estimate nitrogen depletion rate in the open pit. These field bins were initiated in fall of 2017 and consist of around 150-200 kg of material forming a 0.8 – 1 m thick reactive rock column. Leachate data showed that within one year of field bin operation, the nitrate concentration was reduced by > 90% in both field bins. In that year, both nitrite and ammonia were reduced to below detection limit. To account for uncertainties related to an experimental runtime of only one year and to maintain conservatism, the annual nitrogen depletion rate for the FMS pit walls was set to 80% (Table 3-6).

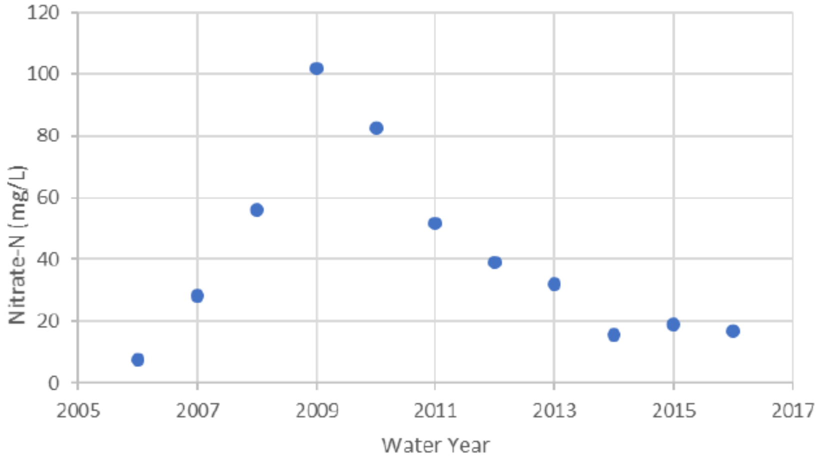


**Figure 3-2: Nitrate Concentration Trends Observed in a Waste Rock Monitoring Station at the Roman-Trend Mine (from Lorax, 2017)**

**Table 3-5:**
**Input Parameters Used to Scale the Roman-Trend Mine N Depletion Rate to FMS Conditions for the WRSA**

| | |
|---|---|
| **Trend-Roman** | |
| Height of WRSA | 70 m |
| Mean Annual Precipitation | 1,000 mm |
| Annual N Depletion Rate | 10% |
| **FMS** | |
| Height of WRSA | 70 m |
| Height of TMF Embankment | 17 m |
| Mean Annual Precipitation | 1,440 mm |

**Notes:** The FMS WRSA height is the maximum value as per AMNS (2019).

**Table 3-6:**
**Annual Nitrogen Depletion Rates Derived for Post-Closure for the Various FMS Mine Components**

| | |
|---|---|
| **WRSA** | |
| Nitrate | 25% |
| Nitrite | |
| Ammonia | |
| **Pit Runoff** | |
| Nitrate | 80% |
| Nitrite | |
| Ammonia | |
| **TMF Embankments** | |
| Nitrate | 60% |
| Nitrite | |
| Ammonia | |

# 4. Source Term Results

## 4.1 Waste Rock and Ore

### 4.1.1 Waste Rock Storage Areas

Geochemical source terms for the PAG and NAG WRSAs at FMS are given in Table 4-1 and Table 4-2, respectively.

**Table 4-1:**
**Geochemical Source Term Concentrations for the PAG WRSA**

| | | EOM | | PC | |
|---|---|---|---|---|---|
| | | Base Case | Upper Case | Base Case | Upper Case |
| pH | - | 7.5 | 7.5 | 4.0 | 3.5 |
| Sulphate | mg/L | 978 | 1189 | 2439 | 3013 |
| Al | mg/L | 0.0058 | 0.0059 | 0.19 | 0.21 |
| Ag | mg/L | 0.000050 | 0.000070 | 0.000060 | 0.000070 |
| As | mg/L | 0.0078 | 0.016 | 0.024 | 0.025 |
| B | mg/L | 0.21 | 0.30 | 0.17 | 0.25 |
| Ca | mg/L | 49 | 46 | 36 | 35 |
| Cd | mg/L | 0.000030 | 0.000070 | 0.011 | 0.020 |
| Co | mg/L | 0.0011 | 0.0025 | 0.33 | 0.45 |
| Cr | mg/L | 0.00050 | 0.0010 | 0.0018 | 0.0020 |
| Cu | mg/L | 0.0010 | 0.0020 | 0.12 | 0.21 |
| Fe | mg/L | 0.0041 | 0.0042 | 14 | 63 |
| Hg | mg/L | 0.000010 | 0.000010 | 0.000010 | 0.000010 |
| K | mg/L | 13 | 16 | 7.8 | 7.9 |
| Mg | mg/L | 10 | 12 | 16 | 17 |
| Mn | mg/L | 0.16 | 0.21 | 1.1 | 1.3 |
| Mo | mg/L | 0.0015 | 0.0039 | 0.00020 | 0.00039 |
| Na | mg/L | 35 | 48 | 17 | 34 |
| Ni | mg/L | 0.020 | 0.048 | 2.3 | 3.8 |
| Pb | mg/L | 0.00040 | 0.0012 | 0.14 | 0.46 |
| Sb | mg/L | 0.000090 | 0.00022 | 0.00029 | 0.00030 |
| Se | mg/L | 0.00081 | 0.0017 | 0.0059 | 0.0063 |
| Tl | mg/L | 0.000050 | 0.00010 | 0.0012 | 0.0014 |
| U | mg/L | 0.0065 | 0.0089 | 0.025 | 0.039 |
| Zn | mg/L | 0.0040 | 0.0041 | 3.2 | 3.4 |

**Notes:** EOM = End of Mining; PC = Post-Closure.

**Table 4-2:**
**Geochemical Source Term Concentrations for the NAG WRSA**

| | | EOM | | PC | |
|---|---|---|---|---|---|
| | | Base Case | Upper Case | Base Case | Upper Case |
| pH | - | 7.5 | 7.5 | 7.5 | 7.5 |
| Sulphate | mg/L | 1146 | 1370 | 902 | 1095 |
| Al | mg/L | 0.0059 | 0.0059 | 0.0058 | 0.0058 |
| Ag | mg/L | 0.000050 | 0.000080 | 0.000070 | 0.000080 |
| As | mg/L | 0.0073 | 0.014 | 0.0044 | 0.0045 |
| B | mg/L | 0.26 | 0.37 | 0.18 | 0.25 |
| Ca | mg/L | 46 | 44 | 50 | 47 |
| Cd | mg/L | 0.000030 | 0.000080 | 0.000060 | 0.000090 |
| Co | mg/L | 0.0014 | 0.0030 | 0.0018 | 0.0026 |
| Cr | mg/L | 0.00050 | 0.0010 | 0.0022 | 0.0023 |
| Cu | mg/L | 0.0010 | 0.0020 | 0.010 | 0.020 |
| Fe | mg/L | 0.0041 | 0.0042 | 0.0041 | 0.0041 |
| Hg | mg/L | 0.000010 | 0.000010 | 0.000010 | 0.000010 |
| K | mg/L | 15 | 19 | 9.3 | 9.5 |
| Mg | mg/L | 12 | 14 | 6.6 | 7.1 |
| Mn | mg/L | 0.14 | 0.20 | 0.11 | 0.13 |
| Mo | mg/L | 0.0018 | 0.0053 | 0.0036 | 0.0074 |
| Na | mg/L | 36 | 50 | 26 | 27 |
| Ni | mg/L | 0.022 | 0.052 | 0.0093 | 0.015 |
| Pb | mg/L | 0.00045 | 0.0013 | 0.00058 | 0.0024 |
| Sb | mg/L | 0.00010 | 0.00024 | 0.00034 | 0.00036 |
| Se | mg/L | 0.00090 | 0.0022 | 0.00090 | 0.00095 |
| Tl | mg/L | 0.000050 | 0.00010 | 0.00022 | 0.00027 |
| U | mg/L | 0.0064 | 0.0089 | 0.0029 | 0.0045 |
| Zn | mg/L | 0.0045 | 0.0046 | 0.0045 | 0.0047 |

**Notes:** EOM = End of Mining; PC = Post-Closure.

### 4.1.2 Low-Grade Ore Stockpile

Geochemical source terms for the low-grade ore stockpile are given in Table 4-3.

**Table 4-3:**
**Geochemical Source Term Concentrations for the Low-Grade Ore Stockpile**

| | | **EOM** | | **PC** | |
|---|---|---|---|---|---|
| | | Base Case | Upper Case | Base Case | Upper Case |
| pH | - | 7.5 | 7.5 | 4.5 | 4.0 |
| Sulphate | mg/L | 764 | 1562 | 3652 | 4254 |
| Al | mg/L | 0.0058 | 0.0059 | 0.15 | 0.22 |
| Ag | mg/L | 0.000080 | 0.000080 | 0.00013 | 0.00014 |
| As | mg/L | 0.0042 | 0.0098 | 0.019 | 0.029 |
| B | mg/L | 0.31 | 0.49 | 0.42 | 0.42 |
| Ca | mg/L | 55 | 42 | 33 | 32 |
| Cd | mg/L | 0.000020 | 0.000060 | 0.0064 | 0.0099 |
| Co | mg/L | 0.00064 | 0.0024 | 0.53 | 0.82 |
| Cr | mg/L | 0.00050 | 0.0010 | 0.0037 | 0.0040 |
| Cu | mg/L | 0.0010 | 0.0020 | 0.062 | 0.071 |
| Fe | mg/L | 0.0041 | 0.0042 | 4.4 | 15 |
| Hg | mg/L | 0.000010 | 0.000010 | 0.000020 | 0.000020 |
| K | mg/L | 13 | 19 | 16 | 17 |
| Mg | mg/L | 12 | 13 | 25 | 27 |
| Mn | mg/L | 0.20 | 0.22 | 1.4 | 2.2 |
| Mo | mg/L | 0.0011 | 0.0021 | 0.0012 | 0.0014 |
| Na | mg/L | 36 | 54 | 27 | 29 |
| Ni | mg/L | 0.026 | 0.043 | 19 | 27 |
| Pb | mg/L | 0.00087 | 0.0022 | 0.037 | 0.041 |
| Sb | mg/L | 0.000080 | 0.00010 | 0.00057 | 0.00062 |
| Se | mg/L | 0.0030 | 0.0044 | 0.011 | 0.014 |
| Tl | mg/L | 0.000050 | 0.00010 | 0.0012 | 0.0013 |
| U | mg/L | 0.0029 | 0.0037 | 0.010 | 0.017 |
| Zn | mg/L | 0.0046 | 0.0048 | 2.5 | 2.8 |

**Notes:** EOM = End of Mining; PC = Post-Closure.

### 4.1.3 Pit Walls

Pit wall source terms used for input into the site-wide water quality model are presented in Table 4-4.

**Table 4-4:**
**Geochemical Source Term Concentrations for FMS Pit Wall Runoff**

| | | EOM | | PC | |
|---|---|---|---|---|---|
| | | Base Case | Upper Case | Base Case | Upper Case |
| pH | - | 7.5 | 7.5 | 7.5 | 7.5 |
| Sulphate | mg/L | 704 | 964 | 658 | 801 |
| Al | mg/L | 0.0058 | 0.0058 | 0.0058 | 0.0058 |
| Ag | mg/L | 0.000070 | 0.000070 | 0.000070 | 0.000070 |
| As | mg/L | 0.011 | 0.023 | 0.0069 | 0.0075 |
| B | mg/L | 0.069 | 0.10 | 0.042 | 0.058 |
| Ca | mg/L | 57 | 50 | 59 | 53 |
| Cd | mg/L | 0.000010 | 0.000020 | 0.000010 | 0.000020 |
| Co | mg/L | 0.00087 | 0.0023 | 0.0015 | 0.0020 |
| Cr | mg/L | 0.00050 | 0.0010 | 0.0020 | 0.0021 |
| Cu | mg/L | 0.0010 | 0.0020 | 0.0077 | 0.013 |
| Fe | mg/L | 0.0041 | 0.0041 | 0.0040 | 0.0041 |
| Hg | mg/L | 0.000010 | 0.000010 | 0.000010 | 0.000010 |
| K | mg/L | 18 | 23 | 11 | 11 |
| Mg | mg/L | 9.9 | 12 | 5.7 | 6.0 |
| Mn | mg/L | 0.092 | 0.11 | 0.071 | 0.090 |
| Mo | mg/L | 0.0073 | 0.017 | 0.012 | 0.022 |
| Na | mg/L | 33 | 46 | 24 | 25 |
| Ni | mg/L | 0.037 | 0.080 | 0.028 | 0.042 |
| Pb | mg/L | 0.00053 | 0.0015 | 0.00051 | 0.0016 |
| Sb | mg/L | 0.00014 | 0.00030 | 0.00048 | 0.00051 |
| Se | mg/L | 0.0014 | 0.0024 | 0.00092 | 0.0010 |
| Tl | mg/L | 0.000050 | 0.00010 | 0.00018 | 0.00022 |
| U | mg/L | 0.016 | 0.021 | 0.0086 | 0.013 |
| Zn | mg/L | 0.0042 | 0.0043 | 0.0040 | 0.0043 |

**Notes:** EOM = End of Mining; PC = Post-Closure.

### 4.1.4 Nitrogen Source Terms

Nitrogen concentrations predicted for drainage from the WRSAs, pit walls, and the TMF embankment at EOM are presented in

Table 4-5. The PC scenario involves an annual nitrogen depletion rate rather than absolute concentrations. The approach chosen to derive this rate is described in Section 3.

**Table 4-5:**
**Nitrogen Species Source Term Concentrations for FMS Mine Components at End of Mining**

| | unit | End of Mining | |
|---|---|---|---|
| | | **Base Case** | **Upper Case** |
| **WRSA** | | | |
| Nitrate | mg N/L | 13 | 26 |
| Nitrite | mg N/L | 0.3 | 0.59 |
| Ammonia | mg N/L | 1.6 | 3.2 |
| **Pit Runoff** | | | |
| Nitrate | mg N/L | 5.5 | 18 |
| Nitrite | mg N/L | 0.17 | 0.54 |
| Ammonia | mg N/L | 1.0 | 6.9 |
| **TMF Embankments** | | | |
| Nitrate | mg N/L | 7.1 | 9.0 |
| Nitrite | mg N/L | 0.17 | 0.30 |
| Ammonia | mg N/L | 0.31 | 0.49 |

## *4.2 Tailings*

### 4.2.1 Tailings Supernatant (End of Mining)

The Base Case FMS tailings process water (supernatant) predictions are given in Table in Table 4-6.

**Table 4-6:**
**Geochemical Source Term Concentrations Associated with the FMS Tailings Supernatant**

| | | **Tailings Supernatant** |
|---|---|---|
| | | Base Case |
| pH | - | 8.0 |
| Sulphate | mg/L | 135 |
| Al | mg/L | 0.026 |
| Ag | mg/L | 0.0000050 |
| As | mg/L | 0.012 |
| B | mg/L | 0.021 |
| Ca | mg/L | 25 |
| Cd | mg/L | 0.0000050 |
| Co | mg/L | 0.0000090 |
| Cr | mg/L | 0.00010 |
| Cu | mg/L | 0.00010 |
| Fe | mg/L | 0.0010 |
| Hg | mg/L | 0.0000050 |
| K | mg/L | 32 |
| Mg | mg/L | 3.5 |
| Mn | mg/L | 0.018 |
| Mo | mg/L | 0.016 |
| Na | mg/L | 63 |
| Ni | mg/L | 0.00076 |
| Pb | mg/L | 0.0000050 |
| Sb | mg/L | 0.00031 |
| Se | mg/L | 0.00028 |
| Tl | mg/L | 0.0000060 |
| U | mg/L | 0.00016 |
| Zn | mg/L | 0.010 |

**Notes:** Al and Fe underwent PHREEQC speciation.

### 4.2.2 TMF Beach Runoff

The source term concentrations predicted for TMF beach runoff are presented in Table 4-7.

**Table 4-7:**
**Predicted Concentrations for Tailings Beach Runoff**

| | | Tailings Beach Runoff | |
|---|---|---|---|
| | | Base Case | Upper Case |
| pH | - | 7.9 | 8.0 |
| Sulphate | mg/L | 79 | 83 |
| Al | mg/L | 0.023 | 0.026 |
| Ag | mg/L | 0.000025 | 0.000025 |
| As | mg/L | 0.0096 | 0.013 |
| B | mg/L | 0.014 | 0.015 |
| Ca | mg/L | 22 | 22 |
| Cd | mg/L | 0.0000050 | 0.0000050 |
| Co | mg/L | 0.000028 | 0.000032 |
| Cr | mg/L | 0.00014 | 0.00015 |
| Cu | mg/L | 0.0011 | 0.0014 |
| Fe | mg/L | 0.0052 | 0.0044 |
| Hg | mg/L | 0.000013 | 0.000020 |
| K | mg/L | 11 | 14 |
| Mg | mg/L | 1.9 | 1.9 |
| Mn | mg/L | 0.011 | 0.012 |
| Mo | mg/L | 0.0096 | 0.014 |
| Na | mg/L | 43 | 54 |
| Ni | mg/L | 0.00045 | 0.00050 |
| Pb | mg/L | 0.000025 | 0.000030 |
| Sb | mg/L | 0.00045 | 0.00045 |
| Se | mg/L | 0.00023 | 0.00033 |
| Tl | mg/L | 0.0000040 | 0.0000050 |
| U | mg/L | 0.00024 | 0.00025 |
| Zn | mg/L | 0.0010 | 0.0010 |

**Notes:** Al and Fe underwent PHREEQC speciation

### 4.2.3 Tailings Pore Water (Long-Term)

The final source term concentrations predicted for the long-term FMS TMF pore water are presented in Table 4-8.

**Table 4-8:**
**Long-Term (Post-Closure) Pore Water Concentrations Predicted for the FMS TMF**

| | | Tailings Pore Water | |
|---|---|---|---|
| | | Base Case | Upper Case |
| pH | - | 8.1 | 8.1 |
| Sulphate | mg/L | 225 | 244 |
| Al | mg/L | 0.0055 | 0.010 |
| Ag | mg/L | 0.0000050 | 0.0000050 |
| As | mg/L | 0.053 | 0.11 |
| B | mg/L | 0.052 | 0.053 |
| Ca | mg/L | 42 | 44 |
| Cd | mg/L | 0.000011 | 0.000022 |
| Co | mg/L | 0.0000050 | 0.0000070 |
| Cr | mg/L | 0.00010 | 0.00010 |
| Cu | mg/L | 0.00016 | 0.00029 |
| Fe | mg/L | 0.00063 | 0.0011 |
| Hg | mg/L | 0.0000050 | 0.0000050 |
| K | mg/L | 40 | 45 |
| Mg | mg/L | 6.6 | 7.3 |
| Mn | mg/L | 0.22 | 0.39 |
| Mo | mg/L | 0.040 | 0.055 |
| Na | mg/L | 89 | 92 |
| Ni | mg/L | 0.00073 | 0.0012 |
| Pb | mg/L | 0.0000030 | 0.0000050 |
| Sb | mg/L | 0.000090 | 0.00014 |
| Se | mg/L | 0.00017 | 0.00031 |
| Tl | mg/L | 0.0000040 | 0.0000060 |
| U | mg/L | 0.00023 | 0.00025 |
| Zn | mg/L | 0.00021 | 0.00028 |

**Notes:** Al and Fe underwent PHREEQC speciation

### 4.3 Overburden

Source terms for the FMS till and topsoil stockpiles are presented in Table 4-9. Note that the same source terms are applied to the EOM and PC scenarios.

**Table 4-9:**
**Geochemical Source Term Concentrations for the Till and Topsoil Stockpiles**

| | | Topsoil Stockpile | | Till Stockpile | |
|---|---|---|---|---|---|
| | | Base Case | Upper Case | Base Case | Upper Case |
| pH | mg/L | 5.5 | 5.0 | 6.7 | 5.5 |
| Sulphate | mg/L | 1.7 | 2.2 | 36 | 68 |
| Al | mg/L | 0.078 | 0.55 | 0.0078 | 0.10 |
| Ag | mg/L | 0.000030 | 0.000030 | 0.000030 | 0.000030 |
| As | mg/L | 0.0025 | 0.0070 | 0.0021 | 0.015 |
| B | mg/L | 0.0050 | 0.0050 | 0.0055 | 0.017 |
| Ca | mg/L | 0.95 | 1.1 | 15 | 42 |
| Cd | mg/L | 0.000030 | 0.000060 | 0.000030 | 0.00029 |
| Co | mg/L | 0.00069 | 0.00096 | 0.00039 | 0.011 |
| Cr | mg/L | 0.00076 | 0.0011 | 0.00025 | 0.00086 |
| Cu | mg/L | 0.00095 | 0.0027 | 0.0017 | 0.0041 |
| Fe | mg/L | 0.23 | 0.42 | 0.023 | 0.18 |
| Hg | mg/L | 0.000030 | 0.000030 | 0.000030 | 0.000030 |
| K | mg/L | 0.67 | 1.4 | 0.81 | 1.3 |
| Mg | mg/L | 0.41 | 0.53 | 2.3 | 6.5 |
| Mn | mg/L | 0.087 | 0.11 | 0.19 | 0.72 |
| Mo | mg/L | 0.000050 | 0.000050 | 0.00059 | 0.0065 |
| Na | mg/L | 1.4 | 2.1 | 4.4 | 6.2 |
| Ni | mg/L | 0.0014 | 0.0017 | 0.0011 | 0.020 |
| Pb | mg/L | 0.00013 | 0.00094 | 0.00011 | 0.00052 |
| Sb | mg/L | 0.000050 | 0.000050 | 0.00023 | 0.00054 |
| Se | mg/L | 0.00077 | 0.00096 | 0.00051 | 0.00091 |
| Tl | mg/L | 0.000050 | 0.000050 | 0.000050 | 0.000090 |
| U | mg/L | 0.000080 | 0.00010 | 0.000060 | 0.00075 |
| Zn | mg/L | 0.0050 | 0.0099 | 0.0050 | 0.014 |

**Notes:** EOM = End of Mining; PC = Post-Closure.

# 5. Recommended Future Work

Geochemical source term predictions heavily rely on theoretical constraints, representative geochemical testwork, and the availability of site analogue data. To close data gaps that would increase the confidence in the geochemical source term predictions for future model iterations, the following recommendations are made:

- Continued operation of FMS PAG humidity cells to assess the long-term effect of metal leaching behaviour in site-specific materials as well as to understand material-specific metal mobility under acidic conditions.
- Additional sampling and static testing of waste rock material to increase the confidence in the sulphur and NP contents as well as PAG proportions within this population, since these parameters have a direct impact on the source term model results.
- Collection of site-specific topsoil samples to understand and asses this material's geochemical variability and in support of topsoil stockpile source terms.
- Continued tracking and reporting of Touquoy WRSA tonnage, footprint, and lithological proportions along with continued waste rock drainage monitoring to allow for better calibration of model and scaling factors which can be applied to the FMS WRSA in future model iterations. This is especially relevant for nitrogen-specific source terms, since nitrogen commonly shows lag times in its release from larger waste rock facilities.
- Concentrate from the FMS processing plant will be shipped to the Touquoy site where the final ore extraction step will be conducted using cyanidation. It is expected that the relatively small quantity of tailings generated during this process will be co-deposited with Beaver Dam tailings in the Touquoy open pit. To understand the geochemical impact of this tailings disposal plan, it is recommended that this material be tested via ABA and potentially other characterization methods.

# 6. Closure

This Lorax report was prepared and reviewed by the undersigned.

Yours sincerely,
**Lorax Environmental Services Ltd.**

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# Appendix F.2

Fifteen Mile Stream Project - ML/ARD Assessment Report,
Lorax Environmental Services Ltd.

# *Fifteen Mile Stream Project – ML/ARD Assessment Report*

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**Project No. A490-2**

**28 August 2019**

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Atlantic Gold

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# APPENDICES

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# 1. Introduction

Atlantic Gold

# 1 Introduction

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

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

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

# 2. Geology

Atlantic Gold

# 2 Geology

## 2.1 Regional Geology

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

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

## 2.2 Site Geology

The Meguma Group is the dominant unit occurring in the area near the FMS site. The Goldenville Formation is further subdivided, from oldest to youngest, into the Moose River Member, the Tangier Member and the Taylors Head Member. Claystone and siltstone are present in the Moose River and Tangier Members but are minor in the Taylors Head Member. Overall there is a decrease in the proportion of fine-grained sediments from the oldest to the youngest units within the Goldenville Formation. The Touquoy, Beaver Dam, and FMS sites are found along the trend of an anticline within the same geologic units. The Moose River-Beaver Dam east-northeast-trending anticline contains both the Touquoy and Beaver Dam gold deposits and may be equivalent to the FMS anticline which contains the FMS site (FSSI, 2015). The anticline forms a dome structure, with both limbs dipping to the north (FSSI, 2015). The metamorphic facies in the FMS region are amphibolite to staurolite facies. The Moose River Member of the Goldenville Formation is the dominant stratigraphic unit that will be disturbed by mining activity in the FMS pit. This unit is comprised of alternating argillite and greywacke units (FSSI, 2015). While many unique lithologies and geologic structures are tracked during core logging, argillite and greywacke along with two interbedded intermediates (argillite- and greywacke-dominated) represent the four major rock types by volume identified on site. In an effort to be consistent with the geological observations from site while simultaneously allowing for a representative and simplified geo-environmental model, these four major rock types are being carried forward in this ML/ARD assessment. A more detailed description of these units is given in Table 3-1.

# 3. Samples and Analytical Methods

# 3 Samples and Analytical Methods

## 3.1 Sample Selection and Collection

### 3.1.1 Mine Rock Samples

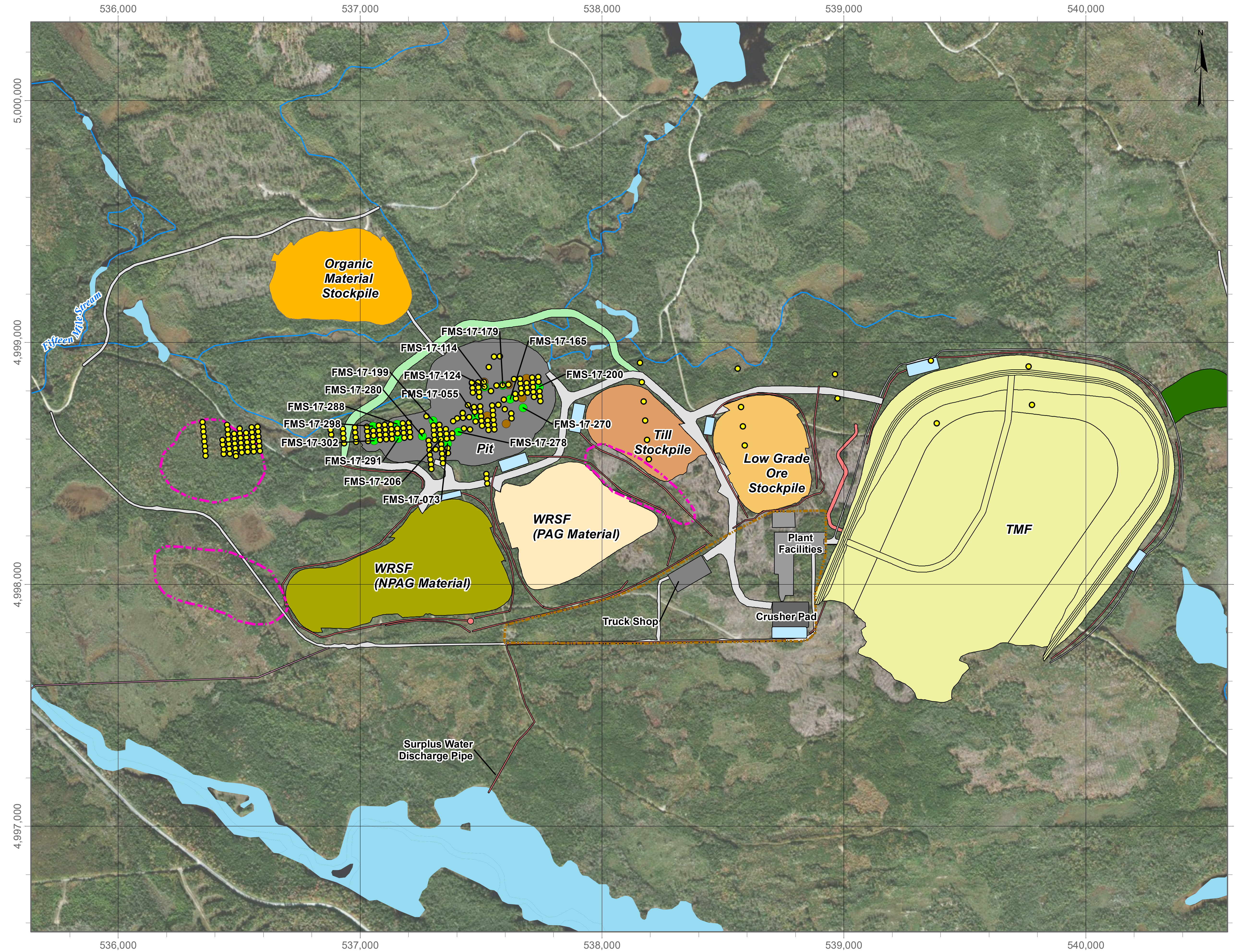
A total of 60 FMS drill core samples have been collected in support of this geochemical assessment. Generally, 1m-intervals were chosen for this sample selection. Static test analyses, including acid base accounting (ABA) and solid phase elements were carried out on all samples, and based on these results, a subset of samples was selected for kinetic testwork (humidity cells). The humidity cell subsamples were also assessed for mineralogy, particle size distribution, shake flask extractions (SFE), and leaching tests. Additional drill core intervals were selected for the initiation of a field bin. A subsample from the material used to fill the field bin was submitted for ABA, solid phase elements, and mineralogy.

When the samples for the geochemical testwork were originally selected, the designation between low-grade ore and waste was based on the Au grade rather than the spatial association with the waste ore zones. Since this time, the spatial extent of the ore shell has been better defined. This has resulted in a greater than anticipated proportion of ore samples in the static testing dataset, as well as some of the humidity cell samples being comprised of a mix of ore and waste intervals. An in-fill sampling and geologic modelling program has since been conducted by AMNS in order to close the spatial gaps identified for the waste rock zone within the pit. This sampling program consisted of 38 additional composite samples collected over 5 m intervals based on the geological block model. The FMS geologic units and sample descriptions are provided in Table 3-1, whereas the sample locations and drill core details are presented in Appendix 3-1. The location of the sampled drill holes is provided in Figure 3-1.

Five humidity cells (HC1 through HC5) were initiated using crushed drill core material covering median to 75$^{th}$ percentile sulphur contents for each of the four lithologies and ore material, as summarized in Table 3-2. Field bin LX-18-FB3 was filled with manually split drill core selected from the four main lithologies in order to represent the expected proportions in the waste rock pile (Table 3-3). The objective of the kinetic testing program is to provide sulphide oxidation and leaching rates to be used as input for the geochemical source term model.

**Table 3-1:**
**FMS Geologic Units and Sample Descriptions**

| Geologic Unit | Description | Code | No. Samples |
|---|---|---|---|
| Argillite | argillite with < 5% greywacke interbeds | AR | 26 |
| Argillite-Greywacke | argillite with 5-49% greywacke interbeds | AG | 11 |
| Greywacke-Argillite | greywacke with 20-50% argillite interbeds | GA | 14 |
| Greywacke | greywacke with < 20% argillite interbeds | GW | 24 |
| Ore | Ore designation is based on the ore shell | Ore | 23 |




## LEGEND

- Drillhole Collar
- Sampled - Static Testing
- Sampled - Field Bin

**Updated Infrastructure**

- Access Road
- Collection Pond
- Crusher Pad
- Haul Road
- LGSP
- Open Pit
- Organic Material Stockpile
- Plant
- Potential Borrow Site
- Seloam Brook Diversion
- TMF
- Till Stockpile
- Topsoil Stockpile
- Transmission Spur Line
- Transmission Spur Line option 2
- Plant and Admin Building
- Truck Shop
- WRSF NPAG
- WRSF PAG
- Water Management

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

**1:15,000**

0 200 400 Meters

| | |
|---|---|
| **DATE SAVED:** | Aug 14, 2019 |
| **DRAWN BY:** | GM |
| **REVIEWED:** | JO |
| **VERSION:** | 1 |

CLIENT:

ATLANTIC GOLD

LORAX ENVIRONMENTAL

PROJECT:

**FMS Project - ML/ARD Assessment Report**

TITLE:

FMS Drill Hole Locations

PROJECT #: A490-2 FIGURE: 3-1

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**Table 3-2:**
**Summary of FMS Humidity Cell Samples**

| Humidity Cell ID | Lithology | Designation | Hole ID | Interval (m) | |
|---|---|---|---|---|---|
| | | | | *From* | *To* |
| HC 1 | AG | waste | FMS-17-124 | 70 | 71 |
| | | ore | FMS-17-124 | 82 | 83 |
| HC 2 | AR | waste | FMS-17-055 | 50 | 51 |
| | | ore | FMS-17-124 | 130 | 131 |
| HC 3 | GA | waste | FMS-17-073 | 9 | 10 |
| | | waste | FMS-17-199 | 29 | 30 |
| HC 4 | GW | waste | FMS-17-124 | 46 | 47 |
| | | waste | FMS-17-199 | 5 | 6 |
| HC 5 | Ore | ore | FMS-17-055 | 83 | 84 |
| | | ore | FMS-17-055 | 70 | 71 |

**Table 3-3:**
**Summary of Core Proportions Making up the FMS Field Bin Sample**

| Lithology | Meters of Drill Core Selected (m) | Proportion in Field Bin (%) |
|---|---|---|
| AR | 70 | 53 |
| AG | 15 | 11 |
| GA | 18 | 14 |
| GW | 28 | 21 |
| *Total* | *131* | *100* |

### 3.1.2 Tailings Samples

Two tailings samples were selected from the metallurgical testing (KM5446) conducted by ALS Laboratories on FMS ore materials in September 2017. These metallurgical tests simulated a split circuit utilizing a hydroflotation and conventional rougher flotation. For geochemical analyses including ABA, solid phase elements, and SFE, weighted composites of the hydrofloat and rougher tailings were provided from two representative test runs (Test 8 and 42).

More recent metallurgical testing (KM5644) including ore composite samples from an expanded mining area was completed in the fall of 2018. Two additional tailings samples representing a conventional mill circuit (Test 10) and a split circuit (Test 6) were provided to Lorax in slurry form for environmental testing. The 2018 conventional tailings material is also being used for saturated column testing, initiated in March 2019, to constrain the geochemical behaviour within the saturated zone of the TMF. This conventional tailings stream is considered representative of the material that will ultimately be deposited in the FMS TMF (Tiver, pers. comm., 2019) and includes a rougher and a cleaner circuit to produce an ore concentrate which will be processed at the Touquoy mill (Figure 3-2).

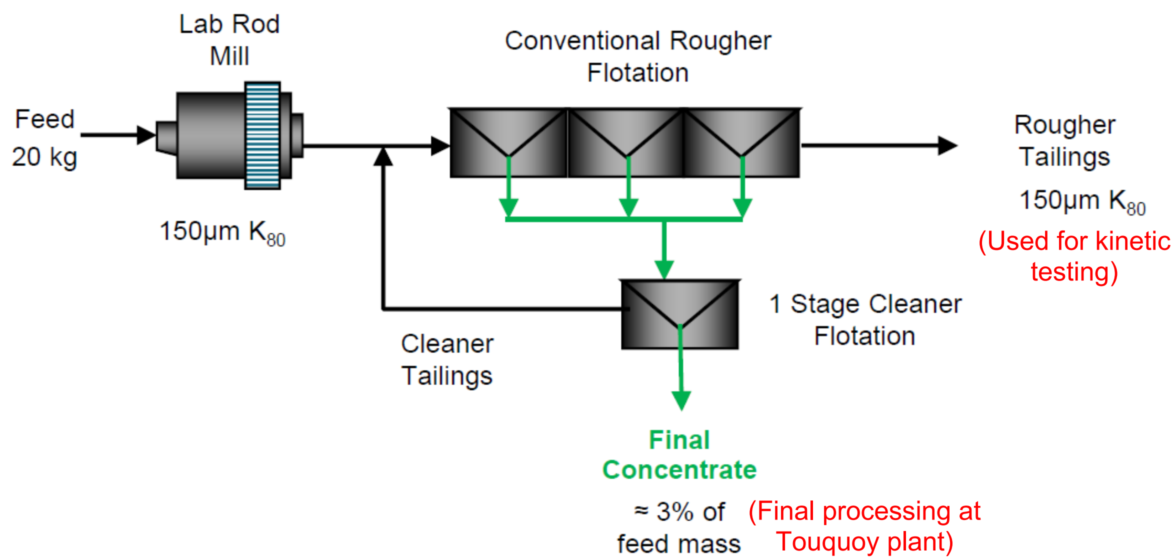


**Figure 3-2: Flowsheet for the 2018 metallurgical testing (KM5644) from which the FMS conventional tailings sample was derived.**

## *3.2 Analytical Methods*

### 3.2.1 Static Test Methods

Static tests that were carried out to characterize mine rock, tailings, and overburden samples include acid base accounting (ABA), aqua-regia digestible elemental abundance, mineralogical investigations, and leachate tests. Note that the 38 samples collected as part of the AMNS in-fill sampling program only underwent ABA analysis. The following sections provide a brief overview of all methods utilized. Static testing was conducted at ALS Laboratories for the drill core and the field bin subsample, while the tailings samples were submitted for analysis at SGS Canada Inc.

#### *3.2.1.1 Mineralogy*

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

The field bin sample was also submitted to SGS Canada Inc. for QEMSCAN (Quantitative Evaluation of Minerals by Scanning Electron Microscopy). This analysis provides information on the modal mineral abundances in addition to information regarding grain sizes and exposure surfaces of the sulphide and carbonate minerals in the sample. Arsenic and sulphur deportment was also investigated during this analysis.

#### *3.2.1.2 Acid-Base Accounting*

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

#### *3.2.1.3 Aqua-Regia Digestible Elemental Abundance*

Solid phase elemental abundance analyses are conducted on pulverized samples by digesting a sample in aqua regia acid ($HNO_3$ + 3 HCl). The extract is then diluted and analyzed for metals by inductively coupled plasma mass spectrometry (ICP-MS). Data from these analyses are used to characterize materials and to identify elements of potential environmental concern. The degree of enrichment as compared to average upper continental crust abundance (AUCCA; Rudnick and Gao, 2014) can provide a general indication of the overall metal enrichment. However, enrichment does not necessarily indicate that the element will become problematic, since the leaching rate is highly dependent on other factors, including the metal-phase associations, grain size, the geochemistry of infiltrating waters, and the depositional environment.

#### *3.2.1.4 Short-Term Leach Testing*

Short-term leach tests at different water/solids ratios were conducted at SGS Canada Inc. on the FMS material. Metal contents measured in leaching tests provide a measure of the mass of readily soluble metals which will be immediately available for leaching upon exposure to infiltrating water. Shake flask extractions (SFE) consist of agitating a representative sample in water, typically at a water/solids ratio of 3:1, for 24 hours. Standard SFE tests were conducted on the humidity cell samples and the field bin subsample. Additional leach tests were also conducted at 1:1 and 0.5:1 water/solids ratios for the field bin subsample in an effort to better understand mineral solubility limits and the effect of water/solid ratios on drainage chemistry. The leachate chemistry from these tests can be used as a cursory tool in determining the initial leachate chemistry of water in contact with disturbed rock. These tests do not give insight into reaction rates and the timing for delayed onset of ARD.

### 3.2.2 Particle Size Distribution

Particle size distribution (PSD) analyses were carried out at SGS Canada Inc. to quantify the relative distribution of grain sizes of material placed in the humidity cell tests. It is important to have an estimate of the specific surface area of the humidity cell samples as the kinetic rate at which a material will react is in part dependent on the specific surface area of the sample. The specific surface area is also required when scaling between laboratory and field conditions. Standard mechanical sieving methods were used to characterize the general PSD of samples. No PSD data is available for the field bin sample due to an error in the initial sample preparation.

### 3.2.3 Kinetic Test Methods

#### *3.2.3.1 Humidity Cells*

Humidity cell testing is used to mimic the natural weathering processes that act on crushed rock or tailings material. The results are used as the basis to predict geochemical loading rates from these materials when stored in surface facilities under oxidizing conditions. These experiments provide data on the primary weathering rates of waste materials and, therefore, the results from this type of testing may be used to estimate the rate of acid generation and metal release to the environment. As well, these data may be used to estimate drainage chemistry via upscaling models.

Laboratory-based humidity cells are set up at SGS Canada Inc. These cells are typically composed of a plexiglass cylinder filled with approximately 1 kg of sample crushed to 80% passing <6.4 mm. The contents of the cells are subjected to moist air for three days, followed by dry air for three days (< 10% relative humidity). At the end of each wet/dry cycle, the contents of the cell are leached with 500 mL distilled de-ionized water on the seventh day (Price, 1997; Lapakko, 2003). The purpose of the leaching step is to recover any readily soluble products that have formed due to mineral dissolution or sulphide oxidation in order to determine the dissolved load contributed from the previous week's test. The leachate is then analyzed for pH, alkalinity and any solutes of interest.

#### *3.2.3.2 Field Bin*

One field bin containing drill core from FMS was set up near the Touquoy mine site in September 2018 alongside Touquoy (n=2) and Cochrane Hill (n=1) field bins (Figure 3-3). The containers used are industrial-grade, 115L plastic drums that have been tested for this purpose at several other minesites. Approximately 170 kg of drill core for this field bin was selected in proportions to represent the different lithologies expected in the waste rock pile. The drill core samples were combined using the cone and quartering method, whereby the selected drill core intervals were combined and mixed in a large pile which was divided into quarters and opposite quarters were removed to fill the field bin. The remaining material was piled back into a cone and the quartering process was repeated until the bin was full (Figure 3-3). A representative subsample for static testing was collected from the remaining material.

**Figure 3-3: Setup of field bins near the Touquoy site (left) and FMS core materials used to construct LX-18-FB3 (right).**

Natural precipitation passes through the rock material and drains out of the bottom of the field bin via a small hole that is connected to collection jugs via HDPE tubing. Leachate samples are taken when a sufficient water volume has collected in the collection jug (or otherwise monthly when not frozen) and submitted to Maxxam Laboratories for water quality analysis. The initial sample was collected by manually irrigating the field bin with approximately 3L of distilled water.

#### *3.2.3.3 Saturated Column*

Saturated column testwork is used to characterize leachate geochemistry of tailings material under suboxic conditions, which will help inform mine waste management plans and water quality predictions. One saturated column was constructed, housed and sub-sampled at the Lorax laboratory in Vancouver, B.C. The column was constructed using a Plexiglass cylinder (15.0 cm in diameter, 20.0 cm in length; Figure 3-4). The bottom of the column was lined with a dispersion plate, a sheet of non-reactive polyester fabric, and a layer of silica sand (500 g) to allow for the even distribution of water over the surface area of the column bottom prior to contacting the column substrate. The column was equipped with an inlet at the base of the column and one port at the top of the column for sampling. Note that the experiment was designed so that influent entered from the bottom of the column and flowed upward. In other words, the bottom of the column is effectively upgradient and the top of the column is downgradient. This is a standard approach to ensure even flow through the column materials and minimize the risk of uncontrolled gravity-driven drainage and development of preferential flow paths (Jurjovec *et al.,* 2002; Petrunic *et al.,* 2005). The column contains approximately 7 kg of Test 10 tailings material and decanted tailings supernatant was used as influent for the experiment. Representative sub-samples of the tailings and supernatant were collected for static testing and water quality analyses, respectively.

For each sampling event, leachate was collected from the top port of the column and passed through a 0.45 µm cellulose acetate filter before being collected in high-density polyethylene sample bottles. To preserve redox speciation and minimize the potential for oxidation artifacts, sample bottles were purged with nitrogen gas to displace oxygen from the bottles prior to sampling. Approximately 200 - 250 mL of column effluent was collected over 48 hours for each sampling event. Samples were collected bi-weekly for three months then subsequently collected monthly throughout the rest of the experimental period. Following collection, samples were submitted to ALS Environmental Laboratories in Burnaby, B.C. for the following standard analyses:

- Nitrate, nitrite, sulphate, chloride, bromide, fluoride;
- Dissolved organic carbon (DOC), total dissolved phosphorus and ammonia; and
- Dissolved metals (including mercury).

Total alkalinity, pH and conductivity were measured in-house at the Lorax laboratory.

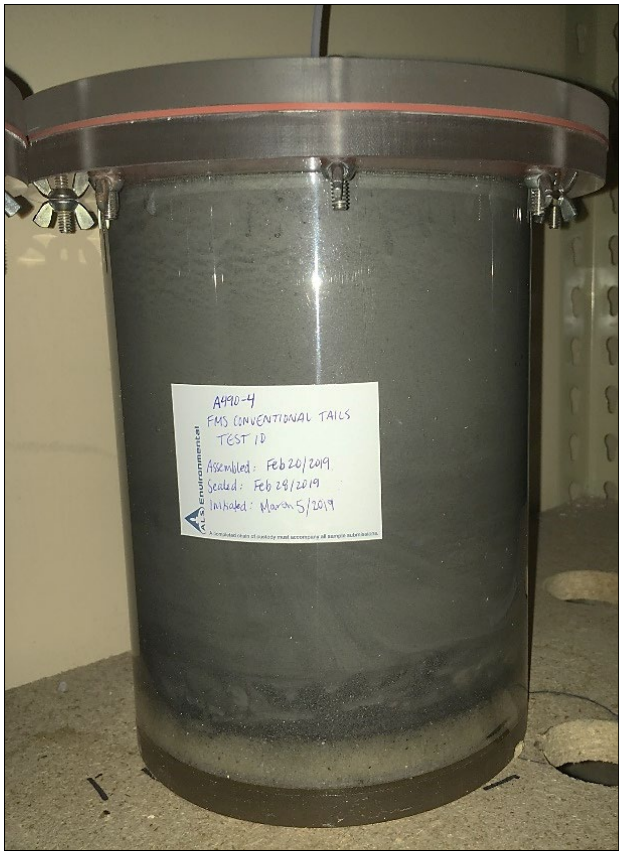


**Figure 3-4: Setup of the saturated column at the Lorax laboratory.**

### *3.3 Quality Assurance and Quality Control*

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

# 4. Results

Atlantic Gold

# 4 Results

Static test analyses were carried out on all samples to determine the geochemical characteristics of materials to be disturbed during development of the proposed FMS Mine. Kinetic tests were carried out on a subset of mine rock samples to predict geochemical behaviour as weathering proceeds. Kinetic test results presented in this section were also used to develop geochemical source terms (Lorax, 2019) for a site-wide water quality model, which is presented under separate cover

## 4.1 Mine Rock

### 4.1.1 Static Test Results

#### *4.1.1.1 Mineralogy*

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

Results of the XRD analyses for mine rock samples are summarized in Table 4.1, with the full report results provided in Appendix 4-1. The mineralogical investigation determined that samples are composed primarily of quartz, muscovite, andesine, albite, and chlorite with lesser amounts of biotite, calcite, pyrrhotite, chalcopyrite, pyrite, ilmenite, and spinel. Pyrrhotite is the dominant sulphide mineral (0.9% to 2.4%) and is present in four of the five samples. The one sample where pyrrhotite was not detected by XRD analysis contained minor chalcopyrite (0.3%). Calcite is the dominant carbonate mineral, comprising up to 9.8%; however, two of the five samples do not contain any XRD-detectable carbonates. Additional neutralization capacity may be afforded by silicate phases, including such as chlorite and biotite, which are present in all samples.

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

Table 4.2 provides an overview of key petrographic observations and illustrates that samples HC2 (AR) and HC4 (GW) have the highest relative proportions of argillite and greywacke clasts, respectively. Although HC 3 (GA) is made up of almost equal amounts of argillite and greywacke clasts, it can be said that the rock units defined during core logging correspond well with the grain size proportions identified on a thin section scale. In the following, textural relationships will be discussed across the various subsamples unless observations were made in particular samples.

Both end-member material types show a similar mineral inventory, although the relative mineral abundances vary. As shown by XRD analysis and confirmed by optical methods, the proportion of argillite clasts correlates positively with muscovite/illite and chlorite abundances, and negatively with quartz and feldspar contents. The occurrence of muscovite/illite, chlorite and biotite as matrix (clay) replacement phases in both greywacke and argillite suggests low prograde metamorphism, potentially related to the ore genesis phase.

Argillite aggregates are characterized by an overall finer grain size distribution with a higher relative content of sericite/muscovite and clay minerals. Feldspar and quartz appear as rounded grains and are moderately- to well-sorted. Due to the larger proportion of clay and mica minerals a higher degree of foliation is generally observed in argillite fragments compared with greywacke clasts (Figure 4-1a), although more randomly-oriented textures are present as well (Figure 4-1b).

**Table 4.1:**
**Summary of XRD Results for FMS Humidity Cell Samples**

| Mineral Phase | Ideal Formula | HC 1 | HC 2 | HC 3 | HC 4 | HC 5 |
|---|---|---|---|---|---|---|
| | | AG | AR | GA | GW | Ore |
| | | (wt %) | (wt %) | (wt %) | (wt %) | (wt %) |
| Quartz | $SiO_2$ | 36.2 | 30.6 | 34.9 | 38.9 | 39.0 |
| Muscovite | $KAl_2(AlSi_3O_{10})(OH)_2$ | 29.8 | 47.1 | 27.6 | 16.3 | 28.1 |
| Biotite | $K(Mg,Fe)_3(AlSi_3O_{10})(OH)_2$ | 3.5 | 2.7 | 3.6 | 2.1 | 3.6 |
| Chlorite | $(Fe,(Mg,Mn)_5,Al)(Si_3Al)O_{10}(OH)_8$ | 7.6 | 9.9 | 7.9 | 4.1 | 9.1 |
| Albite | $NaAlSi_3O_8$ | 8.1 | - | 15.8 | 28.0 | 5.0 |
| Andesine | $Na_{0.6}Ca_{0.4}Al_{1.4}Si_{2.6}O_8$ | 12.1 | 8.8 | 7.2 | - | 10.4 |
| Calcite | $CaCO_3$ | - | - | 1.4 | 9.8 | 1.6 |
| Pyrrhotite | $Fe_{(1-x)}S$ | 2.4 | 0.9 | 1.2 | - | 1.0 |
| Chalcopyrite | $CuFeS_2$ | - | - | - | 0.3 | - |
| Pyrite | $FeS_2$ | - | - | - | - | 0.3 |
| Ilmenite | $FeTiO_3$ | 0.4 | - | 0.5 | 0.4 | 0.4 |
| Spinel | $MgAl_2O_4$ | - | - | - | - | 1.6 |

**Note:** A hyphen indicates the phase was not detected.
Lithology codes: AG – argillite-greywacke, AR – argillite, GA – greywacke-argillite, GW – greywacke.

While low-grade metamorphic minerals such as muscovite/sericite and chlorite commonly make up the groundmass of argillite clasts, some occurrences are dominated by turbid, primary or secondary clay minerals indicating less intense prograde or low-temperature retrograde alteration, respectively. Retrograde clay-alteration is inferred where this dark turbid appearance overprints any prograde mica-alteration patterns (Figure 4-1c), such as biotite. Biotite in argillite samples is commonly distinctly larger-grained than the surrounding groundmass and forms tabular grains that seem to have grown independently of the sedimentary or shistose orientation within the matrix. Secondary ilmenite and magnetite (±rutile, ±hematite) grains make up a significant portion (>50%) of the opaque mineral inventory in most samples and generally display a spongy texture. These phases are mostly found as disseminated lens-like aggregates in argillite clasts.

Greywacke fragments are moderately- to poorly-sorted and primarily composed of rounded quartz and feldspar grains making up >70% of the volume of most fragments. The groundmass is typically composed of fine grained muscovite/sericite ± clay, with patches of chlorite filling interstices (Figure 4-3d). Biotite commonly occurs as a medium- to coarse-grained (0.1 – 0.5 mm) hydrothermal alteration phase that may be anhedral or subhedral. Grain orientation/foliation is noticeable in the more poorly-sorted greywacke clasts and minor or absent in the coarser-grained well-sorted occurrences (Figure 4-1d). Individual quartz and feldspar grains typically make up a range in grain sized from 0.075 to 0.2 mm, however individual monomineralic grain fragments can reach > 0.5 mm in length.

Sulphides are primarily represented by pyrrhotite (>90%) with minor arsenopyrite, pyrite, and chalcopyrite being observed as accessory sulphide phases. Pyrrhotite may occur as hydrothermal fracture fill (Figure 4-2a,b) or, less commonly, as a replacive phase in the argillite and greywacke groundmass. In argillite clasts, it may form elongated grains along the foliation plane of the ambient matrix (Figure 4-2c). Arsenopyrite and chalcopyrite are generally associated with pyrrhotite and mostly occur as secondary precipitates in hydrothermal veins containing quartz ± chlorite ± biotite ± carbonate (Figure 4-2a,b). While pyrrhotite and chalcopyrite generally form an- to subhedral crystals, arsenopyrite more commonly forms euhedral laths or prisms. Arsenopyrite and chalcopyrite appear relatively fresh with little indication of weathering, while pyrrhotite displays minor weathering rims and pitted surfaces (Figure 4-2c). Some larger pyrrhotite grains have undergone considerable fragmentation which may be a result of chemical weathering or physical processes. These fragmented grains have an increased surface area which can be expected to increase sulphide oxidation rates. Pyrite was only observed in HC1, where it most commonly occupies interstitial space and microfractures (Figure 4-2d), although small (<0.1 mm) discrete pyrite grains were occasionally observed. Due to their fine grain-size, sulphide weathering phases could not be conclusively identified by optical methods alone, however it is assumed that a mixture of poorly crystalline or amorphous hydrous ferric oxides (HFO) and clay minerals make up the observed oxidation products.

**Table 4.2:**
**Overview of petrographic observations relevant to the ML/ARD characteristics of the different humidity cell samples**

| Sample ID | Unit | Greywacke clasts | Argillite clasts | Sulphides (abundance, habit, grain size, occurrence) | Carbonates |
|---|---|---|---|---|---|
| HC 1 | AG | 66% | 34% | Pyrrhotite: 2-3%; isometric to elongated an- to subhedral grains; 0.08 - 1.5 mm; relatively fresh with some larger grains heavily fragmented.<br>Pyrite: 0.1-0.5%; anhedral mostly as vein fill, 0.1-0.9 mm; commonly fragmented and partially weathered<br>Chalcopyrite: trace; anhedral blebs exsolved from pyrrhotite, <0.15 mm, unweathered.<br>Arsenopyrite: trace; euhedral prisms, <0.12 mm; mostly as inclusions in larger pyrrhotite grains; fresh. | Rare (<1%) calcite observed replacing feldspar in argillite clasts and associated with coarser-grained alteration patches and hydrothermal veins containing quartz, biotite ± chlorite ± sulphides |
| HC 2 | AR | 100% | 0% | Pyrrhotite: 1%; isometric to elongated an- to subhedral grains; 0.1 - 1 mm; may occur as hydrothermal vein fill or as oriented masses in argillite and greywacke clasts; partially weathered (pitted).<br>Arsenopyrite: 0.1-0.5%; euhedral prisms and subhedral platy aggregates, 0.05 - 0.8 mm; occurs in association with pyrrhotite in quartz ± carbonate veins; fresh.<br>Chalcopyrite: trace; anhedral blebs exsolved from pyrrhotite, <0.25 mm, fresh. | Rare (<1%) calcite associated with coarser-grained alteration patches and hydrothermal veins containing quartz, biotite ± chlorite ± sulphides |
| HC 3 | GA | 47% | 53% | Pyrrhotite: 0.5-1%; isometric to elongated an- to subhedral grains; 0.1 - 0.8 mm; may occur as hydrothermal vein fill or as oriented masses in argillite and greywacke clasts; partially weathered (pitted).<br>Arsenopyrite: trace; subhedral platy aggregates, 0.05 - 0.35 mm; occurs in association with pyrrhotite in quartz ± carbonate veins; fresh.<br>Chalcopyrite: trace; anhedral blebs exsolved from pyrrhotite, <0.08 mm, fresh. | Common (>1%) calcite predominantly associated with quartz, biotite ± chlorite ± sulphides as hydrothermal vein fill and in replacive patches. |
| HC 4 | GW | 5% | 95% | Pyrrhotite: 0.5%; isometric to elongated anhedral grains; 0.05 - 0.6 mm; replacive and as vein fill; relatively fresh with some larger grains showing fragmentation and partially weathered (pitted).<br>Arsenopyrite: trace; euhedral prisms, <0.1 mm; mostly as inclusions in larger<br>Chalcopyrite: trace; anhedral blebs exsolved from pyrrhotite, <0.15 mm, unweathered. pyrrhotite grains; fresh. | Abundant (10%) calcite common in greywacke groundmass replacing clay/mica and feldspar; also associated with quartz and sulphides as hydrothermal vein fill and in replacive patches. |
| HC 5 | Ore | 89% | 11% | Pyrrhotite: 1-2%; isometric to elongated an- to subhedral grains; 0.1 - 1 mm; may occur as hydrothermal vein fill or as oriented masses in argillite and greywacke clasts; partially weathered and fragmented.<br>Arsenopyrite: 0.1-0.5%; euhedral to subhedral platy aggregates, 0.1 - 0.75 mm; occurs in association with pyrrhotite in quartz ± carbonate veins; fresh.<br>Chalcopyrite: trace; anhedral blebs exsolved from pyrrhotite, <0.25 mm, fresh.<br>Pyrite: trace; anhedral dispersed grains, 0.05-0.15 mm; fresh | Common (>1%) calcite predominantly associated with quartz ± biotite ± sulphides as hydrothermal vein fill and in replacive patches. |

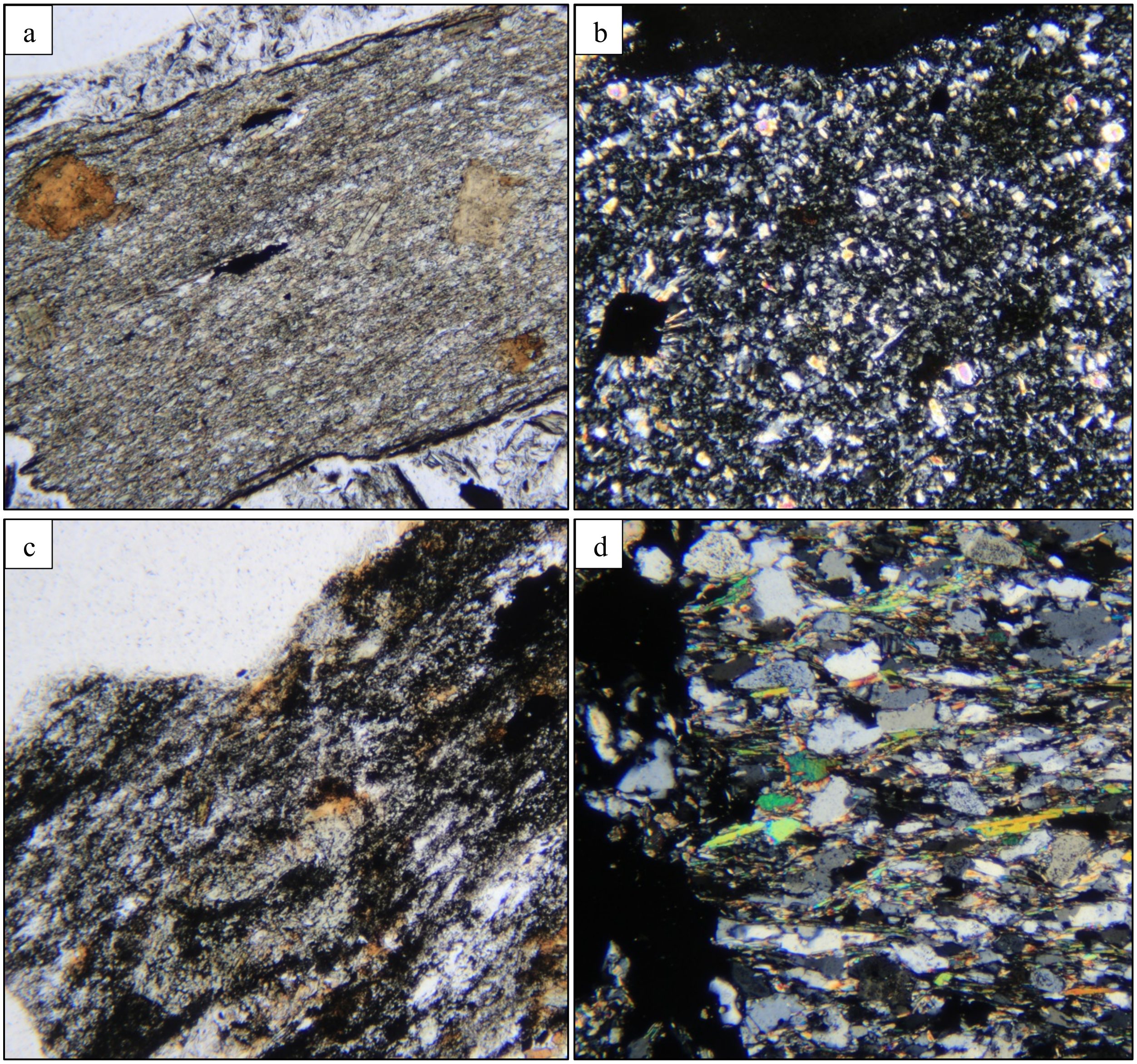


**Figure 4-1: Transmitted light photomicrographs from thin sections of FMS humidity cell material. (a) Typical example of a strongly oriented/foliated argillite clast containing hydrothermal biotite (Plane-polarized light = PPL); (b) argillite with randomly-oriented matrix components (crossed polars = XPL); (c) Argillite clast with dark, very fine-grained clay-minerals making up the matrix in between quartz and feldspar grains; (d) Typical example of a moderately-sorted greywacke clast (XPL). Coloured, foliated muscovite/sericite fill interstices between rounded feldspar and quartz grains (grey, brown).**

**Field of view (FOV) = 1.5 mm.**

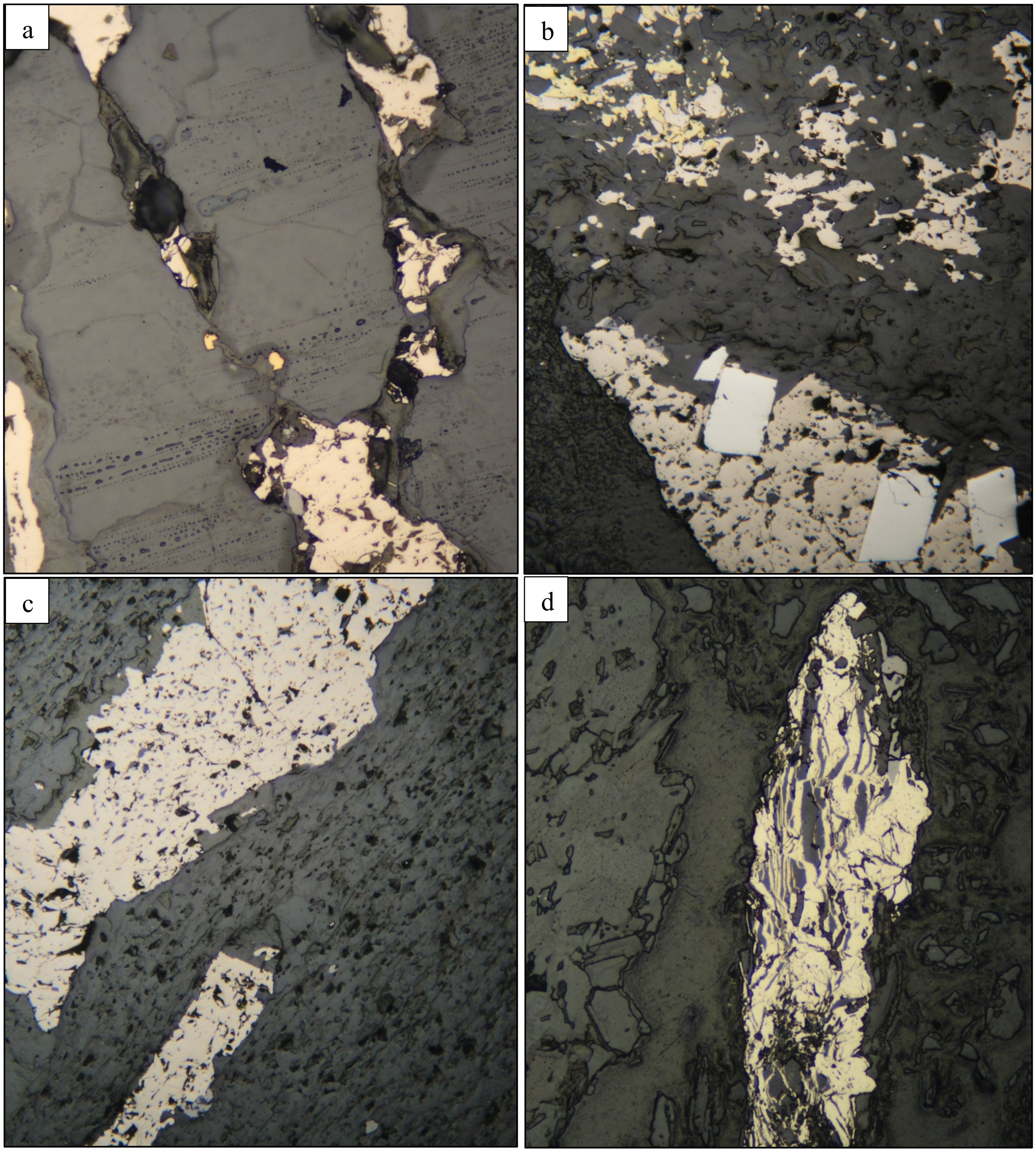


**Figure 4-2: Reflected light photomicrographs from thin sections of FMS humidity cell material. (a) Pyrrhotite (brown) and minor chalcopyrite (yellow) co-precipitated in hydrothermal quartz-chlorite vein; (FOV = 0.5 mm); (b) Hydrothermal vein containing pitted pyrrhotite (brown), exsolved chalcopyrite (yellow), and euhedral arsenopyrite (white prisms); (c) Replacive, elongated pyrrhotite crystals in argillitic matrix; (d) Pyrite precipitate filling microfracture pore space.**

**FOV = 1.1 mm unless otherwise stated.**

Carbonate phases are primarily represented by calcite and were identified in all samples with HC4 containing significant amounts (~10%). Although discrete subhedral grains were observed, the vast majority of carbonate is present as anhedral patches replacing clay and feldspar or as secondary precipitate in hydrothermal veins. With the exception of HC4 where calcite appears to be ubiquitous, in most samples, calcite occurs in association with secondary quartz ± chlorite ± biotite, commonly embedding pyrrhotite or arsenopyrite.

The field bin subsample (LX-18-FB3) was submitted for QEMSCAN analysis (Appendix 4-1) which is a relatively novel technique to gain more detailed mineralogical information in conjunction with XRD analysis. In general, the modal mineralogy for the field bin sample is in agreement with the results from XRD and petrographic analysis conducted on the humidity cell samples. The modal mineralogy indicates that quartz, plagioclase, and sericite/muscovite are the three main minerals in the sample (>20%, by mass; Figure 4-3). Other common minerals (>1%, by mass) include chlorite, biotite, kaolinite, calcite, Ti-oxides, and K-feldspar. Sulphide minerals present in the sample include pyrrhotite (0.69%), pyrite (0.48%), arsenopyrite (0.076%), sphalerite (0.003%), and other sulphides (0.005%). The amount of pyrite detected in the field bin subsample is in contrast with observations from the petrographic investigation where pyrite was a relatively minor sulphide component. Further, no discrete chalcopyrite was identified by via QEMSCAN. Calcite (2.7%) is the dominant carbonate mineral; although, trace amounts of dolomite (0.002%) were identified in this analysis.

QEMSCAN can also be used to determine the degree of exposure of the mineral grains, which provides an indication of how reactive the mineral is expected to be. The analysis indicates that over 60% of the pyrite surfaces show <10% liberation, while pyrrhotite has a slightly greater proportion of somewhat exposed mineral grains (Figure 4-4). Arsenopyrite was also included due to As being identified as a potential parameter of concern. The majority (77%) of the arsenopyrite is locked inside grains. The exposure of the carbonate grains is variable with 36% of mineral grains being >50% exposed. This suggests that the majority of carbonate is available for the neutralization of acid generated by from sulphide oxidation.

The variability in the grain size of the different minerals is summarized in Figure 4-5. This analysis indicates that pyrite is present dominantly as very fine-grained material with 88% of the grains being ≤ +25µm in size. In contrast, the pyrrhotite grains are larger with approximately half of the grains between +150 µm to +300 µm in size and only 6% ≤ +25µm in size. The majority (72%) of arsenopyrite grains are +150 µm to +212 µm. Almost all (99.4%) of the As present in the field bin subsample is contained within the arsenopyrite. The remaining 0.6% of the As is present in gersdorffite. It should be noted that QEMSCAN analysis is not capable of identifying adsorbed fractions of As which, especially in fine-grained sedimentary materials, may contribute a significant portion to the leachable As inventory. Carbonate grain size is variable, although the majority (74%) of the grains are between +53 µm and +150 µm.

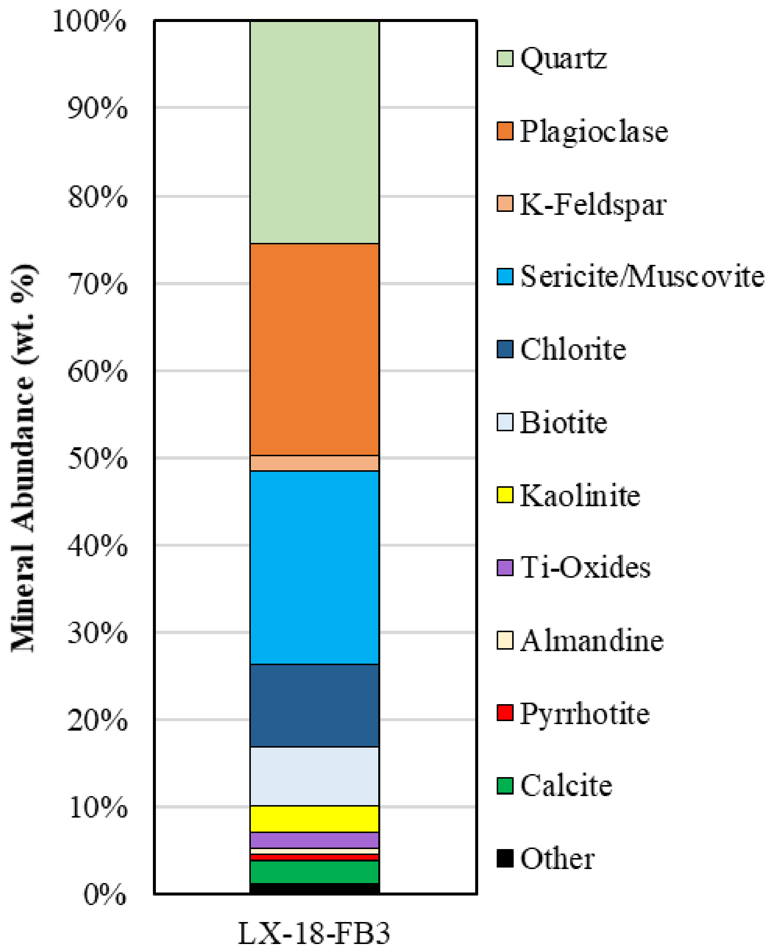


**Figure 4-3: Modal Mineralogy of the FMS Field Bin Sample LX-18-FB3. Note that minerals below 0.5% are combined as 'Other' on this figure.**

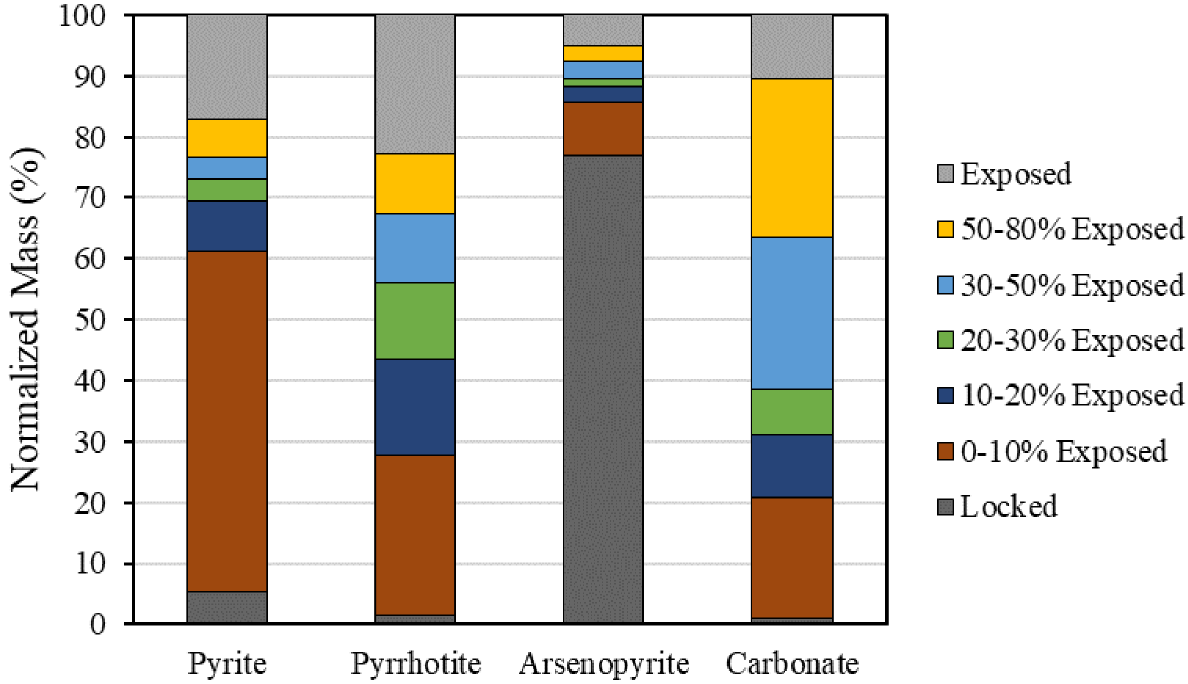


**Figure 4-4: Normalized mass of pyrite, pyrrhotite, arsenopyrite, and carbonate grains for different degrees of grain exposure.**

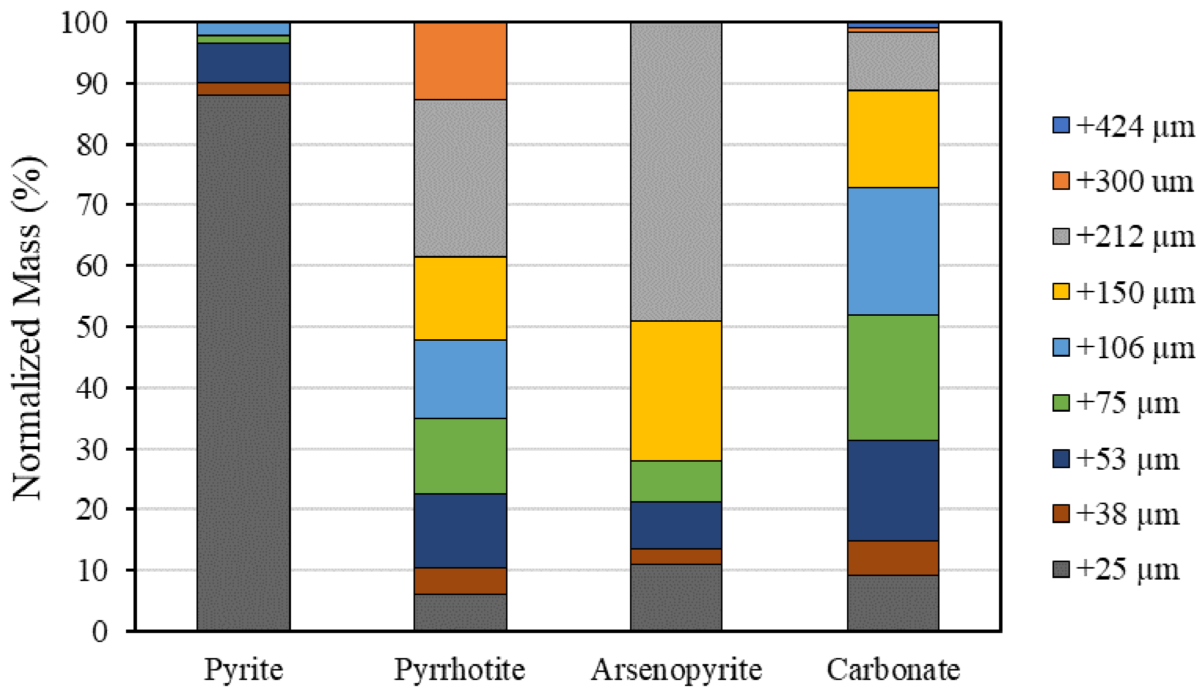


**Figure 4-5: Normalized mass of pyrite, pyrrhotite, arsenopyrite, and carbonate grains for different grain sizes.**

#### *4.1.1.2 Acid Base Accounting*

ARD will only result from the weathering of sulphide-bearing rocks if there is insufficient alkalinity produced to buffer the acidity generated by the sulphide oxidation process. The oxidation of pyrite produces two sources of acid; one from the oxidation of sulphide and the other from the oxidation/hydrolysis of iron. While a variety of mineral dissolution reactions may buffer acid, the minerals most typically responsible for acid neutralization are fast dissolving carbonates such as calcite and dolomite. At a $pH < 6.3$, the pyrite oxidation and carbonate neutralization reaction is typically expressed as:

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

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

The full set of ABA analyses for all mine rock samples is presented in Appendix 4-2 and includes paste pH, total S, sulphate S, sulphide S, acid potential (AP), total inorganic C, total C, modified neutralization potential (NP), and fizz rating. A summary of the mine rock ABA results is provided in Table 4-3, with the humidity cell test subsample results presented in Table 4.4.

##### *4.1.1.2.1 Paste pH*

Paste pH provides an indication of whether a sample is currently generating acidity at the time of sampling. Paste pH values for all samples range from 7.9 to 9.3, indicating that these samples are not currently acid generating. The ore samples show the widest range of pH values, ranging from 7.9 to 9.2, with a median pH value of 8.7 (Table 4-3).

## Table 4-3:
## Summary of Acid-Base Accounting Results for FMS Mine Rock Lithologies

| Sample Type | Paste pH | Total S | Sulphate S | Sulphide S | TIC | CaNP | Modified NP | NPR |
|---|---|---|---|---|---|---|---|---|
| | | % | % | % | % | kg $CaCO_3$/t | kg $CaCO_3$/t | Mod. NP/AP |
| ARGILLITE (AR) n = 26 | | | | | | | | |
| Min | 7.9 | 0.11 | <0.010 | 0.10 | <0.20 | <4.5 | <5.0 | 0.37 |
| Median | 8.5 | 0.36 | <0.010 | 0.35 | 0.30 | 6.8 | 12 | 1.0 |
| Max | 9.0 | 0.90 | 0.030 | 0.88 | 2.9 | 66 | 69 | 6.8 |
| ARGILLITE-GREYWACKE (AG) n = 11 | | | | | | | | |
| Min | 8.1 | 0.050 | <0.010 | 0.040 | <0.20 | <4.5 | 8.0 | 1.0 |
| Median | 8.7 | 0.27 | <0.010 | 0.27 | 0.50 | 11 | 18 | 2.3 |
| Max | 9.1 | 0.47 | 0.030 | 0.46 | 1.1 | 25 | 30 | 14 |
| GREYWACKE-ARGILLITE (GA) n = 14 | | | | | | | | |
| Min | 8.2 | 0.020 | <0.010 | 0.020 | <0.20 | <4.5 | 8.0 | 0.78 |
| Median | 8.9 | 0.28 | <0.010 | 0.27 | 0.80 | 18 | 23 | 2.4 |
| Max | 9.1 | 0.55 | 0.020 | 0.53 | 1.9 | 43 | 47 | 43 |
| GREYWACKE (GW) n = 24 | | | | | | | | |
| Min | 8.3 | 0.040 | <0.010 | 0.030 | <0.20 | <4.5 | 10 | 0.83 |
| Median | 8.9 | 0.19 | <0.010 | 0.18 | 1.1 | 25 | 31 | 5.0 |
| Max | 9.3 | 0.56 | 0.020 | 0.54 | 5.4 | 123 | 128 | 27 |
| ORE n = 23 | | | | | | | | |
| Min | 7.9 | 0.12 | <0.010 | 0.12 | <0.20 | <4.5 | 6.0 | 0.37 |
| Median | 8.6 | 0.44 | <0.010 | 0.42 | 0.60 | 14 | 16 | 1.1 |
| Max | 9.2 | 1.1 | 0.030 | 1.0 | 2.6 | 59 | 61 | 6.9 |

**Notes**: n = number of samples used in statistical distribution.
Values below detection limit were set at the detection limit for calculation of NP, AP, and NPR values.
Sulphate S is calculated using the HCl method.
AP (acid potential) calculated using sulphide S (% non-sulphate S x 31.25).
CaNP (carbonate neutralization potential) calculated using total inorganic carbon (% TIC x (100.09/44.01) x 10).
Modified NP is obtained by the modified Sobek method.
NPR = neutralization potential ratio; calculated as Modified NP / AP.

**Table 4.4:**
**Summary of acid-base accounting results for kinetic test subsamples**

| Sample ID | Paste pH | Total S | Sulphate S | Sulphide S | Total C | CaNP | Modified NP | NPR |
|---|---|---|---|---|---|---|---|---|
| | | % | % | % | % | kg $CaCO_3$/t | kg $CaCO_3$/t | Mod. NP/AP |
| ***Humidity Cells*** | | | | | | | | |
| ARGILLITE-GREYWACKE (AG) | | | | | | | | |
| HC1 | 8.5 | 0.35 | <0.010 | 0.35 | <0.20 | <4.5 | 9.0 | 1.0 |
| ARGILLITE (AR) | | | | | | | | |
| HC2 | 8.1 | 0.59 | 0.020 | 0.57 | 0.25 | 5.7 | 9.0 | 0.63 |
| GREYWACKE-ARGILLITE (GA) | | | | | | | | |
| HC3 | 8.9 | 0.51 | 0.020 | 0.49 | 0.50 | 11 | 16 | 1.1 |
| GREYWACKE (GW) | | | | | | | | |
| HC4 | 8.6 | 0.23 | <0.010 | 0.22 | 3.9 | 88 | 91 | 14 |
| ORE | | | | | | | | |
| HC5 | 8.4 | 0.59 | 0.020 | 0.57 | 0.55 | 13 | 18 | 1.0 |
| ***Field Bin*** | | | | | | | | |
| LX-18-FB3 | 8.1 | 0.40 | <0.010 | 0.39 | 0.25 | 19 | 27 | 2.2 |

**Notes:** Humidity cell are made up of two samples. An average value is presented and a 1:1 mixture is assumed.
Values in grey italics are at or below the analytical detection limit. Values were set at the detection limit for calculation of NP, AP, and NPR values.
Sulphate S is calculated using the HCl method.
AP (acid potential) calculated using sulphide S (% non-sulphate S x 31.25).
CaNP (carbonate neutralization potential) calculated using total inorganic carbon (% TIC x (100.09/44.01) x 10).
Modified NP is obtained by the modified Sobek method.
NPR = neutralization potential ratio; calculated as Modified NP / AP.

*4.1.1.2.2 Sulphur Species and Acid Potential*

The total sulphur (S) contents of the FMS samples vary from 0.040% to 0.90%, excluding the ore samples (Table 4-3). Of the four main waste rock types, the AR samples have the highest median total S content (0.36%) and the GW samples have the lowest (0.19%). Overall, the ore samples have slightly higher total S contents, varying from 0.12% to 1.1% (median: 0.44%). The sulphate S contents are generally low in most samples and typically fall at or below the detection limit (0.01%) but can reach up to 0.030%. Sulphide S contents are strongly correlated with total S (Figure 4-6) and indicate that most of the sulphur present in samples is in the form of sulphide. The sulphide S contents, excluding the ore samples, range from 0.020% in a GA sample up to a maximum of 0.88% in an AR sample, with median values falling between 0.18% (GW samples) and 0.35% (AR samples). In the ore samples, the sulphide S contents range from 0.12% to 1.0% (median: 0.42%).

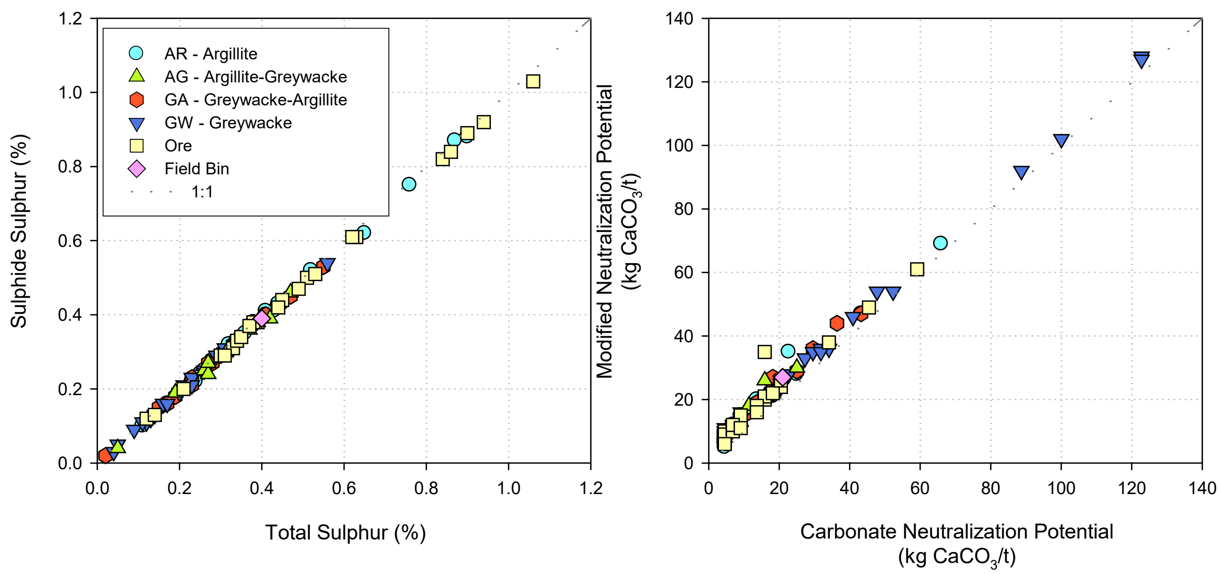


**Figure 4-6: Plots showing sulphide sulphur *versus* total sulphur and modified neutralization potential *versus* carbonate neutralization potential for the FMS mine rock samples.**

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

In general, the humidity cell test subsamples are considered to be representative of median to high S contents for the different lithologies and are therefore conservative. Total sulphur contents are generally slightly (HC1, HC4, HC5) to considerably (HC2, HC3) higher than the respective static test populations. The total S values for the latter humidity cells are 0.59%, 0.51% for HC2 and HC3, respectively, while the median values for each of the corresponding static test datasets are 0.36% and 0.28%, respectively. The field bin subsample has total sulphur values (0.4%, Table 4.4) that is higher than median content of any waste rock lithology and can therefore also be considered conservative.

*4.1.1.2.3 Neutralization Potential*

The total inorganic carbon (TIC) content of the FMS samples ranges from detection level values (<0.20%) up to 5.4%, with the highest median values measured in the GW samples (1.1%; Table 4-3). It is assumed that the inorganic C is present as carbonate minerals and thus TIC values are used to calculate the carbonate neutralization potential (CaNP). The resulting CaNP values of the FMS samples range from detection level values (<5.0 kg $CaCO_3$/t) up to 123 kg $CaCO_3$/t. The GW samples have the highest median CaNP value at 25 kg $CaCO_3$/t, while the AR samples have the lowest median CaNP value (6.8 kg $CaCO_3$/t; Table 4-3). The ore samples have median CaNP values within this range (14 kg $CaCO_3$/t).

The modified NP values are generally consistent with the calculated CaNP values, albeit systematically slightly higher (Figure 4-6, Table 4-3). This suggests that minerals other than carbonates (*i.e.,* silicates) are responsible for acid-neutralization in the modified NP tests. This NP is not as readily available as the CaNP; however, when sulphide values are low, as is the case at FMS, the NP from the dissolution of non-carbonate minerals will contribute to the neutralization of the low rates of acid production. Silicate minerals that act as neutralizing agents may include biotite, chlorite, and certain clay minerals, all of which were identified in the mineralogical analysis. For the remainder of this assessment, modified NP is used as the basis for NPR (NP/AP) calculations in order to quantify a material's ARD potential.

The NP values of the humidity cells are generally close to the median values for the lithologies that they represent, except for HC4 (GW) which has higher NP relative to the median for the GW static test samples. The modified NP for HC4 is 91 kg $CaCO_3$/t, while the median modified NP for the GW population was calculated to be 31 kg $CaCO_3$/t (Table 4.4). The NP of the field bin sample (27 kg $CaCO_3$/t) is within the range of median values observed for the different static test lithologies.

*4.1.1.2.4 Neutralization potential ratio*

The neutralization potential ratio (NPR) is calculated as the ratio of NP to AP and is presented based on the modified NP (Table 4-3). In the absence of long-term kinetic test data, the NPR value is the most important parameter in the evaluation of a material's likelihood to generate ARD. Adopting guidelines set out in Price (2009), a value >2 is considered to be NAG, whereas a value <2 is considered to be PAG. Figure 4-7 plots the NPR versus total sulphur and modified NP showing weak negative and positive correlations, respectively. These plots suggest that neither modified NP nor total sulphur alone can be used as a reliable proxy NPR and geochemical class.

The PAG and NAG proportions for each of the four major waste rock lithologies and ore samples are given in Table 4-5. There is a marked positive relationship with respect to the proportion of argillite within the lithological unit and the PAG% where the AR unit has the highest relative amount of PAG samples (81%) while the GW unit hosts the lowest (4%). It is important to note that the PAG% presented above assumes equal weighting of each of the static test samples in relation to the overall database. This method of calculation does not take into account the spatial distribution of the samples and is prone to bias where there is spatial clustering of the data. For the purpose of geochemical source term modelling, which requires more spatially representative PAG waste rock tonnages, the NPR values will be integrated into a 3D geological modelling software (Leapfrog$^{TM}$) to produce an interpolated grade shell at the NPR=2 cutoff. The results and implications of this modelling exercise are presented in Lorax (2019).

All humidity cells are PAG, except for the HC4 (GW) which was classified as NAG. The field bin subsample is NAG with an NPR value of 2.2 (Table 4.4).

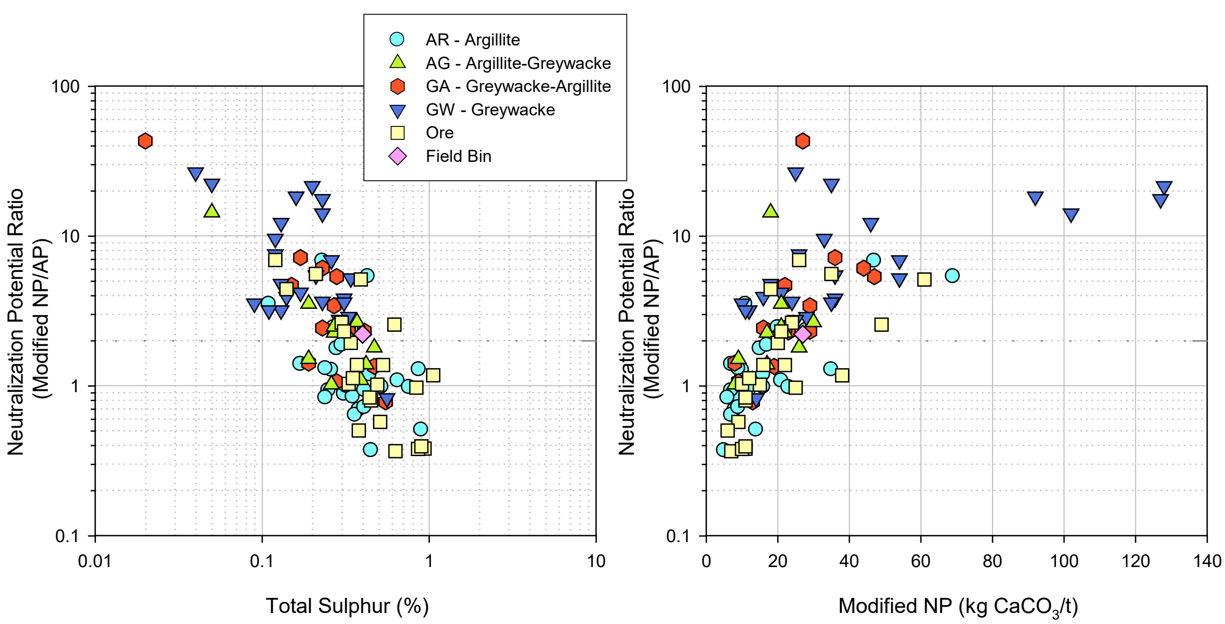


**Figure 4-7: Plots showing neutralization potential ratio (NPR) versus total S and modified NP for the FMS mine rock samples.**

**Table 4-5:
PAG and NAG Proportions of the FMS Mine Rock Units**

| Unit | % PAG | % NAG |
|---|---|---|
| Argillite (AR) | 81% | 19% |
| Argillite-Greywacke (AG) | 45% | 55% |
| Greywacke-Argillite (GA) | 29% | 71% |
| Greywacke (GW) | 4% | 96% |
| Ore | 70% | 30% |
| ***Total (waste rock only)*** | *53%* | 47% |

**Notes:** PAG – Potentially Acid Generating; NAG – Non-Acid Generating. Values are based on equal weighting of static test samples and do not represent volumetric proportions required for source term development.

### *4.1.1.3 Total Solid Phase Elemental Analysis Results*

The results of the total solid phase elemental analysis are presented in Appendix 4-3 and summarized in Table 4.6. Elements that are greater than 3x their respective AUCCA values (Rudnick and Gao, 2014) include Ag, As, Cu, Pb, Sb, and Zn. Solid phase concentrations of Ag, As, Pb, and Sb are enriched by a factor greater than 10 above the AUCCA in one or more samples. It is noteworthy that the elevated As concentrations (>10x AUCCA) occur in all FMS lithologies, while elevated levels of the other elements are limited to the ore samples. Several of the elements have AUCCA that are considerably lower than the analytical detection limit. These include Ag, Bi, Cd, Hg, Sb, Tl, U, and W. Only values that are above 2x the detection limit are considered in Table 4.6 .

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

A summary of the kinetic test samples' total solid phase elemental results is included in Table 4.7. The concentrations of As in humidity cell subsamples are presented as compared to the range for each of the major rock types (Figure 4-8). The As concentrations for HC1 (AG), HC3 (GA), and HC4 (GW) are within the 25$^{th}$ to 75$^{th}$ percentile values for the static test dataset for these units. Arsenic contents are high in HC2 (AR) and HC5 (ore) relative to the respective static test datasets. The As concentration is 1,700 ppm for HC2 and 1,609 ppm for HC5, while the median values are 50 ppm for the AR samples and 178 ppm for the ore samples (Table 4.6). The As content in the field bin subsample (386 ppm) is within the range of the values in the drill core static testing dataset.

**Table 4.6:**
**Summary of solid phase element results for FMS mine rock samples**

| Sample Type | Ag | As | Cu | Pb | Sb | Zn |
|---|---|---|---|---|---|---|
| | ppm | ppm | ppm | ppm | ppm | ppm |
| ARGILLITE (AR) n = 17 | | | | | | |
| Min | <0.20 | 2.0 | 24 | 2.0 | <2.0 | 61 |
| Median | <0.20 | 50 | 44 | 8.0 | <2.0 | 101 |
| Max | 0.20 | 8430 | 73 | 30 | 3.0 | 117 |
| ARGILLITE-GREYWACKE (AG) n = 4 | | | | | | |
| Min | <0.20 | 21 | 25 | 2.0 | <2.0 | 93 |
| Median | <0.20 | 189 | 31 | 8.5 | <2.0 | 101 |
| Max | <0.20 | 1560 | 36 | 28 | <2.0 | 114 |
| GREYWACKE-ARGILLITE (GA) n = 6 | | | | | | |
| Min | <0.20 | 41 | 13 | 8.0 | <2.0 | 74 |
| Median | <0.20 | 412 | 32 | 9.0 | <2.0 | 81 |
| Max | 0.30 | 3850 | 45 | 18 | 2.0 | 87 |
| GREYWACKE (GW) n = 8 | | | | | | |
| Min | <0.20 | 16 | 14 | 3.0 | <2.0 | 27 |
| Median | <0.20 | 66 | 23 | 7.5 | <2.0 | 56 |
| Max | <0.20 | 1070 | 34 | 10 | 3.0 | 84 |
| ORE n = 25 | | | | | | |
| Min | <0.20 | 14 | 11 | 3.0 | <2.0 | 39 |
| Median | <0.20 | 178 | 36 | 10 | <2.0 | 87 |
| Max | 0.60 | 5850 | 101 | 218 | 5.0 | 293 |
| AUCCA | 0.053 | 4.8 | 28 | 17 | 0.4 | 67 |

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

**Table 4.7:**
**Summary of solid phase element results for kinetic test subsamples**

| Sample ID | Ag | As | Cu | Pb | Sb | Zn |
|---|---|---|---|---|---|---|
| | ppm | ppm | ppm | ppm | ppm | ppm |
| *Humidity Cells* | | | | | | |
| ARGILLITE-GREYWACKE (AG) | | | | | | |
| HC1 | <0.20 | 59 | 47 | 10 | <2.0 | 84 |
| ARGILLITE (AR) | | | | | | |
| HC2 | 0.20 | 1700 | 49 | 12 | <2.0 | 92 |
| GREYWACKE-ARGILLITE (GA) | | | | | | |
| HC3 | <0.20 | 1785 | 35 | 9.0 | <2.0 | 80 |
| GREYWACKE (GW) | | | | | | |
| HC4 | <0.20 | 111 | 29 | 8.0 | <2.0 | 47 |
| ORE | | | | | | |
| HC5 | <0.20 | 1609 | 47 | 9.0 | <2.0 | 92 |
| *Field Bin* | | | | | | |
| LX-18-FB3 | 0.50 | 386 | 36 | 16 | <2.0 | 85 |
| AUCCA | 0.053 | 4.8 | 28 | 17 | 0.4 | 67 |

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

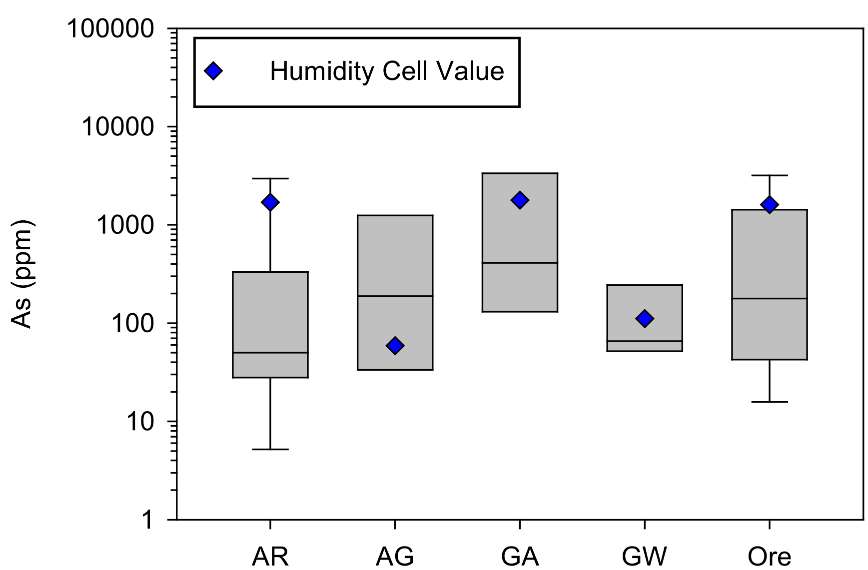


**Figure 4-8: Box plots showing the range of As concentrations as compared to the humidity cell subsamples. Box limits represent 25th and 75th percentile levels, the horizontal bar represents the median level, and the whiskers represent the 10th and 90th percentile values.**

#### *4.1.1.4 Shake Flask Extraction and Leaching Test Results*

The humidity cell subsamples were submitted for the standard shake flask extraction (SFE) test at a 3:1 water/solid ratio, while the field bin subsample was submitted for three leaching tests at different water solid ratios (Table 4.8). The full SFE and leaching test results are provided in Appendix 4-4. The shake flask extraction (SFE) and other leaching test results are compared to the Canadian Council for Ministers of the Environment (CCME) water quality guidelines for the protection of aquatic life (CCME, 2018). These guidelines are used for reference only in order to provide an indication of parameters which are of potential concern in runoff from the excavated material. Different water quality standards may apply at different water monitoring stations within and downstream of the FMS site. It should be noted that, as per the test method protocol, the agitation of the overburden samples in water may release higher concentrations of certain species than what would be expected in contact water drainage.

Parameters that were elevated relative to the CCME guidelines in the leachate from the samples include As in all samples, Al in all samples except for HC4 (GW) and HC5 (ore) subsamples and F in only the 0.5:1 leaching test for the field bin sample. The As concentrations are above 10 times the guideline in the leachate from the HC3 (GA) and HC4 (GW) SFE tests as well as the field bin samples for the 1:1 and 0.5:1 water/solid leaching tests (Table 4.8). The As concentration in the leachate is not directly correlated to the solid phase As content. While HC3 (GA) does have both the highest concentration of As in the solid phase (1,785 ppm) and in the leachate (0.29 mg/L), HC2 (AR) has comparable As in the solid phase (1,700 ppm) and an order of magnitude lower As concentrations in the leachate (0.031 mg/L). In contrast, HC4 (GW) has lower solid phase As content (111 ppm) and relatively high As concentrations in the leachate (0.16 mg/L). The variability of As concentrations in the leachate is not due to differences in pH as the leachate for all samples remained circumneutral (pH range: 7.9 to 8.2). This suggests that the As mobility is more strongly tied to factors other than the solid-phase content, such as time of exposure, mineralogical association and grain liberation.

The leaching tests conducted at different water/solid ratios are intended to identify trends elemental mobility trends under changing environmental conditions. Theoretically, if the dissolved species behaved conservatively and no attenuation or mineral solubility constraints were in effect, a 6-fold increase in concentrations, proportional to the decrease in solid/rock ratio, would be expected. Chloride is commonly used as a conservative tracer and shows an increase by a factor of 6.4 between the 3:1 and 0.5:1 tests.

**Table 4.8:**
**Summary of SFE and Leaching Test Results for FMS Kinetic Test Samples**

| Parameter | Units | CCME WQG | | HC 1 | HC 2 | HC 3 | HC 4 | HC 5 | LX-18-FB3 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Short Term | Long Term | | | | | | 3:1 | 1:1 | 0.5:1 |
| pH | | 6.5-9 | - | 7.87 | 7.94 | 8.11 | 7.99 | 7.97 | 8.16 | 8.02 | 7.98 |
| Conductivity | µS/cm | - | - | 129 | 134 | 78 | 114 | 154 | 96 | 176 | 301 |
| Chloride | mg/L | 640 | 120 | 12 | 14 | 3 | 12 | 8 | 5 | 17 | 32 |
| Fluoride | mg/L | - | 0.12 | 0.060 | 0.090 | < 0.060 | < 0.060 | 0.070 | < 0.060 | 0.12 | 0.21 |
| Sulphate | mg/L | - | - | 9.0 | 9.0 | 5.0 | 3.0 | 23 | 7.0 | 17 | 32 |
| **Dissolved Metals** | | | | | | | | | | | |
| Ag | mg/L | - | 0.00025 | < 0.00005 | < 0.00005 | < 0.00005 | < 0.00005 | < 0.00005 | < 0.00005 | < 0.00005 | < 0.00005 |
| Al[a] | mg/L | - | 0.1 | 0.13 | 0.14 | 0.21 | 0.099 | 0.090 | 0.46 | 0.32 | 0.16 |
| As | mg/L | - | 0.005 | 0.0089 | 0.031 | 0.29 | 0.16 | 0.023 | 0.044 | 0.059 | 0.084 |
| B | mg/L | 29 | 1.5 | 0.0090 | 0.0090 | 0.011 | 0.022 | 0.0090 | 0.011 | 0.014 | 0.028 |
| Cd | mg/L | 0.001 | 0.00009 | < 0.000003 | < 0.000003 | < 0.000003 | 0.000003 | 0.000003 | < 0.000003 | < 0.000003 | 0.000005 |
| Co | mg/L | - | - | 0.000073 | 0.000011 | 0.000011 | 0.000025 | 0.000054 | 0.000021 | 0.000063 | 0.00019 |
| Cr | mg/L | - | 0.001 | 0.00012 | 0.000080 | 0.00021 | 0.00016 | 0.00010 | 0.000060 | 0.000070 | 0.00015 |
| Cu[b] | mg/L | - | 0.002 | 0.00014 | 0.00015 | 0.00024 | 0.000040 | 0.00016 | 0.00023 | 0.00032 | 0.0012 |
| Fe | mg/L | - | 0.3 | < 0.0070 | 0.0070 | 0.012 | < 0.0070 | < 0.0070 | < 0.0070 | < 0.0070 | < 0.0070 |
| Hg | µg/L | | 0.026 | < 0.010 | < 0.010 | < 0.010 | < 0.010 | < 0.010 | < 0.010 | < 0.010 | < 0.010 |
| Mn | mg/L | - | - | 0.024 | 0.013 | 0.011 | 0.037 | 0.044 | 0.020 | 0.021 | 0.045 |
| Mo | mg/L | - | 0.073 | 0.00017 | 0.00040 | 0.00015 | 0.00012 | 0.00010 | 0.00015 | 0.00060 | 0.0017 |
| Ni[b] | mg/L | - | 0.025 | 0.0015 | 0.00040 | 0.00060 | 0.0025 | 0.0011 | 0.00040 | 0.0012 | 0.0031 |
| Pb[b] | mg/L | - | 0.001 | 0.000010 | 0.000020 | 0.000020 | < 0.000010 | < 0.000010 | < 0.000010 | 0.000030 | 0.000030 |
| Sb | mg/L | - | - | 0.00030 | 0.00040 | 0.00070 | 0.00030 | 0.00030 | < 0.00020 | 0.00060 | 0.0011 |
| Se | mg/L | - | 0.001 | 0.000050 | 0.000070 | < 0.000040 | < 0.000040 | 0.000070 | 0.000060 | 0.00012 | 0.00019 |
| Tl | mg/L | - | 0.0008 | 0.000013 | 0.0000070 | < 0.000005 | 0.0000070 | 0.0000070 | 0.0000060 | 0.000011 | 0.000018 |
| U | mg/L | 0.033 | 0.015 | 0.000042 | 0.000040 | 0.000055 | 0.000076 | 0.00012 | 0.000096 | 0.00028 | 0.00089 |
| Zn | mg/L | 0.037 | 0.007 | < 0.0020 | < 0.0020 | < 0.0020 | < 0.0020 | < 0.0020 | < 0.0020 | < 0.0020 | < 0.0020 |

**Notes:** Values shaded in light grey are above the long-term CCME guideline; values shaded in dark grey are above 10x the CCME guideline; no values are above the short-term CCME guidelines.
[a]Aluminum guideline is based on pH > 6.5.
[b]Hardness dependent guidelines are based on a hardness of 10 mg/L.
CCME – Canadian Council for Ministers of the Environment; WQG – Water quality guideline for the protection of aquatic life.

Of the parameters identified as potential parameters of concern, Cu and Sb show the greatest increase between the 3:1 and 0.5:1 tests, by a factor of 5.2 and 5.5, respectively. Cu concentrations increase from 0.00023 mg/L to 0.0012 mg/L, while Sb concentrations increase from <0.0002 mg/L to 0.0011 mg/L. The relative increase in these parameters indicates that these elements are reasonably conservative. In contrast, As increases in concentration by a factor of less than 2 from 0.044 to 0.084 mg/L suggesting that attenuation mechanisms may occur at relatively high water/solid ratios. Interestingly, Al dissolved concentrations decrease significantly with decreasing water/solid ratios (Table 4.8). These test results will be further investigated in the context of field bin leachate data, once available and considered in the derivation of geochemical source terms where applicable.

#### *4.1.1.5 Particle Size Distribution Results*

The particle size distribution results for the humidity cell subsamples are presented in Appendix 4-5 and summarized in Figure 4-9. All humidity cell subsamples were crushed to $P_{80}$ < 6.4 mm, in line with the standard particle size for humidity cells (Price, 2009). The PSD results show that the humidity cell subsamples have a similar particle size distribution, although HC4 (GW) has a relatively lower proportion of fines as compared to other humidity cell samples. This is consistent with site observations were argillite-rich material is generally found to be more friable than the greywacke unit.

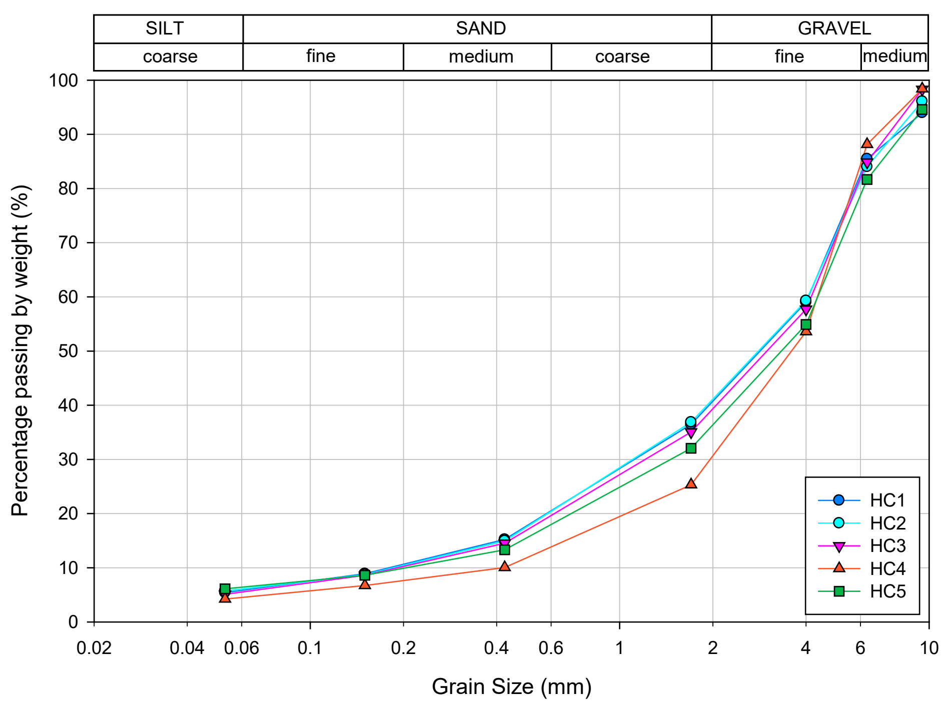


**Figure 4-9: FMS Humidity Cell Particle Size Distribution.**

### 4.1.2 Kinetic Test Results

#### *4.1.2.1 Humidity Cells*

Laboratory kinetic test procedures are designed to quantify weathering rates under standardized conditions. During the initial cycles of laboratory kinetic testing, sulphate and metals often have highly variable release rates before stabilizing at a relatively constant rate (Sapsford *et al.,* 2009). This variability is a response to exposure of fresh surfaces of crushed material and the dissolution of stored oxidation products that may have accumulated in the samples during storage prior to being placed in a humidity cell. Once exposed mineral surfaces have equilibrated to this environment, stable reaction rates can be determined. Humidity cells often require many weeks to approach geochemical stability, and reaction rates rarely remain constant on a week-to-week basis. It should be noted that aqueous concentrations in the weekly/biweekly rinse water should not be considered as direct predictions of on-site drainage chemistry due to the high water/solid ratio used in this type of testing (Sapsford *et al.,* 2009). In reality, conditions within large-scale mine rock storage facilities are much different with lower water/rock ratios, incomplete flushing of particle surfaces, and secondary minerals frequently reaching saturation and precipitating out of solution. Humidity cell leaching rates are however used in the derivation of geochemical source terms for various FMS site facilities as described in Lorax (2019).

The humidity cell program for the FMS mine rocks consists of five humidity cells covering the four main lithologies (AR, AG, GA, and GW) as well as one ore sample. Sample descriptions are provided in Table 3-2 and experimental methods are described in Section 3.2.3. Static characterization testwork, including mineral identification, ABA, solid phase element determination, and PSD were completed on subsamples of each of the humidity cells (presented in Section 4.1.1). Results of the static testwork show that the subsamples are considered to be representative or conservative with respect to the corresponding lithologies. Humidity cell tests were initiated in August 2018 and, at the time of reporting, had been operated for almost 40 weeks. This represents the full extent of the humidity cell experimental runtime for some samples (HC3, HC4, HC5), while HC1 (AG) and HC2 (AR) are ongoing past the 40 week mark (currently at 50 weeks), since these cells are the most likely candidates to turn acidic and provide loading rates for long-term, low-pH conditions draining off PAG waste rock.

The full set of leachate results are presented in Appendix 4-6 and summarized in the sections below.

#### *4.1.2.1.1 pH and Sulphate Loading*

The leachate from all humidity cells remained circum-neutral for the duration of the current test period. All pH values are between 6.5 and 8.1 (Figure 4-10). The lowest pH values were produced in the later experimental cycles of HC1 and HC2 consistently dropping below 7.5. the two greywacke-dominated waste rock samples (HC3 and HC4) show pH values above pH 7.5 throughout most of the experimental duration. Trends observed for pH are also reflected by the alkalinity produced by the individual cells with HC1 and HC2 showing continuously decreasing alkalinity values below 10 mg $CaCO_3$/L. As mentioned previously, the goal of the continued operation of these cells is the production of acidic leachates once all NP is depleted.

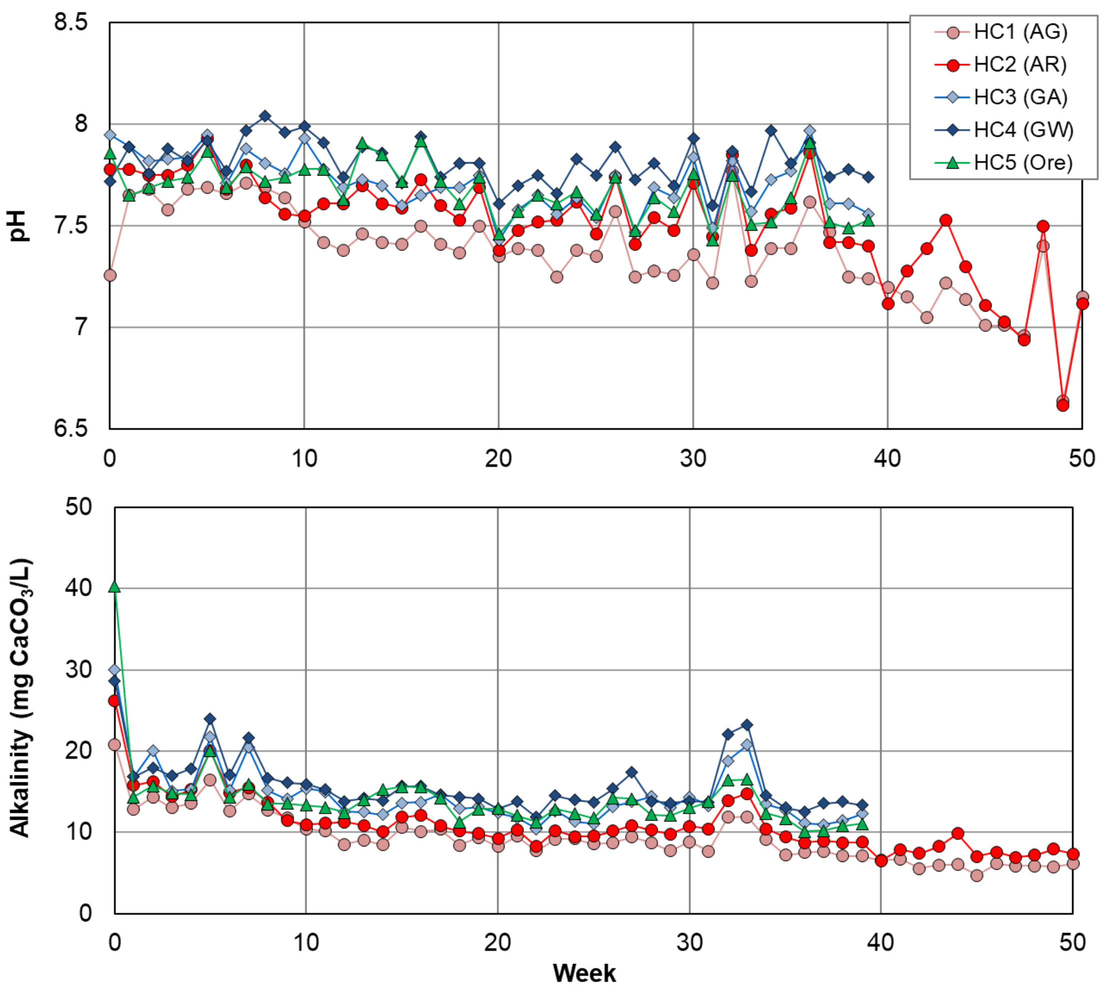


**Figure 4-10: pH and alkalinity in leachates from FMS humidity cells**

Concentrations measured from humidity cells are susceptible to changes in the volume of water added and collected at the end of each cycle, and hence, concentration data do not provide a strictly quantitative estimate of drainage chemistry. To provide a more functional parameter which can be used to compare results between different humidity cells, sulphate and metal concentrations in the leachate are normalized to the mass of sample in the humidity cell and the volume of leachate collected each week, producing weekly mass loadings (mg solute/kg sample/wk).

Elevated sulphate loading rates are expected in the first few weeks of the test due to dissolution and flushing of readily soluble surface oxidation products (*e.g.,* secondary sulphates). HC5 (ore) has the highest sulphate loading rates in week 0, while the waste rock humidity cells show initial peak sulphate concentrations in week 1 or 2 of the early sampling cycles (Figure 4-11). An interesting trend is evident for all humidity cells: following an early drop in sulphate loading rates after the initial flush, values increase again after week 6 and show somewhat more stable or slightly decreasing values after week 20 of the tests. This signature is inferred to be a result of increasing sulphide oxidation rates after oxidation products have been rinsed from the sulphide surfaces.

Stable sulphate leaching rates are highest in the ore sample (HC5) which releases between 12 and 17 mg/kg/wk after week 20. HC1 (AG) releases the highest sulphate loads of the waste humidity cells with a slightly decreasing trend from 15 mg/kg/wk in week 20 to around 10 mg/kg/wk in more recent sampling cycles. All other waste rock cells release between 5 and 10 mg/kg/wk after week 20. HC 2 (AR) shows a sharp increase in sulphate loads in the most recent sampling cycle (Figure 4-11) which may be explained by the corresponding drop in pH during this time period. Overall, there is no good correlation between the sulphate load and sulphide S (Figure 4-12) showing that for the tested materials sulphide content is not a reliable predictor of sulphate release rates.

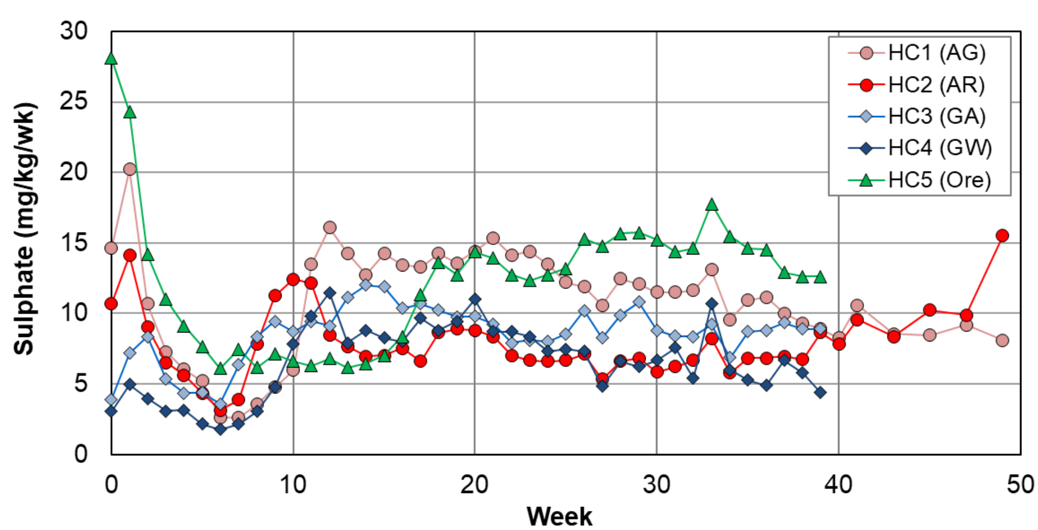


**Figure 4-11: Sulphate loading rates in FMS humidity cell leachates**

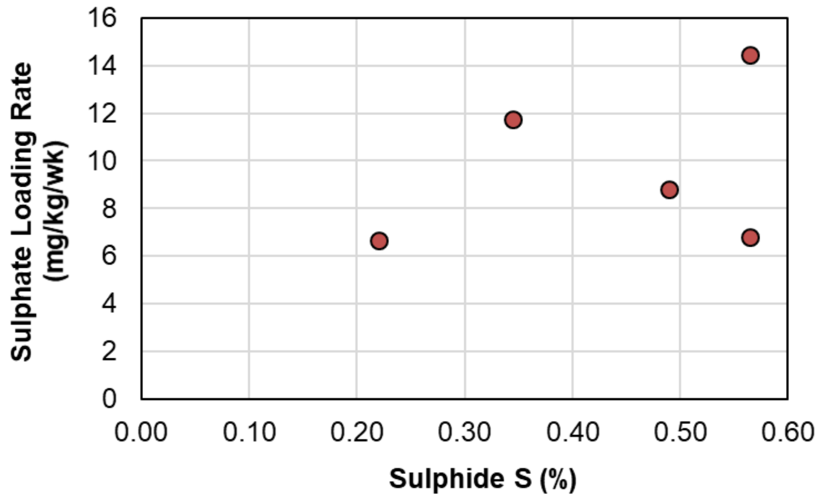


**Figure 4-12: Median sulphate loading rate (cycles 20-40) *versus* sulphide S.**

*4.1.2.1.2 Carbonate Molar Ratio*

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

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

In the most simplistic scenario for pyrite oxidation, when carbonate minerals are present, the oxidation-neutralization reaction is pH-dependent. Assuming no Ca and $SO_4$ are lost to gypsum precipitation, two carbonate consumption reactions can describe the process, including:

at pH < 6.3:

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

at 6.3<pH<10.3:

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

Neutralization of acidity up to pH levels of 6.3 produce one mole of Ca (+ Mg) for each mole of $SO_4$ released, producing a CMR = 1.0. At pH levels above 6.3, $H_2CO_3$ is not the dominant form of inorganic carbon in an aqueous solution and the bicarbonate ion ($HCO_3^-$) is by far the most abundant. Thus, at near-neutral pH levels, calcium carbonate is less efficient at neutralizing acidity and twice as much carbonate is required to produce a balanced solution. Under these conditions, 4 moles of Ca (+ Mg) are theoretically released relative to 2 moles of $SO_4$ producing a CMR = 2.0. The relationships derived from these chemical equations assume that pyrite oxidation is the sole source of sulphur and iron in the product that take the form of sulphate and iron hydroxide, respectively. Thus, the oxidation of other sulphide minerals, dissolution of soluble sulphate minerals, the formation of other secondary products, or dissolution of carbonates by dilute waters in the absence of significant sulphide oxidation may alter this relationship (Mattson, 2005). If it is assumed that $Fe(OH)_3$ is produced as a product of pyrrhotite oxidation, the moles of acidity released during this reaction are identical to that of pyrite oxidation (Nicholson, 1994).

By week 11, the CMR for all the humidity cells had decreased to values between 1 and 2 with HC4 periodically producing values above 2 in the later experimental stages (Figure 4-13). This is likely due to more carbonate being dissolved than needed to neutralize acidity generated from sulphide oxidation in this sample. For all other samples, the long-term CMR values suggest carbonate dissolution in response to sulphide oxidation.

The CMR can be used to calculate the CaNP depletion rate which can in turn be used to calculate the amount of time required to consume all available CaNP from the humidity cell samples. It can be assumed that bulk silicate NP will be available to buffer acidity beyond the depletion of carbonate, however for this high-level assessment carbonate depletion was conservatively chosen as the point marking the onset of acidic drainage. In reality, other factors such as water-rock contact and grain liberation are expected to play an important role with respect to ARD timing. For this exercise, the CaNP depletion rate was calculated as follows:

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

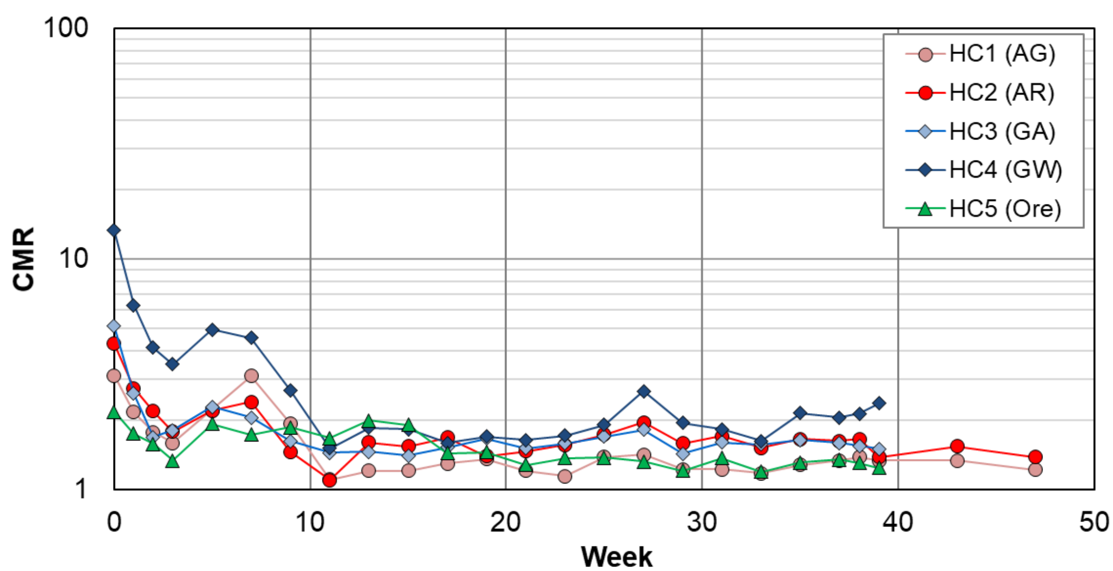


**Figure 4-13: CMR values for FMS humidity cell leachate**

Note that for the purposes of calculating NP depletion rates and the time for complete depletion of NP, the initial sulphate production rates, which reflect the flushing of non-acid generating surface oxidation products such as gypsum, were not considered. Rather the relatively stable CaNP depletion rates in later cycles of the tests more appropriately reflect depletion based on sulphate produced by sulphide oxidation. This prevents overestimating carbonate depletion rates and thereby underestimating the lag time to the onset of acidic conditions.

No correlation was found of NP depletion rate and solid-phase sulphide or modified NP content. Therefore, the average NP depletion rate was calculated independently of these parameters for the last five available cycles from all humidity cells with CMR data (cycles 33-39) yielding a value of 0.014 kg $CaCO_3$/t/wk. Applying this HC-specific rate to the PAG humidity cell NP values, model results suggest that carbonate depletion times will range from 6 (HC1) to 15 (HC3) years for these cells.

The same CaNP depletion rate was also applied to the range of NP measured in the PAG waste rock samples within the FMS static test population to quantify a range of lag times that can be expected until acidic drainage is released. The result of this exercise is shown in Figure 4-14 and illustrates that it will take approximately 10 years for 50% of all PAG samples to turn acidic. Importantly, up to 40% of all PAG samples are expected to produce acidic contact water within 6 years. The 6-year mark corresponds with the detection limit for CaNP (4.5 kg $CaCO_3$/t) which implies that acidic conditions may develop earlier in these samples. Overall however, these values are conservative as they do not consider the reduced sulphide oxidation rate at colder temperatures or the slowing of oxidation rates due to coating of sulphide minerals over time. A temperature-correction factor of 0.3 has been proposed to estimate the sulphate leaching rate around 10°C versus 22°C (Dockrey and Mattson, 2016).

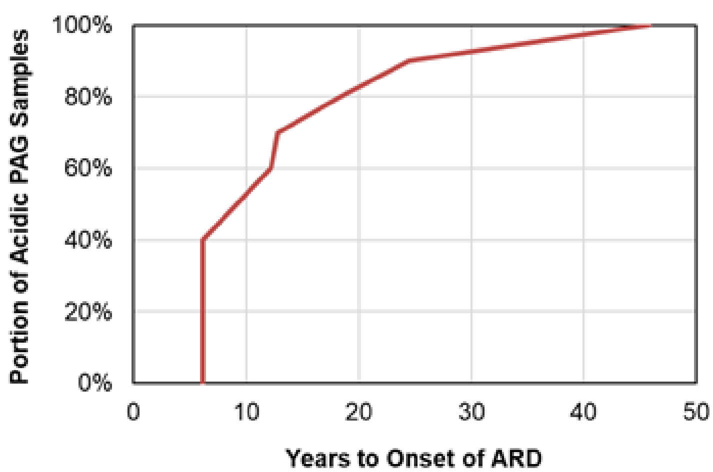


**Figure 4-14: Estimate of time to onset of acidic conditions in FMS PAG samples**

#### *4.1.2.1.3 Metal Leaching Trends*

The trends in leachate mass loading rates over time are provided in Figure 4-15 for selected species. As and Cu were shown to have elevated concentrations with respect to 3x the AUCCA in the mine rocks (Section 4.1.1.3). Although Ni was not identified as a potential parameter of concern in the solid-phase, it is known to be associated with sulphide minerals in Nova Scotian slates (Lund *et al.,* 1987).

The As loading rates are initially highest for HC3 (GA) and HC4 (GW) and decrease from approximately 0.1 to 0.02 (HC3) and 0.005 (HC4) mg/kg/wk. HC3 has relatively high As in the solid phase (1,785 ppm); however, HC4 does not (111 ppm). This indicates that, as already seen for the SFE tests, As mobility does not directly correlate with As content in the solid phase. The other three humidity cells have relatively stable to slightly decreasing As loading rates with values less than or near 0.01 mg/kg/wk. The ore cell (HC5) displays a temporarily increasing As loading rate between weeks 16 and 30 (Figure 4-15). HC1 (AG) has both the lowest As loading rate (approximately 0.004 mg/kg/wk) and the lowest As solid phase concentration (59 ppm).

Cu shows relatively low and erratic loading rates for all humidity cells Cu loading rates most commonly fall between 0.0001 and 0.001 mg/kg/wk with no discernable lithological or temporal trends.

After initially relatively high values (>0.001 mg/kg/wk), Ni loading rates drop around or below 0.0001 mg/kg/wk for most cell with the exception of HC5 (ore) which shows a slight increase in Ni mobility after week 25. It is assumed that Ni loading rates are strongly tied to sulphide oxidation rates with marked increases expected for samples producing acidic drainage after NP has been depleted.

### *4.1.2.2 Field Bin*

Field kinetic testing is used to help predict the drainage chemistry from the mine rock. These tests provide an indication of runoff chemistry under mine site conditions and are conducted at a larger scale relative to humidity cells. The FMS field bin was first sampled following setup in September 2018. This initial sample was collected after irrigating the field bin with distilled water. Subsequent samples were collected in response to natural precipitation events when sufficient leachate is available for analysis, roughly once a month when temperatures are above freezing. Full field bin leachate results are provided in Appendix 4-7.

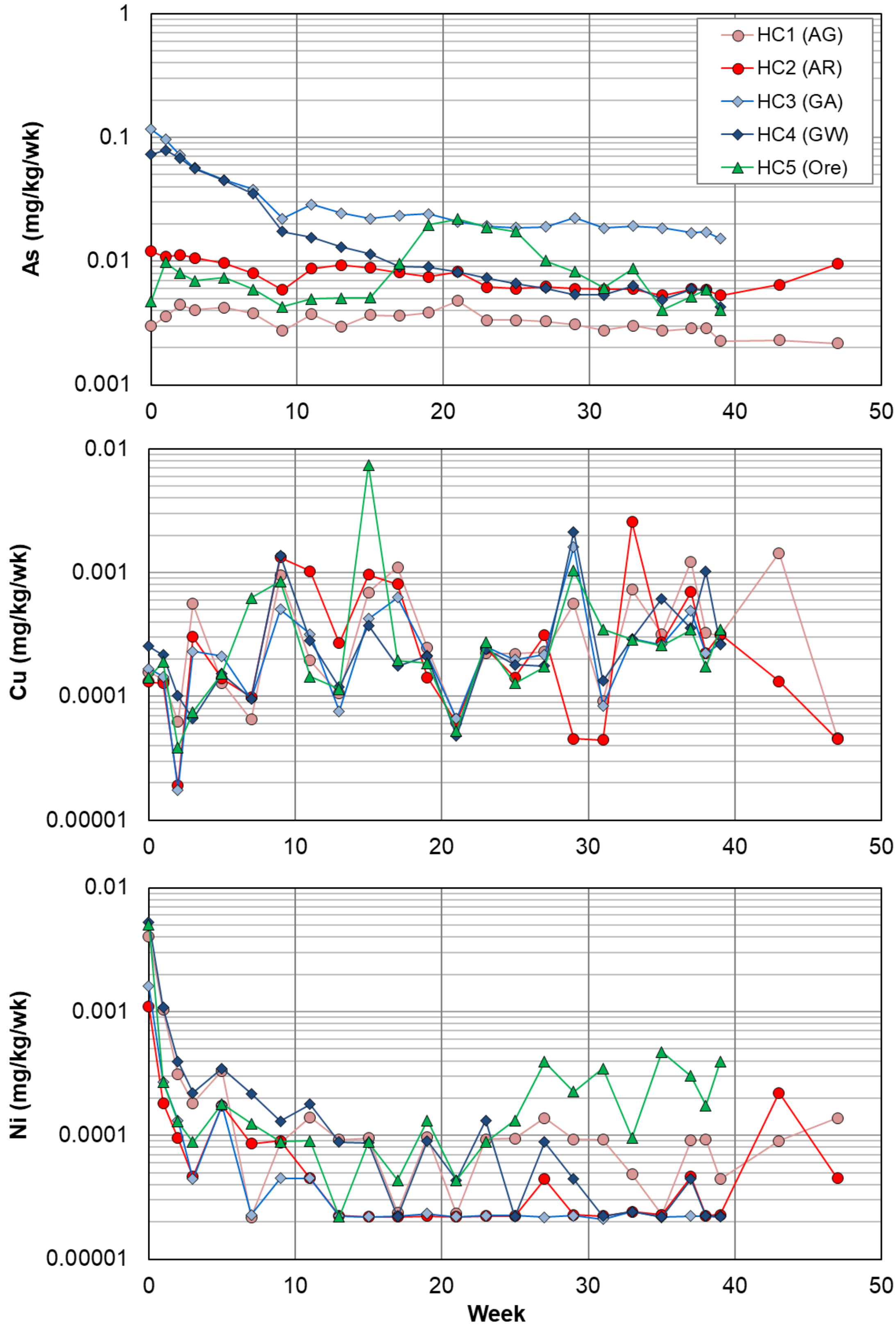


**Figure 4-15: As, Cu, and Ni in leachate from the FMS humidity cells**

Both median and maximum field bin leachate results are compared to CCME guidelines for the protection of aquatic life to provide an indication of parameters that may be of concern in the leachates (Table 4.9). Median values of field bin leachates (n = 8) do not exceed any short-term nor long-term guidelines. Maximum concentrations observed in the leachates are above long-term CCME guidelines for Cl, Al, As, and Ni. These maxima occur in the first sample collected (September 2018), with the exception of Al. This is expected due to flushing of readily soluble sulphide oxidation products that may have formed prior to field bin installation; therefore, the chemistry of the initial sample is not considered reflective of long-term stable geochemical conditions.

**Table 4.9:**
**Summary of FMS field bin leachate chemistry**

| **Parameter** | **Units** | **CCME WQG** | | **FB-3 (n=8)** | |
|---|---|---|---|---|---|
| | | Short Term | Long Term | Median | Maximum |
| pH | pH | 6.5-9 | - | 7.38 | 7.73 |
| Conductivity | µS/cm | - | - | 190 | 990 |
| Hardness ($CaCO_3$) | mg/L | - | - | 92.5 | 450 |
| Chloride | mg/L | 640 | 120 | 5.1 | 130 |
| Fluoride | mg/L | - | 0.12 | <0.10 | <0.10 |
| Sulphate | mg/L | - | - | 57.5 | 250 |
| Nitrate-N | mg/L | 550 | 13 | 0.066 | 0.54 |
| Nitrite-N | mg/L | - | 0.06 | 0.013 | 0.058 |
| Ammonia-N[a] | mg/L | - | 0.14 | 0.063 | 0.10 |
| **Dissolved Metals** | | | | | |
| Al[b] | mg/L | - | 0.1 | 0.011 | 0.13 |
| As | mg/L | - | 0.005 | 0.0033 | 0.0064 |
| B | mg/L | 29 | 1.5 | <0.050 | <0.050 |
| Cd | mg/L | 0.001 | 0.00009 | 0.000013 | 0.000088 |
| Ca | mg/L | - | - | 34 | 160 |
| Cr | mg/L | - | 0.001 | <0.0010 | <0.0010 |
| Co | mg/L | - | - | 0.0019 | 0.040 |
| Cu[c] | mg/L | - | 0.002 | 0.00079 | 0.0020* |
| Fe | mg/L | - | 0.3 | <0.050 | 0.057 |
| Pb[c] | mg/L | - | 0.001 | <0.00050 | 0.00050 |
| Mg | mg/L | - | - | 1.45 | 11.0 |
| Mn | mg/L | - | - | 0.09 | 1.4 |
| Mo | mg/L | - | 0.073 | <0.0020 | 0.0028 |
| Ni[c] | mg/L | - | 0.025 | 0.0165 | 0.230 |
| K | mg/L | - | - | 2.0 | 13 |
| Se | mg/L | - | 0.001 | <0.0010 | <0.0010 |
| Ag | mg/L | - | 0.00025 | <0.00010 | <0.00010 |
| Na | mg/L | - | - | 1.7 | 13 |
| Tl | mg/L | - | 0.0008 | <0.00010 | <0.00010 |
| U | mg/L | 0.033 | 0.015 | 0.00061 | 0.0015 |
| Zn | mg/L | 0.037 | 0.007 | <0.0050 | <0.0050 |

**Notes:** Values shaded in light grey are above the long-term CCME guideline; no values are above the short-term CCME guidelines.
[a]Ammonia guideline is based on a temperature of 20°C and a pH of 8.5. Guideline is converted from total ammonia to total ammonia-N by multiplying the value by 0.8224.
[b]Aluminum guideline is based on pH > 6.5
[c]Hardness dependent guidelines are based on a hardness of 10 mg/L
CCME – Canadian Council for Ministers of the Environment; WQG – Water quality guideline for the protection of aquatic life
*Value was measured at detection limit of <0.002 mg/L

## 4.2 Tailings

The following provides an overview of the geochemistry of the four FMS tailings samples obtained to date. Only the conventional circuit tailings sample from the 2018 metallurgical tests (Test 10 - KM5644) was used for saturated column testing to assess the material's leaching behaviour under subaqueous conditions.

### 4.2.1 Static Test Results

#### *4.2.1.1 Acid-Base Accounting Results*

All tailings samples have slightly basic paste pH ranging from 8.1 to 8.3 (Table 4-10). With the exception of the Test 42 material, all tailings samples show a total S content of 0.20% or higher with the highest content measured in the 2018 Test 6 (split circuit) sample (0.25%). Sulphate S is below the detection limit in all four samples (<0.01 %). Sulphide S levels are also low (≤0.02%; Table 4-9) in the 2017 tailings samples where sulphide was determined analytically via $HNO_3$ digestion. This method is known to result in incomplete dissolution of pyrrhotite which was identified in FMS mine rock. Hence, sulphide contents were calculated as non-sulphate S ([Total S] – [sulphate S]) to maintain conservatism for the 2018 samples.

All tailings samples have comparable CaNP and modified NP values (Table 4-10). Similar to trends observed in mine rock, the modified NP values are slightly higher than the CaNP, indicating that minerals other than carbonates may provide some neutralization. The NPR is calculated using the AP based on total S and the modified NP. Both 2017 tailings samples are NAG with NPR values of 2.1 and 5.6. For the 2018 tailings, the split circuit sample (Test 6) has PAG character (NPR = 1.6) while the conventional circuit sample (Test 10) used for kinetic testing is NAG with an NPR of 2.0 (Table 4-10). The full tailings ABA results are included in Appendix 4-8.

**Table 4-10:**
**Summary of FMS tailings ABA results**

| Sample ID | Met. Test ID | Year | Paste pH | Total S | Sulphate S | Sulphide S | CaNP | Modified NP | NPR |
|---|---|---|---|---|---|---|---|---|---|
| | | | | % | % | % | *kg $CaCO_3$/t* | *kg $CaCO_3$/t* | *Mod.NP/ AP* |
| Test 8 | KM5446 | 2017 | 8.3 | 0.21 | <0.010 | 0.020 | 11 | 14 | 2.1 |
| Test 42 | | | 8.3 | 0.085 | <0.010 | 0.010 | 13 | 15 | 5.6 |
| Test 6 | KM5644 | 2018 | 8.1 | 0.25 | <0.010 | 0.25 | 11 | 12 | 1.6 |
| Test 10 | | | 8.2 | 0.20 | <0.010 | 0.20 | 11 | 12 | 2.0 |

**Notes**:

Sulphate S is determined using the HCl method; Sulphide S is determined using the Sobek 1:7 nitric acid leach with ICP finish;
CaNP (carbonate neutralization potential) calculated using total inorganic carbon (% TIC x (100.09/12.01) x 10);
Modified NP is obtained by the modified Sobek method;
NPR = neutralization potential ratio; calculated as Modified NP / AP.

#### 4.2.1.2 Total Solid Phase Elemental Analysis Results

The solid-phase element concentrations are generally below 3x the AUCCA in the tailings samples (Appendix 4-8). The main element of concern identified with this screening method is As, which is above 10x the AUCCA in the Test 8 sample (2017) and both 2018 tailings samples. At 43 ppm it also exceeds 3x the AUCCA in the Test 42 sample (Table 4-11). The 2018 Test 10 material also showed an enrichment in solid-phase Zn. The detection limit for Se is above 10x the AUCCA so it is unknown if the Se content is indeed elevated in the studied tailings samples.

#### 4.2.1.3 Shake Flask Extraction Results

Tailings SFE results are compared to the CCME water quality guidelines for the protection of aquatic life (CCME, 2018) in order to provide some indication of parameters which may be of potential concern in short-term runoff from the material. Parameters that were elevated relative to the CCME guidelines in the extracts from the tailings samples include Al and As (Table 4-12). Although As is elevated in the solid phase in the tailings samples, the As concentrations in the leachate do not appear to be directly correlated with the solid phase As. This is most evident in the Test 42 sample which shows the lowest solid phase As content (43 ppm) while leaching the highest As concentration of all samples (0.019 mg/L).

**Table 4-11:**
**Summary of solid phase element results for FMS tailings samples**

| **Sample ID** | **Units** | **Test 8** | **Test 42** | **Test 6** | **Test 10** | **AUCCC** |
|---|---|---|---|---|---|---|
| **Met. Test ID** | | KM5446 | | KM5644 | | |
| **Year** | | 2017 | | 2018 | | |
| Ag | ppm | 0.030 | 0.010 | 0.030 | 0.030 | 0.053 |
| As | ppm | 176 | 43 | 335 | 225 | 4.8 |
| Cu | ppm | 4.2 | 3.6 | 5.4 | 9.6 | 28 |
| Pb | ppm | 6.4 | 4.7 | 4.4 | 29 | 17 |
| Sb | ppm | 0.13 | 0.050 | 0.36 | 0.35 | 0.40 |
| Se | ppm | <1.0 | <1.0 | <1.0 | <1.0 | 0.090 |
| Zn | ppm | 90 | 88 | 96 | 209 | 67 |

**Notes:** AUCCA = average upper continental crust abundance (Rudnick and Gao, 2014);
Values greater than 3x the AUCCA are shaded in light grey; values greater than 10x the AUCCA are shaded in dark grey.

**Table 4-12:
Summary of SFE results for FMS tailings samples**

| Sample ID | Units | Test 8 | Test 42 | Test 6 | Test 10 | CCME WQG | |
|---|---|---|---|---|---|---|---|
| | | | | | | Short Term | Long Term |
| **Met. Test ID** | | KM5446 | | KM5644 | | | |
| **Year** | | 2017 | | 2018 | | | |
| pH | | 8.1 | 8.2 | 7.95 | 7.93 | 6.5-9 | - |
| Conductivity | µS/cm | 134 | 123 | 157.48 | 177.6 | - | - |
| Sulphate | mg/L | 18 | 16 | 29 | 30 | - | - |
| **Dissolved Metals** | | | | | | | |
| Ag | mg/L | < 0.00005 | < 0.00005 | < 0.00005 | < 0.00005 | - | 0.00025 |
| Al[a] | mg/L | 0.15 | 0.23 | 0.13 | 0.13 | - | 0.1 |
| As | mg/L | 0.013 | 0.019 | 0.013 | 0.0066 | - | 0.005 |
| B | mg/L | 0.0080 | 0.0070 | 0.012 | 0.015 | 29 | 1.5 |
| Cd | mg/L | < 0.000003 | < 0.000003 | 0.0000050 | 0.0000050 | 0.001 | 0.00009 |
| Co | mg/L | 0.000036 | 0.000044 | 0.000032 | 0.000023 | - | - |
| Cr | mg/L | 0.00019 | 0.00077 | 0.00015 | 0.00013 | - | 0.001 |
| Cu[b] | mg/L | 0.00045 | 0.00038 | 0.00070 | 0.0014 | - | 0.002 |
| Fe | mg/L | 0.039 | 0.061 | 0.020 | 0.050 | - | 0.3 |
| Hg | ug/L | < 0.01 | < 0.01 | < 0.01 | 0.020 | - | 0.026 |
| Mn | mg/L | 0.0059 | 0.0016 | 0.012 | 0.011 | - | - |
| Mo | mg/L | 0.0025 | 0.0019 | 0.0057 | 0.014 | - | 0.073 |
| Ni[b] | mg/L | 0.00030 | 0.00020 | 0.00040 | 0.00050 | - | 0.025 |
| Pb[b] | mg/L | 0.000050 | 0.000050 | 0.000030 | 0.000020 | - | 0.001 |
| Sb | mg/L | 0.00050 | 0.00040 | < 0.0009 | < 0.0009 | - | - |
| Se | mg/L | 0.00018 | 0.00021 | 0.00033 | 0.00013 | - | 0.001 |
| Tl | mg/L | 0.0000070 | 0.0000060 | 0.0000050 | < 0.000005 | - | 0.0008 |
| U | mg/L | 0.00035 | 0.00033 | 0.00025 | 0.00023 | 0.033 | 0.015 |
| Zn | mg/L | < 0.002 | < 0.002 | < 0.002 | < 0.002 | 0.037 | 0.007 |

**Notes:** Values shaded in grey are above the long-term CCME guideline; no values are above the short-term CCME guidelines
[a]Aluminum guideline is based on pH > 6.5
[b]Hardness dependent guidelines are based on a hardness of 10 mg/L
CCME – Canadian Council for Ministers of the Environment;
WQG – Water quality guideline for the protection of aquatic life

## 4.2.2 Kinetic Test Results

### *4.2.2.1 Saturated Columns*

#### *4.2.2.1.1 Influent Chemistry*

As described in Section 3.2.3.3, tailings supernatant was used as the influent source for the saturated column experiment. Supernatant inflow geochemistry is summarized in Table 4-13. Supernatant water reflects general tailings porewater chemistry and is characterized by slightly basic pH and elevated DOC, with the major ion inventory dominated by bicarbonate alkalinity, $SO_4$, Ca, and K. Fluoride, arsenic, and zinc concentrations in saturated column influent are elevated relative to CCME guidelines. At

0.012 mg/L, arsenic concentrations exceed guidelines by approximately 2.5 times. CCME guidelines are used here merely as a reference point for saturated column testwork. Site wide water quality modelling considering the site-wide water balance and geochemical loading predictions (source terms) will identify whether parameters become an environmental concern.

**Table 4-13:
Summary of Saturated Column Influent Chemistry**

| Parameter | Unit | Test 10 Supernatant | CCME WQG | |
|---|---|---|---|---|
| | | | Short Term | Long Term |
| T-Alk | mg/L | 79 | - | - |
| pH | s.u. | 7.95 | 6.5-9 | - |
| Conductivity | uS/cm | 314 | - | - |
| DOC | mg/L | 11.4 | - | - |
| $NH_3$ | mg/L | 0.352 | - | - |
| $NO_3$-N | mg/L | 0.0480 | - | - |
| $NO_2$-N | mg/L | 0.0048 | - | - |
| T-$PO_4$ | mg/L | *< 0.002* | - | - |
| $SO_4$ | mg/L | 47.1 | - | - |
| Na | mg/L | 11.2 | - | - |
| Ca | mg/L | 24.7 | - | - |
| K | mg/L | 32.0 | - | - |
| Cl | mg/L | 15.0 | 640 | 120 |
| Mg | mg/L | 3.47 | - | - |
| Si | mg/L | 1.66 | - | - |
| F | mg/L | 0.284 | - | 0.12 |
| Al | mg/L | 0.0944 | - | 0.1 |
| Sb | mg/L | 0.000305 | | |
| As | mg/L | 0.0119 | - | 0.1 |
| Ba | mg/L | 0.00664 | - | - |
| Cd | mg/L | *< 0.000005* | 0.001 | 0.00009 |
| Cr | mg/L | *< 0.0001* | - | 0.001 |
| Co | mg/L | 0.0000094 | - | - |
| Cu | mg/L | *< 0.0001* | - | 0.002 |
| Fe | mg/L | *< 0.001* | - | 0.3 |
| Pb | mg/L | *< 0.000005* | - | 0.001 |
| Li | mg/L | 0.00587 | - | - |
| Mn | mg/L | 0.0182 | - | - |
| Hg | mg/L | *< 0.000005* | - | 0.026 |
| Mo | mg/L | 0.0160 | - | 0.073 |
| Ni | mg/L | 0.000762 | - | 0.025 |
| Se | mg/L | 0.000276 | - | 0.001 |
| Ag | mg/L | *< 0.000005* | - | 0.00025 |
| Sr | mg/L | 0.160 | - | - |
| Tl | mg/L | 0.0000061 | - | 0.0008 |
| V | mg/L | 0.000109 | - | - |
| Zn | mg/L | 0.0101 | 0.037 | 0.007 |

**Note:** Values in grey italics are below detection limit.
All metal concentrations represent the dissolved fraction.
Values shaded in grey are above the long-term CCME guideline; no values are above the short-term CCME guidelines

#### *4.2.2.1.2 Effluent Chemistry*

Saturated column testwork is used to help characterize the leachate behaviour of the tailings material fully under saturated conditions. This report provides interim results from the ongoing saturated column test that was initiated in March 2019 and, at the time of reporting, have been running for 18 weeks. A complete set of interim column leachate results are presented in Appendix 4-9 and summarized in this section.

Column effluent is slightly basic through the duration of the current experimental period. All pH values are between 8.05 and 8.31 (Figure 4-16). Total alkalinity shows a gradual increase from 120 mg/L $CaCO_3$ in Week 0 to 160 mg/L $CaCO_3$ in Week 18. Conversely, sulphate concentrations decline from 95 mg/L to near influent concentrations (47 mg/L) by Week 10 (Figure 4-16).

Reducing conditions in column substrate are driven by the oxidation of sulphide minerals and organic compounds. Organic matter in tailings material may be in the form of organic-based mill reagents, detritus entering the TMF, in situ growth of algae/bacteria, or organics provided in the column influent. Indeed, supernatant water quality results show the presence of measurable DOC (~11 mg/L). For the current experimental phase, DOC in leachates is consistently near or below influent concentrations, reaching levels as low as 4.4 mg/L. This indicates that decomposition of DOC by microbial activity is occurring within the column.

The first terminal electron acceptor to be utilized in the absence of oxygen is nitrate ($NO_3$). The saturated column shows evidence of $NO_3$ reduction as $NO_3$ carried in the influent (0.05 mg/L) is completely consumed to concentrations below method detection limit (MDL) values (<0.005) in the first leachate sample (Week 0) Figure 4-17). The dominant nitrogen species in column effluent is ammonia ($NH_3$), which is a reduced species that typically dominates nitrogen speciation under anaerobic conditions. The persistence of $NH_3$ in column leachate indicates that conditions are sufficiently reducing (*i.e.,* oxygen is absent) to favor $NO_3$ reduction and $NH_3$ stability.

Following denitrification and continued absence of oxygen, the next available electron acceptor and the next reaction in the thermodynamically predicted order of redox reactions is manganese (Mn IV) reduction. In the current experimental phase, there is evidence of the reductive dissolution of Mn-oxides. As labile DOC is readily available within the column and most of the available $NO_3$ is reduced, bacterially mediated reductive dissolution of Mn-oxides (assumed to be present as $MnO_2$) is expected to occur, leading to elevated Mn(II) in the leachate. This is demonstrated by the increase in Mn concentrations between column influent (0.018 mg/L) and column leachates (Figure 4-17). Manganese concentrations in leachates show an upward trend from Week 0 through 18, reaching a maximum concentration of 0.114 mg/L in Week 18. While column effluent has detectable Fe concentrations (maximum of 0.0082 mg/L) by Week 4, values are consistently just above or near influent concentrations, indicating that reductive dissolution of Fe is not occurring to any significant extent. This may be due to the availability of more energetically favorable oxidants (*i.e.,* Mn) or Fe-oxides being present in crystalline forms that are not easily accessible for microbial respiration.

The suboxic conditions of the column will inhibit acid generation and metal leaching associated with sulfide oxidation; however, metal leaching can still proceed through other mechanisms, including reductive dissolution reactions, the rinsing of water-soluble oxides, and ion-exchange processes. The most significant trace metal of interest released from the saturated column is arsenic (As), which shows a 3-fold concentration increase compared to influent by Week 18 (Figure 4-18Arsenic concentrations steadily increased from Week 0 through 18, suggesting conditions in the column are trending to favour As release. The maximum As concentrations are reached in Week 18 (0.035 mg/L) and are 7x the CCME guideline. Other elements of interest, such as Co and Ni, show evidence of elevated concentrations in Week 0 but reached near or below influent values by Week 2 (Figure 4-18). This behaviour is consistent with the rinsing of water-soluble oxides and mineral surface bound metals. While Ni concentrations remained near or below influent concentrations (0.00076 mg/L) and well below CCME guidelines (0.025 mg/L) by Week 2, Co concentrations climbed above influent values (0.0000094 mg/L) at Week 10 and continue in an upward trend through Week 18.

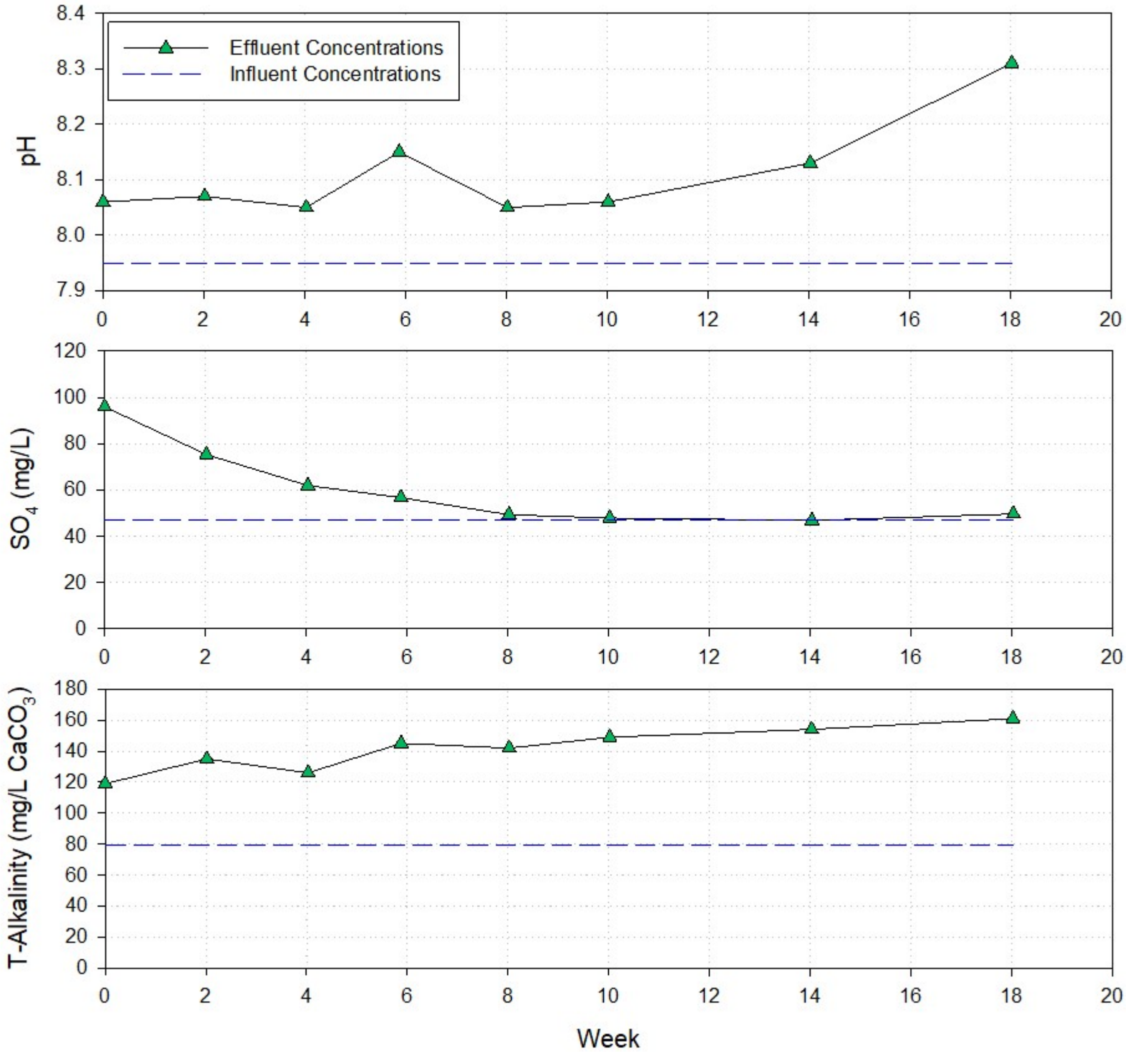


**Figure 4-16: Saturated column time series profiles of pH, $SO_4$, and T-Alkalinity in column effluent over the 18 week experiment period**

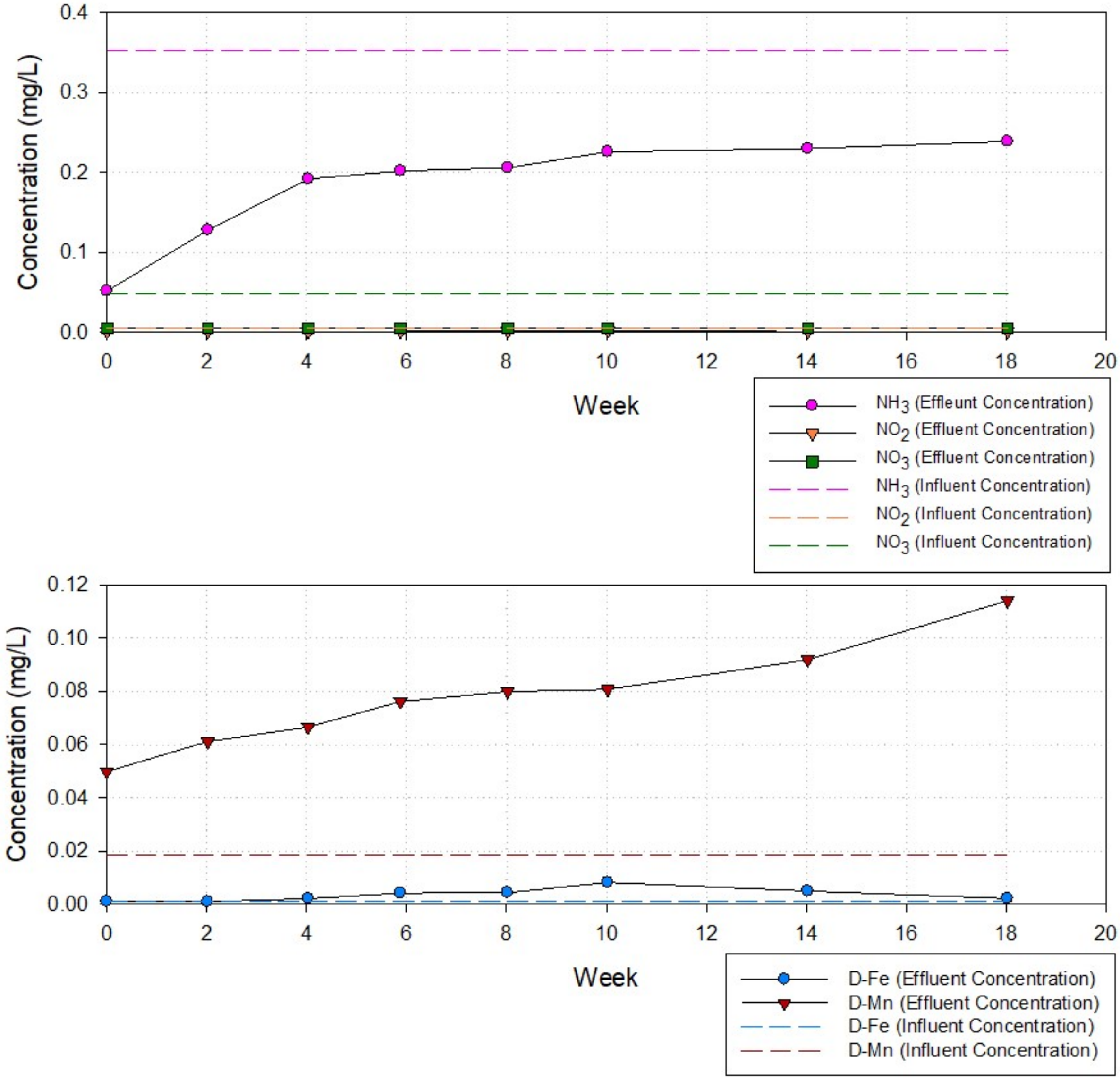


**Figure 4-17: Saturated column time series profiles of Nitrogen species, D-Fe, and D-Mn in column effluent over the 18 week experiment period**

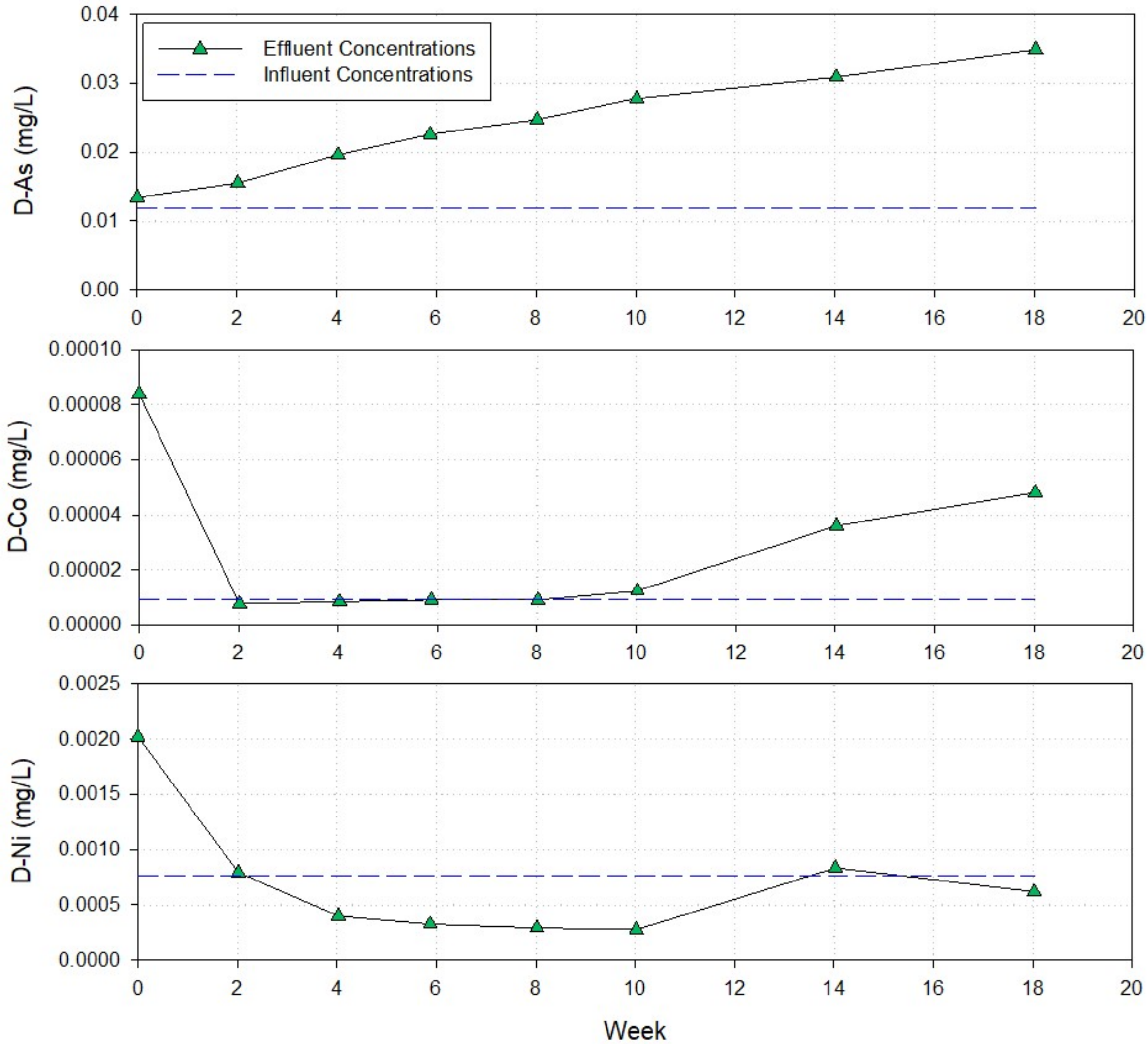


**Figure 4-18: Saturated column time series profiles of D-As, D-Co, and D-Ni in column effluent over the 18 week experiment period**

# 5. Conclusions

# 5 Conclusions

The ML/ARD characterization of the FMS samples included static test characterization of mine rock and tailings samples. In addition, ongoing kinetic testing on mine rock and tailings samples includes humidity cells, a field bin and a saturated column. The key conclusions of the geochemical characterization include:

- FMS strata that will be mined include argillite (AR) and greywacke (GW) from the Moose River Member, which also hosts the Touquoy deposit to the southwest.
- The FMS mine rock is composed dominantly of quartz, plagioclase, and sericite/muscovite. Pyrrhotite is the main sulphide mineral in the humidity cell samples (up to 2.4 wt. %); however, the QEMSCAN results for the field bin subsample indicate that significant pyrite is also present in this sample. Pyrrhotite is present as coarser grains relative to pyrite, which is dominantly very fine-grained (≤ +25µm in size). Calcite was the main carbonate mineral present; HC4 (GW) contains significant calcite (9.8 wt. %), while the field bin subsample calcite content is 2.7%.
- The QEMSCAN analysis indicated that the majority of As present in the field bin subsample was present in the arsenopyrite. However, 77% of the arsenopyrite is locked within mineral grains and was most commonly observed in hydrothermal veins generally associated with pyrrhotite.
- The total S contents of the mine rock samples vary from 0.020% to 1.1%, including the ore samples. The median total S content of the ore samples is slightly higher relative to the median total S for the four main rock types (0.44 wt. % and 0.27 wt. %, respectively). The total S for the field bin subsample was 0.40%. The majority of the total S is present as sulphide S.
- The GW samples have the highest median modified NP value at 31 kg $CaCO_3$/t, while the AR samples have the lowest (12 kg $CaCO_3$/t). The ore samples have a median modified NP of 16 kg $CaCO_3$/t, while the field bin subsample has a modified NP of 27 kg $CaCO_3$/t.
- Samples from the GW are predominantly NAG (96%) while samples from the other three lithologies have higher PAG proportions. There is a clear relationship of PAG% with the relative amount of argillite contained within the rock type, where the AR unit (<5% greywacke interbeds) shows the highest PAG proportion of 81%.
- Elements of potential concern based on the solid phase elemental analysis include Ag, As, Cu, Pb, Sb, and Zn. These elements, excluding Cu and Zn, are enriched by

a factor greater than 10x above the AUCCA in one or more samples. As is elevated above 10x the AUCCA in all lithologies.

- The SFE results indicate that As and Al are potential parameters of concern in runoff from the mine rock. The elevated As concentrations in the leachate are not correlated to the solid phase As content. Other parameters highlighted in the solid phase analyses were not above the CCME water quality guidelines in the SFE leachate.
- Leachate from all humidity cells remained circum-neutral for the duration of the humidity cell experiments.
- Sulphate loading rates for the humidity cells HC2, HC3, and HC5 begin to stabilize after approximately 15 weeks of humidity cell testing. The highest sulphate release rates were observed in HC5 (ore) with values between 10 and 20 mg/kg/wk. HC1 (AG) showed the highest sulphate loading rates of any waste rock cell for the bulk of the experimental duration, however in more recent analytical cycles HC 2 (AR) has started to exceed HC1 rates.
- An estimated time to NP depletion was determined from the average CMR and sulphate loading rate for stable conditions of the kinetic test. Calculations suggests that the carbonate will be depleted from the FMS mine rock between approximately 6 and 15 years. A conservative estimate for time to NP depletion for the static test samples indicates that approximately 50% of the PAG samples will become acidic within 10 years after exposure to the atmposphere. This estimate does not consider the slower sulphide oxidation rates in colder temperatures, which would be expected to delay the onset of acid generation.
- Of the parameters of concern identified in the solid phase analysis, As had the highest loading rate in the humidity cells. Humidity cell samples with high solid phase As concentrations did not necessarily have high As loading rates.
- Median field bin leachate concentrations do not exceed any short-term nor long-term guidelines. Maximum concentrations observed in the leachates are above respective long-term CCME guidelines for Cl, Al, As, and Ni where maxima occur in the first sample collected (September 2018), with the exception of Al.
- The four tailings samples have variable but relatively low total S contents between 0.085% and 0.25%, dominantly in the form of pyrrhotite. Using total S as the proxy to calculate AP, only the 2018 split circuit sample (Test 6) showed an NPR value below 2 and is therefore classified as PAG. The sample produced by Test 10

representing the conventional flotation circuit, which is expected to be implemented for full-scale operations, is NAG (NPR = 2.0).

- Arsenic is the main parameter of concern in the tailings, due to elevated concentrations in both the solid phase elemental analysis and in the SFE leachate.
- Reducing conditions were established in the saturated column, evidenced by the consumption of DOC, denitrification, $NH_3$ stability, and Mn-oxide reduction.
- The most significant trace metal of interest released in the saturated column leachate is As. Arsenic concentrations steadily increased from Week 0 through 18, suggesting conditions in the column are trending to favour As release. The maximum As concentrations reached (0.035 mg/L) are 7x the CCME guideline.

# 6. Closure

Atlantic Gold

# 6 Closure

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

Sincerely,

**LORAX ENVIRONMENTAL SERVICES LTD.**

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# Appendices

# *Appendix 3-1: Sample Locations and Drill Core Details*

Atlantic Gold

**Appendix 3-1: Sample Locations and Drill Core Details**

| Hole ID | From (m) | To (m) | Lithology | Grade |
|---|---|---|---|---|
| FMS-17-055 | 5 | 6 | AR | Waste |
| FMS-17-055 | 15 | 16 | AR | Waste |
| FMS-17-055 | 25 | 26 | AR | Ore |
| FMS-17-055 | 30 | 31 | AR | Ore |
| FMS-17-055 | 43 | 44 | AR | Ore |
| FMS-17-055 | 50 | 51 | AR | Waste |
| FMS-17-055 | 55 | 56 | AR | Ore |
| FMS-17-055 | 70 | 71 | AR | Ore |
| FMS-17-055 | 83 | 84 | AG | Ore |
| FMS-17-055 | 90 | 91 | GW | Ore |
| FMS-17-055 | 98 | 99 | AR | Ore |
| FMS-17-055 | 111 | 112 | GW | Ore |
| FMS-17-055 | 120 | 121 | AR | Waste |
| FMS-17-055 | 126 | 127 | AR | Waste |
| FMS-17-073 | 9 | 10 | GA | Waste |
| FMS-17-073 | 15 | 16 | AR | Waste |
| FMS-17-073 | 22 | 23 | GW | Waste |
| FMS-17-073 | 30 | 31 | GW | Waste |
| FMS-17-073 | 33 | 34 | AR | Waste |
| FMS-17-073 | 37 | 38 | AR | Waste |
| FMS-17-073 | 44 | 45 | AR | Waste |
| FMS-17-078 | 20 | 25 | AR | Ore |
| FMS-17-078 | 40 | 45 | AR | Waste |
| FMS-17-114 | 23 | 28 | AG | Waste |
| FMS-17-114 | 55 | 60 | AG | Waste |
| FMS-17-124 | 34 | 35 | AR | Waste |
| FMS-17-124 | 40 | 41 | AG | Waste |
| FMS-17-124 | 46 | 47 | GW | Waste |
| FMS-17-124 | 50 | 51 | AR | Waste |
| FMS-17-124 | 53 | 54 | AR | Waste |
| FMS-17-124 | 60 | 61 | AR | Waste |
| FMS-17-124 | 67 | 68 | AR | Waste |
| FMS-17-124 | 70 | 71 | AG | Waste |
| FMS-17-124 | 73 | 74 | GA | Waste |
| FMS-17-124 | 82 | 83 | AG | Ore |
| FMS-17-124 | 89 | 90 | AR | Ore |
| FMS-17-124 | 106 | 107 | AR | Ore |
| FMS-17-124 | 122 | 123 | AR | Ore |
| FMS-17-124 | 130 | 131 | AR | Ore |
| FMS-17-124 | 140 | 141 | GA | Ore |
| FMS-17-124 | 145 | 146 | AR | Ore |
| FMS-17-165 | 10 | 11 | AR | Waste |
| FMS-17-165 | 16 | 17 | GA | Waste |
| FMS-17-165 | 18 | 19 | GW | Waste |
| FMS-17-165 | 21 | 22 | GA | Waste |
| FMS-17-165 | 26 | 27 | GA | Waste |
| FMS-17-165 | 30 | 31 | AR | Waste |
| FMS-17-165 | 40 | 41 | AR | Ore |
| FMS-17-165 | 55 | 56 | AR | Ore |
| FMS-17-165 | 65 | 66 | GW | Ore |
| FMS-17-165 | 83 | 84 | AG | Ore |
| FMS-17-165 | 95 | 96 | AG | Waste |
| FMS-17-165 | 110 | 111 | GW | Waste |
| FMS-17-179 | 25 | 30 | GW | Waste |
| FMS-17-199 | 5 | 6 | GW | Waste |
| FMS-17-199 | 10 | 11 | GW | Waste |
| FMS-17-199 | 20 | 21 | GW | Waste |
| FMS-17-199 | 29 | 30 | GA | Waste |

**Appendix 3-1: Sample Locations and Drill Core Details**

| Hole ID | From (m) | To (m) | Lithology | Grade |
|---|---|---|---|---|
| FMS-17-199 | 39 | 40 | AG | Waste |
| FMS-17-199 | 80 | 81 | AR | Waste |
| FMS-17-200 | 7 | 8 | GW | Waste |
| FMS-17-200 | 13 | 14 | AR | Waste |
| FMS-17-200 | 20 | 21 | GW | Waste |
| FMS-17-200 | 27 | 28 | AG | Waste |
| FMS-17-200 | 35 | 36 | GA | Waste |
| FMS-17-206 | 40 | 45 | AR | Waste |
| FMS-17-270 | 55 | 60 | AG | Ore |
| FMS-17-274 | 20 | 25 | GW | Waste |
| FMS-17-274 | 65 | 70 | AR | Waste |
| FMS-17-274 | 100 | 105 | AG | Waste |
| FMS-17-278 | 80 | 85 | GW | Waste |
| FMS-17-280 | 42 | 47 | GW | Waste |
| FMS-17-288 | 20 | 25 | AG | Waste |
| FMS-17-288 | 45 | 50 | GW | Waste |
| FMS-17-291 | 35 | 40 | GA | Waste |
| FMS-17-298 | 20 | 25 | GW | Waste |
| FMS-17-298 | 40 | 45 | AR | Ore |
| FMS-17-302 | 20 | 25 | AR | Waste |
| FMS-17-302 | 40 | 45 | GW | Waste |
| FMS-18-388 | 45 | 50 | GA | Waste |
| FMS-18-388 | 70 | 75 | AR | Waste |
| FMS-18-388 | 110 | 115 | AR | Waste |
| FMS-18-388 | 175 | 180 | GW | Waste |
| FMS-18-389 | 20 | 25 | AR | Waste |
| FMS-18-389 | 40 | 45 | GA | Waste |
| FMS-18-389 | 75 | 80 | GA | Waste |
| FMS-18-389 | 115 | 120 | GW | Waste |
| FMS-18-416 | 20 | 25 | GW | Waste |
| FMS-18-416 | 40 | 45 | GW | Waste |
| FMS-18-416 | 75 | 80 | GA | Waste |
| FMS-18-416 | 115 | 120 | AR | Waste |
| FMS-18-416 | 145 | 150 | GW | Waste |
| FMS-18-423 | 20 | 25 | GA | Waste |
| FMS-18-423 | 40 | 45 | AG | Waste |
| FMS-18-423 | 80 | 85 | GW | Waste |
| FMS-18-440 | 45 | 50 | GA | Waste |
| FMS-18-440 | 70 | 75 | GW | Waste |
| FMS-18-440 | 110 | 115 | AG | Waste |

# *Appendix 4-1: Mineralogy Results*

*APPENDIX 4-1-1: XRD RESULTS*

*APPENDIX 4-1-2: QEMSCAN RESULTS*

Atlantic Gold

# Quantitative X-Ray Diffraction by Rietveld Refinement

| | |
|---|---|
| ***Report Prepared for:*** | *SGS Canada Inc* |
| ***Project Number/ LIMS No.*** | *14094-01B/MI4520-OCT18* |
| ***Batch No.*** | *1827 CH-FMS* |
| ***Sample Receipt:*** | *October 19, 2018* |
| ***Sample Analysis:*** | *October 26, 2018* |
| ***Reporting Date:*** | *October 30, 2018* |

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

***Contents:***



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Senior Mineralogist

Huyun Zhou, Ph.D., P.Geo.
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**ACCREDITATION:** SGS Minerals Services Lakefield is accredited to the requirements of ISO/IEC 17025 for specific tests as listed on our scope of accreditation, including geochemical, mineralogical and trade mineral tests. To view a list of the accredited methods, please visit the following website and search SGS Canada - Minerals Services - Lakefield: http://palcan.scc.ca/SpecsSearch/GLSearchForm.do.

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## Method Summary

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

### *Mineral Identification and Interpretation:*

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

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

### *Quantitative Rietveld Analysis:*

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

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



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Member of the SGS Group (SGS SA)

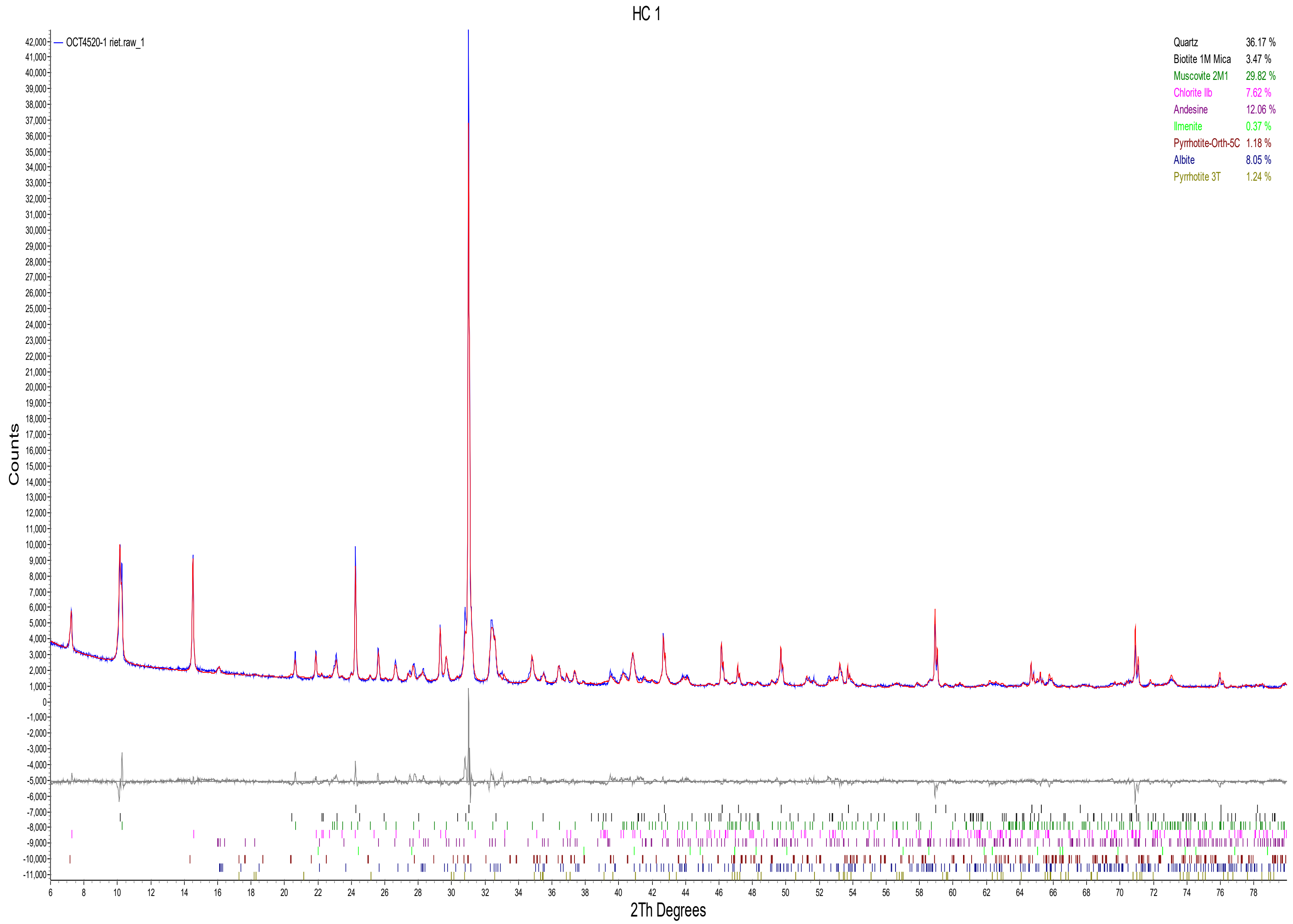
# Summary of Rietveld Quantitative Analysis X-Ray Diffraction Results

| Mineral/ Compound | Formula | HC 1 OCT4520-01 (wt %) | HC 2 OCT4520-02 (wt %) | HC 3 OCT4520-03 (wt %) | HC 4 OCT4520-04 (wt %) | HC 5 OCT4520-05 (wt %) |
|---|---|---|---|---|---|---|
| Quartz | $SiO_2$ | 36.2 | 30.6 | 34.9 | 38.9 | 39.0 |
| Biotite | $K(Mg,Fe)_3(AlSi_3O_{10})(OH)_2$ | 3.5 | 2.7 | 3.6 | 2.1 | 3.6 |
| Muscovite | $KAl_2(AlSi_3O_{10})(OH)_2$ | 29.8 | 47.1 | 27.6 | 16.3 | 28.1 |
| Chlorite | $(Fe,(Mg,Mn)_5,Al)(Si_3Al)O_{10}(OH)_8$ | 7.6 | 9.9 | 7.9 | 4.1 | 9.1 |
| Andesine | $Na_{0.6}Ca_{0.4}Al_{1.4}Si_{2.6}O_8$ | 12.1 | 8.8 | 7.2 | - | 10.4 |
| Albite | $NaAlSi_3O_8$ | 8.1 | - | 15.8 | 28.0 | 5.0 |
| Ilmenite | $FeTiO_3$ | 0.4 | - | 0.5 | 0.4 | 0.4 |
| Pyrrhotite | $Fe_{(1-x)}S$ | 2.4 | 0.9 | 1.2 | - | 1.0 |
| Calcite | $CaCO_3$ | - | - | 1.4 | 9.8 | 1.6 |
| Chalcopyrite | $CuFeS_2$ | - | - | - | 0.3 | - |
| Spinel | $MgAl_2O_4$ | - | - | - | - | 1.6 |
| Pyrite | $FeS_2$ | - | - | - | - | 0.3 |
| Maghemite | $\gamma\text{-}Fe_2O_3$ | - | - | - | - | - |
| Dolomite | $CaMg(CO_3)_2$ | - | - | - | - | - |
| Chlorapatite | $Ca_5(PO_4)_3Cl$ | - | - | - | - | - |
| TOTAL | | 100 | 100 | 100 | 100 | 100 |

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

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

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


HC 1
OCT4520-1 riet.raw_1
Counts
2Th Degrees
Quartz 36.17 %
Biotite 1M Mica 3.47 %
Muscovite 2M1 29.82 %
Chlorite IIb 7.62 %
Andesine 12.06 %
Ilmenite 0.37 %
Pyrrhotite-Orth-5C 1.18 %
Albite 8.05 %
Pyrrhotite 3T 1.24 %

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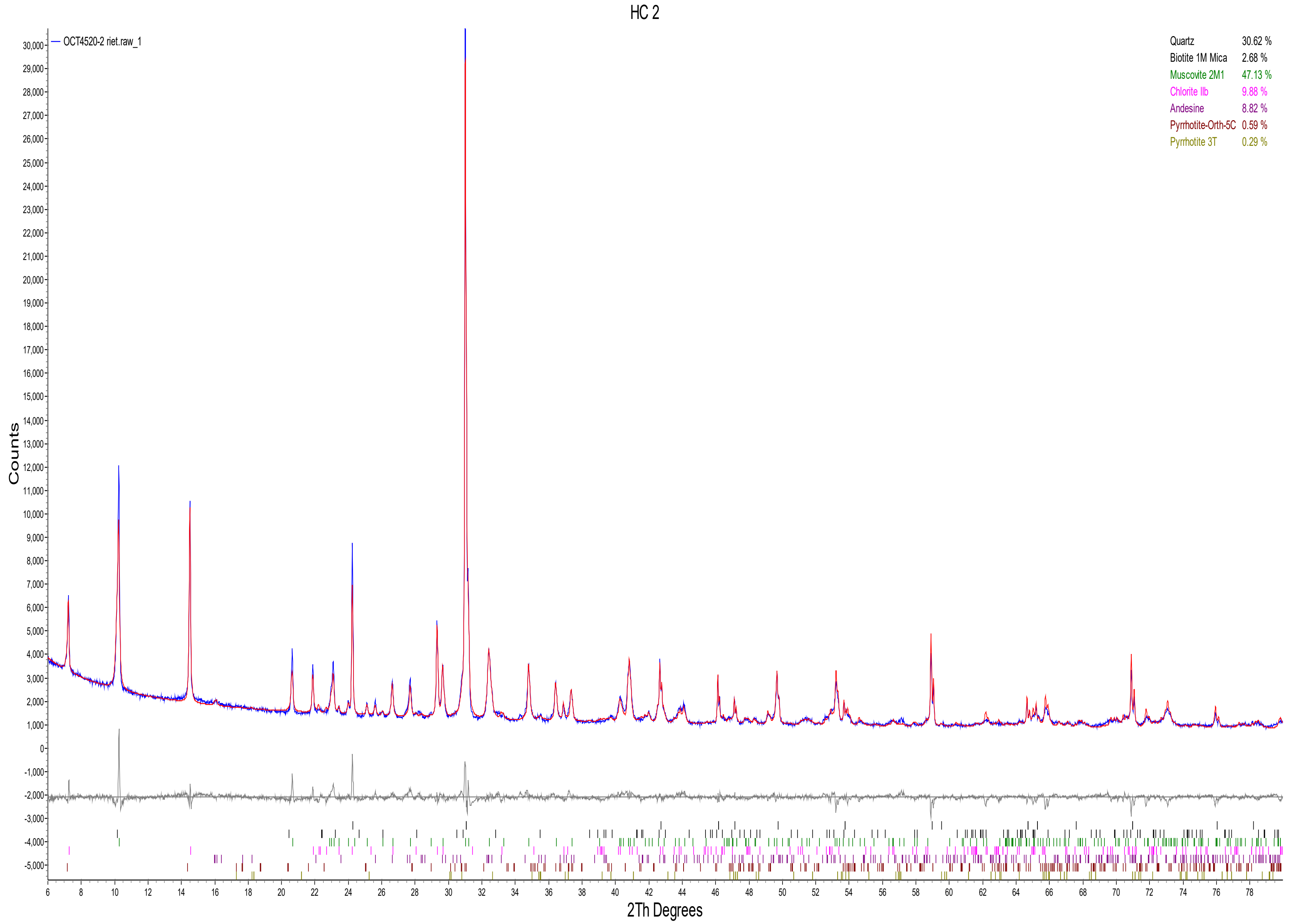

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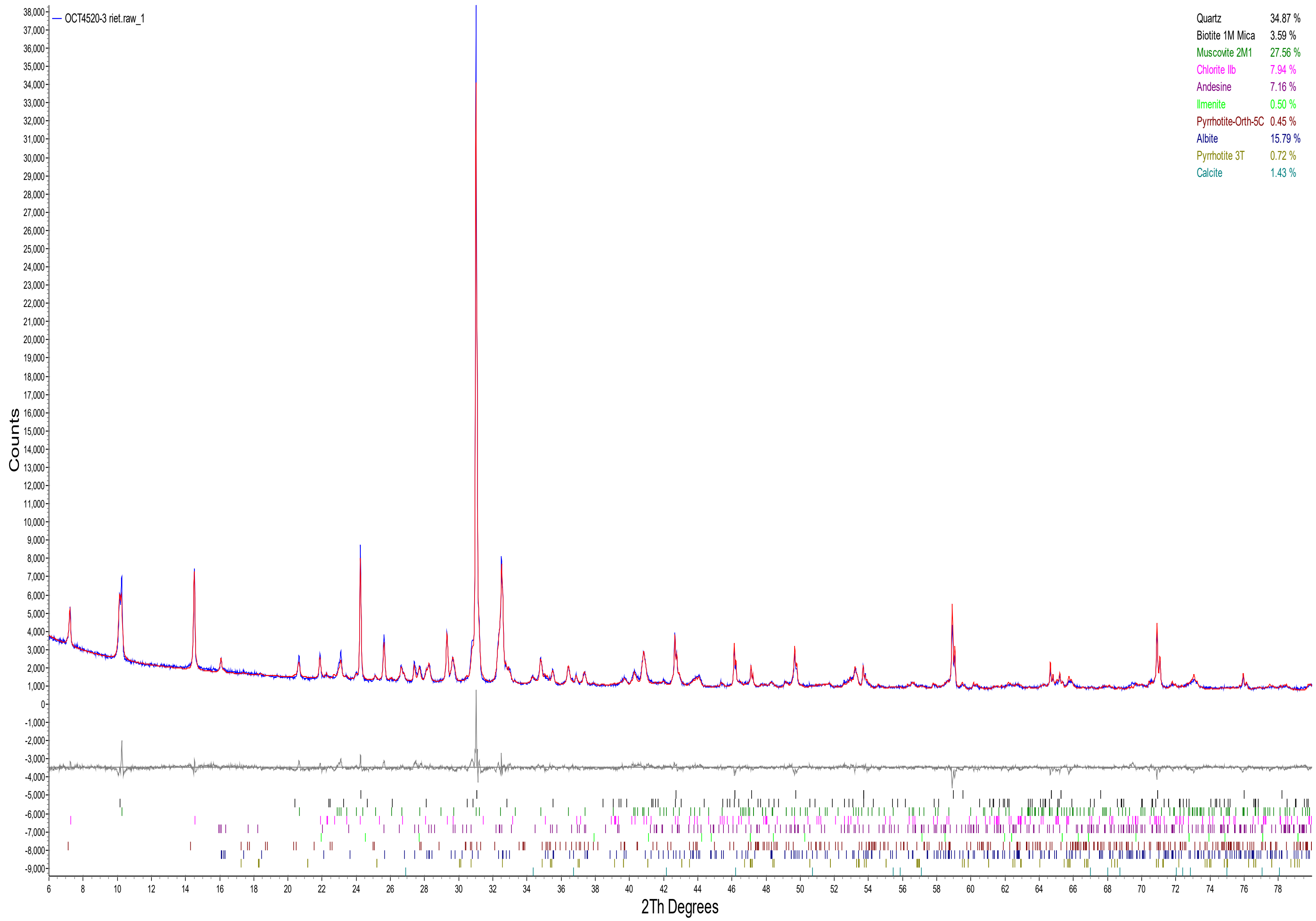
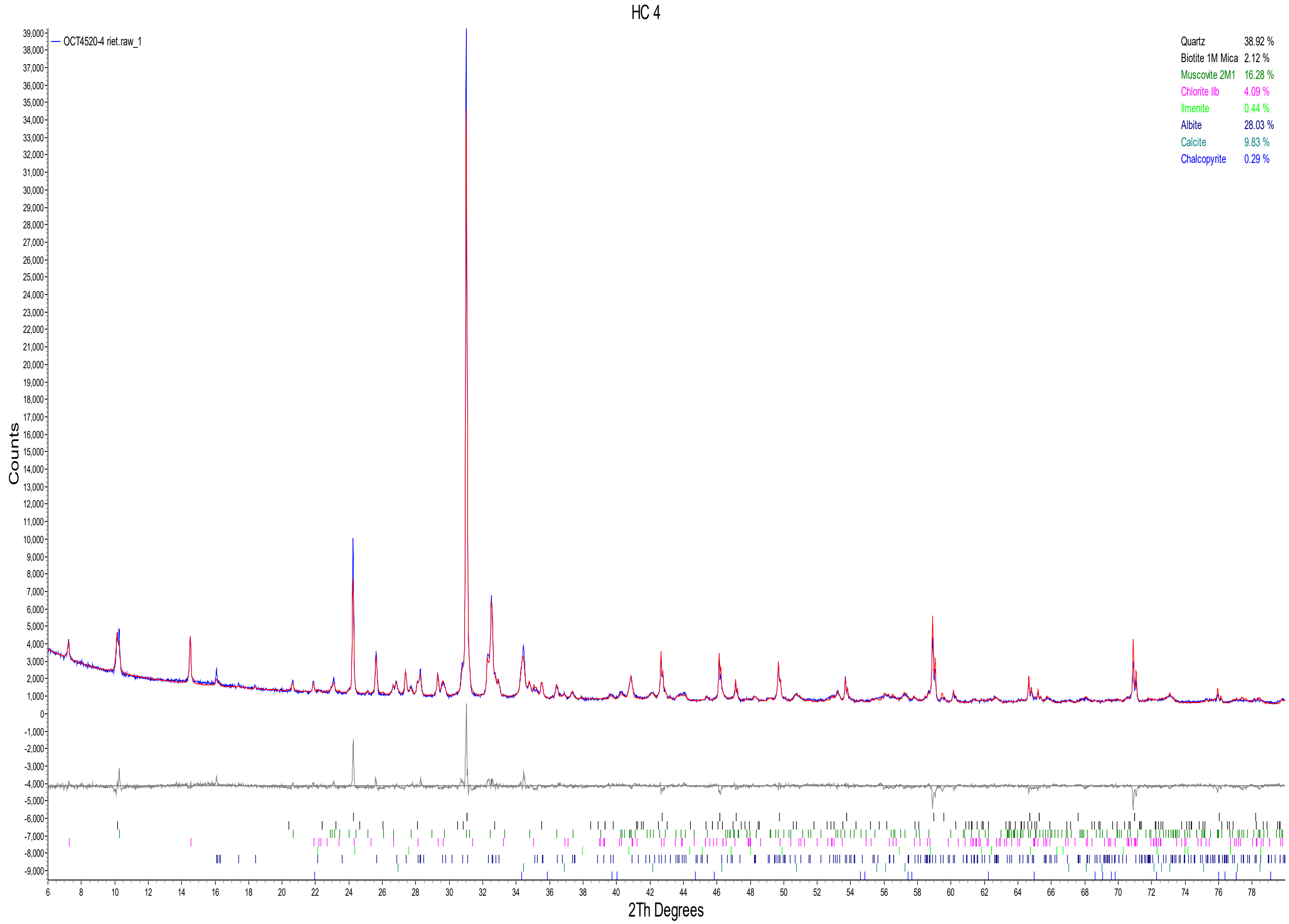
30-Oct-18

HC 3




HC 4
OCT4520-4 riet.raw_1
Quartz 38.92 %
Biotite 1M Mica 2.12 %
Muscovite 2M1 16.28 %
Chlorite IIb 4.09 %
Ilmenite 0.44 %
Albite 28.03 %
Calcite 9.83 %
Chalcopyrite 0.29 %
Counts
2Th Degrees

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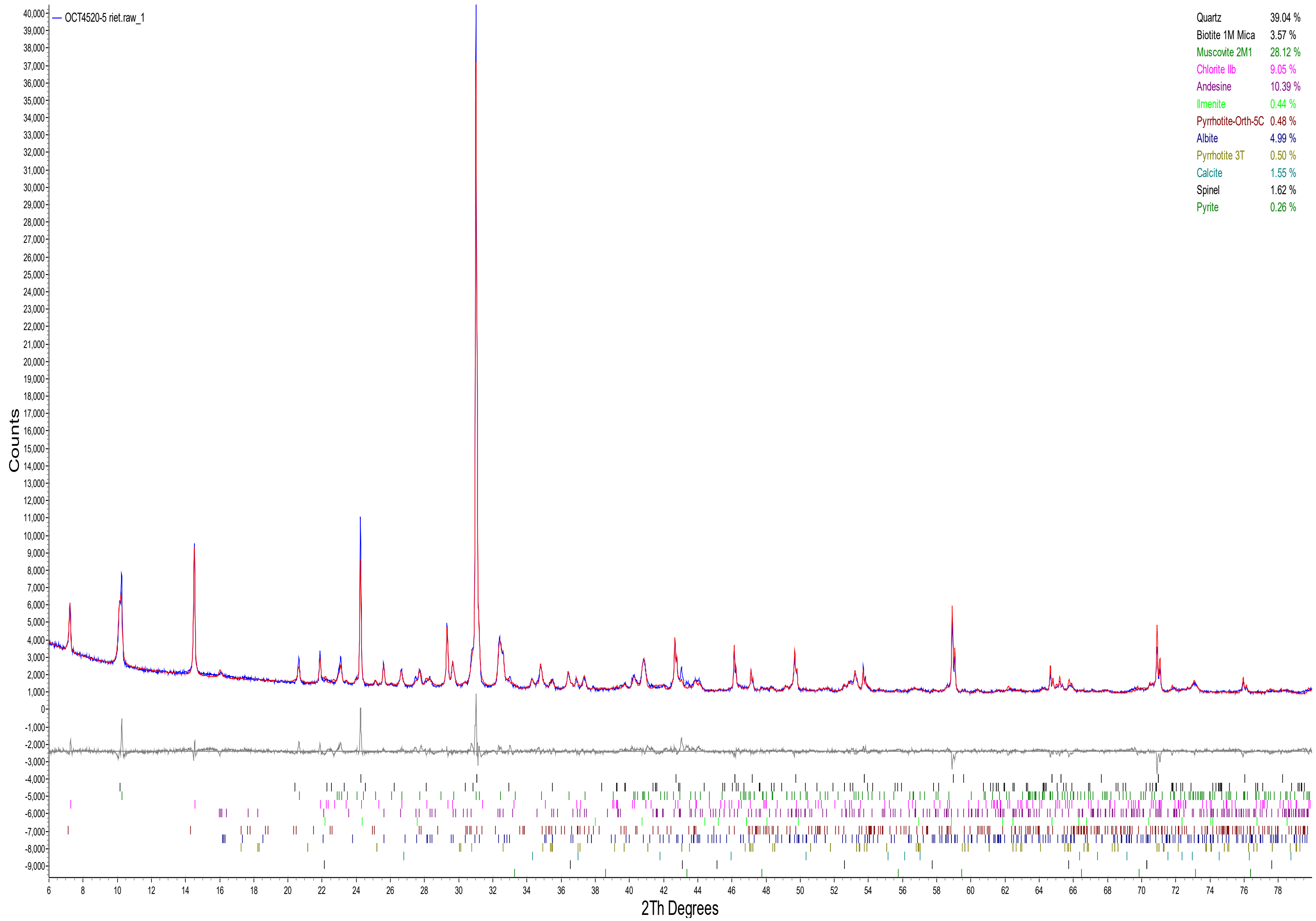
HC 5



# QEMSCAN DATA

**prepared for:**

## Lorax Environmental Services Ltd

**CA20I-14936-01**
**MI7013-OCT18**
**August 20, 2019**

**Prepared by:**


**Lain Glossop/Sarah Prout**
**Senior Mineralogist/Senior Mineralogist**

SGS Canada
3260 Production Way
Burnaby, BC
Canada, V5A 4W4

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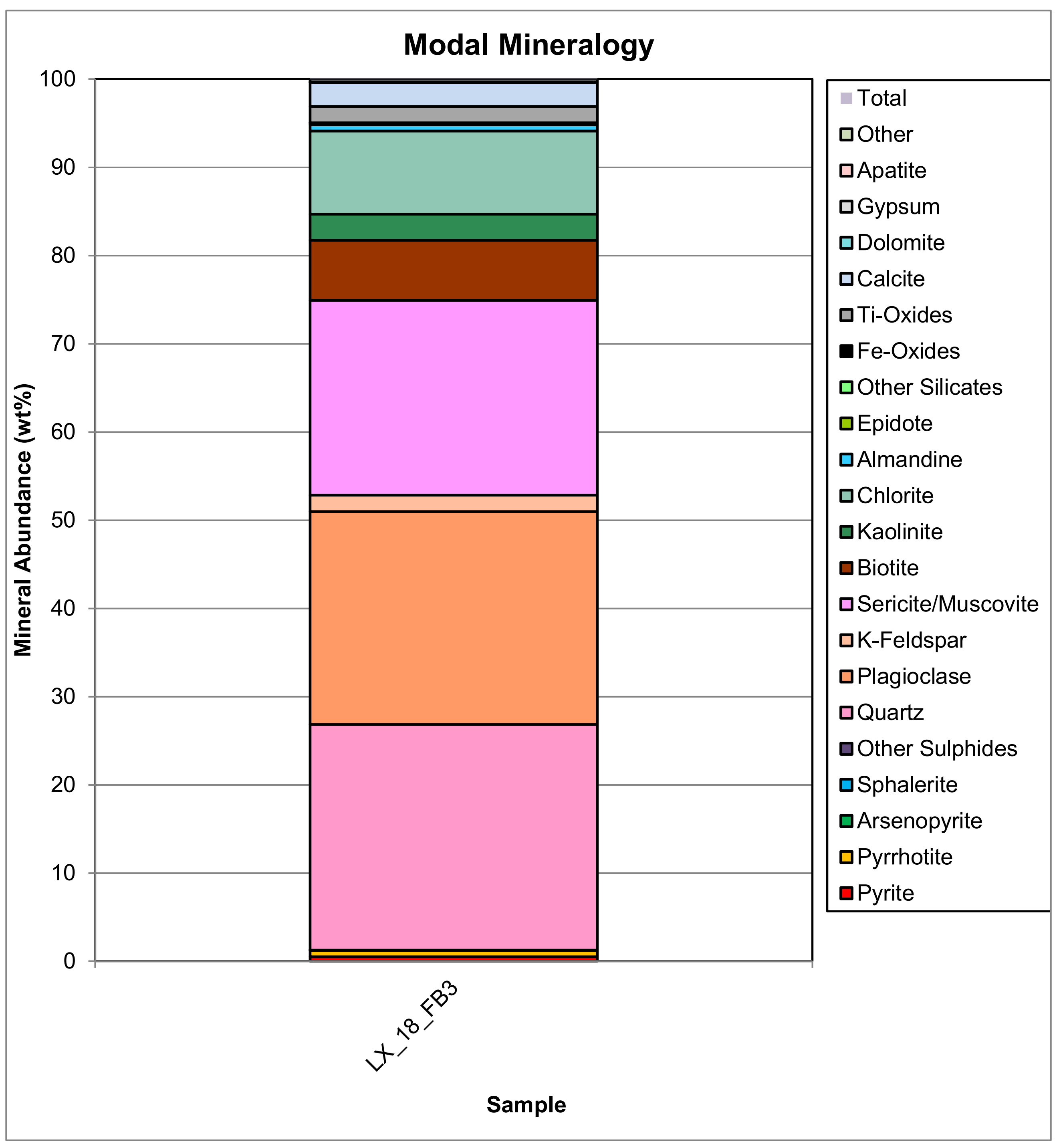
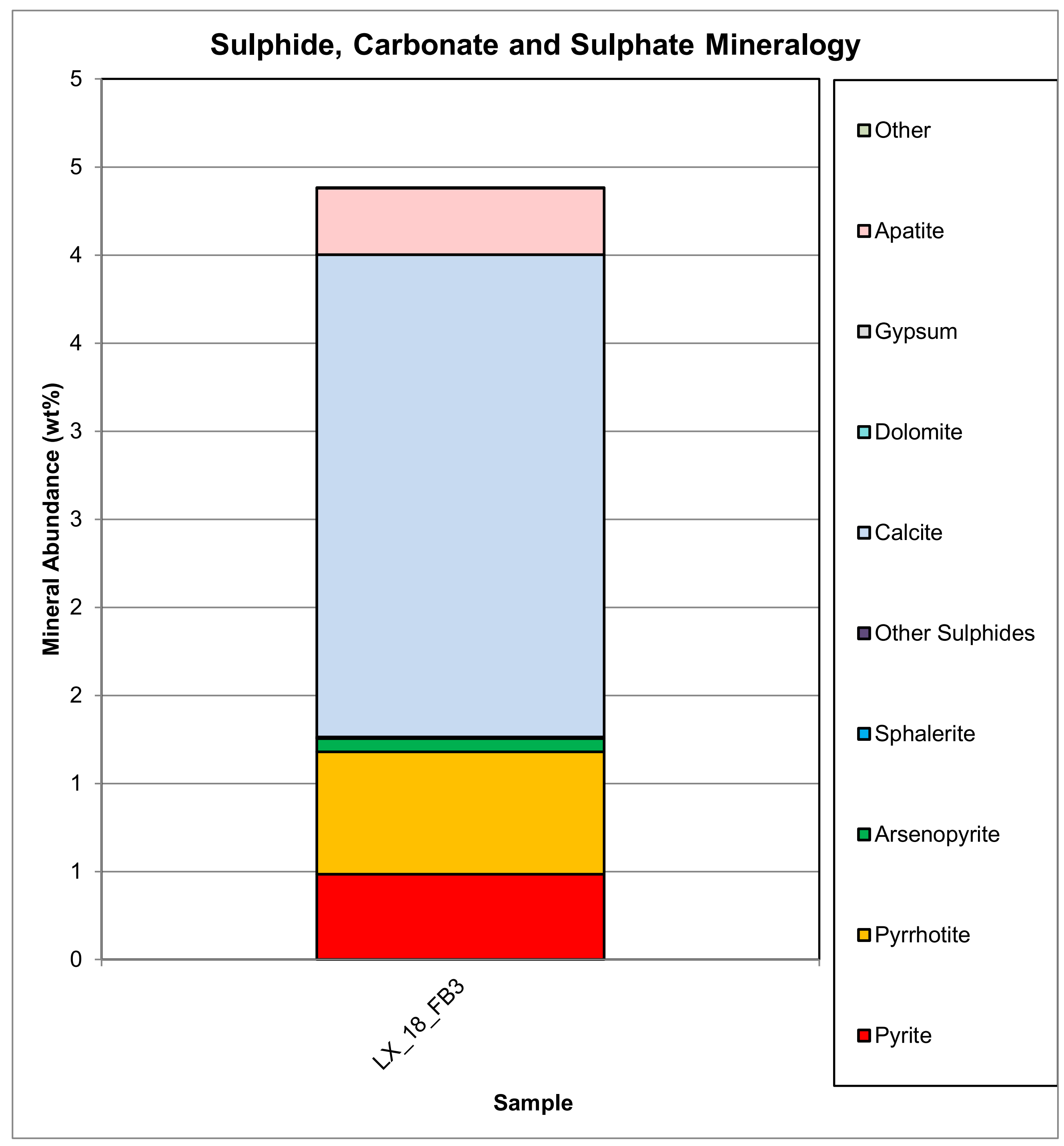
| Mineral Mass % | LX_18_FB3 |
|---|---|
| Pyrite | 0.48 |
| Pyrrhotite | 0.69 |
| Arsenopyrite | 0.08 |
| Sphalerite | 0.00 |
| Other Sulphides | 0.01 |
| Quartz | 25.6 |
| Plagioclase | 24.1 |
| K-Feldspar | 1.83 |
| Sericite/Muscovite | 22.1 |
| Biotite | 6.81 |
| Kaolinite | 2.95 |
| Chlorite | 9.40 |
| Almandine | 0.72 |
| Epidote | 0.08 |
| Other Silicates | 0.13 |
| Fe-Oxides | 0.01 |
| Ti-Oxides | 1.85 |
| Calcite | 2.74 |
| Dolomite | 0.00 |
| Gypsum | 0.00 |
| Apatite | 0.38 |
| Other | 0.00 |
| **Total** | **100** |



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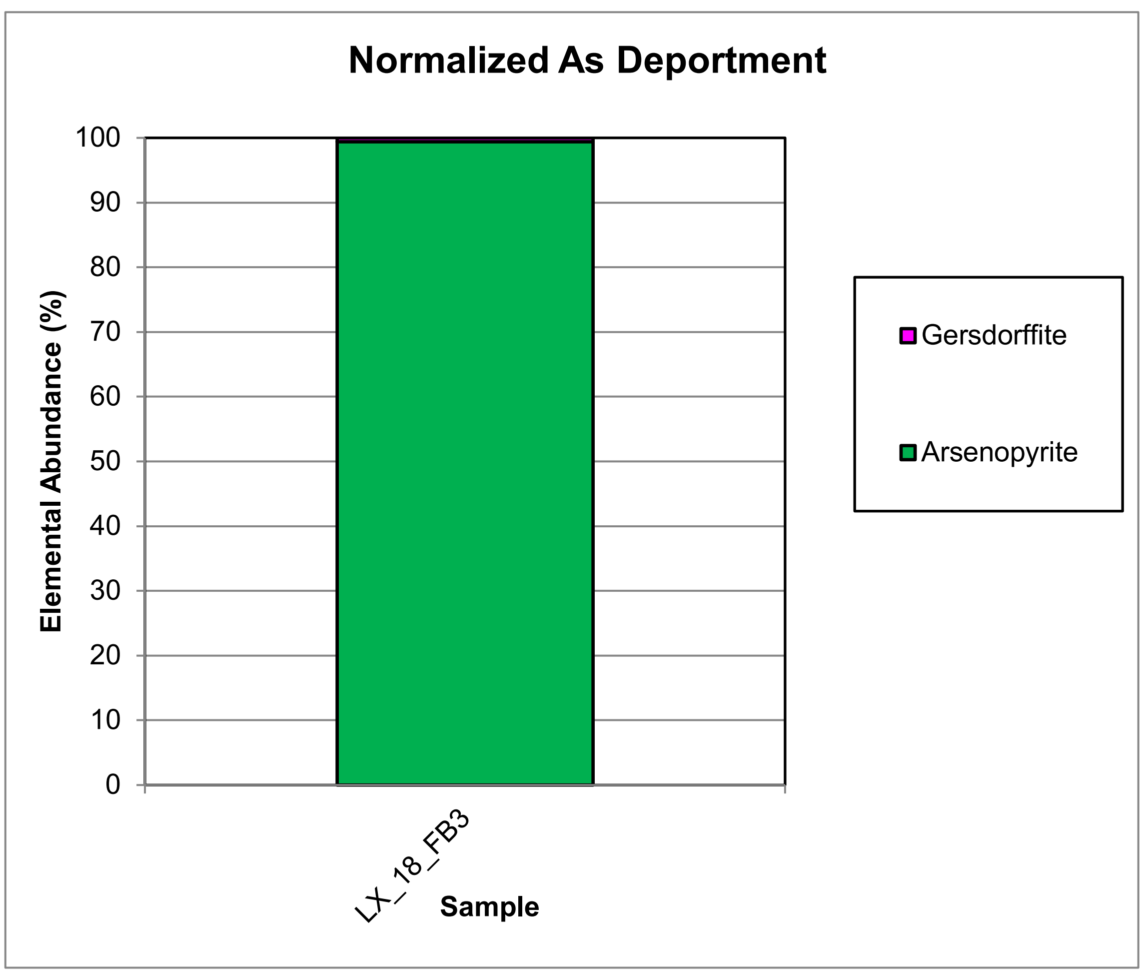
**As Deportment**

**Absolute**

| Mineral M | LX_18_FB3 |
|---|---|
| Arseno| | 0.03 |
| Gersdo | 0.00 |
| Total | 0.03 |

**Normalized**

| Mineral M | LX_18_FB3 |
|---|---|
| Arseno| | 99.4 |
| Gersdo | 0.57 |
| Total | 100 |



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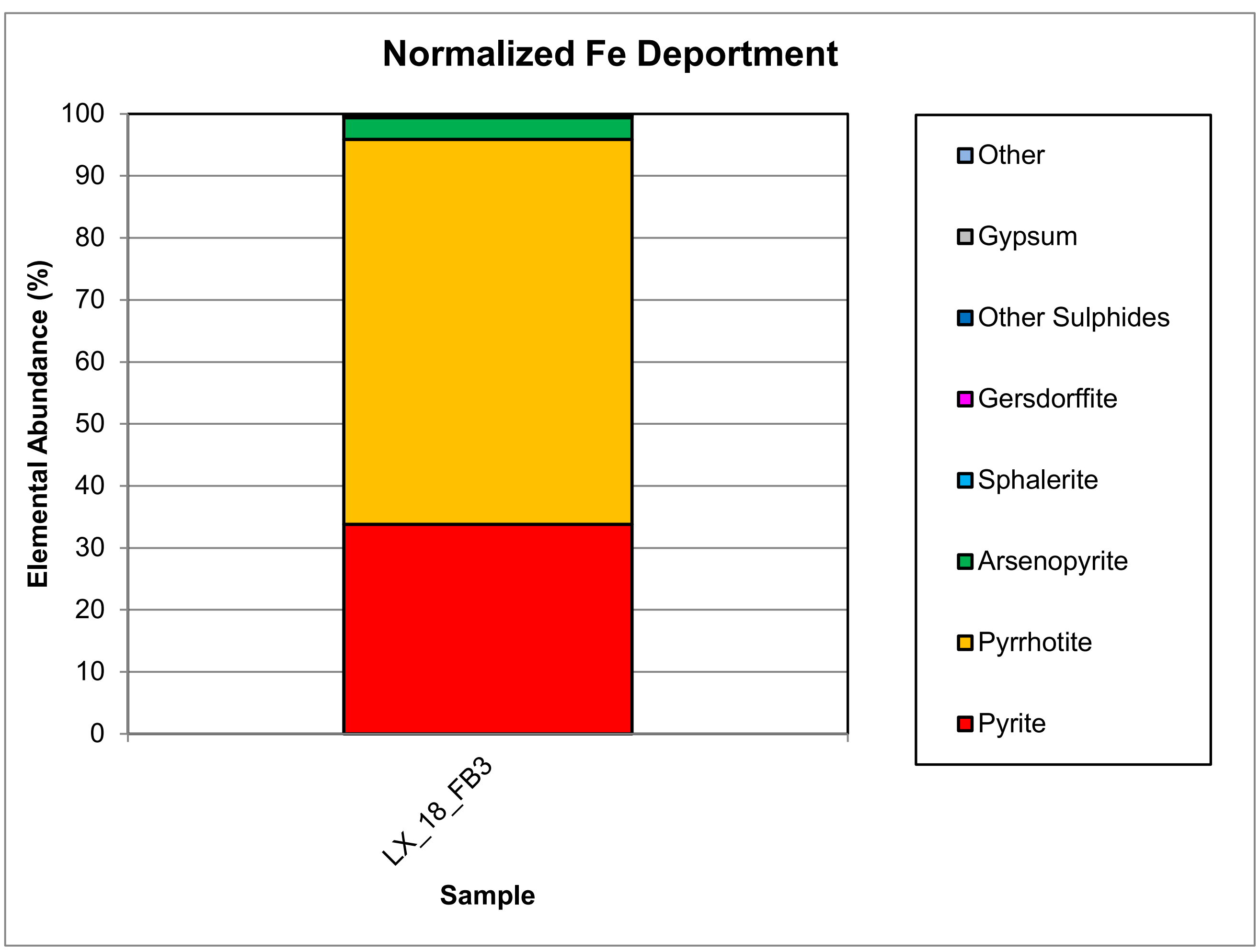
**S Deportment**

**Absolute**

| **Mineral** | **LX_18_FB3** |
|---|---|
| Pyrite | 0.14 |
| Pyrrhoti | 0.26 |
| Arsenoן | 0.01 |
| Sphaler | 0.00 |
| Gersdo | 0.00 |
| Other S | 0.00 |
| Gypsun | 0.00 |
| Other | 0.00 |
| Total | 0.42 |

**Normalized**

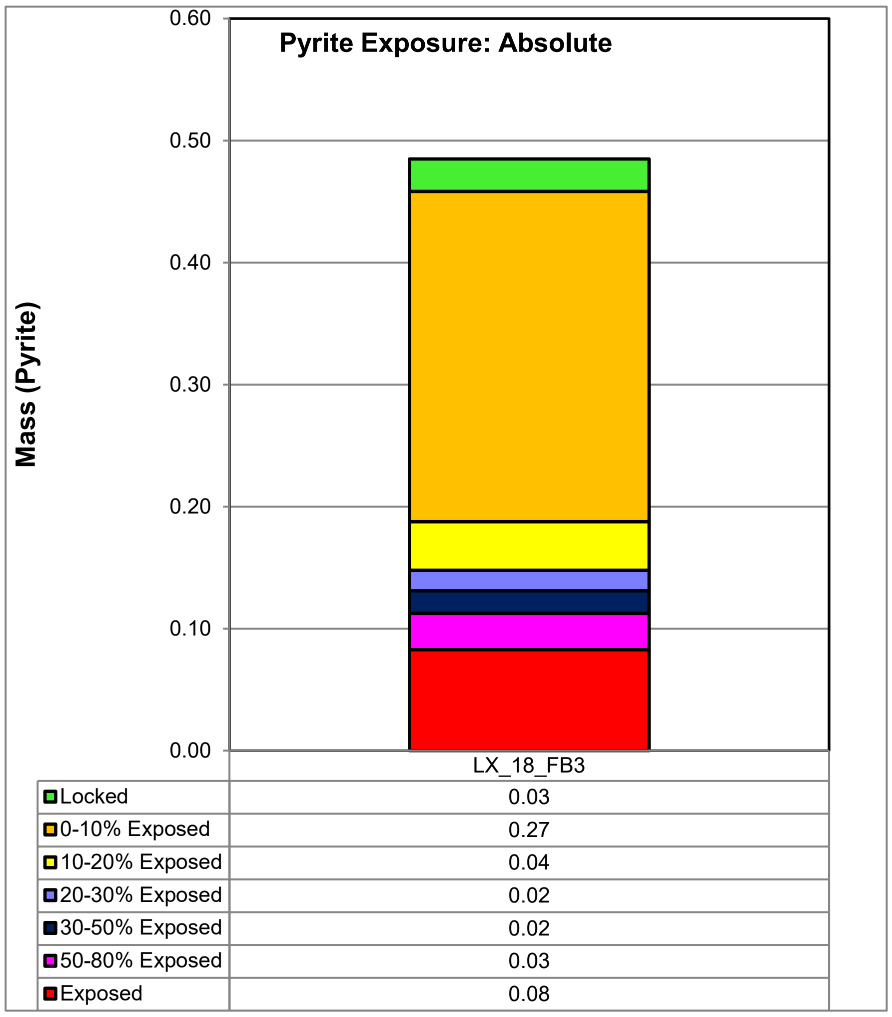
| **Mineral** | **LX_18_FB3** |
|---|---|
| Pyrite | 33.8 |
| Pyrrhoti | 62.1 |
| Arsenoן | 3.53 |
| Sphaler | 0.25 |
| Gersdo | 0.02 |
| Other S | 0.30 |
| Gypsun | 0.03 |
| Other | 0.02 |
| Total | 100 |



*High Definition Mineralogical Analysis using QEMSCAN (Quantitative Evaluation of Materials by Scanning Electron Microscopy)*

**Pyrite Exposure**

**Pyrite Exposure: Absolute**



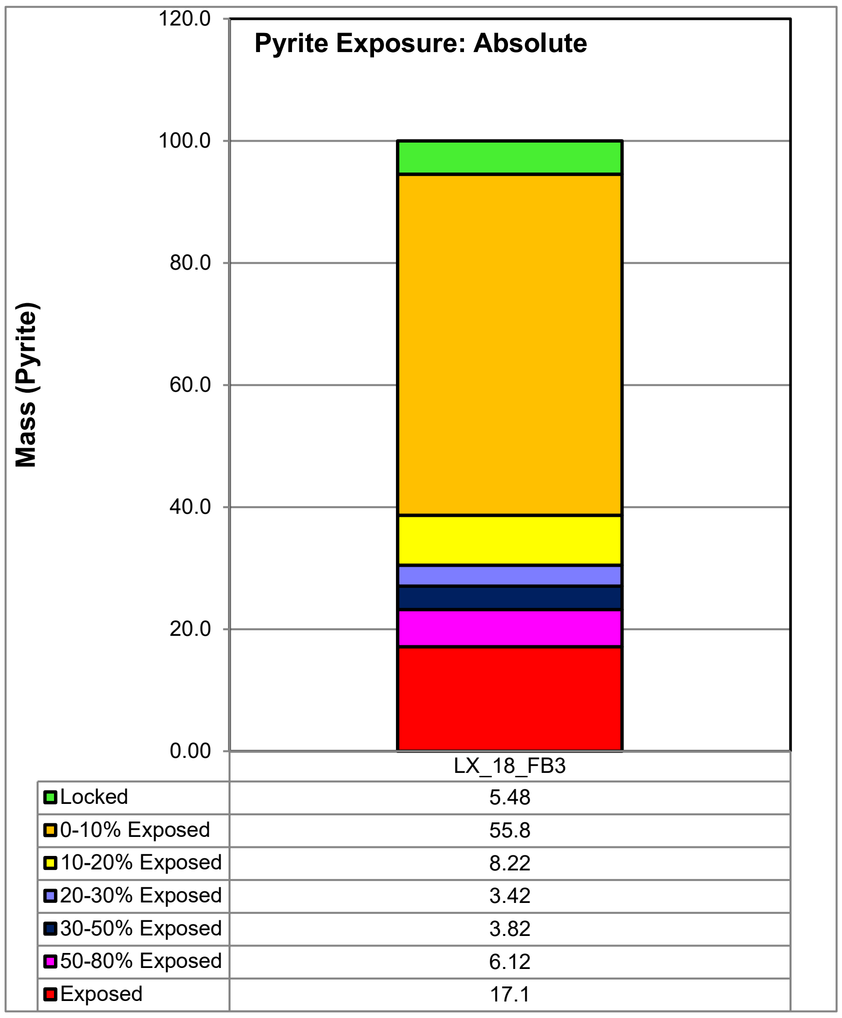

**Absolute Mass of Pyrite Across Samples**

| Mineral Name | LX_18_FB3 | LX_18_FB4 |
|---|---|---|
| **Exposed** | 0.08 | 0.00 |
| **50-80% Exposed** | 0.03 | 0.00 |
| **30-50% Exposed** | 0.02 | 0.00 |
| **20-30% Exposed** | 0.02 | 0.01 |
| **10-20% Exposed** | 0.04 | 0.41 |
| **0-10% Exposed** | 0.27 | 0.16 |
| **Locked** | 0.03 | 0.02 |
| **Total** | 0.48 | 0.60 |

*High Definition Mineralogical Analysis using QEMSCAN (Quantitative Evaluation of Materials by Scanning Electron Microscopy)*

**Pyrite Exposure**
**Pyrite Exposure: Absolute**

**Pyrite Exposure: Normalized**



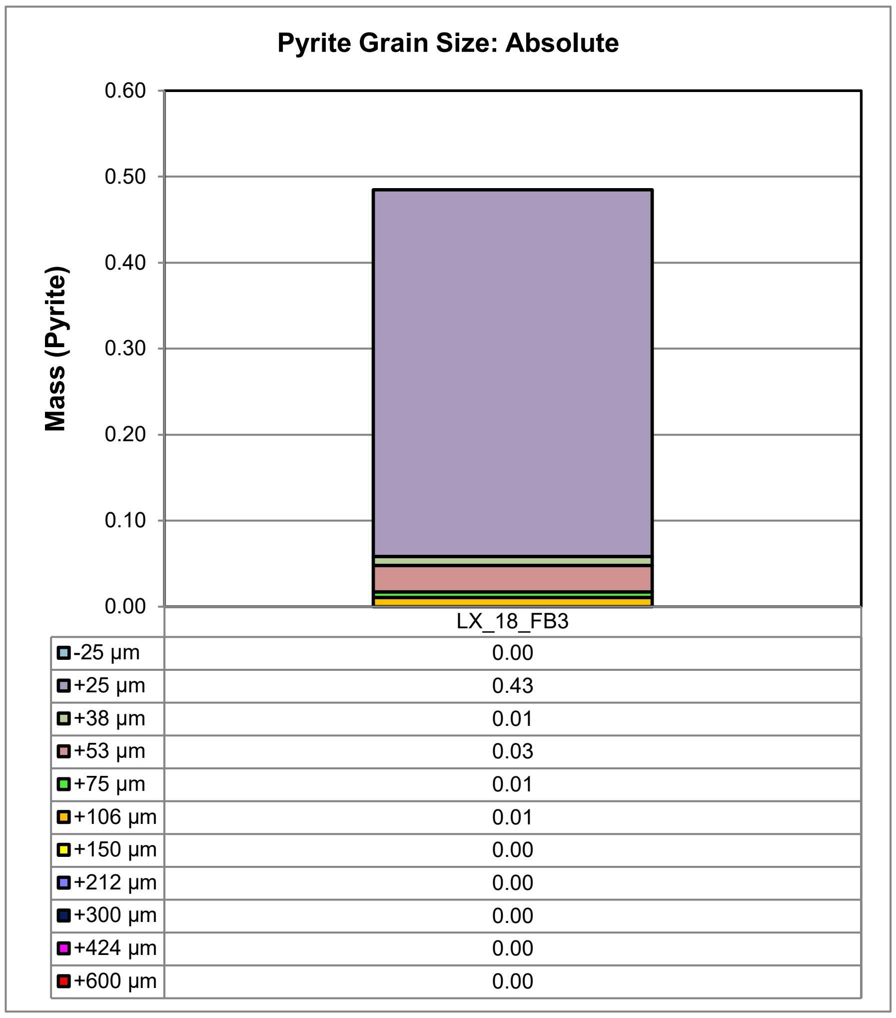

**Normalized Mass of Pyrite Across Samples**

| Mineral Name | LX_18_FB3 |
|---|---|
| Exposed | 17.1 |
| 50-80% Exposed | 6.12 |
| 30-50% Exposed | 3.82 |
| 20-30% Exposed | 3.42 |
| 10-20% Exposed | 8.22 |
| 0-10% Exposed | 55.8 |
| Locked | 5.48 |
| Total | 100.0 |

*High Definition Mineralogical Analysis using QEMSCAN (Quantitative Evaluation of Materials by Scanning Electron Microscopy)*

**Pyrite Grain Size**

**Pyrite Grain Size: Absolute**




**Absolute Mass of Pyrite Across Samples**

| Mineral Name | LX_18_FB3 |
|---|---|
| **+600 µm** | 0.00 |
| **+424 µm** | 0.00 |
| **+300 µm** | 0.00 |
| **+212 µm** | 0.00 |
| **+150 µm** | 0.00 |
| **+106 µm** | 0.01 |
| **+75 µm** | 0.01 |
| **+53 µm** | 0.03 |
| **+38 µm** | 0.01 |
| **+25 µm** | 0.43 |
| **-25 µm** | 0.00 |
| **Total** | 0.48 |

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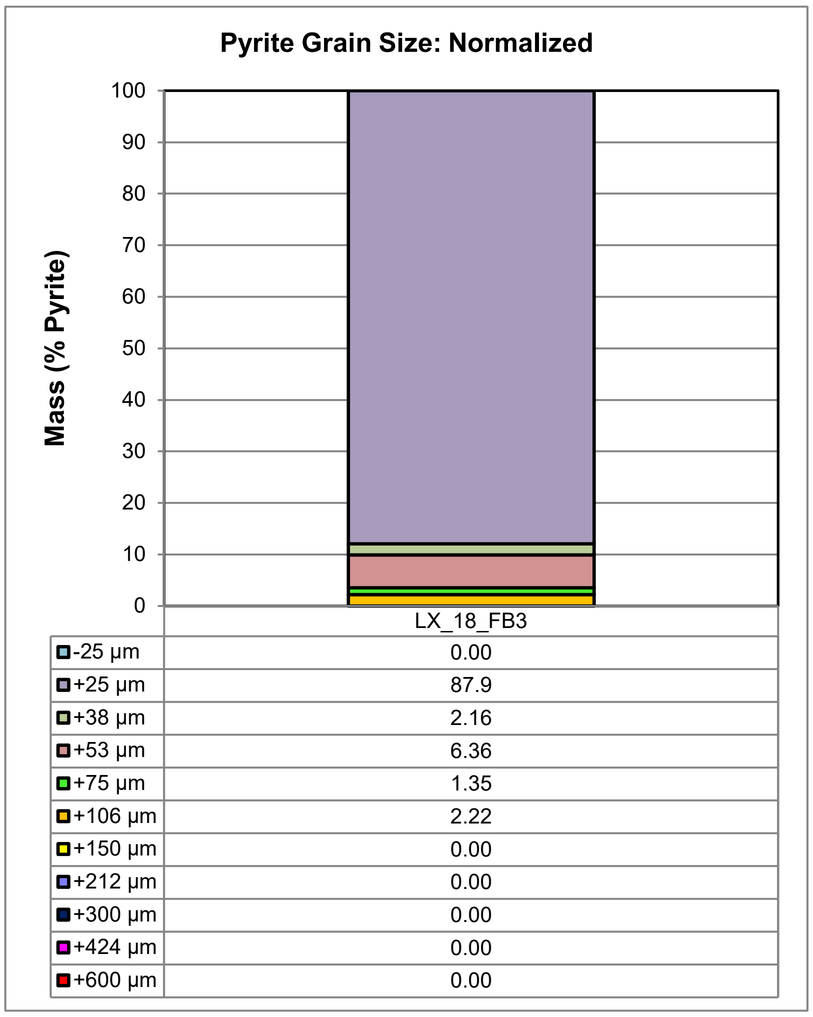
**Pyrite Grain Size**
**Pyrite Grain Size: Absolute**

**Pyrite Grain Size: Normalized**




**Normalized Mass of Pyrite Across Samples**

| Mineral Name | LX_18_FB3 |
|---|---|
| +600 µm | 0.00 |
| +424 µm | 0.00 |
| +300 µm | 0.00 |
| +212 µm | 0.00 |
| +150 µm | 0.00 |
| +106 µm | 2.22 |
| +75 µm | 1.35 |
| +53 µm | 6.36 |
| +38 µm | 2.16 |
| +25 µm | 87.9 |
| -25 µm | 0.00 |
| Total | 100.0 |

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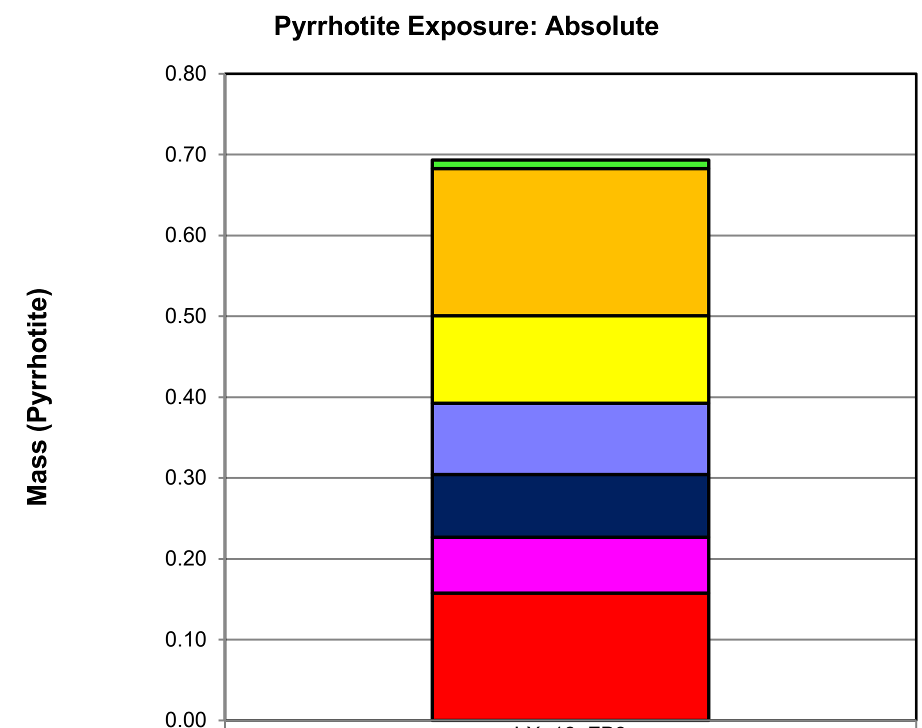
*High Definition Mineralogical Analysis using QEMSCAN (Quantitative Evaluation of Materials by Scanning Electron Microscopy)*

**Pyrrhotite Exposure**
**Pyrrhotite Exposure: Absolute**




| | LX_18_FB3 |
|---|---|
| Locked | 0.01 |
| 0-10% Exposed | 0.18 |
| 10-20% Exposed | 0.11 |
| 20-30% Exposed | 0.09 |
| 30-50% Exposed | 0.08 |
| 50-80% Exposed | 0.07 |
| Exposed | 0.16 |

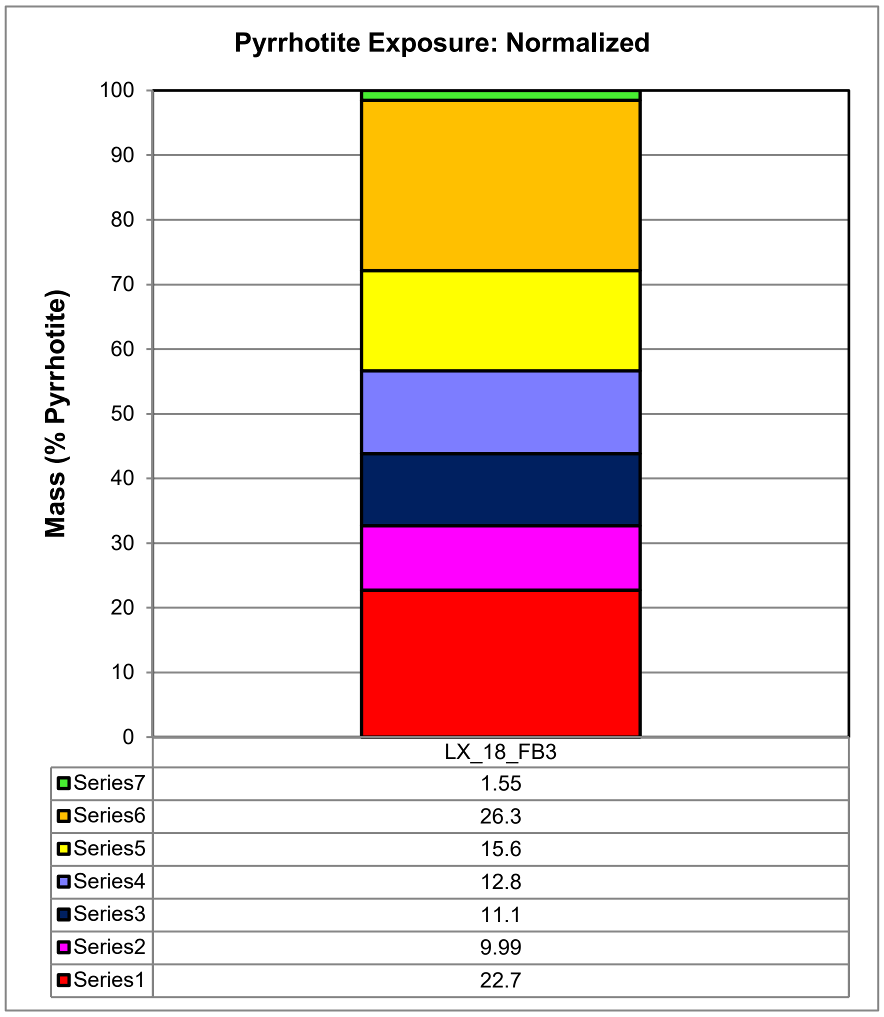
**Absolute Mass of Pyrrhotite Across Samples**

| Mineral Name | LX_18_FB3 |
|---|---|
| Exposed | 0.16 |
| 50-80% Exposed | 0.07 |
| 30-50% Exposed | 0.08 |
| 20-30% Exposed | 0.09 |
| 10-20% Exposed | 0.11 |
| 0-10% Exposed | 0.18 |
| Locked | 0.01 |
| Total | 0.69 |

*High Definition Mineralogical Analysis using QEMSCAN (Quantitative Evaluation of Materials by Scanning Electron Microscopy)*

**Pyrrhotite Exposure**
**Pyrrhotite Exposure: Absolute**

**Pyrrhotite Exposure: Normalized**




**Normalized Mass of Pyrrhotite Across Samples**

| Mineral Name | LX_18_FB3 |
|---|---|
| Exposed | 22.7 |
| 50-80% Exposed | 9.99 |
| 30-50% Exposed | 11.1 |
| 20-30% Exposed | 12.8 |
| 10-20% Exposed | 15.6 |
| 0-10% Exposed | 26.3 |
| Locked | 1.55 |
| Total | 100.0 |

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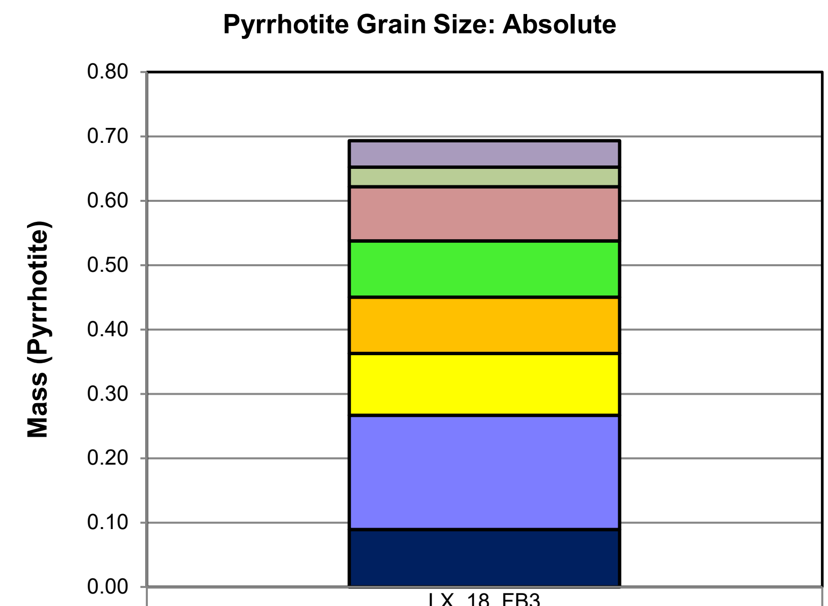
*High Definition Mineralogical Analysis using QEMSCAN (Quantitative Evaluation of Materials by Scanning Electron Microscopy)*

**Pyrrhotite Grain Size**

**Pyrrhotite Grain Size: Absolute**




| | LX_18_FB3 |
|---|---|
| -25 µm | 0.00 |
| +25 µm | 0.04 |
| +38 µm | 0.03 |
| +53 µm | 0.08 |
| +75 µm | 0.09 |
| +106 µm | 0.09 |
| +150 µm | 0.10 |
| +212 µm | 0.18 |
| +300 µm | 0.09 |
| +424 µm | 0.00 |
| +600 µm | 0.00 |

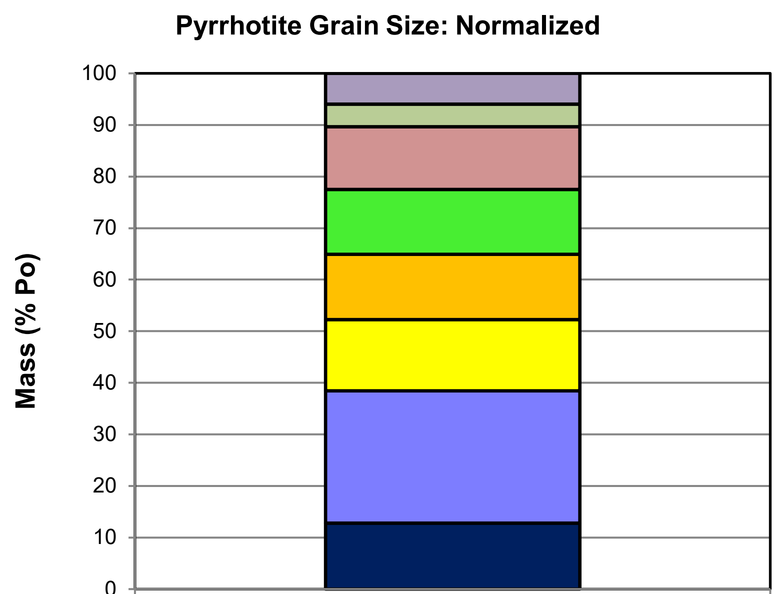
**Absolute Mass of Pyrrhotite Across Samples**

| Mineral Name | LX_18_FB3 |
|---|---|
| +600 µm | 0.00 |
| +424 µm | 0.00 |
| +300 µm | 0.09 |
| +212 µm | 0.18 |
| +150 µm | 0.10 |
| +106 µm | 0.09 |
| +75 µm | 0.09 |
| +53 µm | 0.08 |
| +38 µm | 0.03 |
| +25 µm | 0.04 |
| -25 µm | 0.00 |
| Total | 0.69 |

*High Definition Mineralogical Analysis using QEMSCAN (Quantitative Evaluation of Materials by Scanning Electron Microscopy)*

**Pyrrhotite Grain Size**
**Pyrrhotite Grain Size: Absolute**

**Pyrrhotite Grain Size: Normalized**




| | LX_18_FB3 |
|---|---|
| -25 µm | 0.00 |
| +25 µm | 5.97 |
| +38 µm | 4.36 |
| +53 µm | 12.2 |
| +75 µm | 12.5 |
| +106 µm | 12.7 |
| +150 µm | 13.8 |
| +212 µm | 25.6 |
| +300 µm | 12.8 |
| +424 µm | 0.00 |
| +600 µm | 0.00 |

**Normalized Mass of Pyrrhotite Across Samples**

| Mineral Name | LX_18_FB3 |
|---|---|
| +600 µm | 0.00 |
| +424 µm | 0.00 |
| +300 µm | 12.8 |
| +212 µm | 25.6 |
| +150 µm | 13.8 |
| +106 µm | 12.7 |
| +75 µm | 12.5 |
| +53 µm | 12.2 |
| +38 µm | 4.36 |
| +25 µm | 5.97 |
| -25 µm | 0.00 |
| Total | 100.0 |

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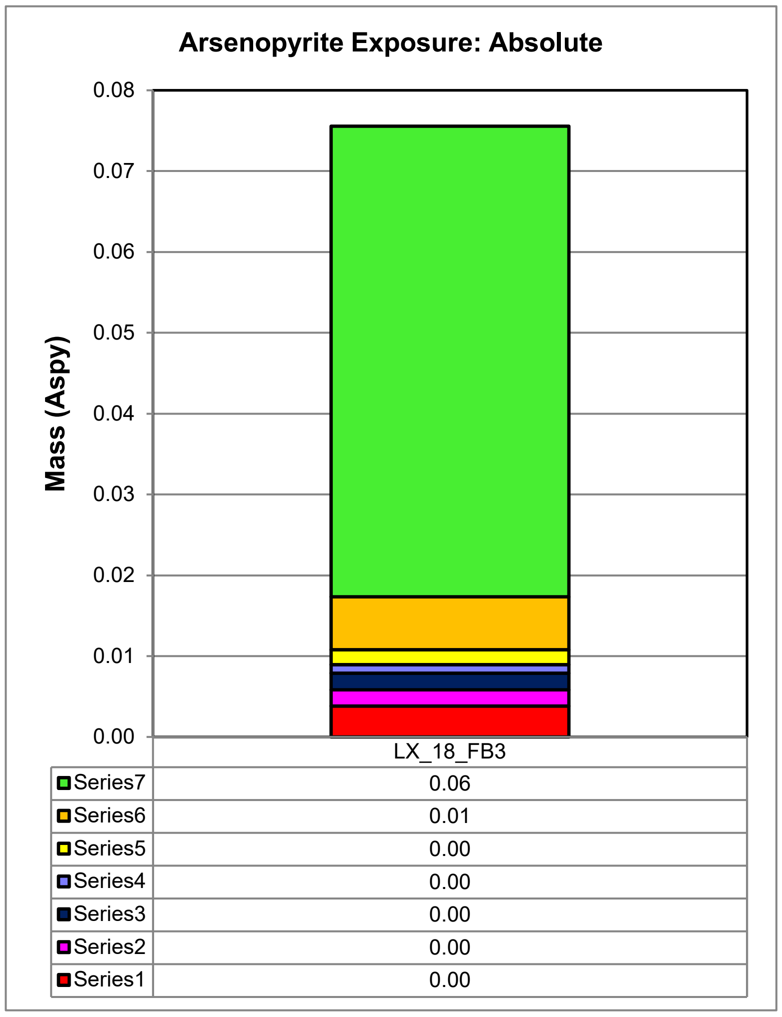
*High Definition Mineralogical Analysis using QEMSCAN (Quantitative Evaluation of Materials by Scanning Electron Microscopy)*

**Arsenopyrite Exposure**
**Arsenopyrite Exposure: Absolute**




**Absolute Mass of Arsenopyrite Across Samples**

| Mineral Name | LX_18_FB3 |
|---|---|
| Exposed | 0.00 |
| 50-80% Exposed | 0.00 |
| 30-50% Exposed | 0.00 |
| 20-30% Exposed | 0.00 |
| 10-20% Exposed | 0.00 |
| 0-10% Exposed | 0.01 |
| Locked | 0.06 |
| Total | 0.08 |

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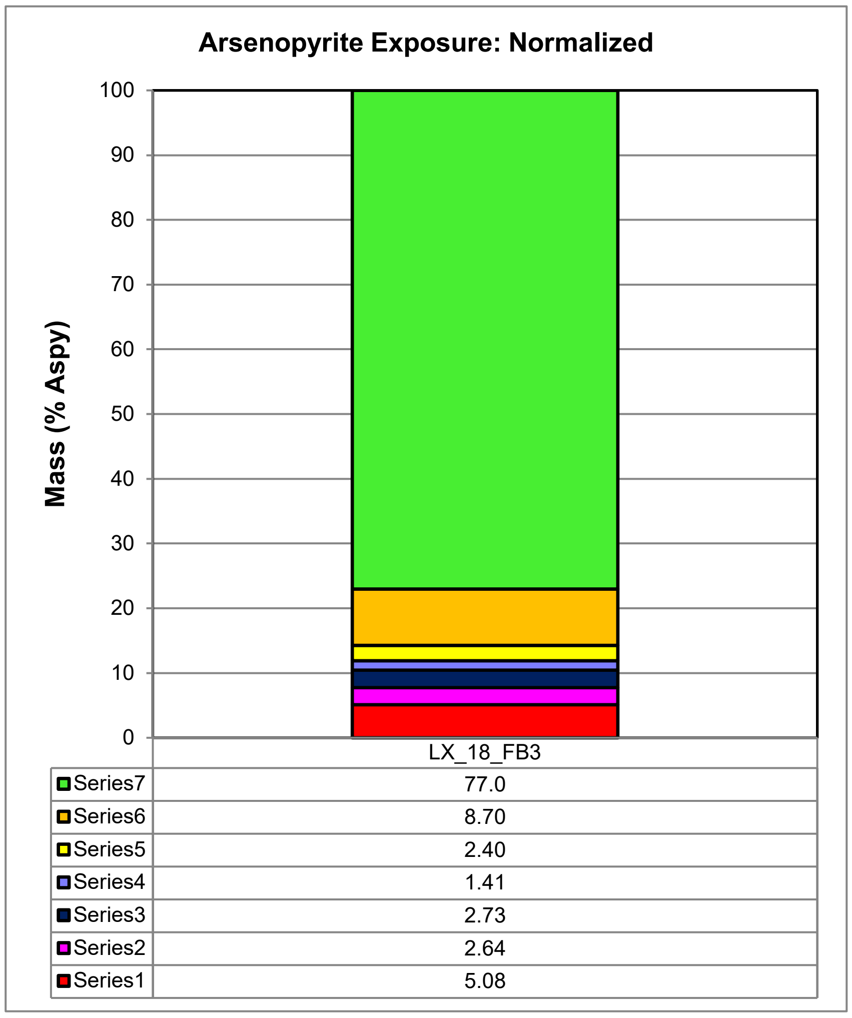
*High Definition Mineralogical Analysis using QEMSCAN (Quantitative Evaluation of Materials by Scanning Electron Microscopy)*

**Arsenopyrite Exposure**
**Arsenopyrite Exposure: Absolute**

**Arsenopyrite Exposure: Normalized**




**Normalized Mass of Arsenopyrite Across Samples**

| Mineral Name | LX_18_FB3 |
|---|---|
| Exposed | 5.08 |
| 50-80% Exposed | 2.64 |
| 30-50% Exposed | 2.73 |
| 20-30% Exposed | 1.41 |
| 10-20% Exposed | 2.40 |
| 0-10% Exposed | 8.70 |
| Locked | 77.0 |
| Total | 100.0 |

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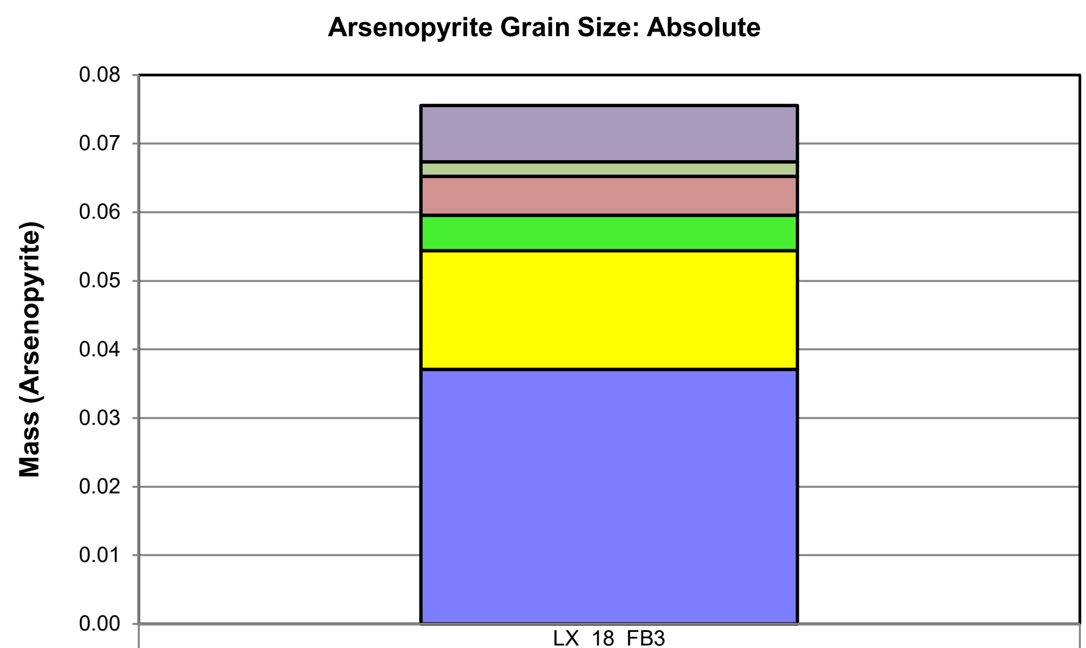
*High Definition Mineralogical Analysis using QEMSCAN (Quantitative Evaluation of Materials by Scanning Electron Microscopy)*

**Arsenopyrite Grain Size**
**Arsenopyrite Grain Size: Absolute**




| | LX_18_FB3 |
|---|---|
| +25 µm | 0.01 |
| +38 µm | 0.00 |
| +53 µm | 0.01 |
| +75 µm | 0.01 |
| +106 µm | 0.00 |
| +150 µm | 0.02 |
| +212 µm | 0.04 |
| +300 µm | 0.00 |
| +424 µm | 0.00 |
| +600 µm | 0.00 |

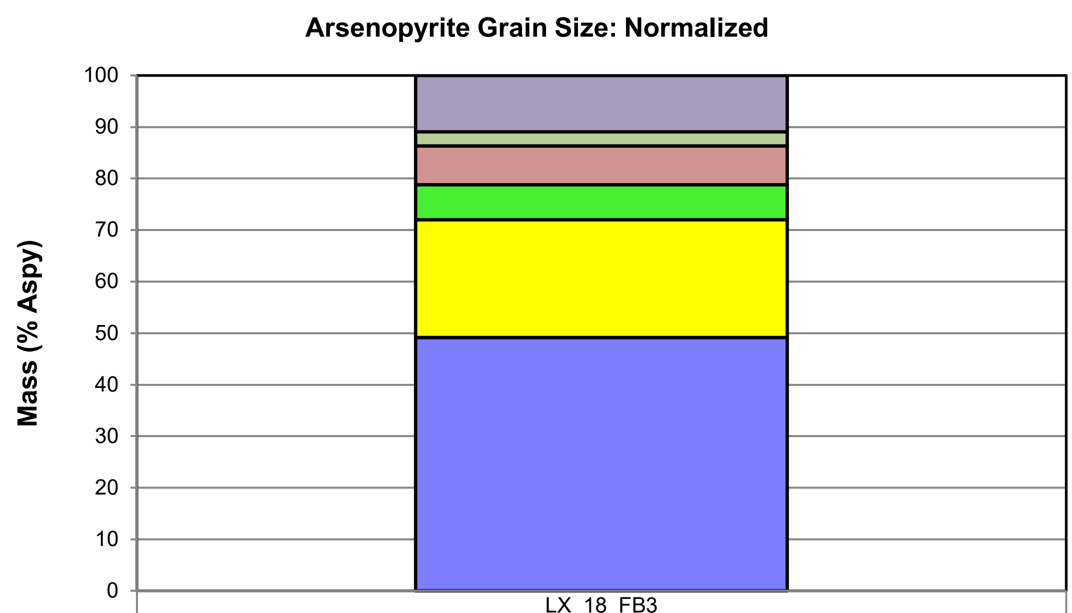
**Absolute Mass of Arsenopyrite Across Samples**

| Mineral Name | LX_18_FB3 |
|---|---|
| +600 µm | 0.00 |
| +424 µm | 0.00 |
| +300 µm | 0.00 |
| +212 µm | 0.04 |
| +150 µm | 0.02 |
| +106 µm | 0.00 |
| +75 µm | 0.01 |
| +53 µm | 0.01 |
| +38 µm | 0.00 |
| +25 µm | 0.01 |
| -25 µm | 0.00 |
| Total | 0.08 |

*High Definition Mineralogical Analysis using QEMSCAN (Quantitative Evaluation of Materials by Scanning Electron Microscopy)*

**Arsenopyrite Grain Size**
**Arsenopyrite Grain Size: Absolute**

**Arsenopyrite Grain Size: Normalized**




| | LX_18_FB3 |
|---|---|
| -25 µm | 0.00 |
| +25 µm | 10.9 |
| +38 µm | 2.76 |
| +53 µm | 7.52 |
| +75 µm | 6.80 |
| +106 µm | 0.00 |
| +150 µm | 22.9 |
| +212 µm | 49.1 |
| +300 µm | 0.00 |
| +424 µm | 0.00 |
| +600 µm | 0.00 |

**Normalized Mass of Arsenopyrite Across Samples**

| Mineral Name | LX_18_FB3 |
|---|---|
| +600 µm | 0.00 |
| +424 µm | 0.00 |
| +300 µm | 0.00 |
| +212 µm | 49.1 |
| +150 µm | 22.9 |
| +106 µm | 0.00 |
| +75 µm | 6.80 |
| +53 µm | 7.52 |
| +38 µm | 2.76 |
| +25 µm | 10.9 |
| -25 µm | 0.00 |
| Total | 100.0 |

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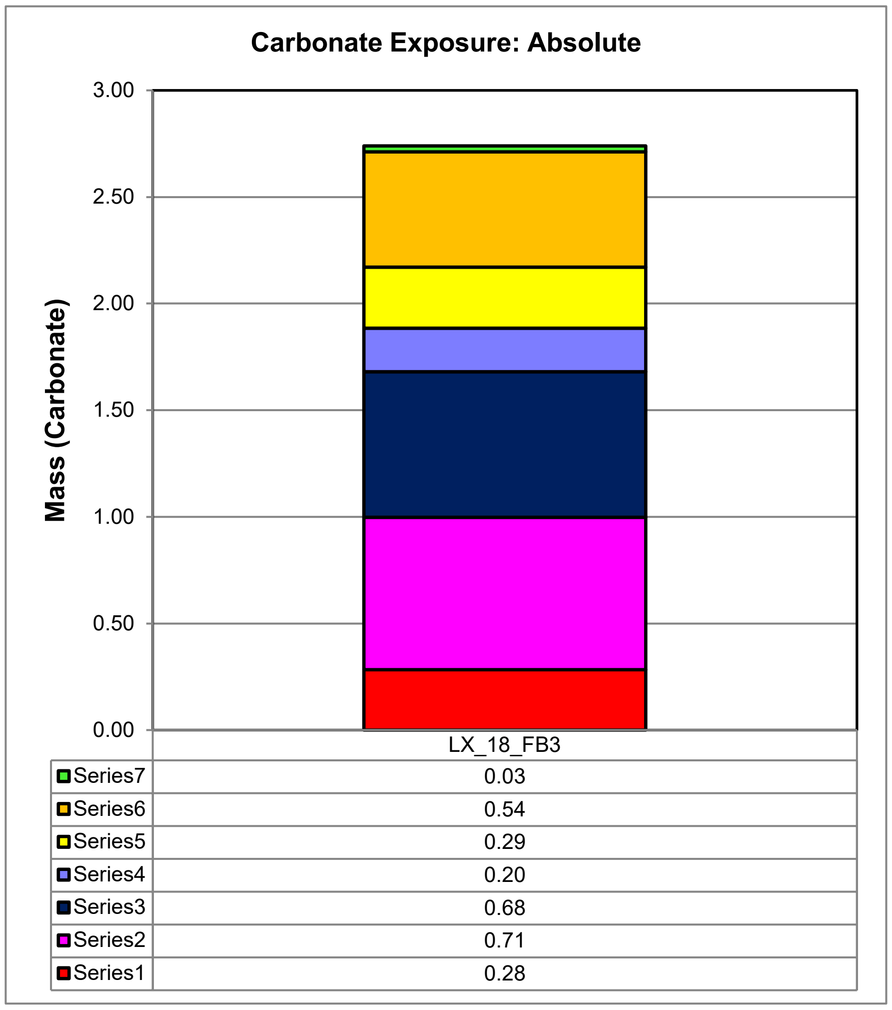
*High Definition Mineralogical Analysis using QEMSCAN (Quantitative Evaluation of Materials by Scanning Electron Microscopy)*

**Carbonate Exposure**
**Carbonate Exposure: Absolute**




**Absolute Mass of Carbonate Across Samples**

| Mineral Name | LX_18_FB3 |
|---|---|
| Exposed | 0.28 |
| 50-80% Exposed | 0.71 |
| 30-50% Exposed | 0.68 |
| 20-30% Exposed | 0.20 |
| 10-20% Exposed | 0.29 |
| 0-10% Exposed | 0.54 |
| Locked | 0.03 |
| Total | 2.74 |

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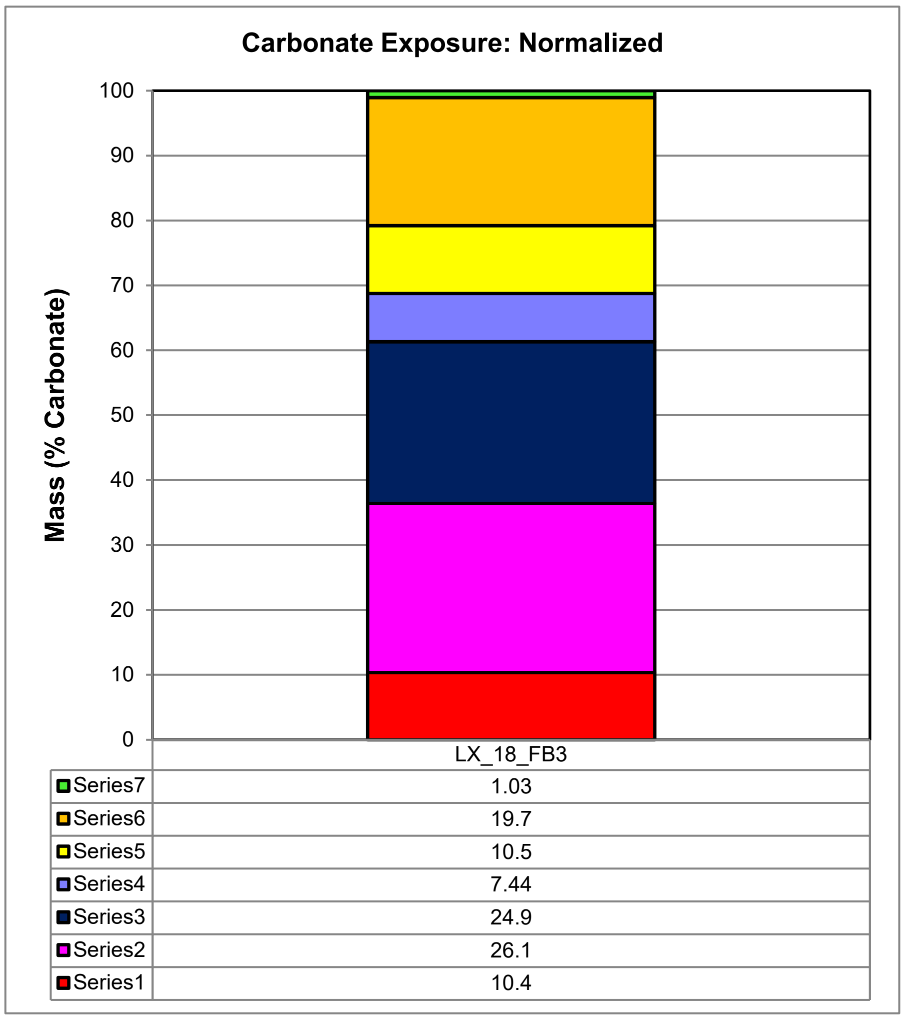
*High Definition Mineralogical Analysis using QEMSCAN (Quantitative Evaluation of Materials by Scanning Electron Microscopy)*

**Carbonate Exposure**
**Carbonate Exposure: Absolute**

**Carbonate Exposure: Normalized**




**Normalized Mass of Carbonate Across Samples**

| Mineral Name | LX_18_FB3 |
|---|---|
| Exposed | 10.4 |
| 50-80% Exposed | 26.1 |
| 30-50% Exposed | 24.9 |
| 20-30% Exposed | 7.44 |
| 10-20% Exposed | 10.5 |
| 0-10% Exposed | 19.7 |
| Locked | 1.03 |
| Total | 100.0 |

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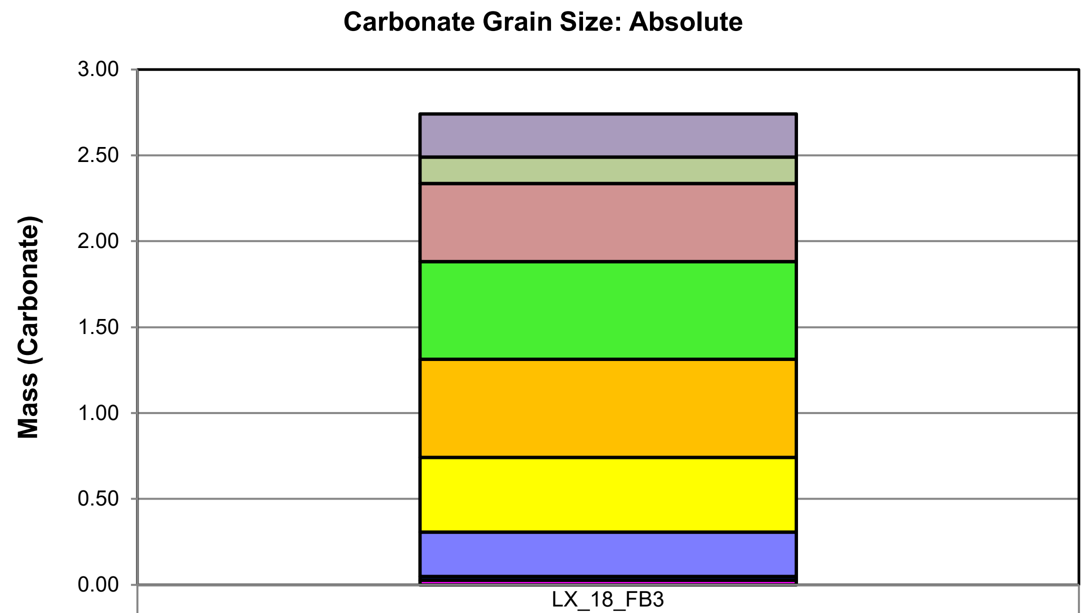
*High Definition Mineralogical Analysis using QEMSCAN (Quantitative Evaluation of Materials by Scanning Electron Microscopy)*

**Carbonate Grain Size**
**Carbonate Grain Size: Absolute**




| | LX_18_FB3 |
|---|---|
| -25 µm | 0.00 |
| +25 µm | 0.25 |
| +38 µm | 0.16 |
| +53 µm | 0.45 |
| +75 µm | 0.57 |
| +106 µm | 0.57 |
| +150 µm | 0.44 |
| +212 µm | 0.26 |
| +300 µm | 0.02 |
| +424 µm | 0.03 |
| +600 µm | 0.00 |

**Absolute Mass of Carbonate Across Samples**

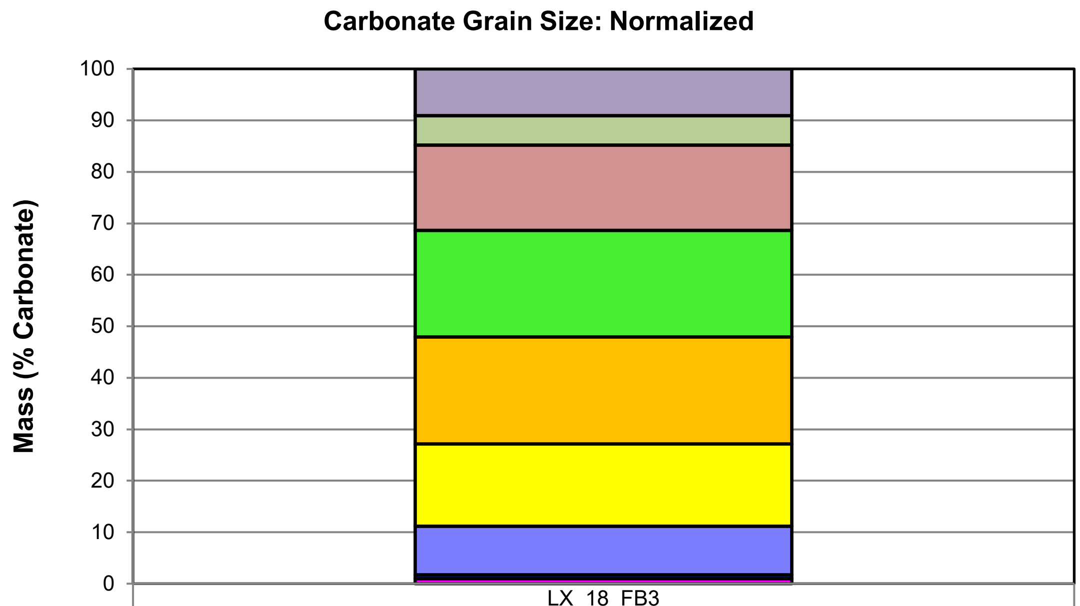
| Mineral Name | LX_18_FB3 | LX_18_FB4 |
|---|---|---|
| **+600 µm** | 0.00 | 0.00 |
| **+424 µm** | 0.03 | 0.02 |
| **+300 µm** | 0.02 | 0.00 |
| **+212 µm** | 0.26 | 0.01 |
| **+150 µm** | 0.44 | 0.03 |
| **+106 µm** | 0.57 | 0.12 |
| **+75 µm** | 0.57 | 0.11 |
| **+53 µm** | 0.45 | 0.12 |
| **+38 µm** | 0.16 | 0.05 |
| **+25 µm** | 0.25 | 0.11 |
| **-25 µm** | 0.00 | 0.00 |
| **Total** | 2.74 | 0.58 |

*High Definition Mineralogical Analysis using QEMSCAN (Quantitative Evaluation of Materials by Scanning Electron Microscopy)*

**Carbonate Grain Size**

**Carbonate Grain Size: Absolute**

**Carbonate Grain Size: Normalized**




| | LX_18_FB3 |
|---|---|
| -25 µm | 0.00 |
| +25 µm | 9.09 |
| +38 µm | 5.67 |
| +53 µm | 16.6 |
| +75 µm | 20.7 |
| +106 µm | 20.8 |
| +150 µm | 15.9 |
| +212 µm | 9.42 |
| +300 µm | 0.77 |
| +424 µm | 0.98 |
| +600 µm | 0.00 |

**Normalized Mass of Carbonate Across Samples**

| Mineral Name | LX_18_FB3 | LX_18_FB4 |
|---|---|---|
| **+600 µm** | 0.00 | 0.00 |
| **+424 µm** | 0.98 | 3.68 |
| **+300 µm** | 0.77 | 0.00 |
| **+212 µm** | 9.42 | 2.48 |
| **+150 µm** | 15.9 | 5.17 |
| **+106 µm** | 20.8 | 21.1 |
| **+75 µm** | 20.7 | 18.6 |
| **+53 µm** | 16.6 | 20.6 |
| **+38 µm** | 5.67 | 8.66 |
| **+25 µm** | 9.09 | 19.7 |
| **-25 µm** | 0.00 | 0.00 |
| **Total** | 100.0 | 100.0 |

# *Appendix X 4-2: Acid-Base Accounting Results*

Atlantic Gold

| Hole ID | From | To | Lithology | Grade | Paste pH | Total S | Sulphate S | Sulphide S | TIC | CaNP | Modified NP | NPR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | m | | | | % | % | % | % CO2 | kg CaCO3/t | kg CaCO3/t | |
| FMS-17-124 | 40 | 41 | AG | Waste | 8.3 | 0.26 | 0.01 | 0.25 | <0.2 | 4.5 | 8 | 1.0 |
| FMS-17-124 | 70 | 71 | AG | Waste | 8.7 | 0.19 | <0.01 | 0.19 | <0.2 | 4.5 | 9 | 1.5 |
| FMS-17-199 | 39 | 40 | AG | Waste | 8.8 | 0.27 | 0.03 | 0.24 | 0.5 | 11.4 | 17 | 2.3 |
| FMS-17-165 | 95 | 96 | AG | Waste | 8.1 | 0.39 | 0.01 | 0.38 | 0.4 | 9.1 | 13 | 1.1 |
| FMS-17-200 | 27 | 28 | AG | Waste | 8.7 | 0.42 | 0.03 | 0.39 | 0.5 | 11.4 | 17 | 1.4 |
| FMS-17-114 | 23 | 28 | AG | Waste | 8.6 | 0.32 | 0.01 | 0.31 | 0.8 | 18.2 | 22 | 2.3 |
| FMS-17-114 | 55 | 60 | AG | Waste | 8.5 | 0.27 | <0.01 | 0.27 | 0.7 | 15.9 | 21 | 2.5 |
| FMS-17-274 | 100 | 105 | AG | Waste | 8.9 | 0.05 | 0.01 | 0.04 | 0.5 | 11.4 | 18 | 14.4 |
| FMS-17-288 | 20 | 25 | AG | Waste | 9.1 | 0.19 | <0.01 | 0.19 | 0.7 | 15.9 | 21 | 3.5 |
| FMS-18-423 | 40 | 45 | AG | Waste | 9 | 0.47 | 0.01 | 0.46 | 0.7 | 15.9 | 26 | 1.8 |
| FMS-18-440 | 110 | 115 | AG | Waste | 9 | 0.37 | 0.01 | 0.36 | 1.1 | 25.0 | 30 | 2.7 |
| # Samples | 11 | | | | | | | | | | | |
| *Min* | | | | | *8.1* | *0.050* | *0.010* | *0.040* | *0.20* | *4.5* | *8.0* | *1.0* |
| *$10^{th}$ PCTL* | | | | | *8.3* | *0.19* | *0.010* | *0.19* | *0.20* | *4.5* | *9.0* | *1.1* |
| *Median* | | | | | *8.7* | *0.27* | *0.010* | *0.27* | *0.50* | *11* | *18* | *2.3* |
| *$90^{th}$ PCTL* | | | | | *9.0* | *0.42* | *0.030* | *0.39* | *0.80* | *18* | *26* | *3.5* |
| *Max* | | | | | *9.1* | *0.47* | *0.030* | *0.46* | *1.1* | *25* | *30* | *14* |
| | | | | | | | | | | | | |
| FMS-17-055 | 5 | 6 | AR | Waste | 7.9 | 0.45 | 0.02 | 0.43 | <0.2 | 4.5 | 5 | 0.4 |
| FMS-17-055 | 15 | 16 | AR | Waste | 8.6 | 0.43 | 0.02 | 0.41 | 2.9 | 65.9 | 69 | 5.4 |
| FMS-17-055 | 50 | 51 | AR | Waste | 8.3 | 0.31 | 0.02 | 0.29 | 0.2 | 4.5 | 8 | 0.9 |
| FMS-17-055 | 120 | 121 | AR | Waste | 8.2 | 0.27 | 0.01 | 0.26 | 0.6 | 13.6 | 20 | 2.5 |
| FMS-17-055 | 126 | 127 | AR | Waste | 8.4 | 0.28 | 0.01 | 0.27 | 0.4 | 9.1 | 15 | 1.8 |
| FMS-17-073 | 15 | 16 | AR | Waste | 8.8 | 0.35 | 0.01 | 0.34 | 0.2 | 4.5 | 9 | 0.8 |
| FMS-17-073 | 33 | 34 | AR | Waste | 8.9 | 0.25 | 0.01 | 0.24 | <0.2 | 4.5 | 7 | 0.9 |
| FMS-17-073 | 37 | 38 | AR | Waste | 8.8 | 0.38 | 0.01 | 0.37 | <0.2 | 4.5 | 8 | 0.7 |
| FMS-17-073 | 44 | 45 | AR | Waste | 8.8 | 0.36 | 0.01 | 0.35 | <0.2 | 4.5 | 7 | 0.6 |
| FMS-17-124 | 34 | 35 | AR | Waste | 8.2 | 0.44 | 0.01 | 0.43 | 0.5 | 11.4 | 16 | 1.2 |
| FMS-17-124 | 50 | 51 | AR | Waste | 8.5 | 0.26 | 0.01 | 0.25 | 0.2 | 4.5 | 10 | 1.3 |
| FMS-17-124 | 53 | 54 | AR | Waste | 8.4 | 0.24 | 0.01 | 0.23 | <0.2 | 4.5 | 6 | 0.8 |
| FMS-17-124 | 60 | 61 | AR | Waste | 8 | 0.24 | 0.02 | 0.22 | 0.2 | 4.5 | 9 | 1.3 |
| FMS-17-165 | 10 | 11 | AR | Waste | 8.1 | 0.9 | 0.02 | 0.88 | 0.4 | 9.1 | 14 | 0.5 |
| FMS-17-199 | 80 | 81 | AR | Waste | 8.3 | 0.65 | 0.03 | 0.62 | 0.8 | 18.2 | 21 | 1.1 |
| FMS-17-124 | 67 | 68 | AR | Waste | 8.5 | 0.17 | 0.01 | 0.16 | <0.2 | 4.5 | 7 | 1.4 |
| FMS-17-165 | 30 | 31 | AR | Waste | 8.4 | 0.3 | 0.01 | 0.29 | 0.6 | 13.6 | 17 | 1.9 |
| FMS-17-200 | 13 | 14 | AR | Waste | 8.9 | 0.11 | 0.01 | 0.1 | 0.3 | 6.8 | 11 | 3.5 |
| FMS-17-078 | 40 | 45 | AR | Waste | 8.6 | 0.87 | <0.01 | 0.87 | 1 | 22.7 | 35 | 1.3 |
| FMS-17-206 | 40 | 45 | AR | Waste | 8.7 | 0.32 | <0.01 | 0.32 | 0.2 | 4.5 | 10 | 1.0 |
| FMS-18-389 | 20 | 25 | AR | Waste | 8.5 | 0.52 | <0.01 | 0.52 | 0.5 | 11.4 | 16 | 1.0 |
| FMS-17-274 | 65 | 70 | AR | Waste | 8.5 | 0.76 | 0.01 | 0.75 | 0.8 | 18.2 | 23 | 1.0 |
| FMS-17-302 | 20 | 25 | AR | Waste | 8.2 | 0.38 | <0.01 | 0.38 | 1.1 | 25.0 | 28 | 2.4 |
| FMS-18-416 | 115 | 120 | AR | Waste | 9 | 0.23 | 0.01 | 0.22 | 1.9 | 43.2 | 47 | 6.8 |
| FMS-18-388 | 70 | 75 | AR | Waste | 9 | 0.41 | <0.01 | 0.41 | 0.3 | 6.8 | 12 | 0.9 |
| FMS-18-388 | 110 | 115 | AR | Waste | 8.8 | 0.41 | 0.01 | 0.4 | 0.2 | 4.5 | 9 | 0.7 |
| # Samples | 26 | | | | | | | | | | | |
| *Min* | | | | | *7.9* | *0.11* | *0.010* | *0.10* | *0.20* | *4.5* | *5.0* | *0.37* |
| *$10^{th}$ PCTL* | | | | | *8.2* | *0.24* | *0.010* | *0.22* | *0.20* | *4.5* | *7.0* | *0.67* |
| *Median* | | | | | *8.5* | *0.36* | *0.010* | *0.35* | *0.30* | *6.8* | *12* | *1.0* |
| *$90^{th}$ PCTL* | | | | | *8.9* | *0.71* | *0.020* | *0.69* | *1.1* | *24* | *32* | *3.0* |
| *Max* | | | | | *9.0* | *0.90* | *0.030* | *0.88* | *2.9* | *66* | *69* | *6.8* |

| **Hole ID** | **From** | **To** | **Lithology** | **Grade** | **Paste pH** | **Total S** | **Sulphate S** | **Sulphide S** | **TIC** | **CaNP** | **Modified NP** | **NPR** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | m | | | | % | % | % | % CO2 | kg CaCO3/t | kg CaCO3/t | |
| | | | | | | | | | | | | |
| FMS-17-073 | 9 | 10 | GA | Waste | 8.9 | 0.55 | 0.02 | 0.53 | 0.4 | 9.1 | 13 | 0.8 |
| FMS-17-124 | 73 | 74 | GA | Waste | 8.4 | 0.28 | <0.01 | 0.28 | 1.9 | 43.2 | 47 | 5.4 |
| FMS-17-165 | 16 | 17 | GA | Waste | 8.8 | 0.28 | 0.01 | 0.27 | 0.2 | 4.5 | 9 | 1.1 |
| FMS-17-165 | 21 | 22 | GA | Waste | 8.5 | 0.23 | 0.02 | 0.21 | 0.5 | 11.4 | 16 | 2.4 |
| FMS-17-165 | 26 | 27 | GA | Waste | 8.2 | 0.33 | 0.01 | 0.32 | 0.8 | 18.2 | 23 | 2.3 |
| FMS-17-199 | 29 | 30 | GA | Waste | 8.8 | 0.47 | 0.02 | 0.45 | 0.6 | 13.6 | 19 | 1.4 |
| FMS-17-200 | 35 | 36 | GA | Waste | 9 | 0.17 | 0.01 | 0.16 | 1.3 | 29.6 | 36 | 7.2 |
| FMS-18-389 | 40 | 45 | GA | Waste | 8.8 | 0.3 | 0.01 | 0.29 | 0.8 | 18.2 | 22 | 2.4 |
| FMS-18-389 | 75 | 80 | GA | Waste | 8.9 | 0.19 | 0.01 | 0.18 | <0.2 | 4.5 | 8 | 1.4 |
| FMS-18-416 | 75 | 80 | GA | Waste | 8.9 | 0.41 | 0.01 | 0.4 | 1.1 | 25.0 | 29 | 2.3 |
| FMS-18-423 | 20 | 25 | GA | Waste | 9.1 | 0.23 | <0.01 | 0.23 | 1.6 | 36.4 | 44 | 6.1 |
| FMS-17-291 | 35 | 40 | GA | Waste | 9.1 | 0.02 | <0.01 | 0.02 | 0.8 | 18.2 | 27 | 43.2 |
| FMS-18-440 | 45 | 50 | GA | Waste | 8.9 | 0.27 | <0.01 | 0.27 | 1.1 | 25.0 | 29 | 3.4 |
| FMS-18-388 | 45 | 50 | GA | Waste | 8.8 | 0.15 | <0.01 | 0.15 | 0.8 | 18.2 | 22 | 4.7 |
| # Samples | 14 | | | | | | | | | | | |
| *Min* | | | | | *8.2* | *0.020* | *0.010* | *0.020* | *0.20* | *4.5* | *8.0* | *0.78* |
| *10$^{th}$ PCTL* | | | | | *8.4* | *0.16* | *0.010* | *0.15* | *0.26* | *5.9* | *10* | *1.2* |
| *Median* | | | | | *8.9* | *0.28* | *0.010* | *0.27* | *0.80* | *18* | *23* | *2.4* |
| *90$^{th}$ PCTL* | | | | | *9.1* | *0.45* | *0.020* | *0.44* | *1.5* | *34* | *42* | *6.9* |
| *Max* | | | | | *9.1* | *0.55* | *0.020* | *0.53* | *1.9* | *43* | *47* | *43* |
| | | | | | | | | | | | | |
| FMS-17-073 | 22 | 23 | GW | Waste | 9.3 | 0.04 | 0.01 | 0.03 | 0.9 | 20.5 | 25 | 26.7 |
| FMS-17-073 | 30 | 31 | GW | Waste | 9.3 | 0.09 | <0.01 | 0.09 | <0.2 | 4.5 | 10 | 3.6 |
| FMS-17-124 | 46 | 47 | GW | Waste | 8.4 | 0.26 | 0.01 | 0.25 | 2.3 | 52.3 | 54 | 6.9 |
| FMS-17-165 | 18 | 19 | GW | Waste | 8.6 | 0.23 | <0.01 | 0.23 | 4.4 | 100.1 | 102 | 14.2 |
| FMS-17-165 | 110 | 111 | GW | Waste | 8.7 | 0.14 | 0.01 | 0.13 | 0.4 | 9.1 | 16 | 3.9 |
| FMS-17-199 | 5 | 6 | GW | Waste | 8.8 | 0.2 | 0.01 | 0.19 | 5.4 | 122.8 | 128 | 21.6 |
| FMS-17-199 | 10 | 11 | GW | Waste | 8.6 | 0.33 | 0.02 | 0.31 | 1 | 22.7 | 28 | 2.9 |
| FMS-17-199 | 20 | 21 | GW | Waste | 8.3 | 0.23 | <0.01 | 0.23 | 5.4 | 122.8 | 127 | 17.7 |
| FMS-17-200 | 7 | 8 | GW | Waste | 8.6 | 0.23 | 0.02 | 0.21 | 0.9 | 20.5 | 24 | 3.7 |
| FMS-17-200 | 20 | 21 | GW | Waste | 9.1 | 0.13 | 0.01 | 0.12 | 1.8 | 40.9 | 46 | 12.3 |
| FMS-17-278 | 80 | 85 | GW | Waste | 9.2 | 0.12 | 0.01 | 0.11 | 0.9 | 20.5 | 26 | 7.6 |
| FMS-17-179 | 25 | 30 | GW | Waste | 8.3 | 0.34 | 0.01 | 0.33 | 2.1 | 47.8 | 54 | 5.2 |
| FMS-18-389 | 115 | 120 | GW | Waste | 9.2 | 0.12 | 0.01 | 0.11 | 1.2 | 27.3 | 33 | 9.6 |
| FMS-17-280 | 42 | 47 | GW | Waste | 9 | 0.05 | <0.01 | 0.05 | 1.3 | 29.6 | 35 | 22.4 |
| FMS-17-274 | 20 | 25 | GW | Waste | 8.4 | 0.56 | 0.02 | 0.54 | 0.4 | 9.1 | 14 | 0.8 |
| FMS-17-288 | 45 | 50 | GW | Waste | 8.7 | 0.29 | <0.01 | 0.29 | 0.9 | 20.5 | 25 | 2.8 |
| FMS-17-298 | 20 | 25 | GW | Waste | 9.1 | 0.21 | <0.01 | 0.21 | 1.4 | 31.8 | 36 | 5.5 |
| FMS-17-302 | 40 | 45 | GW | Waste | 9.2 | 0.13 | 0.01 | 0.12 | 0.3 | 6.8 | 12 | 3.2 |
| FMS-18-416 | 20 | 25 | GW | Waste | 9 | 0.13 | 0.01 | 0.12 | 0.6 | 13.6 | 18 | 4.8 |
| FMS-18-416 | 40 | 45 | GW | Waste | 8.9 | 0.31 | 0.01 | 0.3 | 1.5 | 34.1 | 36 | 3.8 |
| FMS-18-416 | 145 | 150 | GW | Waste | 8.7 | 0.31 | <0.01 | 0.31 | 1.4 | 31.8 | 35 | 3.6 |
| FMS-18-423 | 80 | 85 | GW | Waste | 8.9 | 0.16 | <0.01 | 0.16 | 3.9 | 88.7 | 92 | 18.4 |
| FMS-18-440 | 70 | 75 | GW | Waste | 9 | 0.17 | 0.01 | 0.16 | 0.7 | 15.9 | 21 | 4.2 |
| FMS-18-388 | 175 | 180 | GW | Waste | 9.1 | 0.11 | <0.01 | 0.11 | 0.2 | 4.5 | 11 | 3.2 |
| # Samples | 24 | | | | | | | | | | | |
| *Min* | | | | | *8.3* | *0.040* | *0.010* | *0.030* | *0.20* | *4.5* | *10* | *0.83* |
| *10$^{th}$ PCTL* | | | | | *8.4* | *0.096* | *0.010* | *0.096* | *0.33* | *7.5* | *13* | *3.0* |
| *Median* | | | | | *8.9* | *0.19* | *0.010* | *0.18* | *1.1* | *25* | *31* | *5.0* |
| *90$^{th}$ PCTL* | | | | | *9.2* | *0.32* | *0.017* | *0.31* | *4.3* | *97* | *99* | *21* |
| *Max* | | | | | *9.3* | *0.56* | *0.020* | *0.54* | *5.4* | *123* | *128* | *27* |

| **Hole ID** | **From** | **To** | **Lithology** | **Grade** | **Paste pH** | **Total S** | **Sulphate S** | **Sulphide S** | **TIC** | **CaNP** | **Modified NP** | **NPR** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | m | | | | % | % | % | % CO2 | kg CaCO3/t | kg CaCO3/t | |
| | | | | | | | | | | | | |
| FMS-17-055 | 83 | 84 | AG | Ore | 8.2 | 0.84 | 0.02 | 0.82 | 0.9 | 20.5 | 25 | 1.0 |
| FMS-17-055 | 70 | 71 | AR | Ore | 8.6 | 0.33 | 0.02 | 0.31 | 0.2 | 4.5 | 10 | 1.0 |
| FMS-17-124 | 106 | 107 | AR | Ore | 7.9 | 0.63 | 0.02 | 0.61 | 0.2 | 4.5 | 7 | 0.4 |
| FMS-17-124 | 82 | 83 | AG | Ore | 8.3 | 0.51 | 0.01 | 0.5 | 0.2 | 4.5 | 9 | 0.6 |
| FMS-17-165 | 83 | 84 | AG | Ore | 8.9 | 0.34 | 0.01 | 0.33 | 0.7 | 15.9 | 20 | 1.9 |
| FMS-17-055 | 25 | 26 | AR | Ore | 8.7 | 0.45 | 0.01 | 0.44 | 0.3 | 6.8 | 11 | 0.8 |
| FMS-17-055 | 30 | 31 | AR | Ore | 8.7 | 0.3 | 0.01 | 0.29 | 0.9 | 20.5 | 24 | 2.6 |
| FMS-17-055 | 43 | 44 | AR | Ore | 8.5 | 0.94 | 0.02 | 0.92 | 0.3 | 6.8 | 11 | 0.4 |
| FMS-17-055 | 55 | 56 | AR | Ore | 8.1 | 1.06 | 0.03 | 1.03 | 1.5 | 34.1 | 38 | 1.2 |
| FMS-17-055 | 98 | 99 | AR | Ore | 8.1 | 0.44 | 0.02 | 0.42 | 0.3 | 6.8 | 11 | 0.8 |
| FMS-17-124 | 89 | 90 | AR | Ore | 8.9 | 0.31 | 0.02 | 0.29 | 0.7 | 15.9 | 21 | 2.3 |
| FMS-17-124 | 122 | 123 | AR | Ore | 8.2 | 0.49 | 0.02 | 0.47 | 0.4 | 9.1 | 15 | 1.0 |
| FMS-17-124 | 130 | 131 | AR | Ore | 7.9 | 0.86 | 0.02 | 0.84 | 0.3 | 6.8 | 10 | 0.4 |
| FMS-17-124 | 145 | 146 | AR | Ore | 8.2 | 0.53 | 0.02 | 0.51 | 0.8 | 18.2 | 22 | 1.4 |
| FMS-17-165 | 40 | 41 | AR | Ore | 8.2 | 0.62 | 0.01 | 0.61 | 2 | 45.5 | 49 | 2.6 |
| FMS-17-165 | 55 | 56 | AR | Ore | 8.7 | 0.39 | 0.01 | 0.38 | 2.6 | 59.1 | 61 | 5.1 |
| FMS-17-124 | 140 | 141 | GA | Ore | 8.9 | 0.38 | <0.01 | 0.38 | <0.2 | 4.5 | 6 | 0.5 |
| FMS-17-055 | 90 | 91 | GW | Ore | 8.8 | 0.12 | <0.01 | 0.12 | 0.9 | 20.5 | 26 | 6.9 |
| FMS-17-055 | 111 | 112 | GW | Ore | 9.1 | 0.21 | 0.01 | 0.2 | 0.7 | 15.9 | 35 | 5.6 |
| FMS-17-165 | 65 | 66 | GW | Ore | 9.2 | 0.14 | 0.01 | 0.13 | 0.6 | 13.6 | 18 | 4.4 |
| FMS-17-270 | 55 | 60 | AG | Ore | 8.8 | 0.35 | 0.01 | 0.34 | 0.3 | 6.8 | 12 | 1.1 |
| FMS-17-078 | 20 | 25 | AR | Ore | 8.3 | 0.9 | 0.01 | 0.89 | 0.4 | 9.1 | 11 | 0.4 |
| FMS-17-298 | 40 | 45 | AR | Ore | 8.6 | 0.37 | <0.01 | 0.37 | 0.6 | 13.6 | 16 | 1.4 |
| # Samples | 23 | | | | | | | | | | | |
| *Min* | | | | | *7.9* | *0.12* | *0.010* | *0.12* | *0.20* | *4.5* | *6.0* | *0.37* |
| *10th PCTL* | | | | | *8.1* | *0.23* | *0.010* | *0.22* | *0.20* | *4.5* | *9.2* | *0.39* |
| *Median* | | | | | *8.6* | *0.44* | *0.010* | *0.42* | *0.60* | *14* | *16* | *1.1* |
| *90th PCTL* | | | | | *8.9* | *0.89* | *0.020* | *0.88* | *1.4* | *31* | *37* | *5.0* |
| *Max* | | | | | *9.2* | *1.1* | *0.030* | *1.0* | *2.6* | *59* | *61* | *6.9* |
| | | | | | | | | | | | | |
| ***Field Bin*** | | | | | | | | | | | | |
| LX-18-FB3 | | | Various | Waste | 8.1 | 0.4 | 0.01 | 0.39 | 0.25 | 21 | 27 | 2.2 |

**Notes:**

Values were set at the detection limit for calculation of NP, AP, and NPR values.

Sulphate S is calculated using the HCl method.

AP (acid potential) calculated using sulphide S (% non-sulphate S x 31.25);

CaNP (carbonate neutralization potential) calculated using total inorganic carbon (% TIC x (100.09/44.01) x 10);

Modified NP is obtained by the modified Sobek method.

NPR = neutralization potential ratio; calculated as Modified NP / AP

# *Appendix 4-3: Solid-phase Elemental Analysis Results*

Atlantic Gold

| Hole ID | From | To | Lithology | Grade | Ag | Al | As | B | Ba | Be | Bi | Ca | Cd | Co | Cr | Cu | Fe | Ga | Hg | Hg | K | La | Mg | Mn | Mo | Na | Ni | P | Pb | S | Sb | Sc | Sr | Th | Ti | Tl | U | V | W | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | m | | | ppm | % | ppm | ppm | ppm | ppm | ppm | % | ppm | ppm | ppm | ppm | % | ppm | ppm | ppm | % | ppm | % | ppm | ppm | % | ppm | ppm | ppm | % | ppm | ppm | ppm | ppm | % | ppm | ppm | ppm | ppm | ppm |
| | | | | | 53 | 8.2 | 4.8 | 17 | 628 | 2.1 | 0.16 | 2.6 | 0.090 | 17 | 92 | 28 | 3.9 | 18 | 0.050 | 0.050 | 2.3 | 31 | 1.5 | 774 | 1.1 | 2.4 | 47 | 655 | 17 | 621 | 0.40 | 14 | 320 | 11 | 0.38 | 0.90 | 2.7 | 97 | 1.9 | 67 |
| FMS-17-124 | 40 | 41 | AG | Waste | <0.2 | 2.61 | 21 | <10 | 70 | <0.5 | 2 | 0.27 | <0.5 | 20 | 34 | 25 | 5.05 | 10 | <0.005 | <1 | 0.59 | 30 | 1.26 | 485 | 1 | 0.02 | 37 | 580 | 2 | 0.28 | <2 | 4 | 10 | <20 | 0.11 | <10 | <10 | 36 | <10 | 107 |
| FMS-17-124 | 70 | 71 | AG | Waste | <0.2 | 2.54 | 71 | <10 | 80 | <0.5 | 2 | 0.27 | <0.5 | 21 | 35 | 36 | 4.44 | 10 | <0.005 | 1 | 0.64 | 30 | 1.17 | 573 | <1 | 0.04 | 39 | 500 | 10 | 0.22 | <2 | 4 | 14 | <20 | 0.12 | <10 | <10 | 34 | <10 | 93 |
| FMS-17-199 | 39 | 40 | AG | Waste | <0.2 | 2.51 | 1560 | <10 | 70 | <0.5 | <2 | 0.66 | <0.5 | 14 | 39 | 25 | 4.49 | 10 | <0.005 | <1 | 0.6 | 20 | 1.53 | 779 | 1 | 0.02 | 41 | 750 | 28 | 0.3 | <2 | 4 | 15 | <20 | 0.08 | <10 | <10 | 36 | <10 | 94 |
| FMS-17-165 | 95 | 96 | AG | Waste | <0.2 | 2.7 | 306 | <10 | 60 | 0.5 | <2 | 0.44 | <0.5 | 21 | 35 | 36 | 5.29 | 10 | <0.005 | <1 | 0.56 | 30 | 1.48 | 676 | <1 | 0.02 | 44 | 480 | 7 | 0.43 | <2 | 4 | 13 | <20 | 0.09 | <10 | <10 | 34 | <10 | 114 |
| FMS-17-200 | 27 | 28 | AG | Waste | <0.2 | 2.33 | 22 | <10 | 50 | <0.5 | <2 | 0.65 | <0.5 | 20 | 33 | 43 | 4.78 | 10 | <0.005 | <1 | 0.4 | 30 | 1.12 | 518 | 1 | 0.02 | 38 | 560 | 6 | 0.46 | <2 | 4 | 13 | <20 | 0.09 | <10 | <10 | 33 | <10 | 100 |
| # Samples | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Min | | | | | 0.20 | 2.3 | 21 | 10 | 50 | 0.50 | 2.0 | 0.27 | 0.50 | 14 | 33 | 25 | 4.4 | 10 | 0.0050 | 1.0 | 0.40 | 20 | 1.12 | 485 | 1.0 | 0.020 | 37 | 480 | 2.0 | 0.22 | 2.0 | 4.0 | 10.0 | 20 | 0.080 | 10 | 10 | 33 | 10 | 93 |
| 10th PCTL | | | | | 0.20 | 2.4 | 21 | 10 | 54 | 0.50 | 2.0 | 0.27 | 0.50 | 16 | 33 | 25 | 4.5 | 10 | 0.0050 | 1.0 | 0.46 | 24 | 1.14 | 498 | 1.0 | 0.020 | 37 | 488 | 3.6 | 0.24 | 2.0 | 4.0 | 11.2 | 20 | 0.084 | 10 | 10 | 33 | 10 | 93 |
| Median | | | | | 0.20 | 2.5 | 71 | 10 | 70 | 0.50 | 2.0 | 0.44 | 0.50 | 20 | 35 | 36 | 4.8 | 10 | 0.0050 | 1.0 | 0.59 | 30 | 1.3 | 573 | 1.0 | 0.020 | 39 | 560 | 7.0 | 0.30 | 2.0 | 4.0 | 13 | 20 | 0.090 | 10 | 10 | 34 | 10 | 100 |
| 90th PCTL | | | | | 0.20 | 2.7 | 1058 | 10 | 76 | 0.50 | 2.0 | 0.66 | 0.50 | 21 | 37 | 40 | 5.2 | 10 | 0.0050 | 1.0 | 0.62 | 30 | 1.5 | 738 | 1.0 | 0.032 | 43 | 682 | 21 | 0.45 | 2.0 | 4.0 | 15 | 20 | 0.12 | 10 | 10 | 36 | 10 | 111 |
| Max | | | | | 0.20 | 2.7 | 1560 | 10 | 80 | 0.50 | 2.0 | 0.66 | 0.50 | 21 | 39 | 43 | 5.3 | 10 | 0.0050 | 1.0 | 0.64 | 30 | 1.5 | 779 | 1.0 | 0.040 | 44 | 750 | 28 | 0.46 | 2.0 | 4.0 | 15 | 20 | 0.12 | 10 | 10 | 36 | 10 | 114 |
| FMS-17-055 | 5 | 6 | AR | Waste | <0.2 | 2.56 | 47 | <10 | 40 | 0.6 | <2 | 0.15 | <0.5 | 11 | 29 | 38 | 4.9 | 10 | <0.005 | <1 | 0.36 | 20 | 1.32 | 528 | 1 | 0.02 | 33 | 460 | 11 | 0.48 | <2 | 3 | 6 | <20 | 0.06 | <10 | <10 | 25 | <10 | 103 |
| FMS-17-055 | 15 | 16 | AR | Waste | <0.2 | 1.79 | 50 | <10 | 70 | <0.5 | 2 | 2.63 | <0.5 | 12 | 29 | 52 | 3.78 | 10 | <0.005 | <1 | 0.58 | 30 | 0.85 | 882 | <1 | 0.02 | 30 | 500 | 6 | 0.45 | <2 | 4 | 21 | <20 | 0.1 | <10 | <10 | 29 | <10 | 67 |
| FMS-17-055 | 50 | 51 | AR | Waste | <0.2 | 2.41 | 1580 | <10 | 30 | 0.6 | <2 | 0.26 | <0.5 | 22 | 23 | 24 | 4.77 | 10 | <0.005 | <1 | 0.25 | 20 | 1.27 | 490 | <1 | 0.01 | 37 | 440 | 4 | 0.32 | <2 | 2 | 7 | <20 | 0.03 | <10 | <10 | 20 | <10 | 104 |
| FMS-17-055 | 120 | 121 | AR | Waste | <0.2 | 2.64 | 429 | <10 | 50 | 0.9 | <2 | 0.71 | <0.5 | 20 | 30 | 47 | 4.88 | 10 | <0.005 | <1 | 0.42 | 30 | 1.34 | 664 | 1 | 0.02 | 42 | 470 | 13 | 0.29 | <2 | 3 | 17 | <20 | 0.04 | <10 | <10 | 27 | <10 | 96 |
| FMS-17-055 | 126 | 127 | AR | Waste | <0.2 | 2.39 | 43 | <10 | 50 | 0.7 | <2 | 0.51 | <0.5 | 16 | 29 | 42 | 4.67 | 10 | <0.005 | <1 | 0.35 | 20 | 1.18 | 554 | <1 | 0.02 | 39 | 450 | 15 | 0.3 | <2 | 3 | 12 | <20 | 0.04 | <10 | <10 | 26 | <10 | 90 |
| FMS-17-073 | 15 | 16 | AR | Waste | <0.2 | 2.64 | 29 | <10 | 60 | <0.5 | <2 | 0.29 | <0.5 | 20 | 36 | 51 | 5.04 | 10 | <0.005 | <1 | 0.54 | 30 | 1.41 | 593 | <1 | 0.02 | 43 | 470 | 8 | 0.38 | <2 | 4 | 9 | <20 | 0.09 | <10 | <10 | 35 | <10 | 101 |
| FMS-17-073 | 33 | 34 | AR | Waste | <0.2 | 2.77 | 49 | <10 | 60 | <0.5 | <2 | 0.18 | <0.5 | 20 | 34 | 39 | 5.11 | 10 | <0.005 | <1 | 0.55 | 30 | 1.5 | 557 | <1 | 0.02 | 44 | 520 | 4 | 0.3 | <2 | 4 | 10 | <20 | 0.09 | <10 | <10 | 33 | <10 | 112 |
| FMS-17-073 | 37 | 38 | AR | Waste | <0.2 | 2.68 | 2 | <10 | 70 | <0.5 | <2 | 0.22 | <0.5 | 19 | 36 | 56 | 5.17 | 10 | <0.005 | <1 | 0.62 | 30 | 1.44 | 588 | <1 | 0.02 | 45 | 520 | 5 | 0.42 | <2 | 4 | 8 | <20 | 0.1 | <10 | <10 | 35 | <10 | 107 |
| FMS-17-073 | 44 | 45 | AR | Waste | <0.2 | 2.38 | 6 | <10 | 50 | <0.5 | <2 | 0.17 | <0.5 | 18 | 29 | 42 | 4.5 | 10 | <0.005 | <1 | 0.49 | 30 | 1.25 | 491 | <1 | 0.02 | 38 | 450 | 5 | 0.38 | <2 | 3 | 9 | <20 | 0.08 | <10 | <10 | 26 | <10 | 95 |
| FMS-17-124 | 34 | 35 | AR | Waste | <0.2 | 1.69 | 7 | <10 | 40 | <0.5 | <2 | 0.53 | <0.5 | 15 | 25 | 44 | 3.69 | 10 | <0.005 | <1 | 0.36 | 30 | 0.83 | 378 | <1 | 0.02 | 27 | 390 | 7 | 0.44 | <2 | 3 | 12 | <20 | 0.07 | <10 | <10 | 25 | <10 | 72 |
| FMS-17-124 | 50 | 51 | AR | Waste | <0.2 | 2.47 | 27 | <10 | 70 | <0.5 | <2 | 0.33 | <0.5 | 17 | 31 | 41 | 4.72 | 10 | <0.005 | <1 | 0.55 | 30 | 1.2 | 489 | 1 | 0.02 | 35 | 440 | 3 | 0.29 | <2 | 4 | 10 | <20 | 0.09 | <10 | <10 | 29 | <10 | 96 |
| FMS-17-124 | 53 | 54 | AR | Waste | <0.2 | 2.89 | 133 | <10 | 50 | <0.5 | <2 | 0.19 | <0.5 | 29 | 34 | 49 | 5.59 | 10 | <0.005 | <1 | 0.41 | 30 | 1.44 | 547 | <1 | 0.02 | 45 | 570 | 12 | 0.32 | <2 | 3 | 10 | <20 | 0.07 | <10 | <10 | 30 | <10 | 117 |
| FMS-17-124 | 60 | 61 | AR | Waste | 0.2 | 2.67 | 235 | <10 | 40 | <0.5 | 2 | 0.29 | <0.5 | 23 | 32 | 48 | 5.07 | 10 | <0.005 | <1 | 0.43 | 30 | 1.36 | 550 | 1 | 0.02 | 36 | 430 | 30 | 0.27 | <2 | 3 | 13 | <20 | 0.07 | <10 | <10 | 28 | <10 | 104 |
| FMS-17-165 | 10 | 11 | AR | Waste | <0.2 | 2.27 | 61 | <10 | 50 | <0.5 | <2 | 0.5 | <0.5 | 30 | 28 | 73 | 5.12 | 10 | <0.005 | <1 | 0.41 | 30 | 1.11 | 497 | <1 | 0.02 | 63 | 510 | 10 | 0.94 | <2 | 3 | 10 | <20 | 0.07 | <10 | <10 | 28 | <10 | 94 |
| FMS-17-199 | 80 | 81 | AR | Waste | <0.2 | 1.44 | 8430 | <10 | 30 | <0.5 | <2 | 0.84 | <0.5 | 12 | 16 | 37 | 3.34 | <10 | <0.005 | <1 | 0.16 | 10 | 0.87 | 544 | 1 | 0.01 | 29 | 280 | 10 | 0.7 | 3 | 1 | 13 | <20 | 0.01 | <10 | <10 | 14 | <10 | 61 |
| FMS-17-124 | 67 | 68 | AR | Waste | 0.2 | 2.87 | 714 | <10 | 50 | <0.5 | <2 | 0.21 | <0.5 | 28 | 35 | 32 | 5.33 | 10 | <0.005 | <1 | 0.49 | 30 | 1.42 | 560 | <1 | 0.02 | 52 | 470 | 2 | 0.23 | <2 | 4 | 11 | <20 | 0.07 | <10 | <10 | 30 | <10 | 110 |
| FMS-17-165 | 30 | 31 | AR | Waste | 0.2 | 2.45 | 82 | <10 | 40 | 0.7 | <2 | 0.64 | <0.5 | 23 | 26 | 45 | 4.96 | 10 | <0.005 | <1 | 0.22 | 30 | 1.24 | 547 | <1 | 0.02 | 40 | 550 | 17 | 0.34 | <2 | 2 | 11 | <20 | 0.01 | <10 | <10 | 21 | <10 | 106 |
| FMS-17-200 | 13 | 14 | AR | Waste | <0.2 | 2.59 | 83 | <10 | 70 | <0.5 | <2 | 0.35 | <0.5 | 17 | 34 | 21 | 4.72 | 10 | <0.005 | <1 | 0.64 | 30 | 1.32 | 579 | <1 | 0.02 | 38 | 460 | 3 | 0.13 | <2 | 4 | 10 | <20 | 0.1 | <10 | <10 | 34 | <10 | 103 |
| # Samples | 18 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Min | | | | | 0.20 | 1.4 | 2.0 | 10 | 30 | 0.50 | 2.0 | 0.15 | 0.50 | 11 | 16 | 21 | 3.3 | 10 | 0.0050 | 1.0 | 0.16 | 10 | 0.83 | 378 | 1.0 | 0.010 | 27 | 280 | 2.0 | 0.13 | 2.0 | 1.0 | 6.0 | 20 | 0.010 | 10 | 10 | 14.0 | 10 | 61 |
| 10th PCTL | | | | | 0.20 | 1.8 | 7 | 10 | 37 | 0.50 | 2.0 | 0.18 | 0.50 | 12 | 24 | 30 | 3.8 | 10 | 0.0050 | 1.0 | 0.24 | 20 | 0.86 | 490 | 1.0 | 0.017 | 30 | 418 | 3.0 | 0.26 | 2.0 | 2.0 | 7.7 | 20 | 0.024 | 10 | 10 | 21 | 10 | 71 |
| Median | | | | | 0.20 | 2.5 | 56 | 10 | 50 | 0.50 | 2.0 | 0.31 | 0.50 | 20 | 30 | 43 | 4.9 | 10 | 0.0050 | 1.0 | 0.43 | 30 | 1.3 | 549 | 1.0 | 0.020 | 39 | 465 | 8 | 0.33 | 2.0 | 3.0 | 10 | 20 | 0.070 | 10 | 10 | 28 | 10 | 102 |
| 90th PCTL | | | | | 0.20 | 2.8 | 974 | 10 | 70 | 0.70 | 2.0 | 0.7 | 0.50 | 28 | 35 | 53 | 5.2 | 10 | 0.0050 | 1.0 | 0.59 | 30 | 1.4 | 614 | 1.0 | 0.020 | 47 | 529 | 16 | 0.55 | 2.0 | 4.0 | 14 | 20 | 0.10 | 10 | 10 | 34 | 10 | 111 |
| Max | | | | | 0.20 | 2.9 | 8430 | 10 | 70 | 0.90 | 2.0 | 2.6 | 0.50 | 30 | 36 | 73 | 5.6 | 10 | 0.0050 | 1.0 | 0.64 | 30 | 1.5 | 882 | 1.0 | 0.020 | 63 | 570 | 30 | 0.9 | 3.0 | 4.0 | 21 | 20 | 0.10 | 10 | 10 | 35 | 10 | 117 |
| FMS-17-073 | 9 | 10 | GA | Waste | <0.2 | 1.78 | 399 | <10 | 40 | <0.5 | <2 | 0.46 | <0.5 | 14 | 26 | 38 | 3.88 | <10 | <0.005 | <1 | 0.33 | 30 | 0.86 | 454 | 1 | 0.03 | 30 | 480 | 9 | 0.57 | <2 | 3 | 13 | <20 | 0.05 | <10 | <10 | 27 | <10 | 79 |
| FMS-17-124 | 73 | 74 | GA | Waste | <0.2 | 1.82 | 3850 | <10 | 60 | <0.5 | <2 | 1.77 | <0.5 | 15 | 27 | 13 | 3.51 | 10 | <0.005 | <1 | 0.5 | 20 | 0.94 | 675 | <1 | 0.03 | 28 | 460 | 8 | 0.31 | 2 | 4 | 34 | <20 | 0.06 | <10 | <10 | 30 | <10 | 74 |
| FMS-17-165 | 16 | 17 | GA | Waste | 0.3 | 2.05 | 161 | <10 | 50 | <0.5 | <2 | 0.33 | <0.5 | 19 | 27 | 17 | 3.99 | 10 | <0.005 | <1 | 0.41 | 30 | 0.97 | 399 | <1 | 0.02 | 27 | 470 | 8 | 0.3 | <2 | 3 | 11 | <20 | 0.06 | <10 | <10 | 27 | <10 | 87 |
| FMS-17-165 | 21 | 22 | GA | Waste | <0.2 | 1.98 | 41 | <10 | 40 | <0.5 | <2 | 0.53 | <0.5 | 15 | 31 | 32 | 3.96 | 10 | <0.005 | 1 | 0.34 | 30 | 0.95 | 494 | 1 | 0.03 | 28 | 440 | 10 | 0.26 | <2 | 4 | 13 | <20 | 0.06 | <10 | <10 | 33 | <10 | 82 |
| FMS-17-165 | 26 | 27 | GA | Waste | <0.2 | 1.99 | 424 | <10 | 40 | <0.5 | <2 | 0.86 | <0.5 | 18 | 26 | 45 | 4.08 | 10 | <0.005 | <1 | 0.32 | 20 | 0.99 | 585 | <1 | 0.02 | 38 | 410 | 18 | 0.37 | <2 | 3 | 14 | <20 | 0.04 | <10 | <10 | 26 | <10 | 81 |
| FMS-17-199 | 29 | 30 | GA | Waste | <0.2 | 2.03 | 3170 | <10 | 70 | <0.5 | <2 | 0.71 | <0.5 | 15 | 31 | 32 | 3.83 | 10 | <0.005 | <1 | 0.56 | 30 | 1.19 | 505 | <1 | 0.03 | 34 | 690 | 9 | 0.51 | <2 | 3 | 14 | <20 | 0.06 | <10 | <10 | 31 | <10 | 80 |
| FMS-17-200 | 35 | 36 | GA | Waste | <0.2 | 1.89 | 14 | <10 | 50 | <0.5 | 2 | 1.38 | <0.5 | 15 | 26 | 27 | 3.66 | 10 | <0.005 | 1 | 0.37 | 20 | 0.93 | 584 | <1 | 0.02 | 27 | 410 | 9 | 0.18 | <2 | 3 | 24 | <20 | 0.08 | <10 | <10 | 25 | <10 | 78 |
| # Samples | 7 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Min | | | | | 0.20 | 1.8 | 14.0 | 10 | 40 | 0.50 | 2.0 | 0.33 | 0.50 | 14 | 26 | 13 | 3.5 | 10 | 0.0050 | 1.0 | 0.32 | 20 | 0.86 | 399 | 1.0 | 0.020 | 27 | 410 | 8.0 | 0.18 | 2.0 | 3.0 | 11.0 | 20 | 0.040 | 10 | 10 | 25.0 | 10 | 74 |
| 10th PCTL | | | | | 0.20 | 1.8 | 30 | 10 | 40 | 0.50 | 2.0 | 0.41 | 0.50 | 15 | 26 | 15 | 3.6 | 10 | 0.0050 | 1.0 | 0.33 | 20 | 0.90 | 432 | 1.0 | 0.020 | 27 | 410 | 8.0 | 0.23 | 2.0 | 3.0 | 12.2 | 20 | 0.046 | 10 | 10 | 26 | 10 | 76 |
| Median | | | | | 0.20 | 2.0 | 399 | 10 | 50 | 0.50 | 2.0 | 0.71 | 0.50 | 15 | 27 | 32 | 3.9 | 10 | 0.0050 | 1.0 | 0.37 | 30 | 1.0 | 505 | 1.0 | 0.030 | 28 | 460 | 9 | 0.31 | 2.0 | 3.0 | 14 | 20 | 0.060 | 10 | 10 | 27 | 10 | 80 |
| 90th PCTL | | | | | 0.24 | 2.0 | 3442 | 10 | 64 | 0.50 | 2.0 | 1.5 | 0.50 | 18 | 31 | 41 | 4.0 | 10 | 0.0050 | 1.0 | 0.52 | 30 | 1.1 | 621 | 1.0 | 0.030 | 36 | 564 | 13 | 0.53 | 2.0 | 4.0 | 28 | 20 | 0.07 | 10 | 10 | 32 | 10 | 84 |
| Max | | | | | 0.30 | 2.1 | 3850 | 10 | 70 | 0.50 | 2.0 | 1.8 | 0.50 | 19 | 31 | 45 | 4.1 | 10 | 0.0050 | 1.0 | 0.6 | 30 | 1.2 | 675 | 1.0 | 0.030 | 38 | 690 | 18 | 0.6 | 2.0 | 4.0 | 34 | 20 | 0.08 | 10 | 10 | 33 | 10 | 87 |

| Hole ID | From | To | Lithology | Grade | Ag | Al | As | B | Ba | Be | Bi | Ca | Cd | Co | Cr | Cu | Fe | Ga | Hg | Hg | K | La | Mg | Mn | Mo | Na | Ni | P | Pb | S | Sb | Sc | Sr | Th | Ti | Tl | U | V | W | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | m | | | ppm | % | ppm | ppm | ppm | ppm | ppm | % | ppm | ppm | ppm | ppm | % | ppm | ppm | ppm | % | ppm | % | ppm | ppm | % | ppm | ppm | ppm | % | ppm | ppm | ppm | ppm | % | ppm | ppm | ppm | ppm | ppm |
| FMS-17-073 | 22 | 23 | GW | Waste | <0.2 | 2.14 | 50 | <10 | 60 | <0.5 | <2 | 0.96 | <0.5 | 19 | 38 | 25 | 3.63 | 10 | <0.005 | <1 | 0.5 | 30 | 1.16 | 653 | <1 | 0.03 | 35 | 700 | 4 | 0.05 | <2 | 5 | 20 | <20 | 0.09 | <10 | <10 | 41 | <10 | 79 |
| FMS-17-073 | 30 | 31 | GW | Waste | <0.2 | 2.11 | 71 | <10 | 60 | <0.5 | <2 | 0.31 | <0.5 | 15 | 35 | 14 | 3.65 | 10 | <0.005 | <1 | 0.59 | 30 | 1.14 | 463 | <1 | 0.03 | 34 | 700 | 3 | 0.11 | <2 | 4 | 11 | <20 | 0.09 | <10 | <10 | 36 | <10 | 84 |
| FMS-17-124 | 46 | 47 | GW | Waste | <0.2 | 1.33 | 57 | <10 | 50 | <0.5 | <2 | 2.07 | <0.5 | 10 | 20 | 34 | 2.72 | <10 | <0.005 | <1 | 0.36 | 20 | 0.65 | 765 | <1 | 0.03 | 22 | 300 | 8 | 0.28 | <2 | 3 | 27 | <20 | 0.07 | <10 | <10 | 22 | <10 | 53 |
| FMS-17-165 | 18 | 19 | GW | Waste | <0.2 | 0.7 | 16 | <10 | 20 | <0.5 | <2 | 4.03 | <0.5 | 7 | 11 | 18 | 1.64 | <10 | <0.005 | <1 | 0.12 | 20 | 0.33 | 1105 | <1 | 0.03 | 12 | 280 | 9 | 0.26 | <2 | 1 | 79 | <20 | 0.02 | <10 | <10 | 11 | <10 | 27 |
| FMS-17-165 | 110 | 111 | GW | Waste | <0.2 | 1.79 | 60 | <10 | 100 | <0.5 | <2 | 0.51 | <0.5 | 15 | 36 | 16 | 3.14 | 10 | <0.005 | 1 | 0.7 | 20 | 0.89 | 462 | <1 | 0.04 | 25 | 410 | 4 | 0.15 | <2 | 6 | 19 | <20 | 0.13 | <10 | <10 | 49 | <10 | 68 |
| FMS-17-199 | 5 | 6 | GW | Waste | <0.2 | 0.88 | 165 | <10 | 20 | <0.5 | <2 | 4.85 | <0.5 | 7 | 14 | 24 | 1.91 | <10 | <0.005 | <1 | 0.16 | 20 | 0.55 | 1080 | <1 | 0.03 | 17 | 540 | 8 | 0.23 | <2 | 2 | 83 | <20 | 0.03 | <10 | <10 | 16 | <10 | 40 |
| FMS-17-199 | 10 | 11 | GW | Waste | <0.2 | 1.39 | 1070 | <10 | 30 | <0.5 | <2 | 1.05 | <0.5 | 10 | 22 | 24 | 2.72 | <10 | <0.005 | 1 | 0.2 | 20 | 0.82 | 421 | <1 | 0.04 | 26 | 560 | 10 | 0.36 | 3 | 2 | 15 | <20 | 0.02 | <10 | <10 | 22 | <10 | 59 |
| FMS-17-199 | 20 | 21 | GW | Waste | <0.2 | 1.02 | 270 | <10 | 20 | <0.5 | <2 | 5.03 | <0.5 | 7 | 18 | 22 | 2.07 | <10 | <0.005 | <1 | 0.13 | 20 | 0.59 | 980 | <1 | 0.03 | 19 | 520 | 7 | 0.26 | <2 | 2 | 46 | <20 | 0.01 | <10 | <10 | 18 | <10 | 40 |
| FMS-17-200 | 7 | 8 | GW | Waste | <0.2 | 1.55 | 36 | <10 | 50 | <0.5 | <2 | 0.93 | <0.5 | 14 | 24 | 32 | 3.06 | 10 | <0.005 | <1 | 0.4 | 20 | 0.76 | 440 | <1 | 0.03 | 27 | 330 | 12 | 0.25 | <2 | 4 | 12 | <20 | 0.09 | <10 | <10 | 29 | <10 | 62 |
| FMS-17-200 | 20 | 21 | GW | Waste | <0.2 | 1.49 | 14 | <10 | 50 | <0.5 | <2 | 1.78 | <0.5 | 16 | 25 | 15 | 2.83 | 10 | <0.005 | <1 | 0.35 | 20 | 0.74 | 569 | 1 | 0.03 | 22 | 420 | 6 | 0.14 | <2 | 3 | 26 | <20 | 0.07 | <10 | <10 | 27 | <10 | 63 |
| # Samples | 10 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Min* | | | | | *0.20* | *0.70* | *14* | *10* | *20* | *0.50* | *2.0* | *0.31* | *0.50* | *7.0* | *11* | *14* | *1.6* | *10* | *0.0050* | *1.0* | *0.12* | *20* | *0.33* | *421* | *1.0* | *0.030* | *12* | *280* | *3.0* | *0.050* | *2.0* | *1.0* | *11* | *20* | *0.010* | *10* | *10* | *11* | *10* | *27* |
| *10th PCTL* | | | | | *0.20* | *0.86* | *16* | *10* | *20* | *0.50* | *2.0* | *0.49* | *0.50* | *7.0* | *14* | *15* | *1.9* | *10* | *0.0050* | *1.0* | *0.13* | *20* | *0.53* | *438* | *1.0* | *0.030* | *17* | *298* | *3.9* | *0.10* | *2.0* | *1.9* | *12* | *20* | *0.019* | *10* | *10* | *16* | *10* | *39* |
| *Median* | | | | | *0.20* | *1.4* | *59* | *10* | *50* | *0.50* | *2.0* | *1.4* | *0.50* | *12* | *23* | *23* | *2.8* | *10* | *0.0050* | *1.0* | *0.36* | *20* | *0.75* | *611* | *1.0* | *0.030* | *24* | *470* | *7.5* | *0.24* | *2.0* | *3.0* | *23* | *20* | *0.070* | *10* | *10* | *25* | *10* | *61* |
| *90th PCTL* | | | | | *0.20* | *2.1* | *350* | *10* | *64* | *0.50* | *2.0* | *4.9* | *0.50* | *16* | *36* | *32* | *3.6* | *10* | *0.0050* | *1.0* | *0.60* | *30* | *1.1* | *1083* | *1.0* | *0.040* | *34* | *700* | *10* | *0.29* | *2.1* | *5.1* | *79* | *20* | *0.094* | *10* | *10* | *42* | *10* | *80* |
| *Max* | | | | | *0.20* | *2.1* | *1070* | *10* | *100* | *0.50* | *2.0* | *5.0* | *0.50* | *19* | *38* | *34* | *3.7* | *10* | *0.0050* | *1.0* | *0.70* | *30* | *1.2* | *1105* | *1.0* | *0.040* | *35* | *700* | *12* | *0.36* | *3.0* | *6.0* | *83* | *20* | *0.13* | *10* | *10* | *49* | *10* | *84* |
| FMS-17-055 | 83 | 84 | AG | *Ore* | <0.2 | 2.05 | 2380 | <10 | 60 | <0.5 | <2 | 0.91 | <0.5 | 18 | 29 | 70 | 4.73 | 10 | <0.005 | <1 | 0.51 | 20 | 1.03 | 545 | <1 | 0.02 | 44 | 430 | 7 | 0.81 | <2 | 4 | 13 | <20 | 0.06 | <10 | <10 | 30 | <10 | 78 |
| FMS-17-055 | 70 | 71 | AR | *Ore* | <0.2 | 2.44 | 837 | <10 | 60 | <0.5 | <2 | 0.33 | <0.5 | 16 | 31 | 24 | 4.73 | 10 | <0.005 | <1 | 0.47 | 30 | 1.26 | 551 | <1 | 0.02 | 33 | 460 | 11 | 0.36 | <2 | 3 | 11 | <20 | 0.07 | <10 | <10 | 28 | <10 | 105 |
| FMS-17-124 | 106 | 107 | AR | *Ore* | <0.2 | 2.34 | 4380 | <10 | 50 | <0.5 | <2 | 0.26 | <0.5 | 23 | 29 | 36 | 4.98 | 10 | <0.005 | <1 | 0.51 | 30 | 1.23 | 458 | <1 | 0.01 | 41 | 430 | 3 | 0.64 | 5 | 3 | 8 | <20 | 0.06 | <10 | <10 | 25 | <10 | 97 |
| FMS-17-124 | 82 | 83 | AG | *Ore* | <0.2 | 1.85 | 47 | <10 | 60 | <0.5 | <2 | 0.35 | <0.5 | 16 | 29 | 58 | 3.96 | 10 | <0.005 | <1 | 0.55 | 30 | 0.95 | 443 | <1 | 0.02 | 32 | 440 | 10 | 0.54 | <2 | 4 | 9 | <20 | 0.1 | <10 | <10 | 30 | <10 | 75 |
| FMS-17-165 | 83 | 84 | AG | *Ore* | <0.2 | 1.77 | 94 | <10 | 60 | <0.5 | <2 | 0.76 | <0.5 | 14 | 27 | 26 | 3.4 | 10 | <0.005 | <1 | 0.53 | 20 | 0.89 | 553 | 1 | 0.03 | 23 | 470 | 9 | 0.38 | <2 | 4 | 18 | <20 | 0.08 | <10 | <10 | 34 | <10 | 67 |
| FMS-17-055 | 25 | 26 | AR | *Ore* | <0.2 | 2.27 | 178 | <10 | 50 | <0.5 | <2 | 0.37 | <0.5 | 15 | 30 | 53 | 4.7 | 10 | <0.005 | <1 | 0.4 | 30 | 1.14 | 538 | <1 | 0.02 | 50 | 480 | 10 | 0.47 | <2 | 3 | 12 | <20 | 0.07 | <10 | <10 | 28 | <10 | 90 |
| FMS-17-055 | 30 | 31 | AR | *Ore* | 0.2 | 2.08 | 990 | <10 | 50 | <0.5 | <2 | 0.88 | <0.5 | 23 | 28 | 28 | 4.08 | 10 | <0.005 | <1 | 0.41 | 30 | 1.03 | 607 | 2 | 0.01 | 38 | 510 | 32 | 0.33 | <2 | 3 | 12 | <20 | 0.06 | <10 | <10 | 25 | <10 | 83 |
| FMS-17-055 | 43 | 44 | AR | *Ore* | <0.2 | 2.28 | 1820 | <10 | 50 | <0.5 | <2 | 0.37 | <0.5 | 30 | 27 | 59 | 5.1 | 10 | <0.005 | <1 | 0.44 | 30 | 1.17 | 481 | <1 | 0.01 | 47 | 420 | 3 | 0.88 | <2 | 3 | 10 | <20 | 0.05 | <10 | <10 | 23 | <10 | 94 |
| FMS-17-055 | 55 | 56 | AR | *Ore* | <0.2 | 2.45 | 1300 | <10 | 40 | 0.5 | <2 | 1.51 | <0.5 | 14 | 29 | 101 | 6.02 | 10 | <0.005 | <1 | 0.36 | 30 | 1.29 | 737 | <1 | 0.02 | 49 | 440 | 5 | 1.3 | <2 | 3 | 15 | <20 | 0.04 | <10 | <10 | 24 | <10 | 105 |
| FMS-17-055 | 98 | 99 | AR | *Ore* | <0.2 | 2.41 | 95 | <10 | 50 | 0.7 | <2 | 0.41 | <0.5 | 21 | 28 | 44 | 4.85 | 10 | <0.005 | <1 | 0.36 | 30 | 1.2 | 815 | 1 | 0.01 | 40 | 440 | 15 | 0.45 | <2 | 3 | 11 | <20 | 0.06 | <10 | <10 | 26 | <10 | 100 |
| FMS-17-124 | 89 | 90 | AR | *Ore* | <0.2 | 2.27 | 47 | <10 | 70 | <0.5 | <2 | 0.74 | <0.5 | 13 | 34 | 34 | 4.42 | 10 | <0.005 | <1 | 0.57 | 30 | 1.12 | 612 | <1 | 0.02 | 37 | 470 | 7 | 0.35 | <2 | 4 | 11 | <20 | 0.1 | <10 | <10 | 32 | <10 | 89 |
| FMS-17-124 | 122 | 123 | AR | *Ore* | <0.2 | 2.14 | 1340 | <10 | 60 | 0.6 | <2 | 0.49 | <0.5 | 17 | 28 | 37 | 3.98 | 10 | <0.005 | <1 | 0.46 | 20 | 1.18 | 530 | <1 | 0.02 | 29 | 350 | 19 | 0.51 | <2 | 3 | 9 | <20 | 0.07 | <10 | <10 | 24 | <10 | 87 |
| FMS-17-124 | 130 | 131 | AR | *Ore* | 0.2 | 2.04 | 1820 | <10 | 60 | 0.5 | <2 | 0.42 | <0.5 | 25 | 25 | 74 | 4.33 | 10 | <0.005 | <1 | 0.56 | 30 | 1.03 | 443 | 2 | 0.03 | 46 | 400 | 19 | 0.87 | <2 | 2 | 14 | <20 | 0.08 | <10 | <10 | 24 | <10 | 79 |
| FMS-17-124 | 145 | 146 | AR | *Ore* | <0.2 | 2.54 | 5850 | <10 | 40 | 0.8 | <2 | 0.79 | <0.5 | 20 | 27 | 22 | 5.12 | 10 | <0.005 | <1 | 0.23 | 30 | 1.44 | 846 | <1 | 0.02 | 42 | 500 | 14 | 0.54 | 4 | 2 | 22 | <20 | 0.01 | <10 | <10 | 22 | <10 | 98 |
| FMS-17-165 | 40 | 41 | AR | *Ore* | 0.3 | 1.77 | 1520 | <10 | 30 | 0.5 | 3 | 1.96 | <0.5 | 29 | 17 | 48 | 4.12 | <10 | <0.005 | <1 | 0.17 | 20 | 0.9 | 879 | <1 | 0.01 | 52 | 600 | 25 | 0.68 | <2 | 2 | 27 | <20 | <0.01 | <10 | <10 | 13 | <10 | 92 |
| FMS-17-165 | 55 | 56 | AR | *Ore* | 0.6 | 1.13 | 204 | <10 | 30 | 0.6 | 3 | 2.46 | <0.5 | 20 | 12 | 36 | 2.53 | <10 | <0.005 | 1 | 0.24 | 30 | 0.43 | 982 | <1 | 0.02 | 34 | 590 | 67 | 0.44 | <2 | 2 | 25 | <20 | <0.01 | <10 | <10 | 9 | <10 | 72 |
| FMS-17-124 | 140 | 141 | GA | *Ore* | <0.2 | 2.58 | 17 | <10 | 150 | 0.8 | <2 | 0.13 | 0.7 | 17 | 43 | 39 | 4.47 | 10 | <0.005 | 1 | 1.47 | 10 | 1.2 | 246 | 1 | 0.07 | 33 | 450 | 218 | 0.53 | <2 | 8 | 6 | <20 | 0.21 | <10 | <10 | 61 | <10 | 293 |
| FMS-17-055 | 90 | 91 | GW | *Ore* | <0.2 | 1.08 | 61 | <10 | 40 | <0.5 | <2 | 0.9 | <0.5 | 8 | 19 | 15 | 2.07 | <10 | <0.005 | 1 | 0.34 | 20 | 0.48 | 439 | <1 | 0.03 | 15 | 310 | 6 | 0.13 | <2 | 3 | 16 | <20 | 0.05 | <10 | <10 | 22 | <10 | 39 |
| FMS-17-055 | 111 | 112 | GW | *Ore* | <0.2 | 1.22 | 38 | <10 | 50 | <0.5 | <2 | 1.28 | <0.5 | 10 | 18 | 21 | 2.42 | <10 | <0.005 | <1 | 0.36 | 20 | 0.55 | 545 | <1 | 0.03 | 18 | 300 | 10 | 0.23 | <2 | 2 | 19 | <20 | 0.07 | <10 | <10 | 20 | <10 | 50 |
| FMS-17-165 | 65 | 66 | GW | *Ore* | <0.2 | 1.96 | 977 | <10 | 80 | <0.5 | <2 | 0.63 | <0.5 | 20 | 33 | 11 | 3.49 | 10 | <0.005 | <1 | 0.62 | 20 | 1.01 | 538 | <1 | 0.03 | 31 | 430 | 6 | 0.15 | <2 | 5 | 13 | <20 | 0.08 | <10 | <10 | 43 | <10 | 79 |
| # Samples | 20 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Min* | | | | | *0.20* | *1.1* | *17* | *10* | *30* | *0.50* | *2.0* | *0.13* | *0.50* | *8* | *12* | *11* | *2.1* | *10* | *0.0050* | *1.0* | *0.17* | *10* | *0.4* | *246* | *1.0* | *0.010* | *15* | *300* | *3.0* | *0.13* | *2.0* | *2.0* | *6.0* | *20* | *0.010* | *10* | *10* | *9* | *10* | *39* |
| *10th PCTL* | | | | | *0.20* | *1.2* | *46* | *10* | *39* | *0.50* | *2.0* | *0.32* | *0.50* | *13* | *18* | *20* | *2.5* | *10* | *0.0050* | *1.0* | *0.24* | *20* | *0.5* | *443* | *1.0* | *0.010* | *23* | *346* | *4.8* | *0.22* | *2.0* | *2.0* | *8.9* | *20* | *0.010* | *10* | *10* | *19* | *10* | *65* |
| *Median* | | | | | *0.20* | *2.1* | *907* | *10* | *50* | *0.50* | *2.0* | *0.69* | *0.50* | *18* | *28* | *37* | *4.4* | *10* | *0.0050* | *1.0* | *0.45* | *30* | *1.1* | *545* | *1.0* | *0.020* | *38* | *440* | *10.0* | *0.49* | *2.0* | *3.0* | *13* | *20* | *0.065* | *10* | *10* | *25* | *10* | *88* |
| *90th PCTL* | | | | | *0.21* | *2.5* | *2580* | *10* | *71* | *0.71* | *2.1* | *1.56* | *0.50* | *25* | *33* | *70* | *5.1* | *10* | *0.0050* | *1.0* | *0.58* | *30* | *1.3* | *849* | *1.1* | *0.030* | *49* | *518* | *36* | *0.87* | *2.2* | *4.1* | *22* | *20* | *0.100* | *10* | *10* | *35* | *10* | *105* |
| *Max* | | | | | *0.60* | *2.6* | *5850* | *10* | *150* | *0.80* | *3.0* | *2.46* | *0.70* | *30* | *43* | *101* | *6.0* | *10* | *0.0050* | *1.0* | *1.47* | *30* | *1.4* | *982* | *2.0* | *0.070* | *52* | *600* | *218* | *1.30* | *5.0* | *8.0* | *27* | *20* | *0.210* | *10* | *10* | *61* | *10* | *293* |
| ***Field Bin*** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| LX-18-FB3 | | | | | <0.5 | 2 | 386 | <10 | 50 | <0.5 | <2 | 1.03 | <0.5 | 19 | 29 | 36 | 4.08 | 10 | <0.005 | <1 | 0.41 | 30 | 1.06 | 611 | <1 | 0.02 | 35 | 490 | 16 | 0.4 | <2 | 3 | 24 | <20 | 0.06 | <10 | <10 | 27 | <10 | 85 |

**Notes:**

Values were set at the limit for calculation of statistical distributions;

AUCCC = average upper continental crust concentrations (Rudnick and Gao, 2014);

Values greater than 3x the AUCCC are shaded in light yellow; values greater than 10x the AUCCC are shaded in red.

# *Appendix 4-4: Shake Flask Extraction and Leaching Test Results*

Atlantic Gold

**Appendix 4-4: Shake Flask Extraction and Leaching Test Results**

| | | | CCME WQG | | | | | | | LX-18-FB3 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sample ID** | | | **Short Term** | **Long Term** | **HC 1** | **HC 2** | **HC 3** | **HC 4** | **HC 5** | **Water to Solid Ratio** | | |
| | | | | | | | | | | **3:1** | **1:1** | **0.5:1** |
| **Parameter** | **Method** | **Units** | | | | | | | | | | |
| Volume Nanopure Water | | mL | - | - | 750 | 750 | 750 | 750 | 750 | 750 | 500 | 350 |
| Sample Weight | | g | - | - | 250 | 250 | 250 | 250 | 250 | 250 | 500 | 700 |
| pH | meter | - | 6.5-9 | - | 7.87 | 7.94 | 8.11 | 7.99 | 7.97 | 8.16 | 8.02 | 7.98 |
| Redox | meter | mV | - | - | 362 | 352 | 345 | 347 | 353 | 265 | 312 | 314 |
| Conductivity | meter | µS/cm | - | - | 129 | 134 | 78 | 114 | 154 | 96 | 176 | 301 |
| Acidity (to pH 4.5) | titration | mg $CaCO_3$/L | - | - | #N/A | #N/A | #N/A | #N/A | #N/A | #N/A | #N/A | #N/A |
| Total Acidity (to pH 8.3) | titration | mg $CaCO_3$/L | - | - | 1.5 | 1.4 | 0.8 | 1.3 | 1.5 | 2.3 | 2.8 | 3.0 |
| Alkalinity | titration | mg $CaCO_3$/L | - | - | 32.4 | 31.1 | 29.9 | 34.9 | 36.6 | 29.4 | 40.4 | 55.0 |
| Chloride | Colour | mg/L | 640 | 120 | 12 | 14 | 3 | 12 | 8 | 5 | 17 | 32 |
| Fluoride | IC | mg/L | - | 0.12 | 0.060 | 0.090 | < 0.06 | < 0.06 | 0.070 | < 0.06 | 0.12 | 0.21 |
| Sulphate | Turbidity | mg/L | - | - | 9 | 9 | 5 | 3 | 23 | 7 | 17 | 32 |
| **Ion Balance** | | | | | | | | | | | | |
| Major Anions | Calc | meq/L | - | - | 1.18 | 1.21 | 0.79 | 1.10 | 1.44 | 0.87 | 1.65 | 2.68 |
| Major Cations | Calc | meq/L | - | - | 1.19 | 1.22 | 0.77 | 1.07 | 1.43 | 0.93 | 1.70 | 2.74 |
| Difference | Calc | meq/L | - | - | -0.02 | -0.01 | 0.01 | 0.03 | 0.01 | -0.06 | -0.05 | -0.06 |
| Balance (%) | Calc | % | - | - | -0.6% | -0.4% | 0.8% | 1.3% | 0.3% | -3.3% | -1.6% | -1.1% |
| **Dissolved Metals** | | | | | | | | | | | | |
| Hardness $CaCO_3$ | | mg/L | - | - | 47.2 | 47.2 | 27.6 | 44.4 | 60.6 | 35.8 | 61.3 | 95.3 |
| Aluminum Al[a] | ICP-MS | mg/L | - | 0.1 | 0.134 | 0.140 | 0.206 | 0.099 | 0.090 | 0.462 | 0.319 | 0.155 |
| Antimony Sb | ICP-MS | mg/L | - | - | 0.0003 | 0.0004 | 0.0007 | 0.0003 | 0.0003 | < 0.0002 | 0.0006 | 0.0011 |
| Arsenic As | ICP-MS | mg/L | - | 0.005 | 0.0089 | 0.0307 | 0.285 | 0.161 | 0.0228 | 0.0443 | 0.0592 | 0.0838 |
| Barium Ba | ICP-MS | mg/L | - | - | 0.00236 | 0.00179 | 0.00112 | 0.00192 | 0.00236 | 0.00129 | 0.00270 | 0.00534 |
| Beryllium Be | ICP-MS | mg/L | - | - | < 0.000007 | < 0.000007 | < 0.000007 | < 0.000007 | < 0.000007 | < 0.000007 | < 0.000007 | < 0.000007 |
| Bismuth Bi | ICP-MS | mg/L | - | - | < 0.000007 | < 0.000007 | < 0.000007 | < 0.000007 | < 0.000007 | < 0.000007 | < 0.000007 | < 0.000007 |
| Boron B | ICP-MS | mg/L | 29 | 1.5 | 0.009 | 0.009 | 0.011 | 0.022 | 0.009 | 0.011 | 0.014 | 0.028 |
| Cadmium Cd | ICP-MS | mg/L | 0.001 | 0.00009 | < 0.000003 | < 0.000003 | < 0.000003 | 0.000003 | 0.000003 | < 0.000003 | < 0.000003 | 0.000005 |
| Calcium Ca | ICP-MS | mg/L | - | - | 17.1 | 17.8 | 10.3 | 16.6 | 22.8 | 13.2 | 22.2 | 34.0 |
| Chromium Cr | ICP-MS | mg/L | - | 0.001 | 0.00012 | 0.00008 | 0.00021 | 0.00016 | 0.00010 | 0.00006 | 0.00007 | 0.00015 |
| Cobalt Co | ICP-MS | mg/L | - | - | 0.000073 | 0.000011 | 0.000011 | 0.000025 | 0.000054 | 0.000021 | 0.000063 | 0.000194 |
| Copper Cu[b] | ICP-MS | mg/L | - | 0.002 | 0.00014 | 0.00015 | 0.00024 | 0.00004 | 0.00016 | 0.00023 | 0.00032 | 0.00119 |
| Iron Fe | ICP-MS | mg/L | - | 0.3 | < 0.007 | 0.007 | 0.012 | < 0.007 | < 0.007 | < 0.007 | < 0.007 | < 0.007 |
| Lead Pb[b] | ICP-MS | mg/L | - | 0.001 | 0.00001 | 0.00002 | 0.00002 | < 0.00001 | < 0.00001 | < 0.00001 | 0.00003 | 0.00003 |
| Lithium Li | ICP-MS | mg/L | - | - | 0.0044 | 0.0034 | 0.0032 | 0.0030 | 0.0050 | 0.0034 | 0.0066 | 0.0109 |
| Magnesium Mg | ICP-MS | mg/L | - | - | 1.11 | 0.628 | 0.426 | 0.727 | 0.906 | 0.691 | 1.44 | 2.55 |
| Manganese Mn | ICP-MS | mg/L | - | - | 0.0237 | 0.0133 | 0.0112 | 0.0373 | 0.0443 | 0.0201 | 0.0211 | 0.0445 |
| Mercury Hg | ICP-MS | µg/L | - | 0.026 | < 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.01 |
| Molybdenum Mo | ICP-MS | mg/L | - | 0.073 | 0.00017 | 0.00040 | 0.00015 | 0.00012 | 0.00010 | 0.00015 | 0.00060 | 0.00166 |
| Nickel Ni[b] | ICP-MS | mg/L | - | 0.025 | 0.0015 | 0.0004 | 0.0006 | 0.0025 | 0.0011 | 0.0004 | 0.0012 | 0.0031 |
| Phosphorus P | ICP-MS | mg/L | - | - | 0.015 | 0.014 | < 0.003 | 0.003 | 0.004 | < 0.003 | < 0.003 | 0.004 |
| Potassium K | ICP-MS | mg/L | - | - | 5.95 | 6.30 | 3.99 | 3.04 | 4.58 | 4.08 | 9.79 | 17.5 |
| Selenium Se | ICP-MS | mg/L | - | 0.001 | 0.00005 | 0.00007 | < 0.00004 | < 0.00004 | 0.00007 | 0.00006 | 0.00012 | 0.00019 |
| Silicon Si | ICP-MS | mg/L | - | - | 1.04 | 0.94 | 1.37 | 1.33 | 0.87 | 1.14 | 1.47 | 1.87 |
| Silver Ag | ICP-MS | mg/L | - | 0.00025 | < 0.00005 | < 0.00005 | < 0.00005 | < 0.00005 | < 0.00005 | < 0.00005 | < 0.00005 | < 0.00005 |
| Sodium Na | ICP-MS | mg/L | - | - | 1.78 | 2.30 | 2.06 | 1.95 | 2.01 | 1.41 | 4.27 | 8.34 |
| Strontium Sr | ICP-MS | mg/L | - | - | 0.156 | 0.137 | 0.0223 | 0.0737 | 0.159 | 0.0855 | 0.183 | 0.313 |
| Sulphur (S) | ICP-MS | mg/L | - | - | 4.5 | 4.0 | 1.9 | 1.7 | 9.7 | 3.9 | 9.0 | 17.1 |
| Thallium Tl | ICP-MS | mg/L | - | 0.0008 | 0.000013 | 0.000007 | < 0.000005 | 0.000007 | 0.000007 | 0.000006 | 0.000011 | 0.000018 |
| Tin Sn | ICP-MS | mg/L | - | - | 0.00079 | 0.00086 | 0.00071 | 0.00065 | 0.00086 | 0.00053 | 0.00149 | 0.00300 |
| Titanium Ti | ICP-MS | mg/L | - | - | 0.00044 | 0.00042 | 0.00086 | 0.00015 | 0.00009 | 0.00018 | 0.00026 | 0.00017 |
| Uranium U | ICP-MS | mg/L | 0.033 | 0.015 | 0.000042 | 0.000040 | 0.000055 | 0.000076 | 0.000119 | 0.000096 | 0.000281 | 0.000892 |
| Vanadium V | ICP-MS | mg/L | - | - | 0.00045 | 0.00039 | 0.00107 | 0.00060 | 0.00020 | 0.00093 | 0.00102 | 0.00075 |
| Zinc Zn | ICP-MS | mg/L | 0.037 | 0.007 | < 0.002 | < 0.002 | < 0.002 | < 0.002 | < 0.002 | < 0.002 | < 0.002 | < 0.002 |
| Zirconium Zr | ICP-MS | mg/L | - | - | < 0.002 | < 0.002 | < 0.002 | < 0.002 | < 0.002 | < 0.002 | < 0.002 | < 0.002 |

**Notes:**

Values shaded in light grey are above the long-term CCME guideline; values shaded in dark grey are above 10x the CCME guideline; no values are above the short-term CCME guidelines

[a]Aluminum guideline is based on pH > 6.5

[b]Hardness dependent guidelines are based on a hardness of 10 mg/L

CCME – Canadian Council for Ministers of the Environment; WQG – Water quality guideline for the protection of aquatic life

# *Appendix 4-5: Particle Size Distribution Results*

Atlantic Gold

**Appendix 4-5: Particle Size Distribution Results**

**Cell # 1**

| Sieve | Aperture | Weight Retained | | |
|---|---|---|---|---|
| Designation | | | | Cumulative |
| | (mm) | (g) | (%) | (%) |
| +3/8" | 9.500 | 6.00 | 6.0% | 6.0% |
| - 3/8" +1/4" | 6.300 | 8.50 | 8.5% | 14.5% |
| -1/4" + 5 | 4.000 | 26.40 | 26.5% | 41.0% |
| 5 + 10 | 1.700 | 22.50 | 22.5% | 63.5% |
| -10 + 35 | 0.425 | 21.20 | 21.2% | 84.8% |
| -48 + 100 | 0.150 | 6.30 | 6.3% | 91.1% |
| -200 + 270 | 0.053 | 3.50 | 3.5% | 94.6% |
| -270 | -0.053 | 5.40 | 5.4% | 100.0% |
| | | | | |
| TOTAL | | 99.80 | 100.0% | |

**Cell # 2**

| Sieve | Aperture | Weight Retained | | |
|---|---|---|---|---|
| Designation | | | | Cumulative |
| | (mm) | (g) | (%) | (%) |
| +3/8" | 9.500 | 3.90 | 3.9% | 3.9% |
| - 3/8" +1/4" | 6.300 | 12.00 | 12.1% | 16.0% |
| -1/4" + 5 | 4.000 | 24.60 | 24.7% | 40.7% |
| 5 + 10 | 1.700 | 22.30 | 22.4% | 63.1% |
| -10 + 35 | 0.425 | 21.80 | 21.9% | 85.0% |
| -48 + 100 | 0.150 | 6.20 | 6.2% | 91.3% |
| -200 + 270 | 0.053 | 3.00 | 3.0% | 94.3% |
| -270 | -0.053 | 5.70 | 5.7% | 100.0% |
| | | | | |
| TOTAL | | 99.50 | 100.0% | |

**Cell # 3**

| Sieve | Aperture | Weight Retained | | |
|---|---|---|---|---|
| Designation | | | | Cumulative |
| | (mm) | (g) | (%) | (%) |
| +3/8" | 9.500 | 1.70 | 1.7% | 1.7% |
| - 3/8" +1/4" | 6.300 | 13.40 | 13.5% | 15.2% |
| -1/4" + 5 | 4.000 | 27.10 | 27.3% | 42.5% |
| 5 + 10 | 1.700 | 22.60 | 22.7% | 65.2% |
| -10 + 35 | 0.425 | 20.50 | 20.6% | 85.8% |
| -48 + 100 | 0.150 | 5.90 | 5.9% | 91.8% |
| -200 + 270 | 0.053 | 3.50 | 3.5% | 95.3% |
| -270 | -0.053 | 4.70 | 4.7% | 100.0% |
| | | | | |
| TOTAL | | 99.40 | 100.0% | |

**Cell # 4**

| Sieve | Aperture | Weight Retained | | |
|---|---|---|---|---|
| Designation | | | | Cumulative |
| | (mm) | (g) | (%) | (%) |
| +3/8" | 9.500 | 1.60 | 1.6% | 1.6% |
| - 3/8" +1/4" | 6.300 | 10.20 | 10.3% | 11.9% |
| -1/4" + 5 | 4.000 | 34.40 | 34.7% | 46.6% |
| 5 + 10 | 1.700 | 28.10 | 28.4% | 75.0% |
| -10 + 35 | 0.425 | 15.20 | 15.3% | 90.3% |
| -48 + 100 | 0.150 | 3.30 | 3.3% | 93.6% |
| -200 + 270 | 0.053 | 2.50 | 2.5% | 96.2% |
| -270 | -0.053 | 3.80 | 3.8% | 100.0% |
| | | | | |
| TOTAL | | 99.10 | 100.0% | |

**Cell # 5**

| Sieve | Aperture | Weight Retained | | |
|---|---|---|---|---|
| Designation | | | | Cumulative |
| | (mm) | (g) | (%) | (%) |
| +3/8" | 9.500 | 5.40 | 5.5% | 5.5% |
| - 3/8" +1/4" | 6.300 | 12.90 | 13.1% | 18.5% |
| -1/4" + 5 | 4.000 | 26.70 | 27.1% | 45.6% |
| 5 + 10 | 1.700 | 22.80 | 23.1% | 68.7% |
| -10 + 35 | 0.425 | 18.70 | 18.9% | 87.6% |
| -48 + 100 | 0.150 | 4.70 | 4.8% | 92.4% |
| -200 + 270 | 0.053 | 2.50 | 2.5% | 94.9% |
| -270 | -0.053 | 5.00 | 5.1% | 100.0% |
| | | | | |
| TOTAL | | 98.70 | 100.0% | |

# *Appendix 4-6: Kinetic Test Results*

Atlantic Gold

**Appendix 4-6: Kinetic Test Results**

| Cell No. | Sample ID | Sample Type | Method Reference | Column Dimensions | | Column Packing | | | Total Volume of Initial Flushings | Flushing Rate/Weekly Input* | Temp | Sampling Frequency | Start-up Date | Sampling Day | Operation Procedure |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Inner Diameter (cm) | Length (cm) | Dry Wt. of Sample (kg) | Other Materials Used | Column Material | (mL) | (mL) | (°C) | | 2018 | | |
| HC 1 | Cell # 1 | Waste Rock | MEND | 10.20 | 25.50 | 1.00 | Acrylic perforated disk & nylon mesh | Acrylic | 500 | 500 | 20-22 °C | Weekly | 24-Aug | Friday | Flood Leach |
| HC 2 | Cell # 2 | Waste Rock | MEND | 10.20 | 25.50 | 1.00 | Acrylic perforated disk & nylon mesh | Acrylic | 500 | 500 | 20-22 °C | Weekly | 24-Aug | Friday | Flood Leach |
| HC 3 | Cell # 3 | Waste Rock | MEND | 10.20 | 25.50 | 1.00 | Acrylic perforated disk & nylon mesh | Acrylic | 500 | 500 | 20-22 °C | Weekly | 24-Aug | Friday | Flood Leach |
| HC 4 | Cell # 4 | Waste Rock | MEND | 20.00 | 10.50 | 1.00 | Acrylic perforated disk & nylon mesh | Acrylic | 500 | 500 | 20-22 °C | Weekly | 24-Aug | Friday | Flood Leach |
| HC 5 | Cell # 5 | Ore | MEND | 10.20 | 25.50 | 1.00 | Acrylic perforated disk & nylon mesh | Acrylic | 500 | 500 | 20-22 °C | Weekly | 24-Aug | Friday | Flood Leach |

**Appendix 4-6: Kinetic Test Results**

**HC 1**

| Date | Cycle | Volume mL | | pH | Cond. | Acidity | Acidity | Alkalinity | Sulphate | Chloride | Fluoride | Hardness | Al | Sb | As | Ba | Be | Bi | B | Cd | Ca | Cr | Co | Cu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. | Input | Output | | | (pH 4.5) | (pH 8.3) | | | | | CaCO3 | | | | | | | | | | | | |
| | | | | | umhos/cm | mgCaCO3/L | mgCaCO3/L | mgCaCO3/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 |
| 24-Aug-18 | 0 | 500 | 375 | 7.26 | 382 | #N/A | 4.8 | 20.8 | 39 | 54 | 0.14 | 127 | 0.029 | 0.0003 | 0.0080 | 0.00889 | 0.000027 | 0.000024 | 0.013 | 0.000037 | 44.9 | 0.00004 | 0.00107 | 0.00042 |
| 31-Aug-18 | 1 | 500 | 470 | 7.65 | 268 | #N/A | 3.7 | 12.8 | 43 | 32 | 0.11 | 96.8 | 0.113 | 0.0006 | 0.0076 | 0.00478 | <0.0000035 | <0.0000035 | 0.016 | 0.000064 | 34.1 | <0.000015 | 0.000129 | 0.00029 |
| 07-Sep-18 | 2 | 500 | 445 | 7.68 | 129 | #N/A | 2.5 | 14.4 | 24 | 8 | 0.09 | 44.3 | 0.181 | 0.0006 | 0.0100 | 0.00192 | <0.0000035 | <0.0000035 | 0.028 | <0.0000015 | 15.6 | <0.000015 | 0.000042 | 0.00014 |
| 14-Sep-18 | 3 | 500 | 455 | 7.58 | 84 | #N/A | 1.7 | 13.0 | 16 | 2 | 0.07 | 26.5 | 0.141 | 0.0005 | 0.0089 | 0.00110 | 0.000008 | <0.0000035 | 0.018 | <0.0000015 | 9.36 | 0.00016 | 0.000036 | 0.00123 |
| 21-Sep-18 | 4 | 500 | 465 | 7.68 | 70 | #N/A | 2.3 | 13.6 | 13 | | | | | | | | | | | | | | | |
| 28-Sep-18 | 5 | 500 | 475 | 7.69 | 62 | #N/A | 1.6 | 16.5 | 11 | 1 | <0.03 | 25.4 | 0.179 | 0.0004 | 0.0089 | 0.00107 | <0.0000035 | <0.0000035 | 0.006 | <0.0000015 | 9.04 | <0.000015 | 0.000046 | 0.00027 |
| 05-Oct-18 | 6 | 500 | 440 | 7.66 | 54 | #N/A | 1.8 | 12.6 | 6 | | | | | | | | | | | | | | | |
| 12-Oct-18 | 7 | 500 | 435 | 7.71 | 52 | #N/A | 3.8 | 14.7 | 6 | <0.5 | <0.03 | 19.4 | 0.169 | 0.0003 | 0.0087 | 0.00085 | <0.0000035 | <0.0000035 | 0.005 | <0.0000015 | 6.94 | 0.00017 | 0.000037 | 0.00015 |
| 19-Oct-18 | 8 | 500 | 445 | 7.69 | 51 | #N/A | 1.7 | 12.8 | 8 | | | | | | | | | | | | | | | |
| 26-Oct-18 | 9 | 500 | 435 | 7.64 | 50 | #N/A | 1.5 | 11.8 | 11 | <0.5 | <0.03 | 22.2 | 0.152 | 0.0003 | 0.0063 | 0.00084 | <0.0000035 | <0.0000035 | 0.005 | 0.000004 | 8.02 | 0.00003 | 0.000048 | 0.00218 |
| 02-Nov-18 | 10 | 500 | 460 | 7.52 | 60 | #N/A | 1.7 | 10.4 | 13 | | | | | | | | | | | | | | | |
| 09-Nov-18 | 11 | 500 | 465 | 7.42 | 94 | #N/A | 2.6 | 10.2 | 29 | <0.5 | <0.03 | 33.3 | 0.080 | 0.0002 | 0.0080 | 0.00135 | <0.0000035 | <0.0000035 | 0.004 | 0.000004 | 12.1 | <0.000015 | 0.000054 | 0.00042 |
| 16-Nov-18 | 12 | 500 | 435 | 7.38 | 125 | #N/A | 1.6 | 8.6 | 37 | | | | | | | | | | | | | | | |
| 23-Nov-18 | 13 | 500 | 460 | 7.46 | 106 | #N/A | 2.4 | 9.1 | 31 | <0.5 | <0.03 | 38.9 | 0.078 | <0.0001 | 0.0064 | 0.00161 | 0.000007 | <0.0000035 | 0.002 | <0.0000015 | 14.4 | <0.000015 | 0.000063 | 0.00023 |
| 30-Nov-18 | 14 | 500 | 440 | 7.42 | 96 | #N/A | 2.0 | 8.5 | 29 | | | | | | | | | | | | | | | |
| 07-Dec-18 | 15 | 500 | 475 | 7.41 | 96 | #N/A | 4.3 | 10.6 | 30 | <0.5 | 0.07 | 37.7 | 0.073 | <0.0001 | 0.0077 | 0.00153 | <0.0000035 | <0.0000035 | 0.005 | 0.000003 | 14.1 | <0.000015 | 0.000053 | 0.00146 |
| 14-Dec-18 | 16 | 500 | 480 | 7.50 | 95 | #N/A | 3.6 | 10.1 | 28 | | | | | | | | | | | | | | | |
| 21-Dec-18 | 17 | 500 | 475 | 7.41 | 98 | #N/A | 4.0 | 10.4 | 28 | <0.5 | <0.03 | 37.7 | 0.065 | <0.0001 | 0.0076 | 0.00183 | <0.0000035 | <0.0000035 | 0.002 | 0.000015 | 14.3 | <0.000015 | 0.000086 | 0.00232 |
| 28-Dec-18 | 18 | 500 | 475 | 7.37 | 98 | #N/A | 1.9 | 8.4 | 30 | | | | | | | | | | | | | | | |
| 04-Jan-19 | 19 | 500 | 485 | 7.50 | 95 | #N/A | 3.5 | 9.4 | 28 | <0.5 | <0.03 | 39.5 | 0.066 | <0.0001 | 0.0079 | 0.00185 | <0.0000035 | <0.0000035 | 0.003 | <0.0000015 | 15.0 | 0.00004 | 0.000095 | 0.00051 |
| 11-Jan-19 | 20 | 500 | 480 | 7.35 | 94 | #N/A | 2.7 | 8.3 | 30 | | | | | | | | | | | | | | | |
| 18-Jan-19 | 21 | 500 | 465 | 7.39 | 83 | #N/A | 1.7 | 9.6 | 33 | <0.5 | <0.03 | 41.3 | 0.099 | <0.0001 | 0.0103 | 0.00156 | <0.0000035 | <0.0000035 | 0.003 | 0.000032 | 15.7 | <0.000015 | 0.000054 | 0.00014 |
| 25-Jan-19 | 22 | 500 | 470 | 7.38 | 99 | #N/A | 1.8 | 7.7 | 30 | | | | | | | | | | | | | | | |
| 01-Feb-19 | 23 | 500 | 465 | 7.25 | 101 | #N/A | 2.9 | 9.2 | 31 | <0.5 | <0.03 | 37.0 | 0.057 | <0.0001 | 0.0072 | 0.00149 | <0.0000035 | <0.0000035 | 0.003 | 0.000020 | 14.0 | <0.000015 | 0.000062 | 0.00048 |
| 08-Feb-19 | 24 | 500 | 465 | 7.38 | 93 | #N/A | 3.0 | 9.2 | 29 | | | | | | | | | | | | | | | |
| 15-Feb-19 | 25 | 500 | 470 | 7.35 | 90 | #N/A | 1.7 | 8.6 | 26 | <0.5 | <0.03 | 37.3 | 0.056 | <0.0001 | 0.0071 | 0.00155 | <0.0000035 | <0.0000035 | 0.008 | 0.000018 | 14.3 | <0.000015 | 0.000061 | 0.00047 |
| 22-Feb-19 | 26 | 500 | 440 | 7.57 | 87 | #N/A | 3.2 | 8.7 | 27 | | | | | | | | | | | | | | | |
| 01-Mar-19 | 27 | 500 | 460 | 7.25 | 84 | #N/A | 2.5 | 9.4 | 23 | <0.5 | <0.03 | 33.9 | 0.059 | <0.00045 | 0.0071 | 0.00129 | <0.0000035 | <0.0000035 | 0.004 | 0.000007 | 13.0 | <0.00004 | 0.000057 | 0.0005 |
| 08-Mar-19 | 28 | 500 | 445 | 7.28 | 85 | #N/A | 3.4 | 8.8 | 28 | | | | | | | | | | | | | | | |
| 15-Mar-19 | 29 | 500 | 465 | 7.26 | 79 | #N/A | 2.8 | 7.8 | 26 | <0.5 | <0.03 | 33.1 | 0.050 | <0.00045 | 0.0066 | 0.00134 | <0.0000035 | <0.0000035 | 0.003 | 0.000022 | 12.7 | <0.00004 | 0.000063 | 0.0012 |
| 22-Mar-19 | 30 | 500 | 460 | 7.36 | 82 | #N/A | 3.5 | 8.9 | 25 | | | | | | | | | | | | | | | |
| 29-Mar-19 | 31 | 500 | 460 | 7.22 | 79 | #N/A | 2.6 | 7.7 | 25 | <0.5 | <0.03 | 31.8 | 0.046 | <0.00045 | 0.0060 | 0.00127 | <0.0000035 | <0.0000035 | 0.002 | 0.000032 | 12.2 | <0.00004 | 0.000050 | 0.0002 |
| 05-Apr-19 | 32 | 500 | 465 | 7.77 | 81 | #N/A | 4.6 | 11.9 | 25 | | | | | | | | | | | | | | | |
| 12-Apr-19 | 33 | 500 | 485 | 7.23 | 85 | #N/A | 2.0 | 11.9 | 27 | <0.5 | 0.08 | 33.0 | 0.046 | <0.00045 | 0.0062 | 0.00120 | <0.0000035 | <0.0000035 | 0.003 | 0.000012 | 12.7 | <0.00004 | 0.000064 | 0.0015 |
| 19-Apr-19 | 34 | 500 | 455 | 7.39 | 75 | #N/A | 2.1 | 9.2 | 21 | | | | | | | | | | | | | | | |
| 26-Apr-19 | 35 | 500 | 455 | 7.39 | 74 | #N/A | 2.9 | 7.2 | 24 | <0.5 | <0.03 | 32.0 | 0.049 | <0.00045 | 0.0060 | 0.00131 | <0.0000035 | <0.0000035 | 0.005 | 0.000009 | 12.3 | <0.00004 | 0.000075 | 0.0007 |
| 03-May-19 | 36 | 500 | 465 | 7.62 | 75 | #N/A | 2.8 | 7.6 | 24 | | | | | | | | | | | | | | | |
| 10-May-19 | 37 | 500 | 455 | 7.47 | 74 | #N/A | 1.6 | 7.7 | 22 | <0.5 | <0.03 | 30.5 | 0.048 | <0.00045 | 0.0063 | 0.00126 | <0.0000035 | <0.0000035 | 0.002 | 0.000005 | 11.8 | <0.00004 | 0.000120 | 0.0027 |
| 17-May-19 | 38 | 500 | 465 | 7.25 | 73 | #N/A | 2.6 | 7.1 | 20 | <0.5 | <0.03 | 28.8 | 0.046 | <0.00045 | 0.0062 | 0.00112 | <0.0000035 | <0.0000035 | <0.001 | 0.000009 | 11.1 | <0.00004 | 0.000092 | 0.0007 |
| 24-May-19 | 39 | 500 | 445 | 7.24 | 69 | #N/A | 3.1 | 7.1 | 20 | <0.5 | <0.03 | 27.7 | 0.041 | <0.00045 | 0.0051 | 0.00101 | <0.0000035 | <0.0000035 | 0.003 | <0.0000015 | 10.7 | <0.00004 | 0.000067 | 0.0007 |
| 31-May-19 | 40 | 500 | 460 | 7.20 | 69 | #N/A | 2.7 | 6.6 | 18 | | | | | | | | | | | | | | | |
| 07-Jun-19 | 41 | 500 | 460 | 7.15 | | | | 6.8 | 23 | | | | | | | | | | | | | | | |
| 14-Jun-19 | 42 | 500 | 470 | 7.05 | | | | 5.6 | | | | | | | | | | | | | | | | |
| 21-Jun-19 | 43 | 500 | 450 | 7.22 | | | | 6.0 | 19 | | | 26.5 | 0.045 | <0.00045 | 0.0051 | 0.00106 | <0.0000035 | <0.0000035 | 0.002 | 0.000003 | 10.2 | <0.00004 | 0.000108 | 0.0032 |
| 28-Jun-19 | 44 | 500 | 465 | 7.14 | | | | 6.0 | | | | | | | | | | | | | | | | |
| 05-Jul-19 | 45 | 500 | 445 | 7.01 | | | | 4.7 | 19 | | | | | | | | | | | | | | | |
| 12-Jul-19 | 46 | 500 | 460 | 7.01 | | | | 6.2 | | | | | | | | | | | | | | | | |
| 19-Jul-19 | 47 | 500 | 460 | 6.96 | | | | 5.9 | 20 | | | 25.4 | 0.037 | <0.00045 | 0.0047 | 0.00102 | <0.0000035 | <0.0000035 | 0.003 | 0.000003 | 9.77 | <0.00004 | 0.000052 | <0.0001 |
| 26-Jul-19 | 48 | 500 | 465 | 7.40 | | | | 5.9 | | | | | | | | | | | | | | | | |
| 02-Aug-19 | 49 | 500 | 450 | 6.64 | | | | 5.8 | 18 | | | | | | | | | | | | | | | |
| 09-Aug-19 | 50 | 500 | 440 | 7.15 | | | | 6.2 | | | | | | | | | | | | | | | | |

Jun 07/19. Change in analytical schedule.

**Appendix 4-6: Kinetic Test Results**
**HC 1**

| Date | Cycle | Volume mL | | pH | Cond. | Acidity | Acidity | Alkalinity | Sulphate | Chloride | Fluoride | Hardness | Al | Sb | As | Ba | Be | Bi | B | Cd | Ca | Cr | Co | Cu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. | Input | Output | | | (pH 4.5) | (pH 8.3) | | | | | CaCO3 | | | | | | | | | | | | |
| | | | | | umhos/cm | mgCaCO3/L | mgCaCO3/L | mgCaCO3/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 |
| **Loads** | **mg/kg** | | | | | | | | | | | | | | | | | | | | | | | |
| 24-Aug-18 | 0 | | | 7.26 | | | | | 14.625 | 20.25 | 0.0525 | 47.625 | 0.010875 | 0.0001125 | 0.003 | 0.00333375 | 0.000010125 | 0.000009 | 0.004875 | 0.000013875 | 16.8375 | 0.000015 | 0.00040125 | 0.0001575 |
| 31-Aug-18 | 1 | | | 7.65 | | | | | 20.21 | 15.04 | 0.0517 | 45.496 | 0.05311 | 0.000282 | 0.003572 | 0.0022466 | 0.000001645 | 0.000001645 | 0.00752 | 0.00003008 | 16.027 | 0.00000705 | 0.00006063 | 0.0001363 |
| 07-Sep-18 | 2 | | | 7.68 | | | | | 10.68 | 3.56 | 0.04005 | 19.7135 | 0.080545 | 0.000267 | 0.00445 | 0.0008544 | 1.5575E-06 | 1.5575E-06 | 0.01246 | 6.675E-07 | 6.942 | 0.000006675 | 0.00001869 | 0.0000623 |
| 14-Sep-18 | 3 | | | 7.58 | | | | | 7.28 | 0.91 | 0.03185 | 12.0575 | 0.064155 | 0.0002275 | 0.0040495 | 0.0005005 | 0.00000364 | 1.5925E-06 | 0.00819 | 6.825E-07 | 4.2588 | 0.0000728 | 0.00001638 | 0.00055965 |
| 21-Sep-18 | 4 | | | 7.68 | | | | | 6.045 | | | | | | | | | | | | | | | |
| 28-Sep-18 | 5 | | | 7.69 | | | | | 5.225 | 0.475 | 0.01425 | 12.065 | 0.085025 | 0.00019 | 0.0042275 | 0.00050825 | 1.6625E-06 | 1.6625E-06 | 0.00285 | 7.125E-07 | 4.294 | 0.000007125 | 0.00002185 | 0.00012825 |
| 05-Oct-18 | 6 | | | 7.66 | | | | | 2.64 | | | | | | | | | | | | | | | |
| 12-Oct-18 | 7 | | | 7.71 | | | | | 2.61 | 0.2175 | 0.01305 | 8.439 | 0.073515 | 0.0001305 | 0.0037845 | 0.00036975 | 1.5225E-06 | 1.5225E-06 | 0.002175 | 6.525E-07 | 3.0189 | 0.00007395 | 0.000016095 | 0.00006525 |
| 19-Oct-18 | 8 | | | 7.69 | | | | | 3.56 | | | | | | | | | | | | | | | |
| 26-Oct-18 | 9 | | | 7.64 | | | | | 4.785 | 0.2175 | 0.01305 | 9.657 | 0.06612 | 0.0001305 | 0.0027405 | 0.0003654 | 1.5225E-06 | 1.5225E-06 | 0.002175 | 0.00000174 | 3.4887 | 0.00001305 | 0.00002088 | 0.0009483 |
| 02-Nov-18 | 10 | | | 7.52 | | | | | 5.98 | | | | | | | | | | | | | | | |
| 09-Nov-18 | 11 | | | 7.42 | | | | | 13.485 | 0.2325 | 0.01395 | 15.4845 | 0.0372 | 0.000093 | 0.00372 | 0.00062775 | 1.6275E-06 | 1.6275E-06 | 0.00186 | 0.00000186 | 5.6265 | 0.000006975 | 0.00002511 | 0.0001953 |
| 16-Nov-18 | 12 | | | 7.38 | | | | | 16.095 | | | | | | | | | | | | | | | |
| 23-Nov-18 | 13 | | | 7.46 | | | | | 14.26 | 0.23 | 0.0138 | 17.894 | 0.03588 | 0.000046 | 0.002944 | 0.0007406 | 0.00000322 | 0.00000161 | 0.00092 | 0.00000069 | 6.624 | 0.0000069 | 0.00002898 | 0.0001058 |
| 30-Nov-18 | 14 | | | 7.42 | | | | | 12.76 | | | | | | | | | | | | | | | |
| 07-Dec-18 | 15 | | | 7.41 | | | | | 14.25 | 0.2375 | 0.03325 | 17.9075 | 0.034675 | 0.0000475 | 0.0036575 | 0.00072675 | 1.6625E-06 | 1.6625E-06 | 0.002375 | 0.000001425 | 6.6975 | 0.000007125 | 0.000025175 | 0.0006935 |
| 14-Dec-18 | 16 | | | 7.5 | | | | | 13.44 | | | | | | | | | | | | | | | |
| 21-Dec-18 | 17 | | | 7.41 | | | | | 13.3 | 0.2375 | 0.01425 | 17.9075 | 0.030875 | 0.0000475 | 0.00361 | 0.00086925 | 1.6625E-06 | 1.6625E-06 | 0.00095 | 0.000007125 | 6.7925 | 0.000007125 | 0.00004085 | 0.001102 |
| 28-Dec-18 | 18 | | | 7.37 | | | | | 14.25 | | | | | | | | | | | | | | | |
| 04-Jan-19 | 19 | | | 7.5 | | | | | 13.58 | 0.2425 | 0.01455 | 19.1575 | 0.03201 | 0.0000485 | 0.0038315 | 0.00089725 | 1.6975E-06 | 1.6975E-06 | 0.001455 | 7.275E-07 | 7.275 | 0.0000194 | 0.000046075 | 0.00024735 |
| 11-Jan-19 | 20 | | | 7.35 | | | | | 14.4 | | | | | | | | | | | | | | | |
| 18-Jan-19 | 21 | | | 7.39 | | | | | 15.345 | 0.2325 | 0.01395 | 19.2045 | 0.046035 | 0.0000465 | 0.0047895 | 0.0007254 | 1.6275E-06 | 1.6275E-06 | 0.001395 | 0.00001488 | 7.3005 | 0.000006975 | 0.00002511 | 0.0000651 |
| 25-Jan-19 | 22 | | | 7.38 | | | | | 14.1 | | | | | | | | | | | | | | | |
| 01-Feb-19 | 23 | | | 7.25 | | | | | 14.415 | 0.2325 | 0.01395 | 17.205 | 0.026505 | 0.0000465 | 0.003348 | 0.00069285 | 1.6275E-06 | 1.6275E-06 | 0.001395 | 0.0000093 | 6.51 | 0.000006975 | 0.00002883 | 0.0002232 |
| 08-Feb-19 | 24 | | | 7.38 | | | | | 13.485 | | | | | | | | | | | | | | | |
| 15-Feb-19 | 25 | | | 7.35 | | | | | 12.22 | 0.235 | 0.0141 | 17.531 | 0.02632 | 0.000047 | 0.003337 | 0.0007285 | 0.000001645 | 0.000001645 | 0.00376 | 0.00000846 | 6.721 | 0.00000705 | 0.00002867 | 0.0002209 |
| 22-Feb-19 | 26 | | | 7.57 | | | | | 11.88 | | | | | | | | | | | | | | | |
| 01-Mar-19 | 27 | | | 7.25 | | | | | 10.58 | 0.23 | 0.0138 | 15.594 | 0.02714 | 0.000207 | 0.003266 | 0.0005934 | 0.00000161 | 0.00000161 | 0.00184 | 0.00000322 | 5.98 | 0.0000184 | 0.00002622 | 0.00023 |
| 08-Mar-19 | 28 | | | 7.28 | | | | | 12.46 | | | | | | | | | | | | | | | |
| 15-Mar-19 | 29 | | | 7.26 | | | | | 12.09 | 0.2325 | 0.01395 | 15.3915 | 0.02325 | 0.00020925 | 0.003069 | 0.0006231 | 1.6275E-06 | 1.6275E-06 | 0.001395 | 0.00001023 | 5.9055 | 0.0000186 | 0.000029295 | 0.000558 |
| 22-Mar-19 | 30 | | | 7.36 | | | | | 11.5 | | | | | | | | | | | | | | | |
| 29-Mar-19 | 31 | | | 7.22 | | | | | 11.5 | 0.23 | 0.0138 | 14.628 | 0.02116 | 0.000207 | 0.00276 | 0.0005842 | 0.00000161 | 0.00000161 | 0.00092 | 0.00001472 | 5.612 | 0.0000184 | 0.000023 | 0.000092 |
| 05-Apr-19 | 32 | | | 7.77 | | | | | 11.625 | | | | | | | | | | | | | | | |
| 12-Apr-19 | 33 | | | 7.23 | | | | | 13.095 | 0.2425 | 0.0388 | 16.005 | 0.02231 | 0.00021825 | 0.003007 | 0.000582 | 1.6975E-06 | 1.6975E-06 | 0.001455 | 0.00000582 | 6.1595 | 0.0000194 | 0.00003104 | 0.0007275 |
| 19-Apr-19 | 34 | | | 7.39 | | | | | 9.555 | | | | | | | | | | | | | | | |
| 26-Apr-19 | 35 | | | 7.39 | | | | | 10.92 | 0.2275 | 0.01365 | 14.56 | 0.022295 | 0.00020475 | 0.00273 | 0.00059605 | 1.5925E-06 | 1.5925E-06 | 0.002275 | 0.000004095 | 5.5965 | 0.0000182 | 0.000034125 | 0.0003185 |
| 03-May-19 | 36 | | | 7.62 | | | | | 11.16 | | | | | | | | | | | | | | | |
| 10-May-19 | 37 | | | 7.47 | | | | | 10.01 | 0.2275 | 0.01365 | 13.8775 | 0.02184 | 0.00020475 | 0.0028665 | 0.0005733 | 1.5925E-06 | 1.5925E-06 | 0.00091 | 0.000002275 | 5.369 | 0.0000182 | 0.0000546 | 0.0012285 |
| 17-May-19 | 38 | | | 7.25 | | | | | 9.3 | 0.2325 | 0.01395 | 13.392 | 0.02139 | 0.00020925 | 0.002883 | 0.0005208 | 1.6275E-06 | 1.6275E-06 | 0.000465 | 0.000004185 | 5.1615 | 0.0000186 | 0.00004278 | 0.0003255 |
| 24-May-19 | 39 | | | 7.24 | | | | | 8.9 | 0.2225 | 0.01335 | 12.3265 | 0.018245 | 0.00020025 | 0.0022695 | 0.00044945 | 1.5575E-06 | 1.5575E-06 | 0.001335 | 6.675E-07 | 4.7615 | 0.0000178 | 0.000029815 | 0.0003115 |
| 31-May-19 | 40 | | | 7.2 | | | | | 8.28 | | | | | | | | | | | | | | | |
| 07-Jun-19 | 41 | | | 7.15 | | | | | 10.58 | | | | | | | | | | | | | | | |
| 14-Jun-19 | 42 | | | 7.05 | | | | | | | | | | | | | | | | | | | | |
| 21-Jun-19 | 43 | | | 7.22 | | | | | 8.55 | | | 11.925 | 0.02025 | 0.0002025 | 0.002295 | 0.000477 | 0.000001575 | 0.000001575 | 0.0009 | 0.00000135 | 4.59 | 0.000018 | 0.0000486 | 0.00144 |
| 28-Jun-19 | 44 | | | 7.14 | | | | | | | | | | | | | | | | | | | | |
| 05-Jul-19 | 45 | | | 7.01 | | | | | 8.455 | | | | | | | | | | | | | | | |
| 12-Jul-19 | 46 | | | 7.01 | | | | | | | | | | | | | | | | | | | | |
| 19-Jul-19 | 47 | | | 6.96 | | | | | 9.2 | | | 11.684 | 0.01702 | 0.000207 | 0.002162 | 0.0004692 | 0.00000161 | 0.00000161 | 0.00138 | 0.00000138 | 4.4942 | 0.0000184 | 0.00002392 | 0.000046 |
| 26-Jul-19 | 48 | | | 7.4 | | | | | | | | | | | | | | | | | | | | |
| 02-Aug-19 | 49 | | | 6.64 | | | | | 8.1 | | | | | | | | | | | | | | | |

**Appendix 4-6: Kinetic Test Results**
**HC 1**

| Date | Cycle No. | Fe | Pb | Li | Mg | Mn | Hg | Mo | Ni | P | K | Se | Si | Ag | Na | Sr | S | Tl | Sn | Ti | U | V | Zn | Zr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | mg/L | mg/L | mg/L | mg/L | mg/L | ug/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L |
| 24-Aug-18 | 0 | 0.010 | 0.00003 | 0.0087 | 3.53 | 0.147 | <0.005 | 0.00039 | 0.0108 | 0.029 | 17.4 | 0.00012 | 1.22 | <0.000025 | 6.86 | 0.481 | 14.8 | 0.000053 | 0.00224 | <0.000025 | 0.000232 | 0.00023 | <0.001 | <0.001 |
| 31-Aug-18 | 1 | <0.0035 | <0.000005 | 0.0052 | 2.82 | 0.0424 | <0.005 | 0.00080 | 0.0022 | 0.012 | 10.8 | 0.00013 | 1.41 | <0.000025 | 4.40 | 0.347 | 15.7 | 0.000016 | 0.00115 | <0.000025 | 0.000463 | 0.00054 | <0.001 | <0.001 |
| 07-Sep-18 | 2 | <0.0035 | 0.00003 | 0.0029 | 1.30 | 0.0157 | <0.005 | 0.00085 | 0.0007 | <0.0015 | 6.50 | 0.00013 | 1.33 | <0.000025 | 1.97 | 0.150 | 9.5 | 0.000007 | 0.00061 | <0.000025 | 0.000271 | 0.00076 | <0.001 | <0.001 |
| 14-Sep-18 | 3 | 0.043 | 0.00005 | 0.0021 | 0.772 | 0.0122 | 0.02 | 0.00036 | 0.0004 | 0.003 | 4.24 | 0.00013 | 1.02 | <0.000025 | 1.00 | 0.0977 | 5.0 | 0.000008 | 0.00035 | 0.00007 | 0.000213 | 0.00075 | <0.001 | <0.001 |
| 21-Sep-18 | 4 | | | | | | | | | | | | | | | | | | | | | | | |
| 28-Sep-18 | 5 | 0.010 | 0.00002 | 0.0021 | 0.678 | 0.0134 | 0.02 | 0.00015 | 0.0007 | <0.0015 | 3.29 | 0.00004 | 1.20 | <0.000025 | 0.56 | 0.0796 | 4.0 | <0.0000025 | 0.00020 | <0.000025 | 0.000296 | 0.00092 | <0.001 | <0.001 |
| 05-Oct-18 | 6 | | | | | | | | | | | | | | | | | | | | | | | |
| 12-Oct-18 | 7 | <0.0035 | 0.00003 | 0.0017 | 0.510 | 0.0105 | <0.005 | 0.00009 | <0.00005 | <0.0015 | 2.50 | <0.00002 | 1.02 | <0.000025 | 0.38 | 0.0550 | 2.7 | 0.000005 | 0.00008 | 0.00017 | 0.000153 | 0.00082 | <0.001 | <0.001 |
| 19-Oct-18 | 8 | | | | | | | | | | | | | | | | | | | | | | | |
| 26-Oct-18 | 9 | 0.016 | <0.000005 | 0.0015 | 0.522 | 0.00319 | 0.05 | 0.00028 | 0.0002 | 0.003 | 2.65 | 0.00007 | 0.79 | <0.000025 | 0.38 | 0.0504 | 3.5 | <0.0000025 | 0.00011 | 0.00070 | 0.000262 | 0.00091 | <0.001 | <0.001 |
| 02-Nov-18 | 10 | | | | | | | | | | | | | | | | | | | | | | | |
| 09-Nov-18 | 11 | <0.0035 | 0.00002 | 0.0016 | 0.755 | 0.00116 | <0.005 | 0.00021 | 0.0003 | <0.0015 | 2.22 | <0.00002 | 0.82 | <0.000025 | 0.28 | 0.0914 | 8.9 | 0.000007 | 0.00009 | 0.00006 | 0.000710 | 0.00041 | <0.001 | <0.001 |
| 16-Nov-18 | 12 | | | | | | | | | | | | | | | | | | | | | | | |
| 23-Nov-18 | 13 | <0.0035 | <0.000005 | 0.0014 | 0.712 | 0.00136 | <0.005 | 0.00027 | 0.0002 | 0.005 | 2.40 | <0.00002 | 0.77 | <0.000025 | 0.24 | 0.0888 | 10.6 | 0.000012 | 0.00012 | <0.000025 | 0.000633 | 0.00031 | <0.001 | <0.001 |
| 30-Nov-18 | 14 | | | | | | | | | | | | | | | | | | | | | | | |
| 07-Dec-18 | 15 | <0.0035 | <0.000005 | 0.0012 | 0.592 | 0.00177 | <0.005 | 0.00050 | 0.0002 | <0.0015 | 2.39 | <0.00002 | 0.87 | <0.000025 | 0.18 | 0.0801 | 9.8 | <0.0000025 | 0.00008 | <0.000025 | 0.000530 | 0.00032 | <0.001 | <0.001 |
| 14-Dec-18 | 16 | | | | | | | | | | | | | | | | | | | | | | | |
| 21-Dec-18 | 17 | <0.0035 | <0.000005 | 0.0010 | 0.497 | 0.00218 | <0.005 | 0.00033 | <0.00005 | <0.0015 | 2.38 | <0.00002 | 0.82 | <0.000025 | 0.17 | 0.0730 | 10.2 | <0.0000025 | 0.00006 | <0.000025 | 0.000501 | 0.00027 | <0.001 | <0.001 |
| 28-Dec-18 | 18 | | | | | | | | | | | | | | | | | | | | | | | |
| 04-Jan-19 | 19 | <0.0035 | 0.00001 | 0.0010 | 0.510 | 0.00146 | <0.005 | 0.00259 | 0.0002 | <0.0015 | 2.32 | 0.00005 | 0.68 | <0.000025 | 0.20 | 0.0690 | 12.6 | <0.0000025 | 0.00002 | <0.000025 | 0.000359 | 0.00023 | <0.001 | <0.001 |
| 11-Jan-19 | 20 | | | | | | | | | | | | | | | | | | | | | | | |
| 18-Jan-19 | 21 | <0.0035 | <0.000005 | 0.0012 | 0.517 | 0.00042 | <0.005 | 0.00038 | <0.00005 | <0.0015 | 2.23 | <0.00002 | 0.72 | <0.000025 | 0.21 | 0.0687 | 11.1 | <0.0000025 | 0.00007 | <0.000025 | 0.000401 | 0.00021 | <0.001 | <0.001 |
| 25-Jan-19 | 22 | | | | | | | | | | | | | | | | | | | | | | | |
| 01-Feb-19 | 23 | <0.0035 | <0.000005 | 0.0017 | 0.483 | 0.00090 | <0.005 | 0.00459 | 0.0002 | <0.0015 | 1.77 | <0.00002 | 0.71 | <0.000025 | 0.22 | 0.0637 | 12.6 | <0.0000025 | 0.00006 | <0.000025 | 0.000350 | 0.00016 | <0.001 | <0.001 |
| 08-Feb-19 | 24 | | | | | | | | | | | | | | | | | | | | | | | |
| 15-Feb-19 | 25 | <0.0035 | <0.000005 | 0.0010 | 0.394 | 0.00114 | <0.005 | 0.00038 | 0.0002 | <0.0015 | 1.95 | <0.00002 | 0.73 | <0.000025 | 0.24 | 0.0482 | 11.9 | 0.000007 | <0.00005 | 0.00007 | 0.000233 | 0.00018 | <0.001 | <0.001 |
| 22-Feb-19 | 26 | | | | | | | | | | | | | | | | | | | | | | | |
| 01-Mar-19 | 27 | <0.0035 | <0.000005 | 0.0027 | 0.350 | 0.00087 | <0.005 | 0.00038 | 0.0003 | <0.0015 | 1.73 | <0.00002 | 0.64 | <0.000025 | 0.23 | 0.0455 | 9.6 | <0.0000025 | 0.00009 | <0.000025 | 0.000187 | 0.00015 | <0.001 | <0.001 |
| 08-Mar-19 | 28 | | | | | | | | | | | | | | | | | | | | | | | |
| 15-Mar-19 | 29 | <0.0035 | 0.00012 | 0.0010 | 0.336 | 0.00127 | <0.005 | 0.00030 | 0.0002 | <0.0015 | 1.64 | <0.00002 | 0.62 | <0.000025 | 0.12 | 0.0416 | 9.7 | <0.0000025 | 0.00019 | <0.000025 | 0.000185 | 0.00016 | <0.001 | <0.001 |
| 22-Mar-19 | 30 | | | | | | | | | | | | | | | | | | | | | | | |
| 29-Mar-19 | 31 | <0.0035 | <0.000005 | 0.0013 | 0.329 | 0.00101 | <0.005 | 0.00028 | 0.0002 | <0.0015 | 1.52 | <0.00002 | 0.59 | <0.000025 | 0.16 | 0.0387 | 11.2 | 0.000010 | <0.00003 | <0.000025 | 0.000131 | 0.00011 | <0.001 | <0.001 |
| 05-Apr-19 | 32 | | | | | | | | | | | | | | | | | | | | | | | |
| 12-Apr-19 | 33 | <0.0035 | <0.000005 | 0.0009 | 0.326 | 0.00100 | <0.005 | 0.00210 | 0.0001 | 0.006 | 1.46 | <0.00002 | 0.59 | <0.000025 | 0.12 | 0.0387 | 7.3 | 0.000009 | 0.00006 | 0.00010 | 0.000228 | 0.00012 | <0.001 | <0.001 |
| 19-Apr-19 | 34 | | | | | | | | | | | | | | | | | | | | | | | |
| 26-Apr-19 | 35 | <0.0035 | 0.00002 | 0.0011 | 0.297 | 0.00196 | <0.005 | 0.00076 | <0.00005 | <0.0015 | 1.53 | <0.00002 | 0.61 | <0.000025 | 0.18 | 0.0353 | 10.4 | 0.000010 | 0.00006 | <0.000025 | 0.000129 | 0.00018 | <0.001 | <0.001 |
| 03-May-19 | 36 | | | | | | | | | | | | | | | | | | | | | | | |
| 10-May-19 | 37 | 0.029 | <0.000005 | 0.0009 | 0.290 | 0.00429 | <0.005 | 0.00029 | 0.0002 | <0.0015 | 1.45 | <0.00002 | 0.60 | <0.000025 | 0.16 | 0.0317 | 9.3 | 0.000009 | <0.00003 | <0.000025 | 0.000131 | 0.00012 | <0.001 | <0.001 |
| 17-May-19 | 38 | <0.0035 | 0.00001 | 0.0009 | 0.262 | 0.00142 | <0.005 | 0.00025 | 0.0002 | <0.0015 | 1.38 | <0.00002 | 0.59 | <0.000025 | 0.15 | 0.0302 | 7.9 | 0.000009 | <0.00003 | <0.000025 | 0.000086 | 0.00011 | <0.001 | <0.001 |
| 24-May-19 | 39 | <0.0035 | <0.000005 | 0.0010 | 0.258 | 0.00134 | <0.005 | 0.00027 | 0.0001 | <0.0015 | 1.37 | <0.00002 | 0.59 | <0.000025 | 0.15 | 0.0283 | 7.8 | 0.000009 | <0.00003 | <0.000025 | 0.000078 | 0.00010 | <0.001 | <0.001 |
| 31-May-19 | 40 | | | | | | | | | | | | | | | | | | | | | | | |
| 07-Jun-19 | 41 | | | | | | | | | | | | | | | | | | | | | | | |
| 14-Jun-19 | 42 | | | | | | | | | | | | | | | | | | | | | | | |
| 21-Jun-19 | 43 | 0.063 | <0.000005 | 0.0007 | 0.245 | 0.00399 | <0.005 | 0.00028 | 0.0002 | <0.0015 | 1.33 | <0.00002 | 0.48 | <0.000025 | 0.16 | 0.0239 | 5.4 | 0.000007 | <0.00003 | <0.000025 | 0.000092 | 0.00009 | <0.001 | <0.001 |
| 28-Jun-19 | 44 | | | | | | | | | | | | | | | | | | | | | | | |
| 05-Jul-19 | 45 | | | | | | | | | | | | | | | | | | | | | | | |
| 12-Jul-19 | 46 | | | | | | | | | | | | | | | | | | | | | | | |
| 19-Jul-19 | 47 | <0.0035 | 0.00002 | 0.0008 | 0.241 | 0.00185 | <0.005 | 0.00089 | 0.0003 | <0.0015 | 1.27 | <0.00002 | 0.50 | <0.000025 | 0.10 | 0.0210 | 7.5 | 0.000008 | <0.00003 | <0.000025 | 0.000090 | 0.00007 | <0.001 | <0.001 |
| 26-Jul-19 | 48 | | | | | | | | | | | | | | | | | | | | | | | |
| 02-Aug-19 | 49 | | | | | | | | | | | | | | | | | | | | | | | |
| 09-Aug-19 | 50 | | | | | | | | | | | | | | | | | | | | | | | |

Jun 07/19. Change in analytica

**Appendix 4-6: Kinetic Test Results**
**HC 1**

| Date | Cycle No. | Fe | Pb | Li | Mg | Mn | Hg | Mo | Ni | P | K | Se | Si | Ag | Na | Sr | S | Tl | Sn | Ti | U | V | Zn | Zr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | mg/L | mg/L | mg/L | mg/L | mg/L | ug/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L |
| **Loads** | **mg/kg** | | | | | | | | | | | | | | | | | | | | | | | |
| 24-Aug-18 | 0 | 0.00375 | 0.00001125 | 0.0032625 | 1.32375 | 0.055125 | 0.001875 | 0.00014625 | 0.00405 | 0.010875 | 6.525 | 0.000045 | 0.4575 | 0.000009375 | 2.5725 | 0.180375 | 5.55 | 0.000019875 | 0.00084 | 0.000009375 | 0.000087 | 0.00008625 | 0.000375 | 0.000375 |
| 31-Aug-18 | 1 | 0.001645 | 0.00000235 | 0.002444 | 1.3254 | 0.019928 | 0.00235 | 0.000376 | 0.001034 | 0.00564 | 5.076 | 0.0000611 | 0.6627 | 0.00001175 | 2.068 | 0.16309 | 7.379 | 0.00000752 | 0.0005405 | 0.00001175 | 0.00021761 | 0.0002538 | 0.00047 | 0.00047 |
| 07-Sep-18 | 2 | 0.0015575 | 0.00001335 | 0.0012905 | 0.5785 | 0.0069865 | 0.002225 | 0.00037825 | 0.0003115 | 0.0006675 | 2.8925 | 0.00005785 | 0.59185 | 0.000011125 | 0.87665 | 0.06675 | 4.2275 | 0.000003115 | 0.00027145 | 0.000011125 | 0.000120595 | 0.0003382 | 0.000445 | 0.000445 |
| 14-Sep-18 | 3 | 0.019565 | 0.00002275 | 0.0009555 | 0.35126 | 0.005551 | 0.0091 | 0.0001638 | 0.000182 | 0.001365 | 1.9292 | 0.00005915 | 0.4641 | 0.000011375 | 0.455 | 0.0444535 | 2.275 | 0.00000364 | 0.00015925 | 0.00003185 | 0.000096915 | 0.00034125 | 0.000455 | 0.000455 |
| 21-Sep-18 | 4 | | | | | | | | | | | | | | | | | | | | | | | |
| 28-Sep-18 | 5 | 0.00475 | 0.0000095 | 0.0009975 | 0.32205 | 0.006365 | 0.0095 | 0.00007125 | 0.0003325 | 0.0007125 | 1.56275 | 0.000019 | 0.57 | 0.000011875 | 0.266 | 0.03781 | 1.9 | 1.1875E-06 | 0.000095 | 0.000011875 | 0.0001406 | 0.000437 | 0.000475 | 0.000475 |
| 05-Oct-18 | 6 | | | | | | | | | | | | | | | | | | | | | | | |
| 12-Oct-18 | 7 | 0.0015225 | 0.00001305 | 0.0007395 | 0.22185 | 0.0045675 | 0.002175 | 0.00003915 | 0.00002175 | 0.0006525 | 1.0875 | 0.0000087 | 0.4437 | 0.000010875 | 0.1653 | 0.023925 | 1.1745 | 0.000002175 | 0.0000348 | 0.00007395 | 0.000066555 | 0.0003567 | 0.000435 | 0.000435 |
| 19-Oct-18 | 8 | | | | | | | | | | | | | | | | | | | | | | | |
| 26-Oct-18 | 9 | 0.00696 | 0.000002175 | 0.0006525 | 0.22707 | 0.00138765 | 0.02175 | 0.0001218 | 0.000087 | 0.001305 | 1.15275 | 0.00003045 | 0.34365 | 0.000010875 | 0.1653 | 0.021924 | 1.5225 | 1.0875E-06 | 0.00004785 | 0.0003045 | 0.00011397 | 0.00039585 | 0.000435 | 0.000435 |
| 02-Nov-18 | 10 | | | | | | | | | | | | | | | | | | | | | | | |
| 09-Nov-18 | 11 | 0.0016275 | 0.0000093 | 0.000744 | 0.351075 | 0.0005394 | 0.002325 | 0.00009765 | 0.0001395 | 0.0006975 | 1.0323 | 0.0000093 | 0.3813 | 0.000011625 | 0.1302 | 0.042501 | 4.1385 | 0.000003255 | 0.00004185 | 0.0000279 | 0.00033015 | 0.00019065 | 0.000465 | 0.000465 |
| 16-Nov-18 | 12 | | | | | | | | | | | | | | | | | | | | | | | |
| 23-Nov-18 | 13 | 0.00161 | 0.0000023 | 0.000644 | 0.32752 | 0.0006256 | 0.0023 | 0.0001242 | 0.000092 | 0.0023 | 1.104 | 0.0000092 | 0.3542 | 0.0000115 | 0.1104 | 0.040848 | 4.876 | 0.00000552 | 0.0000552 | 0.0000115 | 0.00029118 | 0.0001426 | 0.00046 | 0.00046 |
| 30-Nov-18 | 14 | | | | | | | | | | | | | | | | | | | | | | | |
| 07-Dec-18 | 15 | 0.0016625 | 0.000002375 | 0.00057 | 0.2812 | 0.00084075 | 0.002375 | 0.0002375 | 0.000095 | 0.0007125 | 1.13525 | 0.0000095 | 0.41325 | 0.000011875 | 0.0855 | 0.0380475 | 4.655 | 1.1875E-06 | 0.000038 | 0.000011875 | 0.00025175 | 0.000152 | 0.000475 | 0.000475 |
| 14-Dec-18 | 16 | | | | | | | | | | | | | | | | | | | | | | | |
| 21-Dec-18 | 17 | 0.0016625 | 0.000002375 | 0.000475 | 0.236075 | 0.0010355 | 0.002375 | 0.00015675 | 0.00002375 | 0.0007125 | 1.1305 | 0.0000095 | 0.3895 | 0.000011875 | 0.08075 | 0.034675 | 4.845 | 1.1875E-06 | 0.0000285 | 0.000011875 | 0.000237975 | 0.00012825 | 0.000475 | 0.000475 |
| 28-Dec-18 | 18 | | | | | | | | | | | | | | | | | | | | | | | |
| 04-Jan-19 | 19 | 0.0016975 | 0.00000485 | 0.000485 | 0.24735 | 0.0007081 | 0.002425 | 0.00125615 | 0.000097 | 0.0007275 | 1.1252 | 0.00002425 | 0.3298 | 0.000012125 | 0.097 | 0.033465 | 6.111 | 1.2125E-06 | 0.0000097 | 0.000012125 | 0.000174115 | 0.00011155 | 0.000485 | 0.000485 |
| 11-Jan-19 | 20 | | | | | | | | | | | | | | | | | | | | | | | |
| 18-Jan-19 | 21 | 0.0016275 | 0.000002325 | 0.000558 | 0.240405 | 0.0001953 | 0.002325 | 0.0001767 | 0.00002325 | 0.0006975 | 1.03695 | 0.0000093 | 0.3348 | 0.000011625 | 0.09765 | 0.0319455 | 5.1615 | 1.1625E-06 | 0.00003255 | 0.000011625 | 0.000186465 | 0.00009765 | 0.000465 | 0.000465 |
| 25-Jan-19 | 22 | | | | | | | | | | | | | | | | | | | | | | | |
| 01-Feb-19 | 23 | 0.0016275 | 0.000002325 | 0.0007905 | 0.224595 | 0.0004185 | 0.002325 | 0.00213435 | 0.000093 | 0.0006975 | 0.82305 | 0.0000093 | 0.33015 | 0.000011625 | 0.1023 | 0.0296205 | 5.859 | 1.1625E-06 | 0.0000279 | 0.000011625 | 0.00016275 | 0.0000744 | 0.000465 | 0.000465 |
| 08-Feb-19 | 24 | | | | | | | | | | | | | | | | | | | | | | | |
| 15-Feb-19 | 25 | 0.001645 | 0.00000235 | 0.00047 | 0.18518 | 0.0005358 | 0.00235 | 0.0001786 | 0.000094 | 0.000705 | 0.9165 | 0.0000094 | 0.3431 | 0.00001175 | 0.1128 | 0.022654 | 5.593 | 0.00000329 | 0.0000235 | 0.0000329 | 0.00010951 | 0.0000846 | 0.00047 | 0.00047 |
| 22-Feb-19 | 26 | | | | | | | | | | | | | | | | | | | | | | | |
| 01-Mar-19 | 27 | 0.00161 | 0.0000023 | 0.001242 | 0.161 | 0.0004002 | 0.0023 | 0.0001748 | 0.000138 | 0.00069 | 0.7958 | 0.0000092 | 0.2944 | 0.0000115 | 0.1058 | 0.02093 | 4.416 | 0.00000115 | 0.0000414 | 0.0000115 | 0.00008602 | 0.000069 | 0.00046 | 0.00046 |
| 08-Mar-19 | 28 | | | | | | | | | | | | | | | | | | | | | | | |
| 15-Mar-19 | 29 | 0.0016275 | 0.0000558 | 0.000465 | 0.15624 | 0.00059055 | 0.002325 | 0.0001395 | 0.000093 | 0.0006975 | 0.7626 | 0.0000093 | 0.2883 | 0.000011625 | 0.0558 | 0.019344 | 4.5105 | 1.1625E-06 | 0.00008835 | 0.000011625 | 0.000086025 | 0.0000744 | 0.000465 | 0.000465 |
| 22-Mar-19 | 30 | | | | | | | | | | | | | | | | | | | | | | | |
| 29-Mar-19 | 31 | 0.00161 | 0.0000023 | 0.000598 | 0.15134 | 0.0004646 | 0.0023 | 0.0001288 | 0.000092 | 0.00069 | 0.6992 | 0.0000092 | 0.2714 | 0.0000115 | 0.0736 | 0.017802 | 5.152 | 0.0000046 | 0.0000138 | 0.0000115 | 0.00006026 | 0.0000506 | 0.00046 | 0.00046 |
| 05-Apr-19 | 32 | | | | | | | | | | | | | | | | | | | | | | | |
| 12-Apr-19 | 33 | 0.0016975 | 0.000002425 | 0.0004365 | 0.15811 | 0.000485 | 0.002425 | 0.0010185 | 0.0000485 | 0.00291 | 0.7081 | 0.0000097 | 0.28615 | 0.000012125 | 0.0582 | 0.0187695 | 3.5405 | 0.000004365 | 0.0000291 | 0.0000485 | 0.00011058 | 0.0000582 | 0.000485 | 0.000485 |
| 19-Apr-19 | 34 | | | | | | | | | | | | | | | | | | | | | | | |
| 26-Apr-19 | 35 | 0.0015925 | 0.0000091 | 0.0005005 | 0.135135 | 0.0008918 | 0.002275 | 0.0003458 | 0.00002275 | 0.0006825 | 0.69615 | 0.0000091 | 0.27755 | 0.000011375 | 0.0819 | 0.0160615 | 4.732 | 0.00000455 | 0.0000273 | 0.000011375 | 0.000058695 | 0.0000819 | 0.000455 | 0.000455 |
| 03-May-19 | 36 | | | | | | | | | | | | | | | | | | | | | | | |
| 10-May-19 | 37 | 0.013195 | 0.000002275 | 0.0004095 | 0.13195 | 0.00195195 | 0.002275 | 0.00013195 | 0.000091 | 0.0006825 | 0.65975 | 0.0000091 | 0.273 | 0.000011375 | 0.0728 | 0.0144235 | 4.2315 | 0.000004095 | 0.00001365 | 0.000011375 | 0.000059605 | 0.0000546 | 0.000455 | 0.000455 |
| 17-May-19 | 38 | 0.0016275 | 0.00000465 | 0.0004185 | 0.12183 | 0.0006603 | 0.002325 | 0.00011625 | 0.000093 | 0.0006975 | 0.6417 | 0.0000093 | 0.27435 | 0.000011625 | 0.06975 | 0.014043 | 3.6735 | 0.000004185 | 0.00001395 | 0.000011625 | 0.00003999 | 0.00005115 | 0.000465 | 0.000465 |
| 24-May-19 | 39 | 0.0015575 | 0.000002225 | 0.000445 | 0.11481 | 0.0005963 | 0.002225 | 0.00012015 | 0.0000445 | 0.0006675 | 0.60965 | 0.0000089 | 0.26255 | 0.000011125 | 0.06675 | 0.0125935 | 3.471 | 0.000004005 | 0.00001335 | 0.000011125 | 0.00003471 | 0.0000445 | 0.000445 | 0.000445 |
| 31-May-19 | 40 | | | | | | | | | | | | | | | | | | | | | | | |
| 07-Jun-19 | 41 | | | | | | | | | | | | | | | | | | | | | | | |
| 14-Jun-19 | 42 | | | | | | | | | | | | | | | | | | | | | | | |
| 21-Jun-19 | 43 | 0.02835 | 0.00000225 | 0.000315 | 0.11025 | 0.0017955 | 0.00225 | 0.000126 | 0.00009 | 0.000675 | 0.5985 | 0.000009 | 0.216 | 0.00001125 | 0.072 | 0.010755 | 2.43 | 0.00000315 | 0.0000135 | 0.00001125 | 0.0000414 | 0.0000405 | 0.00045 | 0.00045 |
| 28-Jun-19 | 44 | | | | | | | | | | | | | | | | | | | | | | | |
| 05-Jul-19 | 45 | | | | | | | | | | | | | | | | | | | | | | | |
| 12-Jul-19 | 46 | | | | | | | | | | | | | | | | | | | | | | | |
| 19-Jul-19 | 47 | 0.00161 | 0.0000092 | 0.000368 | 0.11086 | 0.000851 | 0.0023 | 0.0004094 | 0.000138 | 0.00069 | 0.5842 | 0.0000092 | 0.23 | 0.0000115 | 0.046 | 0.00966 | 3.45 | 0.00000368 | 0.0000138 | 0.0000115 | 0.0000414 | 0.0000322 | 0.00046 | 0.00046 |
| 26-Jul-19 | 48 | | | | | | | | | | | | | | | | | | | | | | | |
| 02-Aug-19 | 49 | | | | | | | | | | | | | | | | | | | | | | | |

**Appendix 4-6: Kinetic Test Results**
**HC 2**

| Date | Cycle | Volume mL | | pH | Cond. | Acidity | Acidity | Alkalinity | Sulphate | Chloride | Fluoride | Hardness | Al | Sb | As | Ba | Be | Bi | B | Cd | Ca | Cr | Co | Cu | Fe |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. | Input | Output | | | (pH 4.5) | (pH 8.3) | | | | | CaCO3 | | | | | | | | | | | | | |
| | | | | | umhos/cm | mgCaCO3/L | mgCaCO3/L | mgCaCO3/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 |
| 24-Aug-18 | 0 | 500 | 345 | 7.78 | 417 | #N/A | 4.0 | 26.2 | 31 | 63 | 0.16 | 138 | 0.054 | 0.0009 | 0.0349 | 0.00637 | 0.000268 | 0.000283 | 0.017 | 0.000073 | 52.0 | 0.00006 | 0.000113 | 0.00038 | 0.020 |
| 31-Aug-18 | 1 | 500 | 455 | 7.78 | 261 | #N/A | 3.5 | 15.8 | 31 | 40 | 0.13 | 89.1 | 0.140 | 0.0004 | 0.0239 | 0.00335 | *<0.0000035* | *<0.0000035* | 0.021 | 0.000004 | 33.3 | *<0.000015* | 0.000011 | 0.00028 | *<0.0035* |
| 07-Sep-18 | 2 | 500 | 475 | 7.75 | 127 | #N/A | 2.7 | 16.3 | 19 | 11 | 0.12 | 43.4 | 0.216 | 0.0004 | 0.0236 | 0.00148 | *<0.0000035* | *<0.0000035* | 0.014 | *<0.0000015* | 16.2 | *<0.000015* | 0.000013 | 0.00004 | 0.008 |
| 14-Sep-18 | 3 | 500 | 465 | 7.75 | 83 | #N/A | 1.6 | 14.4 | 14 | 2 | 0.09 | 26.0 | 0.165 | 0.0003 | 0.0228 | 0.00083 | *<0.0000035* | *<0.0000035* | 0.013 | *<0.0000015* | 9.75 | 0.00012 | 0.000012 | 0.00065 | 0.010 |
| 21-Sep-18 | 4 | 500 | 470 | 7.80 | 69 | #N/A | 2.4 | 15.3 | 12 | | | | | | | | | | | | | | | | |
| 28-Sep-18 | 5 | 500 | 435 | 7.93 | 58 | #N/A | 1.4 | 20.1 | 10 | 1 | 0.06 | 22.8 | 0.201 | 0.0003 | 0.0221 | 0.00070 | *<0.0000035* | *<0.0000035* | 0.008 | 0.000003 | 8.56 | *<0.000015* | 0.000004 | 0.00032 | 0.016 |
| 05-Oct-18 | 6 | 500 | 450 | 7.68 | 57 | #N/A | 1.9 | 14.9 | 7 | | | | | | | | | | | | | | | | |
| 12-Oct-18 | 7 | 500 | 430 | 7.80 | 60 | #N/A | 3.6 | 15.5 | 9 | *<0.5* | *<0.03* | 22.5 | 0.155 | 0.0002 | 0.0186 | 0.00070 | *<0.0000035* | *<0.0000035* | 0.006 | *<0.0000015* | 8.41 | *<0.000015* | 0.000081 | 0.00023 | 0.011 |
| 19-Oct-18 | 8 | 500 | 460 | 7.64 | 74 | #N/A | 1.9 | 13.7 | 17 | | | | | | | | | | | | | | | | |
| 26-Oct-18 | 9 | 500 | 450 | 7.56 | 89 | #N/A | 1.7 | 11.5 | 25 | *<0.5* | *<0.03* | 38.1 | 0.131 | *<0.0001* | 0.0130 | 0.00100 | *<0.0000035* | *<0.0000035* | 0.007 | 0.000004 | 14.3 | 0.00004 | 0.000072 | 0.00295 | 0.018 |
| 02-Nov-18 | 10 | 500 | 460 | 7.55 | 89 | #N/A | 1.7 | 11.0 | 27 | | | | | | | | | | | | | | | | |
| 09-Nov-18 | 11 | 500 | 450 | 7.61 | 86 | #N/A | 2.4 | 11.2 | 27 | *<0.5* | *<0.03* | 30.8 | 0.088 | *<0.0001* | 0.0194 | 0.00091 | *<0.0000035* | *<0.0000035* | 0.005 | 0.000004 | 11.6 | 0.00004 | 0.000012 | 0.00228 | *<0.0035* |
| 16-Nov-18 | 12 | 500 | 445 | 7.61 | 86 | #N/A | 1.3 | 11.3 | 19 | | | | | | | | | | | | | | | | |
| 23-Nov-18 | 13 | 500 | 450 | 7.70 | 76 | #N/A | 2.1 | 10.9 | 17 | *<0.5* | *<0.03* | 28.4 | 0.115 | *<0.0001* | 0.0207 | 0.00071 | *<0.0000035* | *<0.0000035* | 0.003 | 0.000003 | 10.7 | *<0.000015* | 0.000006 | 0.00060 | *<0.0035* |
| 30-Nov-18 | 14 | 500 | 435 | 7.61 | 66 | #N/A | 1.7 | 10.1 | 16 | | | | | | | | | | | | | | | | |
| 07-Dec-18 | 15 | 500 | 440 | 7.59 | 65 | #N/A | 4.1 | 11.9 | 16 | *<0.5* | *<0.03* | 25.6 | 0.085 | *<0.0001* | 0.0201 | 0.00064 | *<0.0000035* | *<0.0000035* | 0.004 | 0.000006 | 9.65 | *<0.000015* | 0.000009 | 0.00219 | *<0.0035* |
| 14-Dec-18 | 16 | 500 | 470 | 7.73 | 68 | #N/A | 3.1 | 12.1 | 16 | | | | | | | | | | | | | | | | |
| 21-Dec-18 | 17 | 500 | 440 | 7.60 | 68 | #N/A | 3.5 | 10.8 | 15 | *<0.5* | *<0.03* | 26.3 | 0.075 | *<0.0001* | 0.0184 | 0.00065 | *<0.0000035* | *<0.0000035* | 0.003 | 0.000008 | 10.0 | 0.00012 | 0.000033 | 0.00184 | *<0.0035* |
| 28-Dec-18 | 18 | 500 | 455 | 7.53 | 73 | #N/A | 1.8 | 10.2 | 19 | | | | | | | | | | | | | | | | |
| 04-Jan-19 | 19 | 500 | 445 | 7.69 | 69 | #N/A | 3.3 | 9.9 | 20 | *<0.5* | *<0.03* | 29.0 | 0.071 | *<0.0001* | 0.0168 | 0.00068 | *<0.0000035* | *<0.0000035* | 0.003 | *<0.0000015* | 11.0 | *<0.000015* | 0.000041 | 0.00032 | *<0.0035* |
| 11-Jan-19 | 20 | 500 | 440 | 7.38 | 67 | #N/A | 2.7 | 9.3 | 20 | | | | | | | | | | | | | | | | |
| 18-Jan-19 | 21 | 500 | 440 | 7.48 | 61 | #N/A | 1.6 | 10.3 | 19 | *<0.5* | *<0.03* | 29.0 | 0.096 | *<0.0001* | 0.0187 | 0.00073 | *<0.0000035* | *<0.0000035* | 0.004 | 0.000011 | 11.0 | *<0.000015* | 0.000004 | 0.00014 | *<0.0035* |
| 25-Jan-19 | 22 | 500 | 440 | 7.52 | 67 | #N/A | 1.8 | 8.3 | 16 | | | | | | | | | | | | | | | | |
| 01-Feb-19 | 23 | 500 | 445 | 7.53 | 66 | #N/A | 2.8 | 10.2 | 15 | *<0.5* | *<0.03* | 24.4 | 0.065 | *<0.0001* | 0.0139 | 0.00062 | *<0.0000035* | *<0.0000035* | 0.003 | 0.000006 | 9.20 | *<0.000015* | 0.000012 | 0.00055 | *<0.0035* |
| 08-Feb-19 | 24 | 500 | 440 | 7.62 | 63 | #N/A | 3.0 | 9.5 | 15 | | | | | | | | | | | | | | | | |
| 15-Feb-19 | 25 | 500 | 445 | 7.46 | 63 | #N/A | 1.7 | 9.5 | 15 | *<0.5* | *<0.03* | 27.0 | 0.059 | *<0.0001* | 0.0135 | 0.00060 | *<0.0000035* | *<0.0000035* | 0.008 | 0.000008 | 10.3 | *<0.000015* | 0.000011 | 0.00032 | *<0.0035* |
| 22-Feb-19 | 26 | 500 | 445 | 7.74 | 62 | #N/A | 3.0 | 10.2 | 16 | | | | | | | | | | | | | | | | |
| 01-Mar-19 | 27 | 500 | 445 | 7.41 | 58 | #N/A | 2.2 | 10.9 | 12 | *<0.5* | *<0.03* | 24.4 | 0.070 | *<0.00045* | 0.0140 | 0.00065 | *<0.0000035* | *<0.0000035* | 0.003 | *<0.0000015* | 9.29 | *<0.00004* | 0.000011 | 0.0007 | *<0.0035* |
| 08-Mar-19 | 28 | 500 | 440 | 7.54 | 58 | #N/A | 3.2 | 10.3 | 15 | | | | | | | | | | | | | | | | |
| 15-Mar-19 | 29 | 500 | 455 | 7.48 | 55 | #N/A | 2.2 | 9.8 | 15 | *<0.5* | *<0.03* | 24.7 | 0.056 | *<0.00045* | 0.0132 | 0.00055 | *<0.0000035* | *<0.0000035* | 0.003 | 0.000009 | 9.45 | *<0.00004* | 0.000004 | *<0.0001* | *<0.0035* |
| 22-Mar-19 | 30 | 500 | 450 | 7.71 | 59 | #N/A | 3.1 | 10.8 | 13 | | | | | | | | | | | | | | | | |
| 29-Mar-19 | 31 | 500 | 445 | 7.45 | 59 | #N/A | 2.3 | 10.5 | 14 | *<0.5* | *<0.03* | 24.9 | 0.059 | *<0.00045* | 0.0133 | 0.00066 | *<0.0000035* | *<0.0000035* | 0.004 | 0.000003 | 9.49 | *<0.00004* | *<0.000002* | *<0.0001* | *<0.0035* |
| 05-Apr-19 | 32 | 500 | 445 | 7.85 | 59 | #N/A | 4.5 | 14.0 | 15 | | | | | | | | | | | | | | | | |
| 12-Apr-19 | 33 | 500 | 485 | 7.38 | 68 | #N/A | 2.0 | 14.8 | 17 | *<0.5* | *<0.03* | 26.9 | 0.049 | *<0.00045* | 0.0123 | 0.00046 | *<0.0000035* | *<0.0000035* | 0.003 | 0.000005 | 10.3 | *<0.00004* | 0.000033 | 0.0053 | *<0.0035* |
| 19-Apr-19 | 34 | 500 | 445 | 7.56 | 57 | #N/A | 1.9 | 10.5 | 13 | | | | | | | | | | | | | | | | |
| 26-Apr-19 | 35 | 500 | 455 | 7.59 | 59 | #N/A | 2.6 | 9.4 | 15 | *<0.5* | *<0.03* | 25.9 | 0.054 | *<0.00045* | 0.0116 | 0.00066 | *<0.0000035* | *<0.0000035* | 0.004 | *<0.0000015* | 9.92 | *<0.00004* | 0.000014 | 0.0006 | *<0.0035* |
| 03-May-19 | 36 | 500 | 455 | 7.86 | 59 | #N/A | 2.6 | 8.8 | 15 | | | | | | | | | | | | | | | | |
| 10-May-19 | 37 | 500 | 465 | 7.42 | 59 | #N/A | 1.6 | 8.9 | 15 | *<0.5* | *<0.03* | 25.4 | 0.048 | *<0.00045* | 0.0128 | 0.00053 | *<0.0000035* | *<0.0000035* | 0.003 | 0.000004 | 9.76 | *<0.00004* | 0.000029 | 0.0015 | 0.019 |
| 17-May-19 | 38 | 500 | 450 | 7.42 | 63 | #N/A | 2.4 | 8.7 | 15 | *<0.5* | *<0.03* | 25.8 | 0.049 | *<0.00045* | 0.0130 | 0.00052 | *<0.0000035* | *<0.0000035* | 0.002 | *<0.0000015* | 9.95 | *<0.00004* | 0.000035 | 0.0005 | *<0.0035* |
| 24-May-19 | 39 | 500 | 455 | 7.40 | 66 | #N/A | 3.0 | 8.8 | 19 | *<0.5* | *<0.03* | 27.3 | 0.044 | *<0.00045* | 0.0116 | 0.00076 | *<0.0000035* | *<0.0000035* | 0.003 | 0.000007 | 10.5 | *<0.00004* | 0.000026 | 0.0007 | *<0.0035* |
| 31-May-19 | 40 | 500 | 460 | 7.12 | 71 | #N/A | 3.3 | 6.6 | 17 | | | | | | | | | | | | | | | | |
| 07-Jun-19 | 41 | 500 | 455 | 7.28 | | | | 7.9 | 21 | | | | | | | | | | | | | | | | |
| 14-Jun-19 | 42 | 500 | 475 | 7.39 | | | | 7.5 | | | | | | | | | | | | | | | | | |
| 21-Jun-19 | 43 | 500 | 440 | 7.53 | | | | 8.3 | 19 | | | 30.6 | 0.049 | *<0.00045* | 0.0147 | 0.00070 | *<0.0000035* | *<0.0000035* | 0.003 | *<0.0000015* | 11.8 | *<0.00004* | 0.000043 | 0.0003 | 0.152 |
| 28-Jun-19 | 44 | 500 | 460 | 7.30 | | | | 9.8 | | | | | | | | | | | | | | | | | |
| 05-Jul-19 | 45 | 500 | 445 | 7.11 | | | | 7.1 | 23 | | | | | | | | | | | | | | | | |
| 12-Jul-19 | 46 | 500 | 445 | 7.03 | | | | 7.6 | | | | | | | | | | | | | | | | | |
| 19-Jul-19 | 47 | 500 | 450 | 6.94 | | | | 6.9 | 22 | | | 31.8 | 0.044 | *<0.00045* | 0.0211 | 0.00057 | *<0.0000035* | *<0.0000035* | 0.003 | *<0.0000015* | 12.3 | *<0.00004* | 0.000013 | *<0.0001* | *<0.0035* |
| 26-Jul-19 | 48 | 500 | 450 | 7.50 | | | | 7.2 | | | | | | | | | | | | | | | | | |
| 02-Aug-19 | 49 | 500 | 470 | 6.62 | | | | 7.9 | 33 | | | | | | | | | | | | | | | | |
| 09-Aug-19 | 50 | 500 | 435 | 7.12 | | | | 7.4 | | | | | | | | | | | | | | | | | |

Jun 07/19. Change in analytical schedule.

**Appendix 4-6: Kinetic Test Results**
**HC 2**

| Date | Cycle | Volume mL | | pH | Cond. | Acidity | Acidity | Alkalinity | Sulphate | Chloride | Fluoride | Hardness | Al | Sb | As | Ba | Be | Bi | B | Cd | Ca | Cr | Co | Cu | Fe |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. | Input | Output | | | (pH 4.5) | (pH 8.3) | | | | | CaCO3 | | | | | | | | | | | | | |
| | | | | | umhos/cm | mgCaCO3/L | mgCaCO3/L | mgCaCO3/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 |
| **Loads** | **mg/kg** | | | | | | | | | | | | | | | | | | | | | | | | |
| 24-Aug-18 | 0 | | | 7.78 | | | | | 10.695 | 21.735 | 0.0552 | 47.61 | 0.01863 | 0.0003105 | 0.0120405 | 0.00219765 | 0.00009246 | 0.000097635 | 0.005865 | 0.000025185 | 17.94 | 0.0000207 | 0.000038985 | 0.0001311 | 0.0069 |
| 31-Aug-18 | 1 | | | 7.78 | | | | | 14.105 | 18.2 | 0.05915 | 40.5405 | 0.0637 | 0.000182 | 0.0108745 | 0.00152425 | 1.5925E-06 | 1.5925E-06 | 0.009555 | 0.00000182 | 15.1515 | 0.000006825 | 0.000005005 | 0.0001274 | 0.0015925 |
| 07-Sep-18 | 2 | | | 7.75 | | | | | 9.025 | 5.225 | 0.057 | 20.615 | 0.1026 | 0.00019 | 0.01121 | 0.000703 | 1.6625E-06 | 1.6625E-06 | 0.00665 | 7.125E-07 | 7.695 | 0.000007125 | 0.000006175 | 0.000019 | 0.0038 |
| 14-Sep-18 | 3 | | | 7.75 | | | | | 6.51 | 0.93 | 0.04185 | 12.09 | 0.076725 | 0.0001395 | 0.010602 | 0.00038595 | 1.6275E-06 | 1.6275E-06 | 0.006045 | 6.975E-07 | 4.53375 | 0.0000558 | 0.00000558 | 0.00030225 | 0.00465 |
| 21-Sep-18 | 4 | | | 7.80 | | | | | 5.64 | | | | | | | | | | | | | | | | |
| 28-Sep-18 | 5 | | | 7.93 | | | | | 4.35 | 0.435 | 0.0261 | 9.918 | 0.087435 | 0.0001305 | 0.0096135 | 0.0003045 | 1.5225E-06 | 1.5225E-06 | 0.00348 | 0.000001305 | 3.7236 | 0.000006525 | 0.00000174 | 0.0001392 | 0.00696 |
| 05-Oct-18 | 6 | | | 7.68 | | | | | 3.15 | | | | | | | | | | | | | | | | |
| 12-Oct-18 | 7 | | | 7.80 | | | | | 3.87 | 0.215 | 0.0129 | 9.675 | 0.06665 | 0.000086 | 0.007998 | 0.000301 | 0.000001505 | 0.000001505 | 0.00258 | 0.000000645 | 3.6163 | 0.00000645 | 0.00003483 | 0.0000989 | 0.00473 |
| 19-Oct-18 | 8 | | | 7.64 | | | | | 7.82 | | | | | | | | | | | | | | | | |
| 26-Oct-18 | 9 | | | 7.56 | | | | | 11.25 | 0.225 | 0.0135 | 17.145 | 0.05895 | 0.000045 | 0.00585 | 0.00045 | 0.000001575 | 0.000001575 | 0.00315 | 0.0000018 | 6.435 | 0.000018 | 0.0000324 | 0.0013275 | 0.0081 |
| 02-Nov-18 | 10 | | | 7.55 | | | | | 12.42 | | | | | | | | | | | | | | | | |
| 09-Nov-18 | 11 | | | 7.61 | | | | | 12.15 | 0.225 | 0.0135 | 13.86 | 0.0396 | 0.000045 | 0.00873 | 0.0004095 | 0.000001575 | 0.000001575 | 0.00225 | 0.0000018 | 5.22 | 0.000018 | 0.0000054 | 0.001026 | 0.001575 |
| 16-Nov-18 | 12 | | | 7.61 | | | | | 8.455 | | | | | | | | | | | | | | | | |
| 23-Nov-18 | 13 | | | 7.70 | | | | | 7.65 | 0.225 | 0.0135 | 12.78 | 0.05175 | 0.000045 | 0.009315 | 0.0003195 | 0.000001575 | 0.000001575 | 0.00135 | 0.00000135 | 4.815 | 0.00000675 | 0.0000027 | 0.00027 | 0.001575 |
| 30-Nov-18 | 14 | | | 7.61 | | | | | 6.96 | | | | | | | | | | | | | | | | |
| 07-Dec-18 | 15 | | | 7.59 | | | | | 7.04 | 0.22 | 0.0132 | 11.264 | 0.0374 | 0.000044 | 0.008844 | 0.0002816 | 0.00000154 | 0.00000154 | 0.00176 | 0.00000264 | 4.246 | 0.0000066 | 0.00000396 | 0.0009636 | 0.00154 |
| 14-Dec-18 | 16 | | | 7.73 | | | | | 7.52 | | | | | | | | | | | | | | | | |
| 21-Dec-18 | 17 | | | 7.60 | | | | | 6.6 | 0.22 | 0.0132 | 11.572 | 0.033 | 0.000044 | 0.008096 | 0.000286 | 0.00000154 | 0.00000154 | 0.00132 | 0.00000352 | 4.4 | 0.0000528 | 0.00001452 | 0.0008096 | 0.00154 |
| 28-Dec-18 | 18 | | | 7.53 | | | | | 8.645 | | | | | | | | | | | | | | | | |
| 04-Jan-19 | 19 | | | 7.69 | | | | | 8.9 | 0.2225 | 0.01335 | 12.905 | 0.031595 | 0.0000445 | 0.007476 | 0.0003026 | 1.5575E-06 | 1.5575E-06 | 0.001335 | 6.675E-07 | 4.895 | 0.000006675 | 0.000018245 | 0.0001424 | 0.0015575 |
| 11-Jan-19 | 20 | | | 7.38 | | | | | 8.8 | | | | | | | | | | | | | | | | |
| 18-Jan-19 | 21 | | | 7.48 | | | | | 8.36 | 0.22 | 0.0132 | 12.76 | 0.04224 | 0.000044 | 0.008228 | 0.0003212 | 0.00000154 | 0.00000154 | 0.00176 | 0.00000484 | 4.84 | 0.0000066 | 0.00000176 | 0.0000616 | 0.00154 |
| 25-Jan-19 | 22 | | | 7.52 | | | | | 7.04 | | | | | | | | | | | | | | | | |
| 01-Feb-19 | 23 | | | 7.53 | | | | | 6.675 | 0.2225 | 0.01335 | 10.858 | 0.028925 | 0.0000445 | 0.0061855 | 0.0002759 | 1.5575E-06 | 1.5575E-06 | 0.001335 | 0.00000267 | 4.094 | 0.000006675 | 0.00000534 | 0.00024475 | 0.0015575 |
| 08-Feb-19 | 24 | | | 7.62 | | | | | 6.6 | | | | | | | | | | | | | | | | |
| 15-Feb-19 | 25 | | | 7.46 | | | | | 6.675 | 0.2225 | 0.01335 | 12.015 | 0.026255 | 0.0000445 | 0.0060075 | 0.000267 | 1.5575E-06 | 1.5575E-06 | 0.00356 | 0.00000356 | 4.5835 | 0.000006675 | 0.000004895 | 0.0001424 | 0.0015575 |
| 22-Feb-19 | 26 | | | 7.74 | | | | | 7.12 | | | | | | | | | | | | | | | | |
| 01-Mar-19 | 27 | | | 7.41 | | | | | 5.34 | 0.2225 | 0.01335 | 10.858 | 0.03115 | 0.00020025 | 0.00623 | 0.00028925 | 1.5575E-06 | 1.5575E-06 | 0.001335 | 6.675E-07 | 4.13405 | 0.0000178 | 0.000004895 | 0.0003115 | 0.0015575 |
| 08-Mar-19 | 28 | | | 7.54 | | | | | 6.6 | | | | | | | | | | | | | | | | |
| 15-Mar-19 | 29 | | | 7.48 | | | | | 6.825 | 0.2275 | 0.01365 | 11.2385 | 0.02548 | 0.00020475 | 0.006006 | 0.00025025 | 1.5925E-06 | 1.5925E-06 | 0.001365 | 0.000004095 | 4.29975 | 0.0000182 | 0.00000182 | 0.0000455 | 0.0015925 |
| 22-Mar-19 | 30 | | | 7.71 | | | | | 5.85 | | | | | | | | | | | | | | | | |
| 29-Mar-19 | 31 | | | 7.45 | | | | | 6.23 | 0.2225 | 0.01335 | 11.0805 | 0.026255 | 0.00020025 | 0.0059185 | 0.0002937 | 1.5575E-06 | 1.5575E-06 | 0.00178 | 0.000001335 | 4.22305 | 0.0000178 | 0.00000089 | 0.0000445 | 0.0015575 |
| 05-Apr-19 | 32 | | | 7.85 | | | | | 6.675 | | | | | | | | | | | | | | | | |
| 12-Apr-19 | 33 | | | 7.38 | | | | | 8.245 | 0.2425 | 0.01455 | 13.0465 | 0.023765 | 0.00021825 | 0.0059655 | 0.0002231 | 1.6975E-06 | 1.6975E-06 | 0.001455 | 0.000002425 | 4.9955 | 0.0000194 | 0.000016005 | 0.0025705 | 0.0016975 |
| 19-Apr-19 | 34 | | | 7.56 | | | | | 5.785 | | | | | | | | | | | | | | | | |
| 26-Apr-19 | 35 | | | 7.59 | | | | | 6.825 | 0.2275 | 0.01365 | 11.7845 | 0.02457 | 0.00020475 | 0.005278 | 0.0003003 | 1.5925E-06 | 1.5925E-06 | 0.00182 | 6.825E-07 | 4.5136 | 0.0000182 | 0.00000637 | 0.000273 | 0.0015925 |
| 03-May-19 | 36 | | | 7.86 | | | | | 6.825 | | | | | | | | | | | | | | | | |
| 10-May-19 | 37 | | | 7.42 | | | | | 6.975 | 0.2325 | 0.01395 | 11.811 | 0.02232 | 0.00020925 | 0.005952 | 0.00024645 | 1.6275E-06 | 1.6275E-06 | 0.001395 | 0.00000186 | 4.5384 | 0.0000186 | 0.000013485 | 0.0006975 | 0.008835 |
| 17-May-19 | 38 | | | 7.42 | | | | | 6.75 | 0.225 | 0.0135 | 11.61 | 0.02205 | 0.0002025 | 0.00585 | 0.000234 | 0.000001575 | 0.000001575 | 0.0009 | 0.000000675 | 4.4775 | 0.000018 | 0.00001575 | 0.000225 | 0.001575 |
| 24-May-19 | 39 | | | 7.40 | | | | | 8.645 | 0.2275 | 0.01365 | 12.4215 | 0.02002 | 0.00020475 | 0.005278 | 0.0003458 | 1.5925E-06 | 1.5925E-06 | 0.001365 | 0.000003185 | 4.7775 | 0.0000182 | 0.00001183 | 0.0003185 | 0.0015925 |
| 31-May-19 | 40 | | | 7.12 | | | | | 7.82 | | | | | | | | | | | | | | | | |
| 07-Jun-19 | 41 | | | 7.28 | | | | | 9.555 | | | | | | | | | | | | | | | | |
| 14-Jun-19 | 42 | | | 7.39 | | | | | | | | | | | | | | | | | | | | | |
| 21-Jun-19 | 43 | | | 7.53 | | | | | 8.36 | | | 13.464 | 0.02156 | 0.000198 | 0.006468 | 0.000308 | 0.00000154 | 0.00000154 | 0.00132 | 0.00000066 | 5.192 | 0.0000176 | 0.00001892 | 0.000132 | 0.06688 |
| 28-Jun-19 | 44 | | | 7.30 | | | | | | | | | | | | | | | | | | | | | |
| 05-Jul-19 | 45 | | | 7.11 | | | | | 10.235 | | | | | | | | | | | | | | | | |
| 12-Jul-19 | 46 | | | 7.03 | | | | | | | | | | | | | | | | | | | | | |
| 19-Jul-19 | 47 | | | 6.94 | | | | | 9.9 | | | 14.31 | 0.0198 | 0.0002025 | 0.009495 | 0.0002565 | 0.000001575 | 0.000001575 | 0.00135 | 0.000000675 | 5.535 | 0.000018 | 0.00000585 | 0.000045 | 0.001575 |
| 26-Jul-19 | 48 | | | 7.50 | | | | | | | | | | | | | | | | | | | | | |
| 02-Aug-19 | 49 | | | 6.62 | | | | | 15.51 | | | | | | | | | | | | | | | | |

**Appendix 4-6: Kinetic Test Results**
**HC 2**

| Date | Cycle | Pb | Li | Mg | Mn | Hg | Mo | Ni | P | K | Se | Si | Ag | Na | Sr | S | Tl | Sn | Ti | U | V | Zn | Zr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. | | | | | | | | | | | | | | | | | | | | | | |
| | | mg/L | mg/L | mg/L | mg/L | ug/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L |
| 24-Aug-18 | 0 | 0.00025 | 0.0070 | 2.05 | 0.0768 | 0.01 | 0.00116 | 0.0032 | 0.042 | 17.6 | 0.00023 | 1.14 | 0.00005 | 8.59 | 0.432 | 12.1 | 0.000262 | 0.00294 | 0.00009 | 0.000478 | 0.00025 | <0.001 | <0.001 |
| 31-Aug-18 | 1 | 0.00002 | 0.0038 | 1.41 | 0.0182 | <0.005 | 0.00113 | 0.0004 | 0.008 | 10.7 | 0.00018 | 1.35 | <0.000025 | 6.17 | 0.295 | 12.4 | 0.000009 | 0.00119 | <0.000025 | 0.000489 | 0.00056 | <0.001 | <0.001 |
| 07-Sep-18 | 2 | 0.00006 | 0.0021 | 0.688 | 0.00963 | <0.005 | 0.00085 | 0.0002 | <0.0015 | 6.72 | 0.00012 | 1.45 | <0.000025 | 2.80 | 0.137 | 8.2 | 0.000006 | 0.00078 | 0.00041 | 0.000280 | 0.00066 | <0.001 | <0.001 |
| 14-Sep-18 | 3 | 0.00004 | 0.0014 | 0.399 | 0.00710 | 0.02 | 0.00061 | 0.0001 | <0.0015 | 3.91 | 0.00013 | 1.10 | <0.000025 | 1.22 | 0.0884 | 4.2 | 0.000005 | 0.00048 | 0.00007 | 0.000213 | 0.00067 | <0.001 | <0.001 |
| 21-Sep-18 | 4 | | | | | | | | | | | | | | | | | | | | | | |
| 28-Sep-18 | 5 | 0.00003 | 0.0014 | 0.353 | 0.00639 | <0.005 | 0.00039 | 0.0004 | <0.0015 | 3.14 | 0.00006 | 1.19 | <0.000025 | 0.74 | 0.0665 | 3.3 | <0.0000025 | 0.00028 | 0.00022 | 0.000174 | 0.00080 | <0.001 | <0.001 |
| 05-Oct-18 | 6 | | | | | | | | | | | | | | | | | | | | | | |
| 12-Oct-18 | 7 | 0.00004 | 0.0013 | 0.364 | 0.00750 | <0.005 | 0.00032 | 0.0002 | <0.0015 | 2.66 | 0.00004 | 1.04 | <0.000025 | 0.48 | 0.0634 | 3.9 | <0.0000025 | 0.00019 | <0.000025 | 0.000254 | 0.00062 | <0.001 | <0.001 |
| 19-Oct-18 | 8 | | | | | | | | | | | | | | | | | | | | | | |
| 26-Oct-18 | 9 | 0.00002 | 0.0016 | 0.553 | 0.00998 | 0.04 | 0.00059 | 0.0002 | <0.0015 | 3.08 | 0.00014 | 0.78 | <0.000025 | 0.61 | 0.0850 | 8.7 | <0.0000025 | 0.00019 | 0.00094 | 0.000576 | 0.00051 | <0.001 | <0.001 |
| 02-Nov-18 | 10 | | | | | | | | | | | | | | | | | | | | | | |
| 09-Nov-18 | 11 | 0.00002 | 0.0013 | 0.467 | 0.00773 | <0.005 | 0.00030 | 0.0001 | <0.0015 | 2.09 | <0.00002 | 0.77 | <0.000025 | 0.30 | 0.0798 | 7.7 | 0.000006 | 0.00007 | 0.00011 | 0.000486 | 0.00032 | <0.001 | <0.001 |
| 16-Nov-18 | 12 | | | | | | | | | | | | | | | | | | | | | | |
| 23-Nov-18 | 13 | 0.00002 | 0.0011 | 0.395 | 0.00596 | <0.005 | 0.00039 | <0.00005 | 0.006 | 1.88 | <0.00002 | 0.78 | <0.000025 | 0.26 | 0.0647 | 6.6 | 0.000006 | 0.00014 | 0.00006 | 0.000381 | 0.00037 | <0.001 | <0.001 |
| 30-Nov-18 | 14 | | | | | | | | | | | | | | | | | | | | | | |
| 07-Dec-18 | 15 | 0.00001 | 0.0010 | 0.358 | 0.00829 | <0.005 | 0.00038 | <0.00005 | <0.0015 | 1.78 | <0.00002 | 0.81 | <0.000025 | 0.20 | 0.0564 | 5.5 | <0.0000025 | 0.00013 | <0.000025 | 0.000268 | 0.00027 | <0.001 | <0.001 |
| 14-Dec-18 | 16 | | | | | | | | | | | | | | | | | | | | | | |
| 21-Dec-18 | 17 | <0.000005 | 0.0008 | 0.322 | 0.00824 | <0.005 | 0.00037 | <0.00005 | <0.0015 | 1.49 | <0.00002 | 0.64 | <0.000025 | 0.40 | 0.0544 | 5.9 | <0.0000025 | 0.00006 | 0.00007 | 0.000305 | 0.00022 | <0.001 | <0.001 |
| 28-Dec-18 | 18 | | | | | | | | | | | | | | | | | | | | | | |
| 04-Jan-19 | 19 | <0.000005 | 0.0009 | 0.369 | 0.00900 | <0.005 | 0.00078 | <0.00005 | <0.0015 | 1.57 | <0.00002 | 0.57 | <0.000025 | 0.21 | 0.0555 | 8.0 | <0.0000025 | 0.00006 | 0.00009 | 0.000243 | 0.00019 | <0.001 | <0.001 |
| 11-Jan-19 | 20 | | | | | | | | | | | | | | | | | | | | | | |
| 18-Jan-19 | 21 | 0.00003 | 0.0010 | 0.367 | 0.00820 | <0.005 | 0.00036 | <0.00005 | <0.0015 | 1.50 | <0.00002 | 0.62 | <0.000025 | 0.26 | 0.0544 | 6.6 | <0.0000025 | 0.00018 | <0.000025 | 0.000258 | 0.00021 | <0.001 | <0.001 |
| 25-Jan-19 | 22 | | | | | | | | | | | | | | | | | | | | | | |
| 01-Feb-19 | 23 | <0.000005 | 0.0016 | 0.339 | 0.00768 | <0.005 | 0.00164 | <0.00005 | <0.0015 | 1.14 | <0.00002 | 0.57 | <0.000025 | 0.21 | 0.0487 | 6.5 | <0.0000025 | 0.00010 | <0.000025 | 0.000271 | 0.00019 | <0.001 | <0.001 |
| 08-Feb-19 | 24 | | | | | | | | | | | | | | | | | | | | | | |
| 15-Feb-19 | 25 | <0.000005 | 0.0008 | 0.310 | 0.00902 | <0.005 | 0.00032 | <0.00005 | <0.0015 | 1.36 | <0.00002 | 0.55 | <0.000025 | 0.25 | 0.0424 | 7.5 | <0.0000025 | <0.00005 | 0.00005 | 0.000196 | 0.00016 | <0.001 | <0.001 |
| 22-Feb-19 | 26 | | | | | | | | | | | | | | | | | | | | | | |
| 01-Mar-19 | 27 | 0.00003 | 0.0010 | 0.282 | 0.00858 | <0.005 | 0.00040 | 0.0001 | <0.0015 | 1.17 | <0.00002 | 0.53 | <0.000025 | 0.23 | 0.0405 | 5.1 | <0.0000025 | <0.00003 | 0.00333 | 0.000186 | 0.00014 | <0.001 | <0.001 |
| 08-Mar-19 | 28 | | | | | | | | | | | | | | | | | | | | | | |
| 15-Mar-19 | 29 | <0.000005 | 0.0008 | 0.267 | 0.00857 | <0.005 | 0.00032 | <0.00005 | <0.0015 | 1.14 | 0.00006 | 0.51 | <0.000025 | 0.10 | 0.0385 | 5.7 | <0.0000025 | <0.00003 | <0.000025 | 0.000188 | 0.00016 | <0.001 | <0.001 |
| 22-Mar-19 | 30 | | | | | | | | | | | | | | | | | | | | | | |
| 29-Mar-19 | 31 | <0.000005 | 0.0011 | 0.283 | 0.00826 | <0.005 | 0.00031 | <0.00005 | <0.0015 | 1.11 | <0.00002 | 0.52 | <0.000025 | 0.16 | 0.0384 | 6.5 | <0.0000025 | <0.00003 | <0.000025 | 0.000163 | 0.00014 | <0.001 | <0.001 |
| 05-Apr-19 | 32 | | | | | | | | | | | | | | | | | | | | | | |
| 12-Apr-19 | 33 | 0.00027 | 0.0009 | 0.263 | 0.00749 | <0.005 | 0.00066 | <0.00005 | <0.0015 | 1.02 | <0.00002 | 0.50 | <0.000025 | 0.10 | 0.0418 | 4.5 | 0.000006 | 0.00171 | 0.00005 | 0.000301 | 0.00011 | <0.001 | <0.001 |
| 19-Apr-19 | 34 | | | | | | | | | | | | | | | | | | | | | | |
| 26-Apr-19 | 35 | <0.000005 | 0.0009 | 0.273 | 0.00537 | <0.005 | 0.00056 | <0.00005 | <0.0015 | 1.10 | <0.00002 | 0.46 | <0.000025 | 0.17 | 0.0384 | 7.1 | <0.0000025 | 0.00007 | 0.00006 | 0.000169 | 0.00011 | <0.001 | <0.001 |
| 03-May-19 | 36 | | | | | | | | | | | | | | | | | | | | | | |
| 10-May-19 | 37 | 0.00003 | 0.0008 | 0.248 | 0.00493 | <0.005 | 0.00033 | 0.0001 | 0.003 | 1.03 | <0.00002 | 0.50 | <0.000025 | 0.14 | 0.0350 | 6.7 | <0.0000025 | <0.00003 | <0.000025 | 0.000175 | 0.00012 | <0.001 | <0.001 |
| 17-May-19 | 38 | <0.000005 | 0.0009 | 0.234 | 0.00344 | <0.005 | 0.00028 | <0.00005 | <0.0015 | 0.994 | <0.00002 | 0.47 | <0.000025 | 0.13 | 0.0367 | 6.2 | 0.000005 | 0.00007 | <0.000025 | 0.000129 | 0.00010 | <0.001 | <0.001 |
| 24-May-19 | 39 | <0.000005 | 0.0010 | 0.270 | 0.00299 | <0.005 | 0.00030 | <0.00005 | <0.0015 | 1.05 | <0.00002 | 0.46 | <0.000025 | 0.13 | 0.0372 | 6.6 | <0.0000025 | <0.00003 | <0.000025 | 0.000119 | 0.00009 | <0.001 | <0.001 |
| 31-May-19 | 40 | | | | | | | | | | | | | | | | | | | | | | |
| 07-Jun-19 | 41 | | | | | | | | | | | | | | | | | | | | | | |
| 14-Jun-19 | 42 | | | | | | | | | | | | | | | | | | | | | | |
| 21-Jun-19 | 43 | 0.00002 | 0.0007 | 0.242 | 0.00195 | <0.005 | 0.00052 | 0.0005 | <0.0015 | 0.995 | <0.00002 | 0.40 | <0.000025 | 0.14 | 0.0349 | 6.5 | 0.000005 | 0.00020 | <0.000025 | 0.000253 | 0.00008 | <0.001 | <0.001 |
| 28-Jun-19 | 44 | | | | | | | | | | | | | | | | | | | | | | |
| 05-Jul-19 | 45 | | | | | | | | | | | | | | | | | | | | | | |
| 12-Jul-19 | 46 | | | | | | | | | | | | | | | | | | | | | | |
| 19-Jul-19 | 47 | 0.00002 | 0.0009 | 0.245 | 0.00116 | <0.005 | 0.00060 | 0.0001 | <0.0015 | 1.05 | <0.00002 | 0.37 | <0.000025 | 0.10 | 0.0334 | 9.0 | 0.000005 | <0.00003 | 0.00008 | 0.000119 | 0.00006 | <0.001 | <0.001 |
| 26-Jul-19 | 48 | | | | | | | | | | | | | | | | | | | | | | |
| 02-Aug-19 | 49 | | | | | | | | | | | | | | | | | | | | | | |
| 09-Aug-19 | 50 | | | | | | | | | | | | | | | | | | | | | | |

Jun 07/19. Change in analytical schedule.

**Appendix 4-6: Kinetic Test Results**
**HC 2**

| Date | Cycle | Pb | Li | Mg | Mn | Hg | Mo | Ni | P | K | Se | Si | Ag | Na | Sr | S | Tl | Sn | Ti | U | V | Zn | Zr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. | | | | | | | | | | | | | | | | | | | | | | |
| | | mg/L | mg/L | mg/L | mg/L | ug/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L |
| **Loads** | **mg/kg** | | | | | | | | | | | | | | | | | | | | | | |
| 24-Aug-18 | 0 | 0.00008625 | 0.002415 | 0.70725 | 0.026496 | 0.00345 | 0.0004002 | 0.001104 | 0.01449 | 6.072 | 0.00007935 | 0.3933 | 0.00001725 | 2.96355 | 0.14904 | 4.1745 | 0.00009039 | 0.0010143 | 0.00003105 | 0.00016491 | 0.00008625 | 0.000345 | 0.000345 |
| 31-Aug-18 | 1 | 0.0000091 | 0.001729 | 0.64155 | 0.008281 | 0.002275 | 0.00051415 | 0.000182 | 0.00364 | 4.8685 | 0.0000819 | 0.61425 | 0.000011375 | 2.80735 | 0.134225 | 5.642 | 0.000004095 | 0.00054145 | 0.000011375 | 0.000222495 | 0.0002548 | 0.000455 | 0.000455 |
| 07-Sep-18 | 2 | 0.0000285 | 0.0009975 | 0.3268 | 0.00457425 | 0.002375 | 0.00040375 | 0.000095 | 0.0007125 | 3.192 | 0.000057 | 0.68875 | 0.000011875 | 1.33 | 0.065075 | 3.895 | 0.00000285 | 0.0003705 | 0.00019475 | 0.000133 | 0.0003135 | 0.000475 | 0.000475 |
| 14-Sep-18 | 3 | 0.0000186 | 0.000651 | 0.185535 | 0.0033015 | 0.0093 | 0.00028365 | 0.0000465 | 0.0006975 | 1.81815 | 0.00006045 | 0.5115 | 0.000011625 | 0.5673 | 0.041106 | 1.953 | 0.000002325 | 0.0002232 | 0.00003255 | 0.000099045 | 0.00031155 | 0.000465 | 0.000465 |
| 21-Sep-18 | 4 | | | | | | | | | | | | | | | | | | | | | | |
| 28-Sep-18 | 5 | 0.00001305 | 0.000609 | 0.153555 | 0.00277965 | 0.002175 | 0.00016965 | 0.000174 | 0.0006525 | 1.3659 | 0.0000261 | 0.51765 | 0.000010875 | 0.3219 | 0.0289275 | 1.4355 | 1.0875E-06 | 0.0001218 | 0.0000957 | 0.00007569 | 0.000348 | 0.000435 | 0.000435 |
| 05-Oct-18 | 6 | | | | | | | | | | | | | | | | | | | | | | |
| 12-Oct-18 | 7 | 0.0000172 | 0.000559 | 0.15652 | 0.003225 | 0.00215 | 0.0001376 | 0.000086 | 0.000645 | 1.1438 | 0.0000172 | 0.4472 | 0.00001075 | 0.2064 | 0.027262 | 1.677 | 0.000001075 | 0.0000817 | 0.00001075 | 0.00010922 | 0.0002666 | 0.00043 | 0.00043 |
| 19-Oct-18 | 8 | | | | | | | | | | | | | | | | | | | | | | |
| 26-Oct-18 | 9 | 0.000009 | 0.00072 | 0.24885 | 0.004491 | 0.018 | 0.0002655 | 0.00009 | 0.000675 | 1.386 | 0.000063 | 0.351 | 0.00001125 | 0.2745 | 0.03825 | 3.915 | 0.000001125 | 0.0000855 | 0.000423 | 0.0002592 | 0.0002295 | 0.00045 | 0.00045 |
| 02-Nov-18 | 10 | | | | | | | | | | | | | | | | | | | | | | |
| 09-Nov-18 | 11 | 0.000009 | 0.000585 | 0.21015 | 0.0034785 | 0.00225 | 0.000135 | 0.000045 | 0.000675 | 0.9405 | 0.000009 | 0.3465 | 0.00001125 | 0.135 | 0.03591 | 3.465 | 0.0000027 | 0.0000315 | 0.0000495 | 0.0002187 | 0.000144 | 0.00045 | 0.00045 |
| 16-Nov-18 | 12 | | | | | | | | | | | | | | | | | | | | | | |
| 23-Nov-18 | 13 | 0.000009 | 0.000495 | 0.17775 | 0.002682 | 0.00225 | 0.0001755 | 0.0000225 | 0.0027 | 0.846 | 0.000009 | 0.351 | 0.00001125 | 0.117 | 0.029115 | 2.97 | 0.0000027 | 0.000063 | 0.000027 | 0.00017145 | 0.0001665 | 0.00045 | 0.00045 |
| 30-Nov-18 | 14 | | | | | | | | | | | | | | | | | | | | | | |
| 07-Dec-18 | 15 | 0.0000044 | 0.00044 | 0.15752 | 0.0036476 | 0.0022 | 0.0001672 | 0.000022 | 0.00066 | 0.7832 | 0.0000088 | 0.3564 | 0.000011 | 0.088 | 0.024816 | 2.42 | 0.0000011 | 0.0000572 | 0.000011 | 0.00011792 | 0.0001188 | 0.00044 | 0.00044 |
| 14-Dec-18 | 16 | | | | | | | | | | | | | | | | | | | | | | |
| 21-Dec-18 | 17 | 0.0000022 | 0.000352 | 0.14168 | 0.0036256 | 0.0022 | 0.0001628 | 0.000022 | 0.00066 | 0.6556 | 0.0000088 | 0.2816 | 0.000011 | 0.176 | 0.023936 | 2.596 | 0.0000011 | 0.0000264 | 0.0000308 | 0.0001342 | 0.0000968 | 0.00044 | 0.00044 |
| 28-Dec-18 | 18 | | | | | | | | | | | | | | | | | | | | | | |
| 04-Jan-19 | 19 | 0.000002225 | 0.0004005 | 0.164205 | 0.004005 | 0.002225 | 0.0003471 | 0.00002225 | 0.0006675 | 0.69865 | 0.0000089 | 0.25365 | 0.000011125 | 0.09345 | 0.0246975 | 3.56 | 1.1125E-06 | 0.0000267 | 0.00004005 | 0.000108135 | 0.00008455 | 0.000445 | 0.000445 |
| 11-Jan-19 | 20 | | | | | | | | | | | | | | | | | | | | | | |
| 18-Jan-19 | 21 | 0.0000132 | 0.00044 | 0.16148 | 0.003608 | 0.0022 | 0.0001584 | 0.000022 | 0.00066 | 0.66 | 0.0000088 | 0.2728 | 0.000011 | 0.1144 | 0.023936 | 2.904 | 0.0000011 | 0.0000792 | 0.000011 | 0.00011352 | 0.0000924 | 0.00044 | 0.00044 |
| 25-Jan-19 | 22 | | | | | | | | | | | | | | | | | | | | | | |
| 01-Feb-19 | 23 | 0.000002225 | 0.000712 | 0.150855 | 0.0034176 | 0.002225 | 0.0007298 | 0.00002225 | 0.0006675 | 0.5073 | 0.0000089 | 0.25365 | 0.000011125 | 0.09345 | 0.0216715 | 2.8925 | 1.1125E-06 | 0.0000445 | 0.000011125 | 0.000120595 | 0.00008455 | 0.000445 | 0.000445 |
| 08-Feb-19 | 24 | | | | | | | | | | | | | | | | | | | | | | |
| 15-Feb-19 | 25 | 0.000002225 | 0.000356 | 0.13795 | 0.0040139 | 0.002225 | 0.0001424 | 0.00002225 | 0.0006675 | 0.6052 | 0.0000089 | 0.24475 | 0.000011125 | 0.11125 | 0.018868 | 3.3375 | 1.1125E-06 | 0.00002225 | 0.00002225 | 0.00008722 | 0.0000712 | 0.000445 | 0.000445 |
| 22-Feb-19 | 26 | | | | | | | | | | | | | | | | | | | | | | |
| 01-Mar-19 | 27 | 0.00001335 | 0.000445 | 0.12549 | 0.0038181 | 0.002225 | 0.000178 | 0.0000445 | 0.0006675 | 0.52065 | 0.0000089 | 0.23585 | 0.000011125 | 0.10235 | 0.0180225 | 2.2695 | 1.1125E-06 | 0.00001335 | 0.00148185 | 0.00008277 | 0.0000623 | 0.000445 | 0.000445 |
| 08-Mar-19 | 28 | | | | | | | | | | | | | | | | | | | | | | |
| 15-Mar-19 | 29 | 0.000002275 | 0.000364 | 0.121485 | 0.00389935 | 0.002275 | 0.0001456 | 0.00002275 | 0.0006825 | 0.5187 | 0.0000273 | 0.23205 | 0.000011375 | 0.0455 | 0.0175175 | 2.5935 | 1.1375E-06 | 0.00001365 | 0.000011375 | 0.00008554 | 0.0000728 | 0.000455 | 0.000455 |
| 22-Mar-19 | 30 | | | | | | | | | | | | | | | | | | | | | | |
| 29-Mar-19 | 31 | 0.000002225 | 0.0004895 | 0.125935 | 0.0036757 | 0.002225 | 0.00013795 | 0.00002225 | 0.0006675 | 0.49395 | 0.0000089 | 0.2314 | 0.000011125 | 0.0712 | 0.017088 | 2.8925 | 1.1125E-06 | 0.00001335 | 0.000011125 | 0.000072535 | 0.0000623 | 0.000445 | 0.000445 |
| 05-Apr-19 | 32 | | | | | | | | | | | | | | | | | | | | | | |
| 12-Apr-19 | 33 | 0.00013095 | 0.0004365 | 0.127555 | 0.00363265 | 0.002425 | 0.0003201 | 0.00002425 | 0.0007275 | 0.4947 | 0.0000097 | 0.2425 | 0.000012125 | 0.0485 | 0.020273 | 2.1825 | 0.00000291 | 0.00082935 | 0.00002425 | 0.000145985 | 0.00005335 | 0.000485 | 0.000485 |
| 19-Apr-19 | 34 | | | | | | | | | | | | | | | | | | | | | | |
| 26-Apr-19 | 35 | 0.000002275 | 0.0004095 | 0.124215 | 0.00244335 | 0.002275 | 0.0002548 | 0.00002275 | 0.0006825 | 0.5005 | 0.0000091 | 0.2093 | 0.000011375 | 0.07735 | 0.017472 | 3.2305 | 1.1375E-06 | 0.00003185 | 0.0000273 | 0.000076895 | 0.00005005 | 0.000455 | 0.000455 |
| 03-May-19 | 36 | | | | | | | | | | | | | | | | | | | | | | |
| 10-May-19 | 37 | 0.00001395 | 0.000372 | 0.11532 | 0.00229245 | 0.002325 | 0.00015345 | 0.0000465 | 0.001395 | 0.47895 | 0.0000093 | 0.2325 | 0.000011625 | 0.0651 | 0.016275 | 3.1155 | 1.1625E-06 | 0.00001395 | 0.000011625 | 0.000081375 | 0.0000558 | 0.000465 | 0.000465 |
| 17-May-19 | 38 | 0.00000225 | 0.000405 | 0.1053 | 0.001548 | 0.00225 | 0.000126 | 0.0000225 | 0.000675 | 0.4473 | 0.000009 | 0.2115 | 0.00001125 | 0.0585 | 0.016515 | 2.79 | 0.00000225 | 0.0000315 | 0.00001125 | 0.00005805 | 0.000045 | 0.00045 | 0.00045 |
| 24-May-19 | 39 | 0.000002275 | 0.000455 | 0.12285 | 0.00136045 | 0.002275 | 0.0001365 | 0.00002275 | 0.0006825 | 0.47775 | 0.0000091 | 0.2093 | 0.000011375 | 0.05915 | 0.016926 | 3.003 | 1.1375E-06 | 0.00001365 | 0.000011375 | 0.000054145 | 0.00004095 | 0.000455 | 0.000455 |
| 31-May-19 | 40 | | | | | | | | | | | | | | | | | | | | | | |
| 07-Jun-19 | 41 | | | | | | | | | | | | | | | | | | | | | | |
| 14-Jun-19 | 42 | | | | | | | | | | | | | | | | | | | | | | |
| 21-Jun-19 | 43 | 0.0000088 | 0.000308 | 0.10648 | 0.000858 | 0.0022 | 0.0002288 | 0.00022 | 0.00066 | 0.4378 | 0.0000088 | 0.176 | 0.000011 | 0.0616 | 0.015356 | 2.86 | 0.0000022 | 0.000088 | 0.000011 | 0.00011132 | 0.0000352 | 0.00044 | 0.00044 |
| 28-Jun-19 | 44 | | | | | | | | | | | | | | | | | | | | | | |
| 05-Jul-19 | 45 | | | | | | | | | | | | | | | | | | | | | | |
| 12-Jul-19 | 46 | | | | | | | | | | | | | | | | | | | | | | |
| 19-Jul-19 | 47 | 0.000009 | 0.000405 | 0.11025 | 0.000522 | 0.00225 | 0.00027 | 0.000045 | 0.000675 | 0.4725 | 0.000009 | 0.1665 | 0.00001125 | 0.045 | 0.01503 | 4.05 | 0.00000225 | 0.0000135 | 0.000036 | 0.00005355 | 0.000027 | 0.00045 | 0.00045 |
| 26-Jul-19 | 48 | | | | | | | | | | | | | | | | | | | | | | |
| 02-Aug-19 | 49 | | | | | | | | | | | | | | | | | | | | | | |

**Appendix 4-6: Kinetic Test Results**
**HC 3**

| Date | Cycle | Volume mL | | pH | Cond. | Acidity | Acidity | Alkalinity | Sulphate | Chloride | Fluoride | Hardness | Al | Sb | As | Ba | Be | Bi | B | Cd | Ca | Cr | Co | Cu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. | Input | Output | | | (pH 4.5) | (pH 8.3) | | | | | CaCO3 | | | | | | | | | | | | |
| | | | | | umhos/cm | mgCaCO3/L | mgCaCO3/L | mgCaCO3/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 |
| 24-Aug-18 | 0 | 500 | 355 | 7.95 | 189 | #N/A | 3.3 | 30.0 | 11 | 10 | 0.09 | 58.6 | 0.095 | 0.0010 | 0.327 | 0.00241 | 0.000027 | 0.000026 | 0.008 | 0.000036 | 22.0 | 0.00006 | 0.000063 | 0.00047 |
| 31-Aug-18 | 1 | 500 | 450 | 7.89 | 136 | #N/A | 2.9 | 16.9 | 16 | 8 | 0.07 | 43.6 | 0.157 | 0.0010 | 0.213 | 0.00161 | <0.0000035 | <0.0000035 | 0.010 | 0.000029 | 16.0 | <0.000015 | 0.000012 | 0.00032 |
| 07-Sep-18 | 2 | 500 | 440 | 7.82 | 103 | #N/A | 2.4 | 20.1 | 19 | 4 | 0.06 | 33.3 | 0.258 | 0.0009 | 0.163 | 0.00120 | <0.0000035 | <0.0000035 | 0.022 | 0.000003 | 12.3 | <0.000015 | 0.000015 | 0.00004 |
| 14-Sep-18 | 3 | 500 | 445 | 7.83 | 76 | #N/A | 1.5 | 15.1 | 12 | 2 | <0.03 | 22.6 | 0.164 | 0.0007 | 0.127 | 0.00074 | 0.000007 | <0.0000035 | 0.008 | <0.0000015 | 8.32 | 0.00018 | 0.000012 | 0.00052 |
| 21-Sep-18 | 4 | 500 | 435 | 7.84 | 67 | #N/A | 2.2 | 15.3 | 10 | | | | | | | | | | | | | | | |
| 28-Sep-18 | 5 | 500 | 440 | 7.95 | 62 | #N/A | 1.1 | 21.7 | 10 | <0.5 | <0.03 | 23.8 | 0.184 | 0.0005 | 0.103 | 0.00081 | <0.0000035 | <0.0000035 | 0.005 | <0.0000015 | 8.77 | 0.00003 | 0.000009 | 0.00048 |
| 05-Oct-18 | 6 | 500 | 450 | 7.71 | 61 | #N/A | 1.8 | 15.1 | 8 | | | | | | | | | | | | | | | |
| 12-Oct-18 | 7 | 500 | 455 | 7.88 | 78 | #N/A | 3.5 | 20.5 | 14 | <0.5 | <0.03 | 30.1 | 0.190 | 0.0004 | 0.0833 | 0.00095 | <0.0000035 | <0.0000035 | 0.005 | <0.0000015 | 11.1 | 0.00014 | 0.000014 | 0.00021 |
| 19-Oct-18 | 8 | 500 | 440 | 7.81 | 83 | #N/A | 1.5 | 15.2 | 19 | | | | | | | | | | | | | | | |
| 26-Oct-18 | 9 | 500 | 450 | 7.76 | 83 | #N/A | 1.2 | 14.1 | 21 | <0.5 | <0.03 | 35.5 | 0.154 | 0.0003 | 0.0491 | 0.00115 | <0.0000035 | <0.0000035 | 0.003 | <0.0000015 | 13.2 | 0.00004 | 0.000008 | 0.00112 |
| 02-Nov-18 | 10 | 500 | 435 | 7.93 | 87 | #N/A | 0.9 | 15.4 | 20 | | | | | | | | | | | | | | | |
| 09-Nov-18 | 11 | 500 | 450 | 7.78 | 88 | #N/A | 2.2 | 15.0 | 21 | <0.5 | <0.03 | 31.5 | 0.134 | 0.0003 | 0.0639 | 0.00093 | <0.0000035 | <0.0000035 | 0.004 | 0.000003 | 11.7 | 0.00004 | 0.000004 | 0.00071 |
| 16-Nov-18 | 12 | 500 | 415 | 7.69 | 94 | #N/A | 1.1 | 12.6 | 22 | | | | | | | | | | | | | | | |
| 23-Nov-18 | 13 | 500 | 445 | 7.73 | 101 | #N/A | 1.9 | 12.5 | 25 | <0.5 | <0.03 | 38.0 | 0.124 | <0.0001 | 0.0548 | 0.00103 | <0.0000035 | <0.0000035 | 0.002 | 0.000003 | 14.2 | <0.000015 | <0.000002 | 0.00017 |
| 30-Nov-18 | 14 | 500 | 445 | 7.70 | 100 | #N/A | 1.7 | 12.2 | 27 | | | | | | | | | | | | | | | |
| 07-Dec-18 | 15 | 500 | 440 | 7.60 | 96 | #N/A | 3.7 | 13.6 | 27 | <0.5 | <0.03 | 39.5 | 0.116 | <0.0001 | 0.0503 | 0.00097 | <0.0000035 | <0.0000035 | 0.003 | <0.0000015 | 14.9 | <0.000015 | <0.000002 | 0.00096 |
| 14-Dec-18 | 16 | 500 | 450 | 7.65 | 92 | #N/A | 2.9 | 13.7 | 23 | | | | | | | | | | | | | | | |
| 21-Dec-18 | 17 | 500 | 445 | 7.69 | 97 | #N/A | 3.4 | 14.7 | 24 | <0.5 | <0.03 | 38.2 | 0.113 | <0.0001 | 0.0527 | 0.00116 | <0.0000035 | <0.0000035 | 0.003 | 0.000006 | 14.5 | <0.000015 | 0.000018 | 0.00141 |
| 28-Dec-18 | 18 | 500 | 445 | 7.69 | 88 | #N/A | 1.6 | 12.9 | 23 | | | | | | | | | | | | | | | |
| 04-Jan-19 | 19 | 500 | 465 | 7.75 | 83 | #N/A | 2.9 | 13.1 | 21 | <0.5 | <0.03 | 36.3 | 0.124 | <0.0001 | 0.0518 | 0.00094 | <0.0000035 | <0.0000035 | 0.002 | <0.0000015 | 13.8 | 0.00006 | 0.000028 | 0.00046 |
| 11-Jan-19 | 20 | 500 | 445 | 7.43 | 77 | #N/A | 2.2 | 12.4 | 22 | | | | | | | | | | | | | | | |
| 18-Jan-19 | 21 | 500 | 440 | 7.58 | 72 | #N/A | 1.4 | 11.8 | 21 | <0.5 | <0.03 | 32.9 | 0.113 | <0.0001 | 0.0473 | 0.00086 | <0.0000035 | <0.0000035 | 0.003 | 0.000051 | 12.5 | <0.000015 | <0.000002 | 0.00015 |
| 25-Jan-19 | 22 | 500 | 440 | 7.65 | 77 | #N/A | 1.5 | 10.4 | 18 | | | | | | | | | | | | | | | |
| 01-Feb-19 | 23 | 500 | 450 | 7.56 | 78 | #N/A | 2.8 | 12.7 | 18 | <0.5 | <0.03 | 29.6 | 0.086 | <0.0001 | 0.0427 | 0.00080 | <0.0000035 | <0.0000035 | 0.003 | <0.0000015 | 11.2 | <0.000015 | 0.000005 | 0.00056 |
| 08-Feb-19 | 24 | 500 | 445 | 7.64 | 76 | #N/A | 2.7 | 11.4 | 18 | | | | | | | | | | | | | | | |
| 15-Feb-19 | 25 | 500 | 450 | 7.54 | 78 | #N/A | 1.5 | 11.1 | 19 | <0.5 | <0.03 | 33.6 | 0.088 | <0.0001 | 0.0414 | 0.00083 | <0.0000035 | <0.0000035 | 0.007 | <0.0000015 | 12.8 | <0.000015 | <0.000002 | 0.00044 |
| 22-Feb-19 | 26 | 500 | 425 | 7.75 | 88 | #N/A | 2.8 | 13.2 | 24 | | | | | | | | | | | | | | | |
| 01-Mar-19 | 27 | 500 | 435 | 7.47 | 84 | #N/A | 2.3 | 13.8 | 19 | <0.5 | <0.03 | 35.8 | 0.100 | <0.00045 | 0.0434 | 0.00084 | <0.0000035 | <0.0000035 | 0.002 | <0.0000015 | 13.7 | <0.00004 | <0.000002 | 0.0005 |
| 08-Mar-19 | 28 | 500 | 430 | 7.69 | 88 | #N/A | 2.7 | 14.4 | 23 | | | | | | | | | | | | | | | |
| 15-Mar-19 | 29 | 500 | 450 | 7.64 | 81 | #N/A | 2.1 | 13.0 | 24 | <0.5 | <0.03 | 35.8 | 0.106 | <0.00045 | 0.0497 | 0.00082 | <0.0000035 | <0.0000035 | 0.003 | 0.000010 | 13.7 | <0.00004 | <0.000002 | 0.0036 |
| 22-Mar-19 | 30 | 500 | 440 | 7.84 | 81 | #N/A | 2.6 | 14.4 | 20 | | | | | | | | | | | | | | | |
| 29-Mar-19 | 31 | 500 | 420 | 7.49 | 79 | #N/A | 2.4 | 13.3 | 20 | <0.5 | <0.03 | 33.3 | 0.105 | <0.00045 | 0.0439 | 0.00082 | <0.0000035 | <0.0000035 | 0.003 | <0.0000015 | 12.7 | <0.00004 | <0.000002 | 0.0002 |
| 05-Apr-19 | 32 | 500 | 440 | 7.82 | 76 | #N/A | 5.1 | 18.8 | 19 | | | | | | | | | | | | | | | |
| 12-Apr-19 | 33 | 500 | 485 | 7.57 | 77 | #N/A | 1.9 | 20.8 | 19 | <0.5 | <0.03 | 30.9 | 0.084 | <0.00045 | 0.0395 | 0.00073 | <0.0000035 | <0.0000035 | <0.001 | <0.0000015 | 11.9 | <0.00004 | 0.000019 | 0.0006 |
| 19-Apr-19 | 34 | 500 | 430 | 7.73 | 68 | #N/A | 1.7 | 13.5 | 16 | | | | | | | | | | | | | | | |
| 26-Apr-19 | 35 | 500 | 435 | 7.77 | 76 | #N/A | 2.3 | 12.8 | 20 | <0.5 | <0.03 | 34.0 | 0.107 | <0.00045 | 0.0424 | 0.00087 | <0.0000035 | <0.0000035 | 0.003 | 0.000005 | 13.1 | <0.00004 | 0.000015 | 0.0006 |
| 03-May-19 | 36 | 500 | 440 | 7.97 | 77 | #N/A | 2.3 | 11.1 | 20 | | | | | | | | | | | | | | | |
| 10-May-19 | 37 | 500 | 445 | 7.61 | 80 | #N/A | 1.5 | 11.0 | 21 | <0.5 | <0.03 | 34.8 | 0.087 | <0.00045 | 0.0380 | 0.00083 | <0.0000035 | <0.0000035 | 0.002 | <0.0000015 | 13.4 | <0.00004 | 0.000025 | 0.0011 |
| 17-May-19 | 38 | 500 | 445 | 7.61 | 77 | #N/A | 2.1 | 11.4 | 20 | <0.5 | <0.03 | 32.2 | 0.092 | <0.00045 | 0.0385 | 0.00080 | <0.0000035 | <0.0000035 | <0.001 | 0.000004 | 12.4 | <0.00004 | 0.000027 | 0.0005 |
| 24-May-19 | 39 | 500 | 445 | 7.56 | 75 | #N/A | 2.8 | 12.3 | 20 | <0.5 | <0.03 | 31.2 | 0.097 | <0.00045 | 0.0340 | 0.00081 | <0.0000035 | <0.0000035 | 0.002 | 0.000014 | 12.0 | <0.00004 | 0.000019 | 0.0006 |
| **Cell Terminated** | | | | | | | | | | | | | | | | | | | | | | | | |
| **Loads** | **mg/kg** | | | | | | | | | | | | | | | | | | | | | | | |
| 24-Aug-18 | 0 | | | 7.95 | | | | | 3.905 | 3.55 | 0.03195 | 20.803 | 0.033725 | 0.000355 | 0.116085 | 0.00085555 | 0.000009585 | 0.00000923 | 0.00284 | 0.00001278 | 7.81 | 0.0000213 | 0.000022365 | 0.00016685 |
| 31-Aug-18 | 1 | | | 7.89 | | | | | 7.2 | 3.6 | 0.0315 | 19.62 | 0.07065 | 0.00045 | 0.09585 | 0.0007245 | 0.000001575 | 0.000001575 | 0.0045 | 0.00001305 | 7.2 | 0.00000675 | 0.0000054 | 0.000144 |
| 07-Sep-18 | 2 | | | 7.82 | | | | | 8.36 | 1.76 | 0.0264 | 14.652 | 0.11352 | 0.000396 | 0.07172 | 0.000528 | 0.00000154 | 0.00000154 | 0.00968 | 0.00000132 | 5.412 | 0.0000066 | 0.0000066 | 0.0000176 |
| 14-Sep-18 | 3 | | | 7.83 | | | | | 5.34 | 0.89 | 0.01335 | 10.057 | 0.07298 | 0.0003115 | 0.056515 | 0.0003293 | 0.000003115 | 1.5575E-06 | 0.00356 | 6.675E-07 | 3.7024 | 0.0000801 | 0.00000534 | 0.0002314 |
| 21-Sep-18 | 4 | | | 7.84 | | | | | 4.35 | | | | | | | | | | | | | | | |
| 28-Sep-18 | 5 | | | 7.95 | | | | | 4.4 | 0.22 | 0.0132 | 10.472 | 0.08096 | 0.00022 | 0.04532 | 0.0003564 | 0.00000154 | 0.00000154 | 0.0022 | 0.00000066 | 3.8588 | 0.0000132 | 0.00000396 | 0.0002112 |
| 05-Oct-18 | 6 | | | 7.71 | | | | | 3.6 | | | | | | | | | | | | | | | |
| 12-Oct-18 | 7 | | | 7.88 | | | | | 6.37 | 0.2275 | 0.01365 | 13.6955 | 0.08645 | 0.000182 | 0.0379015 | 0.00043225 | 1.5925E-06 | 1.5925E-06 | 0.002275 | 6.825E-07 | 5.0505 | 0.0000637 | 0.00000637 | 0.00009555 |
| 19-Oct-18 | 8 | | | 7.81 | | | | | 8.36 | | | | | | | | | | | | | | | |
| 26-Oct-18 | 9 | | | 7.76 | | | | | 9.45 | 0.225 | 0.0135 | 15.975 | 0.0693 | 0.000135 | 0.022095 | 0.0005175 | 0.000001575 | 0.000001575 | 0.00135 | 0.000000675 | 5.94 | 0.000018 | 0.0000036 | 0.000504 |
| 02-Nov-18 | 10 | | | 7.93 | | | | | 8.7 | | | | | | | | | | | | | | | |
| 09-Nov-18 | 11 | | | 7.78 | | | | | 9.45 | 0.225 | 0.0135 | 14.175 | 0.0603 | 0.000135 | 0.028755 | 0.0004185 | 0.000001575 | 0.000001575 | 0.0018 | 0.00000135 | 5.265 | 0.000018 | 0.0000018 | 0.0003195 |
| 16-Nov-18 | 12 | | | 7.69 | | | | | 9.13 | | | | | | | | | | | | | | | |
| 23-Nov-18 | 13 | | | 7.73 | | | | | 11.125 | 0.2225 | 0.01335 | 16.91 | 0.05518 | 0.0000445 | 0.024386 | 0.00045835 | 1.5575E-06 | 1.5575E-06 | 0.00089 | 0.000001335 | 6.319 | 0.000006675 | 0.00000089 | 0.00007565 |
| 30-Nov-18 | 14 | | | 7.70 | | | | | 12.015 | | | | | | | | | | | | | | | |
| 07-Dec-18 | 15 | | | 7.60 | | | | | 11.88 | 0.22 | 0.0132 | 17.38 | 0.05104 | 0.000044 | 0.022132 | 0.0004268 | 0.00000154 | 0.00000154 | 0.00132 | 0.00000066 | 6.556 | 0.0000066 | 0.00000088 | 0.0004224 |
| 14-Dec-18 | 16 | | | 7.65 | | | | | 10.35 | | | | | | | | | | | | | | | |
| 21-Dec-18 | 17 | | | 7.69 | | | | | 10.68 | 0.2225 | 0.01335 | 16.999 | 0.050285 | 0.0000445 | 0.0234515 | 0.0005162 | 1.5575E-06 | 1.5575E-06 | 0.001335 | 0.00000267 | 6.4525 | 0.000006675 | 0.00000801 | 0.00062745 |
| 28-Dec-18 | 18 | | | 7.69 | | | | | 10.235 | | | | | | | | | | | | | | | |
| 04-Jan-19 | 19 | | | 7.75 | | | | | 9.765 | 0.2325 | 0.01395 | 16.8795 | 0.05766 | 0.0000465 | 0.024087 | 0.0004371 | 1.6275E-06 | 1.6275E-06 | 0.00093 | 6.975E-07 | 6.417 | 0.0000279 | 0.00001302 | 0.0002139 |
| 11-Jan-19 | 20 | | | 7.43 | | | | | 9.79 | | | | | | | | | | | | | | | |
| 18-Jan-19 | 21 | | | 7.58 | | | | | 9.24 | 0.22 | 0.0132 | 14.476 | 0.04972 | 0.000044 | 0.020812 | 0.0003784 | 0.00000154 | 0.00000154 | 0.00132 | 0.00002244 | 5.5 | 0.0000066 | 0.00000088 | 0.000066 |
| 25-Jan-19 | 22 | | | 7.65 | | | | | 7.92 | | | | | | | | | | | | | | | |
| 01-Feb-19 | 23 | | | 7.56 | | | | | 8.1 | 0.225 | 0.0135 | 13.32 | 0.0387 | 0.000045 | 0.019215 | 0.00036 | 0.000001575 | 0.000001575 | 0.00135 | 0.000000675 | 5.04 | 0.00000675 | 0.00000225 | 0.000252 |
| 08-Feb-19 | 24 | | | 7.64 | | | | | 8.01 | | | | | | | | | | | | | | | |
| 15-Feb-19 | 25 | | | 7.54 | | | | | 8.55 | 0.225 | 0.0135 | 15.12 | 0.0396 | 0.000045 | 0.01863 | 0.0003735 | 0.000001575 | 0.000001575 | 0.00315 | 0.000000675 | 5.76 | 0.00000675 | 0.0000009 | 0.000198 |
| 22-Feb-19 | 26 | | | 7.75 | | | | | 10.2 | | | | | | | | | | | | | | | |
| 01-Mar-19 | 27 | | | 7.47 | | | | | 8.265 | 0.2175 | 0.01305 | 15.573 | 0.0435 | 0.00019575 | 0.018879 | 0.0003654 | 1.5225E-06 | 1.5225E-06 | 0.00087 | 6.525E-07 | 5.9595 | 0.0000174 | 0.00000087 | 0.0002175 |
| 08-Mar-19 | 28 | | | 7.69 | | | | | 9.89 | | | | | | | | | | | | | | | |
| 15-Mar-19 | 29 | | | 7.64 | | | | | 10.8 | 0.225 | 0.0135 | 16.11 | 0.0477 | 0.0002025 | 0.022365 | 0.000369 | 0.000001575 | 0.000001575 | 0.00135 | 0.0000045 | 6.165 | 0.000018 | 0.0000009 | 0.00162 |
| 22-Mar-19 | 30 | | | 7.84 | | | | | 8.8 | | | | | | | | | | | | | | | |
| 29-Mar-19 | 31 | | | 7.49 | | | | | 8.4 | 0.21 | 0.0126 | 13.986 | 0.0441 | 0.000189 | 0.018438 | 0.0003444 | 0.00000147 | 0.00000147 | 0.00126 | 0.00000063 | 5.334 | 0.0000168 | 0.00000084 | 0.000084 |
| 05-Apr-19 | 32 | | | 7.82 | | | | | 8.36 | | | | | | | | | | | | | | | |
| 12-Apr-19 | 33 | | | 7.57 | | | | | 9.215 | 0.2425 | 0.01455 | 14.9865 | 0.04074 | 0.00021825 | 0.0191575 | 0.00035405 | 1.6975E-06 | 1.6975E-06 | 0.000485 | 7.275E-07 | 5.7715 | 0.0000194 | 0.000009215 | 0.000291 |
| 19-Apr-19 | 34 | | | 7.73 | | | | | 6.88 | | | | | | | | | | | | | | | |
| 26-Apr-19 | 35 | | | 7.77 | | | | | 8.7 | 0.2175 | 0.01305 | 14.79 | 0.046545 | 0.00019575 | 0.018444 | 0.00037845 | 1.5225E-06 | 1.5225E-06 | 0.001305 | 0.000002175 | 5.6985 | 0.0000174 | 0.000006525 | 0.000261 |
| 03-May-19 | 36 | | | 7.97 | | | | | 8.8 | | | | | | | | | | | | | | | |
| 10-May-19 | 37 | | | 7.61 | | | | | 9.345 | 0.2225 | 0.01335 | 15.486 | 0.038715 | 0.00020025 | 0.01691 | 0.00036935 | 1.5575E-06 | 1.5575E-06 | 0.00089 | 6.675E-07 | 5.963 | 0.0000178 | 0.000011125 | 0.0004895 |
| 17-May-19 | 38 | | | 7.61 | | | | | 8.9 | 0.2225 | 0.01335 | 14.329 | 0.04094 | 0.00020025 | 0.0171325 | 0.000356 | 1.5575E-06 | 1.5575E-06 | 0.000445 | 0.00000178 | 5.518 | 0.0000178 | 0.000012015 | 0.0002225 |
| 24-May-19 | 39 | | | 7.56 | | | | | 8.9 | 0.2225 | 0.01335 | 13.884 | 0.043165 | 0.00020025 | 0.01513 | 0.00036045 | 1.5575E-06 | 1.5575E-06 | 0.00089 | 0.00000623 | 5.34 | 0.0000178 | 0.000008455 | 0.000267 |

**Appendix 4-6: Kinetic Test Results**
**HC 3**

| Date | Cycle No. | Fe | Pb | Li | Mg | Mn | Hg | Mo | Ni | P | K | Se | Si | Ag | Na | Sr | S | Tl | Sn | Ti | U | V | Zn | Zr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | mg/L | mg/L | mg/L | mg/L | mg/L | ug/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L |
| 24-Aug-18 | 0 | 0.012 | 0.00003 | 0.0049 | 0.882 | 0.0699 | <0.005 | 0.00045 | 0.0045 | 0.031 | 8.68 | 0.00009 | 1.44 | <0.000025 | 6.49 | 0.0457 | 5.0 | 0.000027 | 0.00174 | 0.00021 | 0.000156 | 0.00096 | <0.001 | <0.001 |
| 31-Aug-18 | 1 | <0.0035 | <0.000005 | 0.0037 | 0.861 | 0.0183 | <0.005 | 0.00173 | 0.0006 | 0.005 | 6.25 | 0.00006 | 1.36 | <0.000025 | 5.60 | 0.0366 | 7.3 | <0.0000025 | 0.00086 | <0.000025 | 0.000636 | 0.00106 | <0.001 | <0.001 |
| 07-Sep-18 | 2 | 0.013 | 0.00007 | 0.0027 | 0.642 | 0.0130 | <0.005 | 0.00253 | 0.0003 | <0.0015 | 5.44 | 0.00005 | 1.46 | <0.000025 | 3.91 | 0.0319 | 7.9 | <0.0000025 | 0.00063 | 0.00051 | 0.000521 | 0.00121 | <0.001 | <0.001 |
| 14-Sep-18 | 3 | 0.007 | 0.00003 | 0.0019 | 0.436 | 0.0122 | 0.02 | 0.00139 | 0.0001 | <0.0015 | 3.39 | 0.00007 | 1.07 | <0.000025 | 1.98 | 0.0224 | 3.7 | <0.0000025 | 0.00038 | 0.00012 | 0.000458 | 0.00092 | <0.001 | <0.001 |
| 21-Sep-18 | 4 | | | | | | | | | | | | | | | | | | | | | | | |
| 28-Sep-18 | 5 | 0.021 | 0.00003 | 0.0021 | 0.450 | 0.0153 | 0.02 | 0.00056 | 0.0004 | <0.0015 | 3.03 | <0.00002 | 1.13 | <0.000025 | 1.17 | 0.0208 | 3.9 | <0.0000025 | 0.00029 | 0.00013 | 0.000648 | 0.00106 | <0.001 | <0.001 |
| 05-Oct-18 | 6 | | | | | | | | | | | | | | | | | | | | | | | |
| 12-Oct-18 | 7 | <0.0035 | 0.00011 | 0.0021 | 0.540 | 0.00310 | <0.005 | 0.00027 | <0.00005 | <0.0015 | 2.89 | <0.00002 | 1.14 | <0.000025 | 0.78 | 0.0241 | 5.6 | <0.0000025 | 0.00019 | <0.000025 | 0.000843 | 0.00084 | <0.001 | <0.001 |
| 19-Oct-18 | 8 | | | | | | | | | | | | | | | | | | | | | | | |
| 26-Oct-18 | 9 | 0.008 | <0.000005 | 0.0016 | 0.605 | 0.00204 | <0.005 | 0.00031 | 0.0001 | <0.0015 | 3.24 | 0.00011 | 0.79 | <0.000025 | 0.65 | 0.0240 | 7.5 | <0.0000025 | 0.00016 | 0.00028 | 0.000950 | 0.00072 | <0.001 | <0.001 |
| 02-Nov-18 | 10 | | | | | | | | | | | | | | | | | | | | | | | |
| 09-Nov-18 | 11 | <0.0035 | 0.00002 | 0.0018 | 0.555 | 0.00219 | <0.005 | 0.00030 | 0.0001 | <0.0015 | 2.22 | <0.00002 | 0.87 | <0.000025 | 0.44 | 0.0252 | 7.1 | <0.0000025 | 0.00009 | 0.00006 | 0.00104 | 0.00055 | <0.001 | <0.001 |
| 16-Nov-18 | 12 | | | | | | | | | | | | | | | | | | | | | | | |
| 23-Nov-18 | 13 | <0.0035 | <0.000005 | 0.0016 | 0.599 | 0.00230 | <0.005 | 0.00034 | <0.00005 | <0.0015 | 2.19 | <0.00002 | 0.87 | <0.000025 | 0.38 | 0.0267 | 9.2 | <0.0000025 | 0.00014 | <0.000025 | 0.00107 | 0.00046 | <0.001 | <0.001 |
| 30-Nov-18 | 14 | | | | | | | | | | | | | | | | | | | | | | | |
| 07-Dec-18 | 15 | <0.0035 | <0.000005 | 0.0013 | 0.546 | 0.00535 | <0.005 | 0.00023 | <0.00005 | <0.0015 | 2.05 | <0.00002 | 0.85 | <0.000025 | 0.27 | 0.0265 | 9.0 | <0.0000025 | 0.00012 | 0.00015 | 0.000701 | 0.00037 | <0.001 | <0.001 |
| 14-Dec-18 | 16 | | | | | | | | | | | | | | | | | | | | | | | |
| 21-Dec-18 | 17 | <0.0035 | 0.00003 | 0.0014 | 0.474 | 0.00465 | <0.005 | 0.00024 | <0.00005 | <0.0015 | 1.71 | <0.00002 | 0.82 | <0.000025 | 0.25 | 0.0251 | 8.8 | <0.0000025 | 0.00009 | 0.00005 | 0.000852 | 0.00035 | <0.001 | <0.001 |
| 28-Dec-18 | 18 | | | | | | | | | | | | | | | | | | | | | | | |
| 04-Jan-19 | 19 | <0.0035 | <0.000005 | 0.0011 | 0.448 | 0.00437 | <0.005 | 0.00041 | <0.00005 | <0.0015 | 1.78 | <0.00002 | 0.70 | <0.000025 | 0.26 | 0.0223 | 9.9 | <0.0000025 | 0.00006 | 0.00007 | 0.000538 | 0.00033 | <0.001 | <0.001 |
| 11-Jan-19 | 20 | | | | | | | | | | | | | | | | | | | | | | | |
| 18-Jan-19 | 21 | <0.0035 | <0.000005 | 0.0012 | 0.434 | 0.00427 | <0.005 | 0.00163 | <0.00005 | <0.0015 | 1.53 | <0.00002 | 0.64 | <0.000025 | 0.28 | 0.0207 | 7.2 | <0.0000025 | 0.00008 | <0.000025 | 0.000545 | 0.00030 | <0.001 | <0.001 |
| 25-Jan-19 | 22 | | | | | | | | | | | | | | | | | | | | | | | |
| 01-Feb-19 | 23 | <0.0035 | <0.000005 | 0.0011 | 0.408 | 0.00432 | <0.005 | 0.00084 | <0.00005 | <0.0015 | 1.24 | <0.00002 | 0.68 | <0.000025 | 0.24 | 0.0200 | 7.8 | <0.0000025 | 0.00006 | 0.00010 | 0.000540 | 0.00024 | <0.001 | <0.001 |
| 08-Feb-19 | 24 | | | | | | | | | | | | | | | | | | | | | | | |
| 15-Feb-19 | 25 | <0.0035 | <0.000005 | 0.0009 | 0.399 | 0.00465 | <0.005 | 0.00016 | <0.00005 | <0.0015 | 1.48 | <0.00002 | 0.66 | <0.000025 | 0.28 | 0.0181 | 9.3 | <0.0000025 | <0.00005 | 0.00008 | 0.000455 | 0.00024 | <0.001 | <0.001 |
| 22-Feb-19 | 26 | | | | | | | | | | | | | | | | | | | | | | | |
| 01-Mar-19 | 27 | <0.0035 | 0.00001 | 0.0011 | 0.401 | 0.00680 | <0.005 | 0.00024 | <0.00005 | 0.004 | 1.40 | <0.00002 | 0.64 | <0.000025 | 0.27 | 0.0200 | 8.1 | <0.0000025 | 0.00008 | 0.00013 | 0.000396 | 0.00021 | <0.001 | <0.001 |
| 08-Mar-19 | 28 | | | | | | | | | | | | | | | | | | | | | | | |
| 15-Mar-19 | 29 | <0.0035 | <0.000005 | 0.0009 | 0.377 | 0.00471 | <0.005 | 0.00015 | <0.00005 | <0.0015 | 1.44 | <0.00002 | 0.66 | <0.000025 | 0.16 | 0.0202 | 8.9 | <0.0000025 | <0.00003 | <0.000025 | 0.000392 | 0.00027 | <0.001 | <0.001 |
| 22-Mar-19 | 30 | | | | | | | | | | | | | | | | | | | | | | | |
| 29-Mar-19 | 31 | <0.0035 | <0.000005 | 0.0012 | 0.371 | 0.00428 | <0.005 | 0.00017 | <0.00005 | <0.0015 | 1.38 | <0.00002 | 0.63 | <0.000025 | 0.23 | 0.0185 | 9.4 | <0.0000025 | <0.00003 | <0.000025 | 0.000297 | 0.00024 | <0.001 | <0.001 |
| 05-Apr-19 | 32 | | | | | | | | | | | | | | | | | | | | | | | |
| 12-Apr-19 | 33 | <0.0035 | <0.000005 | 0.0009 | 0.318 | 0.00337 | <0.005 | 0.00032 | <0.00005 | <0.0015 | 1.19 | <0.00002 | 0.63 | <0.000025 | 0.15 | 0.0183 | 4.9 | <0.0000025 | 0.00010 | 0.00006 | 0.000518 | 0.00019 | <0.001 | <0.001 |
| 19-Apr-19 | 34 | | | | | | | | | | | | | | | | | | | | | | | |
| 26-Apr-19 | 35 | <0.0035 | 0.00001 | 0.0010 | 0.341 | 0.00449 | <0.005 | 0.00030 | <0.00005 | <0.0015 | 1.36 | <0.00002 | 0.62 | <0.000025 | 0.23 | 0.0188 | 8.6 | 0.000005 | 0.00008 | 0.00008 | 0.000356 | 0.00022 | <0.001 | <0.001 |
| 03-May-19 | 36 | | | | | | | | | | | | | | | | | | | | | | | |
| 10-May-19 | 37 | 0.013 | <0.000005 | 0.0009 | 0.340 | 0.00520 | <0.005 | 0.00014 | <0.00005 | <0.0015 | 1.30 | <0.00002 | 0.62 | <0.000025 | 0.20 | 0.0184 | 9.1 | <0.0000025 | 0.00010 | 0.00011 | 0.000316 | 0.00019 | <0.001 | <0.001 |
| 17-May-19 | 38 | <0.0035 | <0.000005 | 0.0009 | 0.308 | 0.00474 | <0.005 | 0.00010 | <0.00005 | <0.0015 | 1.25 | <0.00002 | 0.61 | <0.000025 | 0.18 | 0.0172 | 7.3 | <0.0000025 | 0.00007 | <0.000025 | 0.000235 | 0.00019 | <0.001 | <0.001 |
| 24-May-19 | 39 | <0.0035 | 0.00003 | 0.0011 | 0.311 | 0.00436 | <0.005 | 0.00010 | <0.00005 | <0.0015 | 1.24 | <0.00002 | 0.59 | <0.000025 | 0.18 | 0.0170 | 6.4 | <0.0000025 | <0.00003 | <0.000025 | 0.000217 | 0.00019 | <0.001 | <0.001 |
| **Cell Terminated** | | | | | | | | | | | | | | | | | | | | | | | | |
| **Loads** | **mg/kg** | | | | | | | | | | | | | | | | | | | | | | | |
| 24-Aug-18 | 0 | 0.00426 | 0.00001065 | 0.0017395 | 0.31311 | 0.0248145 | 0.001775 | 0.00015975 | 0.0015975 | 0.011005 | 3.0814 | 0.00003195 | 0.5112 | 0.000008875 | 2.30395 | 0.0162235 | 1.775 | 0.000009585 | 0.0006177 | 0.00007455 | 0.00005538 | 0.0003408 | 0.000355 | 0.000355 |
| 31-Aug-18 | 1 | 0.001575 | 0.00000225 | 0.001665 | 0.38745 | 0.008235 | 0.00225 | 0.0007785 | 0.00027 | 0.00225 | 2.8125 | 0.000027 | 0.612 | 0.00001125 | 2.52 | 0.01647 | 3.285 | 0.000001125 | 0.000387 | 0.00001125 | 0.0002862 | 0.000477 | 0.00045 | 0.00045 |
| 07-Sep-18 | 2 | 0.00572 | 0.0000308 | 0.001188 | 0.28248 | 0.00572 | 0.0022 | 0.0011132 | 0.000132 | 0.00066 | 2.3936 | 0.000022 | 0.6424 | 0.000011 | 1.7204 | 0.014036 | 3.476 | 0.0000011 | 0.0002772 | 0.0002244 | 0.00022924 | 0.0005324 | 0.00044 | 0.00044 |
| 14-Sep-18 | 3 | 0.003115 | 0.00001335 | 0.0008455 | 0.19402 | 0.005429 | 0.0089 | 0.00061855 | 0.0000445 | 0.0006675 | 1.50855 | 0.00003115 | 0.47615 | 0.000011125 | 0.8811 | 0.009968 | 1.6465 | 1.1125E-06 | 0.0001691 | 0.0000534 | 0.00020381 | 0.0004094 | 0.000445 | 0.000445 |
| 21-Sep-18 | 4 | | | | | | | | | | | | | | | | | | | | | | | |
| 28-Sep-18 | 5 | 0.00924 | 0.0000132 | 0.000924 | 0.198 | 0.006732 | 0.0088 | 0.0002464 | 0.000176 | 0.00066 | 1.3332 | 0.0000088 | 0.4972 | 0.000011 | 0.5148 | 0.009152 | 1.716 | 0.0000011 | 0.0001276 | 0.0000572 | 0.00028512 | 0.0004664 | 0.00044 | 0.00044 |
| 05-Oct-18 | 6 | | | | | | | | | | | | | | | | | | | | | | | |
| 12-Oct-18 | 7 | 0.0015925 | 0.00005005 | 0.0009555 | 0.2457 | 0.0014105 | 0.002275 | 0.00012285 | 0.00002275 | 0.0006825 | 1.31495 | 0.0000091 | 0.5187 | 0.000011375 | 0.3549 | 0.0109655 | 2.548 | 1.1375E-06 | 0.00008645 | 0.000011375 | 0.000383565 | 0.0003822 | 0.000455 | 0.000455 |
| 19-Oct-18 | 8 | | | | | | | | | | | | | | | | | | | | | | | |
| 26-Oct-18 | 9 | 0.0036 | 0.00000225 | 0.00072 | 0.27225 | 0.000918 | 0.00225 | 0.0001395 | 0.000045 | 0.000675 | 1.458 | 0.0000495 | 0.3555 | 0.00001125 | 0.2925 | 0.0108 | 3.375 | 0.000001125 | 0.000072 | 0.000126 | 0.0004275 | 0.000324 | 0.00045 | 0.00045 |
| 02-Nov-18 | 10 | | | | | | | | | | | | | | | | | | | | | | | |
| 09-Nov-18 | 11 | 0.001575 | 0.000009 | 0.00081 | 0.24975 | 0.0009855 | 0.00225 | 0.000135 | 0.000045 | 0.000675 | 0.999 | 0.000009 | 0.3915 | 0.00001125 | 0.198 | 0.01134 | 3.195 | 0.000001125 | 0.0000405 | 0.000027 | 0.000468 | 0.0002475 | 0.00045 | 0.00045 |
| 16-Nov-18 | 12 | | | | | | | | | | | | | | | | | | | | | | | |
| 23-Nov-18 | 13 | 0.0015575 | 0.000002225 | 0.000712 | 0.266555 | 0.0010235 | 0.002225 | 0.0001513 | 0.00002225 | 0.0006675 | 0.97455 | 0.0000089 | 0.38715 | 0.000011125 | 0.1691 | 0.0118815 | 4.094 | 1.1125E-06 | 0.0000623 | 0.000011125 | 0.00047615 | 0.0002047 | 0.000445 | 0.000445 |
| 30-Nov-18 | 14 | | | | | | | | | | | | | | | | | | | | | | | |
| 07-Dec-18 | 15 | 0.00154 | 0.0000022 | 0.000572 | 0.24024 | 0.002354 | 0.0022 | 0.0001012 | 0.000022 | 0.00066 | 0.902 | 0.0000088 | 0.374 | 0.000011 | 0.1188 | 0.01166 | 3.96 | 0.0000011 | 0.0000528 | 0.000066 | 0.00030844 | 0.0001628 | 0.00044 | 0.00044 |
| 14-Dec-18 | 16 | | | | | | | | | | | | | | | | | | | | | | | |
| 21-Dec-18 | 17 | 0.0015575 | 0.00001335 | 0.000623 | 0.21093 | 0.00206925 | 0.002225 | 0.0001068 | 0.00002225 | 0.0006675 | 0.76095 | 0.0000089 | 0.3649 | 0.000011125 | 0.11125 | 0.0111695 | 3.916 | 1.1125E-06 | 0.00004005 | 0.00002225 | 0.00037914 | 0.00015575 | 0.000445 | 0.000445 |
| 28-Dec-18 | 18 | | | | | | | | | | | | | | | | | | | | | | | |
| 04-Jan-19 | 19 | 0.0016275 | 0.000002325 | 0.0005115 | 0.20832 | 0.00203205 | 0.002325 | 0.00019065 | 0.00002325 | 0.0006975 | 0.8277 | 0.0000093 | 0.3255 | 0.000011625 | 0.1209 | 0.0103695 | 4.6035 | 1.1625E-06 | 0.0000279 | 0.00003255 | 0.00025017 | 0.00015345 | 0.000465 | 0.000465 |
| 11-Jan-19 | 20 | | | | | | | | | | | | | | | | | | | | | | | |
| 18-Jan-19 | 21 | 0.00154 | 0.0000022 | 0.000528 | 0.19096 | 0.0018788 | 0.0022 | 0.0007172 | 0.000022 | 0.00066 | 0.6732 | 0.0000088 | 0.2816 | 0.000011 | 0.1232 | 0.009108 | 3.168 | 0.0000011 | 0.0000352 | 0.000011 | 0.0002398 | 0.000132 | 0.00044 | 0.00044 |
| 25-Jan-19 | 22 | | | | | | | | | | | | | | | | | | | | | | | |
| 01-Feb-19 | 23 | 0.001575 | 0.00000225 | 0.000495 | 0.1836 | 0.001944 | 0.00225 | 0.000378 | 0.0000225 | 0.000675 | 0.558 | 0.000009 | 0.306 | 0.00001125 | 0.108 | 0.009 | 3.51 | 0.000001125 | 0.000027 | 0.000045 | 0.000243 | 0.000108 | 0.00045 | 0.00045 |
| 08-Feb-19 | 24 | | | | | | | | | | | | | | | | | | | | | | | |
| 15-Feb-19 | 25 | 0.001575 | 0.00000225 | 0.000405 | 0.17955 | 0.0020925 | 0.00225 | 0.000072 | 0.0000225 | 0.000675 | 0.666 | 0.000009 | 0.297 | 0.00001125 | 0.126 | 0.008145 | 4.185 | 0.000001125 | 0.0000225 | 0.000036 | 0.00020475 | 0.000108 | 0.00045 | 0.00045 |
| 22-Feb-19 | 26 | | | | | | | | | | | | | | | | | | | | | | | |
| 01-Mar-19 | 27 | 0.0015225 | 0.00000435 | 0.0004785 | 0.174435 | 0.002958 | 0.002175 | 0.0001044 | 0.00002175 | 0.00174 | 0.609 | 0.0000087 | 0.2784 | 0.000010875 | 0.11745 | 0.0087 | 3.5235 | 1.0875E-06 | 0.0000348 | 0.00005655 | 0.00017226 | 0.00009135 | 0.000435 | 0.000435 |
| 08-Mar-19 | 28 | | | | | | | | | | | | | | | | | | | | | | | |
| 15-Mar-19 | 29 | 0.001575 | 0.00000225 | 0.000405 | 0.16965 | 0.0021195 | 0.00225 | 0.0000675 | 0.0000225 | 0.000675 | 0.648 | 0.000009 | 0.297 | 0.00001125 | 0.072 | 0.00909 | 4.005 | 0.000001125 | 0.0000135 | 0.00001125 | 0.0001764 | 0.0001215 | 0.00045 | 0.00045 |
| 22-Mar-19 | 30 | | | | | | | | | | | | | | | | | | | | | | | |
| 29-Mar-19 | 31 | 0.00147 | 0.0000021 | 0.000504 | 0.15582 | 0.0017976 | 0.0021 | 0.0000714 | 0.000021 | 0.00063 | 0.5796 | 0.0000084 | 0.2646 | 0.0000105 | 0.0966 | 0.00777 | 3.948 | 0.00000105 | 0.0000126 | 0.0000105 | 0.00012474 | 0.0001008 | 0.00042 | 0.00042 |
| 05-Apr-19 | 32 | | | | | | | | | | | | | | | | | | | | | | | |
| 12-Apr-19 | 33 | 0.0016975 | 0.000002425 | 0.0004365 | 0.15423 | 0.00163445 | 0.002425 | 0.0001552 | 0.00002425 | 0.0007275 | 0.57715 | 0.0000097 | 0.30555 | 0.000012125 | 0.07275 | 0.0088755 | 2.3765 | 1.2125E-06 | 0.0000485 | 0.0000291 | 0.00025123 | 0.00009215 | 0.000485 | 0.000485 |
| 19-Apr-19 | 34 | | | | | | | | | | | | | | | | | | | | | | | |
| 26-Apr-19 | 35 | 0.0015225 | 0.00000435 | 0.000435 | 0.148335 | 0.00195315 | 0.002175 | 0.0001305 | 0.00002175 | 0.0006525 | 0.5916 | 0.0000087 | 0.2697 | 0.000010875 | 0.10005 | 0.008178 | 3.741 | 0.000002175 | 0.0000348 | 0.0000348 | 0.00015486 | 0.0000957 | 0.000435 | 0.000435 |
| 03-May-19 | 36 | | | | | | | | | | | | | | | | | | | | | | | |
| 10-May-19 | 37 | 0.005785 | 0.000002225 | 0.0004005 | 0.1513 | 0.002314 | 0.002225 | 0.0000623 | 0.00002225 | 0.0006675 | 0.5785 | 0.0000089 | 0.2759 | 0.000011125 | 0.089 | 0.008188 | 4.0495 | 1.1125E-06 | 0.0000445 | 0.00004895 | 0.00014062 | 0.00008455 | 0.000445 | 0.000445 |
| 17-May-19 | 38 | 0.0015575 | 0.000002225 | 0.0004005 | 0.13706 | 0.0021093 | 0.002225 | 0.0000445 | 0.00002225 | 0.0006675 | 0.55625 | 0.0000089 | 0.27145 | 0.000011125 | 0.0801 | 0.007654 | 3.2485 | 1.1125E-06 | 0.00003115 | 0.000011125 | 0.000104575 | 0.00008455 | 0.000445 | 0.000445 |
| 24-May-19 | 39 | 0.0015575 | 0.00001335 | 0.0004895 | 0.138395 | 0.0019402 | 0.002225 | 0.0000445 | 0.00002225 | 0.0006675 | 0.5518 | 0.0000089 | 0.26255 | 0.000011125 | 0.0801 | 0.007565 | 2.848 | 1.1125E-06 | 0.00001335 | 0.000011125 | 0.000096565 | 0.00008455 | 0.000445 | 0.000445 |

**Appendix 4-6: Kinetic Test Results**
**HC 4**

| Date | Cycle | Volume mL | | pH | Cond. | Acidity | Acidity | Alkalinity | Sulphate | Chloride | Fluoride | Hardness | Al | Sb | As | Ba | Be | Bi | B | Cd | Ca | Cr | Co | Cu | Fe |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. | Input | Output | | | (pH 4.5) | (pH 8.3) | | | | | CaCO3 | | | | | | | | | | | | | |
| | | | | | umhos/cm | mgCaCO3/L | mgCaCO3/L | mgCaCO3/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 |
| 24-Aug-18 | 0 | 500 | 380 | 7.72 | 327 | #N/A | 3.9 | 28.7 | 8 | 48 | 0.09 | 111 | 0.040 | 0.0005 | 0.192 | 0.00516 | 0.000050 | 0.000049 | 0.010 | 0.000058 | 41.0 | 0.00007 | 0.000225 | 0.00067 | 0.026 |
| 31-Aug-18 | 1 | 500 | 450 | 7.89 | 136 | #N/A | 2.9 | 16.9 | 11 | 34 | 0.07 | 72.1 | 0.090 | 0.0007 | 0.175 | 0.00342 | <0.0000035 | <0.0000035 | 0.012 | 0.000004 | 26.0 | <0.000015 | 0.000025 | 0.00048 | <0.0035 |
| 07-Sep-18 | 2 | 500 | 440 | 7.76 | 115 | #N/A | 2.5 | 18.0 | 9 | 11 | 0.06 | 38.5 | 0.144 | 0.0007 | 0.154 | 0.00181 | <0.0000035 | <0.0000035 | 0.016 | <0.0000015 | 13.9 | <0.000015 | 0.000017 | 0.00023 | <0.0035 |
| 14-Sep-18 | 3 | 500 | 440 | 7.88 | 77 | #N/A | 1.5 | 17.0 | 7 | 3 | <0.03 | 25.5 | 0.118 | 0.0005 | 0.127 | 0.00114 | <0.0000035 | <0.0000035 | 0.004 | 0.000004 | 9.27 | 0.00013 | 0.000020 | 0.00015 | <0.0035 |
| 21-Sep-18 | 4 | 500 | 450 | 7.82 | 64 | #N/A | 2.2 | 17.9 | 7 | | | | | | | | | | | | | | | | |
| 28-Sep-18 | 5 | 500 | 435 | 7.92 | 59 | #N/A | 1.0 | 24.0 | 5 | <0.5 | <0.03 | 25.6 | 0.173 | 0.0004 | 0.103 | 0.00102 | <0.0000035 | <0.0000035 | 0.004 | 0.000003 | 9.42 | <0.000015 | 0.000011 | 0.00035 | <0.0035 |
| 05-Oct-18 | 6 | 500 | 445 | 7.77 | 58 | #N/A | 1.7 | 17.1 | 4 | | | | | | | | | | | | | | | | |
| 12-Oct-18 | 7 | 500 | 435 | 7.97 | 59 | #N/A | 3.3 | 21.7 | 5 | <0.5 | <0.03 | 23.7 | 0.158 | 0.0003 | 0.0801 | 0.00098 | <0.0000035 | <0.0000035 | 0.003 | 0.000003 | 8.72 | 0.00017 | 0.000130 | 0.00022 | 0.017 |
| 19-Oct-18 | 8 | 500 | 435 | 8.04 | 59 | #N/A | 0.7 | 16.7 | 7 | | | | | | | | | | | | | | | | |
| 26-Oct-18 | 9 | 500 | 435 | 7.96 | 65 | #N/A | 0.6 | 16.1 | 11 | <0.5 | <0.03 | 30.9 | 0.159 | 0.0002 | 0.0397 | 0.00129 | <0.0000035 | <0.0000035 | 0.003 | 0.000005 | 11.5 | <0.000015 | 0.000024 | 0.00317 | 0.010 |
| 02-Nov-18 | 10 | 500 | 435 | 7.99 | 80 | #N/A | 0.9 | 16.0 | 18 | | | | | | | | | | | | | | | | |
| 09-Nov-18 | 11 | 500 | 445 | 7.91 | 95 | #N/A | 1.7 | 15.3 | 22 | <0.5 | <0.03 | 34.6 | 0.111 | <0.0001 | 0.0350 | 0.00157 | <0.0000035 | <0.0000035 | 0.002 | 0.000004 | 12.9 | 0.00007 | 0.000025 | 0.00063 | <0.0035 |
| 16-Nov-18 | 12 | 500 | 425 | 7.74 | 110 | #N/A | 1.0 | 13.9 | 27 | | | | | | | | | | | | | | | | |
| 23-Nov-18 | 13 | 500 | 440 | 7.89 | 90 | #N/A | 1.8 | 14.2 | 18 | <0.5 | <0.03 | 34.7 | 0.125 | <0.0001 | 0.0296 | 0.00156 | <0.0000035 | <0.0000035 | <0.001 | 0.000008 | 13.1 | <0.000015 | 0.000017 | 0.00027 | <0.0035 |
| 30-Nov-18 | 14 | 500 | 440 | 7.86 | 90 | #N/A | 1.3 | 14.0 | 20 | | | | | | | | | | | | | | | | |
| 07-Dec-18 | 15 | 500 | 435 | 7.71 | 90 | #N/A | 3.4 | 15.7 | 19 | <0.5 | <0.03 | 36.2 | 0.109 | <0.0001 | 0.0262 | 0.00143 | <0.0000035 | <0.0000035 | 0.002 | 0.000003 | 13.7 | <0.000015 | 0.000020 | 0.00086 | <0.0035 |
| 14-Dec-18 | 16 | 500 | 445 | 7.94 | 85 | #N/A | 2.5 | 15.7 | 18 | | | | | | | | | | | | | | | | |
| 21-Dec-18 | 17 | 500 | 440 | 7.74 | 92 | #N/A | 3.0 | 14.6 | 22 | <0.5 | <0.03 | 36.5 | 0.090 | <0.0001 | 0.0205 | 0.00143 | <0.0000035 | <0.0000035 | <0.001 | 0.000010 | 14.0 | <0.000015 | <0.000002 | 0.00040 | <0.0035 |
| 28-Dec-18 | 18 | 500 | 440 | 7.81 | 86 | #N/A | 1.5 | 14.3 | 20 | | | | | | | | | | | | | | | | |
| 04-Jan-19 | 19 | 500 | 450 | 7.81 | 83 | #N/A | 2.9 | 14.1 | 21 | <0.5 | <0.03 | 37.1 | 0.110 | <0.0001 | 0.0199 | 0.00149 | <0.0000035 | <0.0000035 | <0.001 | <0.0000015 | 14.2 | 0.00004 | 0.000047 | 0.00047 | <0.0035 |
| 11-Jan-19 | 20 | 500 | 440 | 7.61 | 84 | #N/A | 2.1 | 12.9 | 25 | | | | | | | | | | | | | | | | |
| 18-Jan-19 | 21 | 500 | 435 | 7.70 | 85 | #N/A | 1.3 | 13.8 | 20 | <0.5 | <0.03 | 34.1 | 0.111 | <0.0001 | 0.0187 | 0.00135 | <0.0000035 | <0.0000035 | 0.003 | 0.000005 | 13.1 | <0.000015 | 0.000022 | 0.00011 | <0.0035 |
| 25-Jan-19 | 22 | 500 | 435 | 7.75 | 87 | #N/A | 1.5 | 11.9 | 20 | | | | | | | | | | | | | | | | |
| 01-Feb-19 | 23 | 500 | 440 | 7.66 | 87 | #N/A | 2.7 | 14.5 | 19 | <0.5 | <0.03 | 33.9 | 0.102 | <0.0001 | 0.0166 | 0.00131 | <0.0000035 | <0.0000035 | 0.002 | 0.000010 | 13.0 | <0.000015 | 0.000081 | 0.00055 | 0.008 |
| 08-Feb-19 | 24 | 500 | 430 | 7.83 | 80 | #N/A | 2.4 | 14.0 | 17 | | | | | | | | | | | | | | | | |
| 15-Feb-19 | 25 | 500 | 440 | 7.75 | 77 | #N/A | 1.4 | 13.7 | 17 | <0.5 | <0.03 | 33.8 | 0.104 | <0.0001 | 0.0150 | 0.00121 | <0.0000035 | <0.0000035 | 0.007 | 0.000003 | 13.0 | <0.000015 | 0.000020 | 0.00041 | <0.0035 |
| 22-Feb-19 | 26 | 500 | 430 | 7.89 | 77 | #N/A | 2.6 | 15.4 | 17 | | | | | | | | | | | | | | | | |
| 01-Mar-19 | 27 | 500 | 440 | 7.73 | 71 | #N/A | 2.0 | 17.4 | 11 | <0.5 | <0.03 | 30.7 | 0.105 | <0.00045 | 0.0137 | 0.00116 | <0.0000035 | <0.0000035 | <0.001 | 0.000003 | 11.8 | <0.00004 | 0.000022 | 0.0004 | <0.0035 |
| 08-Mar-19 | 28 | 500 | 440 | 7.81 | 70 | #N/A | 2.4 | 13.8 | 15 | | | | | | | | | | | | | | | | |
| 15-Mar-19 | 29 | 500 | 445 | 7.70 | 63 | #N/A | 1.7 | 13.6 | 14 | <0.5 | <0.03 | 28.5 | 0.087 | <0.00045 | 0.0121 | 0.00110 | <0.0000035 | <0.0000035 | <0.001 | 0.000011 | 10.9 | <0.00004 | 0.000007 | 0.0048 | <0.0035 |
| 22-Mar-19 | 30 | 500 | 445 | 7.93 | 71 | #N/A | 2.4 | 13.8 | 15 | | | | | | | | | | | | | | | | |
| 29-Mar-19 | 31 | 500 | 445 | 7.60 | 74 | #N/A | 2.0 | 13.7 | 17 | <0.5 | <0.03 | 32.2 | 0.087 | <0.00045 | 0.0120 | 0.00114 | <0.0000035 | <0.0000035 | 0.003 | <0.0000015 | 12.5 | <0.00004 | 0.000011 | 0.0003 | <0.0035 |
| 05-Apr-19 | 32 | 500 | 450 | 7.87 | 65 | #N/A | 4.0 | 22.1 | 12 | | | | | | | | | | | | | | | | |
| 12-Apr-19 | 33 | 500 | 485 | 7.67 | 92 | #N/A | 1.6 | 23.3 | 22 | <0.5 | <0.03 | 37.2 | 0.083 | <0.00045 | 0.0130 | 0.00116 | <0.0000035 | <0.0000035 | <0.001 | 0.000006 | 14.5 | <0.00004 | 0.000029 | 0.0006 | <0.0035 |
| 19-Apr-19 | 34 | 500 | 430 | 7.97 | 67 | #N/A | 1.6 | 14.6 | 14 | | | | | | | | | | | | | | | | |
| 26-Apr-19 | 35 | 500 | 440 | 7.81 | 58 | #N/A | 2.2 | 13.0 | 12 | <0.5 | <0.03 | 26.7 | 0.090 | <0.00045 | 0.0111 | 0.00104 | <0.0000035 | <0.0000035 | 0.002 | <0.0000015 | 10.3 | <0.00004 | 0.000020 | 0.0014 | <0.0035 |
| 03-May-19 | 36 | 500 | 445 | 7.91 | 58 | #N/A | 2.1 | 12.6 | 11 | | | | | | | | | | | | | | | | |
| 10-May-19 | 37 | 500 | 445 | 7.74 | 71 | #N/A | 1.3 | 13.6 | 15 | <0.5 | <0.03 | 31.9 | 0.101 | <0.00045 | 0.0134 | 0.00118 | <0.0000035 | <0.0000035 | <0.001 | <0.0000015 | 12.4 | <0.00004 | 0.000025 | 0.0008 | 0.010 |
| 17-May-19 | 38 | 500 | 445 | 7.78 | 68 | #N/A | 1.9 | 13.8 | 13 | <0.5 | <0.03 | 28.9 | 0.101 | <0.00045 | 0.0132 | 0.00101 | <0.0000035 | <0.0000035 | <0.001 | 0.000004 | 11.2 | <0.00004 | 0.000036 | 0.0023 | <0.0035 |
| 24-May-19 | 39 | 500 | 440 | 7.74 | 56 | #N/A | 2.8 | 13.4 | 10 | <0.5 | <0.03 | 24.7 | 0.092 | <0.00045 | 0.0097 | 0.00103 | <0.0000035 | <0.0000035 | 0.002 | 0.000003 | 9.54 | <0.00004 | 0.000024 | 0.0006 | <0.0035 |
| **Cell Terminated** | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Loads** | **mg/kg** | | | | | | | | | | | | | | | | | | | | | | | | |
| 24-Aug-18 | 0 | | | 7.72 | | | | | 3.04 | 18.24 | 0.0342 | 42.18 | 0.0152 | 0.00019 | 0.07296 | 0.0019608 | 0.000019 | 0.00001862 | 0.0038 | 0.00002204 | 15.58 | 0.0000266 | 0.0000855 | 0.0002546 | 0.00988 |
| 31-Aug-18 | 1 | | | 7.89 | | | | | 4.95 | 15.3 | 0.0315 | 32.445 | 0.0405 | 0.000315 | 0.07875 | 0.001539 | 0.000001575 | 0.000001575 | 0.0054 | 0.0000018 | 11.7 | 0.00000675 | 0.00001125 | 0.000216 | 0.001575 |
| 07-Sep-18 | 2 | | | 7.76 | | | | | 3.96 | 4.84 | 0.0264 | 16.94 | 0.06336 | 0.000308 | 0.06776 | 0.0007964 | 0.00000154 | 0.00000154 | 0.00704 | 0.00000066 | 6.116 | 0.0000066 | 0.00000748 | 0.0001012 | 0.00154 |
| 14-Sep-18 | 3 | | | 7.88 | | | | | 3.08 | 1.32 | 0.0132 | 11.22 | 0.05192 | 0.00022 | 0.05588 | 0.0005016 | 0.00000154 | 0.00000154 | 0.00176 | 0.00000176 | 4.0788 | 0.0000572 | 0.0000088 | 0.000066 | 0.00154 |
| 21-Sep-18 | 4 | | | 7.82 | | | | | 3.15 | | | | | | | | | | | | | | | | |
| 28-Sep-18 | 5 | | | 7.92 | | | | | 2.175 | 0.2175 | 0.01305 | 11.136 | 0.075255 | 0.000174 | 0.044805 | 0.0004437 | 1.5225E-06 | 1.5225E-06 | 0.00174 | 0.000001305 | 4.0977 | 0.000006525 | 0.000004785 | 0.00015225 | 0.0015225 |
| 05-Oct-18 | 6 | | | 7.77 | | | | | 1.78 | | | | | | | | | | | | | | | | |
| 12-Oct-18 | 7 | | | 7.97 | | | | | 2.175 | 0.2175 | 0.01305 | 10.3095 | 0.06873 | 0.0001305 | 0.0348435 | 0.0004263 | 1.5225E-06 | 1.5225E-06 | 0.001305 | 0.000001305 | 3.7932 | 0.00007395 | 0.00005655 | 0.0000957 | 0.007395 |
| 19-Oct-18 | 8 | | | 8.04 | | | | | 3.045 | | | | | | | | | | | | | | | | |
| 26-Oct-18 | 9 | | | 7.96 | | | | | 4.785 | 0.2175 | 0.01305 | 13.4415 | 0.069165 | 0.000087 | 0.0172695 | 0.00056115 | 1.5225E-06 | 1.5225E-06 | 0.001305 | 0.000002175 | 5.0025 | 0.000006525 | 0.00001044 | 0.00137895 | 0.00435 |
| 02-Nov-18 | 10 | | | 7.99 | | | | | 7.83 | | | | | | | | | | | | | | | | |
| 09-Nov-18 | 11 | | | 7.91 | | | | | 9.79 | 0.2225 | 0.01335 | 15.397 | 0.049395 | 0.0000445 | 0.015575 | 0.00069865 | 1.5575E-06 | 1.5575E-06 | 0.00089 | 0.00000178 | 5.7405 | 0.00003115 | 0.000011125 | 0.00028035 | 0.0015575 |
| 16-Nov-18 | 12 | | | 7.74 | | | | | 11.475 | | | | | | | | | | | | | | | | |
| 23-Nov-18 | 13 | | | 7.89 | | | | | 7.92 | 0.22 | 0.0132 | 15.268 | 0.055 | 0.000044 | 0.013024 | 0.0006864 | 0.00000154 | 0.00000154 | 0.00044 | 0.00000352 | 5.764 | 0.0000066 | 0.00000748 | 0.0001188 | 0.00154 |
| 30-Nov-18 | 14 | | | 7.86 | | | | | 8.8 | | | | | | | | | | | | | | | | |
| 07-Dec-18 | 15 | | | 7.71 | | | | | 8.265 | 0.2175 | 0.01305 | 15.747 | 0.047415 | 0.0000435 | 0.011397 | 0.00062205 | 1.5225E-06 | 1.5225E-06 | 0.00087 | 0.000001305 | 5.9595 | 0.000006525 | 0.0000087 | 0.0003741 | 0.0015225 |
| 14-Dec-18 | 16 | | | 7.94 | | | | | 8.01 | | | | | | | | | | | | | | | | |
| 21-Dec-18 | 17 | | | 7.74 | | | | | 9.68 | 0.22 | 0.0132 | 16.06 | 0.0396 | 0.000044 | 0.00902 | 0.0006292 | 0.00000154 | 0.00000154 | 0.00044 | 0.0000044 | 6.16 | 0.0000066 | 0.00000088 | 0.000176 | 0.00154 |
| 28-Dec-18 | 18 | | | 7.81 | | | | | 8.8 | | | | | | | | | | | | | | | | |
| 04-Jan-19 | 19 | | | 7.81 | | | | | 9.45 | 0.225 | 0.0135 | 16.695 | 0.0495 | 0.000045 | 0.008955 | 0.0006705 | 0.000001575 | 0.000001575 | 0.00045 | 0.000000675 | 6.39 | 0.000018 | 0.00002115 | 0.0002115 | 0.001575 |
| 11-Jan-19 | 20 | | | 7.61 | | | | | 11 | | | | | | | | | | | | | | | | |
| 18-Jan-19 | 21 | | | 7.70 | | | | | 8.7 | 0.2175 | 0.01305 | 14.8335 | 0.048285 | 0.0000435 | 0.0081345 | 0.00058725 | 1.5225E-06 | 1.5225E-06 | 0.001305 | 0.000002175 | 5.6985 | 0.000006525 | 0.00000957 | 0.00004785 | 0.0015225 |
| 25-Jan-19 | 22 | | | 7.75 | | | | | 8.7 | | | | | | | | | | | | | | | | |
| 01-Feb-19 | 23 | | | 7.66 | | | | | 8.36 | 0.22 | 0.0132 | 14.916 | 0.04488 | 0.000044 | 0.007304 | 0.0005764 | 0.00000154 | 0.00000154 | 0.00088 | 0.0000044 | 5.72 | 0.0000066 | 0.00003564 | 0.000242 | 0.00352 |
| 08-Feb-19 | 24 | | | 7.83 | | | | | 7.31 | | | | | | | | | | | | | | | | |
| 15-Feb-19 | 25 | | | 7.75 | | | | | 7.48 | 0.22 | 0.0132 | 14.872 | 0.04576 | 0.000044 | 0.0066 | 0.0005324 | 0.00000154 | 0.00000154 | 0.00308 | 0.00000132 | 5.72 | 0.0000066 | 0.0000088 | 0.0001804 | 0.00154 |
| 22-Feb-19 | 26 | | | 7.89 | | | | | 7.31 | | | | | | | | | | | | | | | | |
| 01-Mar-19 | 27 | | | 7.73 | | | | | 4.84 | 0.22 | 0.0132 | 13.508 | 0.0462 | 0.000198 | 0.006028 | 0.0005104 | 0.00000154 | 0.00000154 | 0.00044 | 0.00000132 | 5.192 | 0.0000176 | 0.00000968 | 0.000176 | 0.00154 |
| 08-Mar-19 | 28 | | | 7.81 | | | | | 6.6 | | | | | | | | | | | | | | | | |
| 15-Mar-19 | 29 | | | 7.70 | | | | | 6.23 | 0.2225 | 0.01335 | 12.6825 | 0.038715 | 0.00020025 | 0.0053845 | 0.0004895 | 1.5575E-06 | 1.5575E-06 | 0.000445 | 0.000004895 | 4.8505 | 0.0000178 | 0.000003115 | 0.002136 | 0.0015575 |
| 22-Mar-19 | 30 | | | 7.93 | | | | | 6.675 | | | | | | | | | | | | | | | | |
| 29-Mar-19 | 31 | | | 7.60 | | | | | 7.565 | 0.2225 | 0.01335 | 14.329 | 0.038715 | 0.00020025 | 0.00534 | 0.0005073 | 1.5575E-06 | 1.5575E-06 | 0.001335 | 6.675E-07 | 5.5625 | 0.0000178 | 0.000004895 | 0.0001335 | 0.0015575 |
| 05-Apr-19 | 32 | | | 7.87 | | | | | 5.4 | | | | | | | | | | | | | | | | |
| 12-Apr-19 | 33 | | | 7.67 | | | | | 10.67 | 0.2425 | 0.01455 | 18.042 | 0.040255 | 0.00021825 | 0.006305 | 0.0005626 | 1.6975E-06 | 1.6975E-06 | 0.000485 | 0.00000291 | 7.0325 | 0.0000194 | 0.000014065 | 0.000291 | 0.0016975 |
| 19-Apr-19 | 34 | | | 7.97 | | | | | 6.02 | | | | | | | | | | | | | | | | |
| 26-Apr-19 | 35 | | | 7.81 | | | | | 5.28 | 0.22 | 0.0132 | 11.748 | 0.0396 | 0.000198 | 0.004884 | 0.0004576 | 0.00000154 | 0.00000154 | 0.00088 | 0.00000066 | 4.532 | 0.0000176 | 0.0000088 | 0.000616 | 0.00154 |
| 03-May-19 | 36 | | | 7.91 | | | | | 4.895 | | | | | | | | | | | | | | | | |
| 10-May-19 | 37 | | | 7.74 | | | | | 6.675 | 0.2225 | 0.01335 | 14.1955 | 0.044945 | 0.00020025 | 0.005963 | 0.0005251 | 1.5575E-06 | 1.5575E-06 | 0.000445 | 6.675E-07 | 5.518 | 0.0000178 | 0.000011125 | 0.000356 | 0.00445 |
| 17-May-19 | 38 | | | 7.78 | | | | | 5.785 | 0.2225 | 0.01335 | 12.8605 | 0.044945 | 0.00020025 | 0.005874 | 0.00044945 | 1.5575E-06 | 1.5575E-06 | 0.000445 | 0.00000178 | 4.984 | 0.0000178 | 0.00001602 | 0.0010235 | 0.0015575 |
| 24-May-19 | 39 | | | 7.74 | | | | | 4.4 | 0.22 | 0.0132 | 10.868 | 0.04048 | 0.000198 | 0.004268 | 0.0004532 | 0.00000154 | 0.00000154 | 0.00088 | 0.00000132 | 4.1976 | 0.0000176 | 0.00001056 | 0.000264 | 0.00154 |

**Appendix 4-6: Kinetic Test Results**
**HC 4**

| Date | Cycle No. | Pb | Li | Mg | Mn | Hg | Mo | Ni | P | K | Se | Si | Ag | Na | Sr | S | Tl | Sn | Ti | U | V | Zn | Zr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | mg/L | mg/L | mg/L | mg/L | ug/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L |
| 24-Aug-18 | 0 | 0.00005 | 0.0068 | 2.05 | 0.159 | <0.005 | 0.00048 | 0.0139 | 0.037 | 9.08 | 0.00011 | 1.17 | 0.00006 | 7.95 | 0.191 | 3.7 | 0.000063 | 0.00178 | 0.00011 | 0.000169 | 0.00039 | <0.001 | <0.001 |
| 31-Aug-18 | 1 | 0.00003 | 0.0046 | 1.77 | 0.0453 | <0.005 | 0.00109 | 0.0024 | <0.0015 | 6.42 | 0.00005 | 1.28 | <0.000025 | 6.16 | 0.135 | 5.4 | 0.000010 | 0.00121 | <0.000025 | 0.000611 | 0.00073 | <0.001 | <0.001 |
| 07-Sep-18 | 2 | 0.00004 | 0.0028 | 0.945 | 0.0348 | 0.02 | 0.00123 | 0.0009 | <0.0015 | 3.94 | 0.00004 | 1.21 | <0.000025 | 3.28 | 0.0670 | 4.3 | 0.000006 | 0.00069 | 0.00010 | 0.000599 | 0.00084 | <0.001 | <0.001 |
| 14-Sep-18 | 3 | 0.00002 | 0.0018 | 0.571 | 0.0329 | 0.03 | 0.00079 | 0.0005 | <0.0015 | 2.42 | 0.00004 | 0.89 | <0.000025 | 1.48 | 0.0452 | 1.8 | 0.000005 | 0.00039 | 0.00006 | 0.000563 | 0.00078 | <0.001 | <0.001 |
| 21-Sep-18 | 4 | | | | | | | | | | | | | | | | | | | | | | |
| 28-Sep-18 | 5 | 0.00004 | 0.0020 | 0.517 | 0.0396 | <0.005 | 0.00033 | 0.0008 | <0.0015 | 2.15 | <0.00002 | 0.94 | <0.000025 | 0.84 | 0.0382 | 2.4 | <0.0000025 | 0.00022 | 0.00010 | 0.000686 | 0.00090 | <0.001 | <0.001 |
| 05-Oct-18 | 6 | | | | | | | | | | | | | | | | | | | | | | |
| 12-Oct-18 | 7 | 0.00003 | 0.0018 | 0.469 | 0.0363 | <0.005 | 0.00016 | 0.0005 | <0.0015 | 1.86 | <0.00002 | 0.89 | <0.000025 | 0.56 | 0.0338 | 2.7 | <0.0000025 | 0.00012 | 0.00025 | 0.000774 | 0.00075 | <0.001 | <0.001 |
| 19-Oct-18 | 8 | | | | | | | | | | | | | | | | | | | | | | |
| 26-Oct-18 | 9 | 0.00001 | 0.0015 | 0.522 | 0.0452 | <0.005 | 0.00019 | 0.0003 | <0.0015 | 2.27 | <0.00002 | 0.63 | <0.000025 | 0.54 | 0.0349 | 4.1 | <0.0000025 | 0.00013 | 0.00039 | 0.000939 | 0.00077 | <0.001 | <0.001 |
| 02-Nov-18 | 10 | | | | | | | | | | | | | | | | | | | | | | |
| 09-Nov-18 | 11 | 0.00001 | 0.0019 | 0.586 | 0.0438 | <0.005 | 0.00010 | 0.0004 | <0.0015 | 1.92 | <0.00002 | 0.64 | <0.000025 | 0.45 | 0.0488 | 7.3 | 0.000006 | 0.00006 | 0.00015 | 0.00148 | 0.00035 | <0.001 | <0.001 |
| 16-Nov-18 | 12 | | | | | | | | | | | | | | | | | | | | | | |
| 23-Nov-18 | 13 | <0.000005 | 0.0016 | 0.487 | 0.0380 | <0.005 | 0.00014 | 0.0002 | <0.0015 | 1.89 | <0.00002 | 0.67 | <0.000025 | 0.31 | 0.0420 | 6.9 | 0.000005 | 0.00019 | <0.000025 | 0.00126 | 0.00036 | <0.001 | <0.001 |
| 30-Nov-18 | 14 | | | | | | | | | | | | | | | | | | | | | | |
| 07-Dec-18 | 15 | <0.000005 | 0.0014 | 0.461 | 0.0439 | <0.005 | 0.00012 | 0.0002 | <0.0015 | 1.93 | <0.00002 | 0.71 | <0.000025 | 0.24 | 0.0417 | 7.2 | <0.0000025 | 0.00006 | <0.000025 | 0.00110 | 0.00029 | <0.001 | <0.001 |
| 14-Dec-18 | 16 | | | | | | | | | | | | | | | | | | | | | | |
| 21-Dec-18 | 17 | 0.00001 | 0.0011 | 0.357 | 0.0367 | <0.005 | 0.00008 | <0.00005 | <0.0015 | 1.53 | <0.00002 | 0.56 | <0.000025 | 0.19 | 0.0397 | 8.1 | <0.0000025 | 0.00007 | <0.000025 | 0.00104 | 0.00025 | <0.001 | <0.001 |
| 28-Dec-18 | 18 | | | | | | | | | | | | | | | | | | | | | | |
| 04-Jan-19 | 19 | <0.000005 | 0.0011 | 0.377 | 0.0397 | <0.005 | 0.00019 | 0.0002 | <0.0015 | 1.66 | <0.00002 | 0.50 | <0.000025 | 0.21 | 0.0360 | 9.4 | <0.0000025 | 0.00004 | <0.000025 | 0.000846 | 0.00028 | <0.001 | <0.001 |
| 11-Jan-19 | 20 | | | | | | | | | | | | | | | | | | | | | | |
| 18-Jan-19 | 21 | 0.00001 | 0.0013 | 0.347 | 0.0363 | <0.005 | 0.00616 | 0.0001 | <0.0015 | 1.47 | <0.00002 | 0.56 | <0.000025 | 0.20 | 0.0326 | 6.6 | <0.0000025 | 0.00006 | <0.000025 | 0.000947 | 0.00028 | <0.001 | <0.001 |
| 25-Jan-19 | 22 | | | | | | | | | | | | | | | | | | | | | | |
| 01-Feb-19 | 23 | 0.00070 | 0.0019 | 0.363 | 0.0356 | <0.005 | 0.00025 | 0.0003 | <0.0015 | 1.30 | <0.00002 | 0.56 | <0.000025 | 0.22 | 0.0348 | 8.6 | <0.0000025 | 0.00013 | <0.000025 | 0.000848 | 0.00021 | 0.002 | <0.001 |
| 08-Feb-19 | 24 | | | | | | | | | | | | | | | | | | | | | | |
| 15-Feb-19 | 25 | <0.000005 | 0.0009 | 0.317 | 0.0360 | <0.005 | 0.00009 | <0.00005 | <0.0015 | 1.44 | <0.00002 | 0.62 | <0.000025 | 0.25 | 0.0265 | 7.8 | <0.0000025 | <0.00005 | 0.00005 | 0.000614 | 0.00022 | <0.001 | <0.001 |
| 22-Feb-19 | 26 | | | | | | | | | | | | | | | | | | | | | | |
| 01-Mar-19 | 27 | 0.00001 | 0.0011 | 0.284 | 0.0453 | <0.005 | 0.00027 | 0.0002 | <0.0015 | 1.24 | 0.00010 | 0.49 | <0.000025 | 0.24 | 0.0253 | 5.4 | <0.0000025 | <0.00003 | 0.00005 | 0.000557 | 0.00019 | <0.001 | <0.001 |
| 08-Mar-19 | 28 | | | | | | | | | | | | | | | | | | | | | | |
| 15-Mar-19 | 29 | 0.00006 | 0.0008 | 0.277 | 0.0370 | <0.005 | 0.00010 | 0.0001 | <0.0015 | 1.20 | <0.00002 | 0.46 | <0.000025 | 0.12 | 0.0226 | 5.7 | <0.0000025 | 0.00007 | 0.00031 | 0.000543 | 0.00017 | <0.001 | <0.001 |
| 22-Mar-19 | 30 | | | | | | | | | | | | | | | | | | | | | | |
| 29-Mar-19 | 31 | <0.000005 | 0.0010 | 0.256 | 0.03301 | <0.005 | 0.00007 | <0.00005 | <0.0015 | 1.18 | <0.00002 | 0.49 | <0.000025 | 0.15 | 0.0252 | 8.7 | <0.0000025 | <0.00003 | <0.000025 | 0.000439 | 0.00019 | <0.001 | <0.001 |
| 05-Apr-19 | 32 | | | | | | | | | | | | | | | | | | | | | | |
| 12-Apr-19 | 33 | <0.000005 | 0.0008 | 0.252 | 0.0330 | <0.005 | 0.00018 | <0.00005 | <0.0015 | 1.11 | <0.00002 | 0.54 | <0.000025 | 0.11 | 0.0301 | 6.4 | 0.000006 | 0.00015 | <0.000025 | 0.000803 | 0.00018 | <0.001 | <0.001 |
| 19-Apr-19 | 34 | | | | | | | | | | | | | | | | | | | | | | |
| 26-Apr-19 | 35 | 0.00004 | 0.0009 | 0.244 | 0.0300 | <0.005 | 0.00019 | <0.00005 | <0.0015 | 1.16 | <0.00002 | 0.46 | <0.000025 | 0.15 | 0.0214 | 5.7 | 0.000005 | 0.00008 | <0.000025 | 0.000552 | 0.00016 | <0.001 | <0.001 |
| 03-May-19 | 36 | | | | | | | | | | | | | | | | | | | | | | |
| 10-May-19 | 37 | 0.00002 | 0.0008 | 0.258 | 0.0273 | <0.005 | 0.00007 | 0.0001 | <0.0015 | 1.16 | <0.00002 | 0.53 | <0.000025 | 0.15 | 0.0239 | 7.0 | 0.000005 | <0.00003 | <0.000025 | 0.000498 | 0.00020 | <0.001 | <0.001 |
| 17-May-19 | 38 | 0.00005 | 0.0008 | 0.229 | 0.0517 | <0.005 | 0.00006 | <0.00005 | <0.0015 | 1.12 | <0.00002 | 0.54 | <0.000025 | 0.13 | 0.0225 | 5.4 | <0.0000025 | 0.00010 | 0.00005 | 0.000389 | 0.00019 | <0.001 | <0.001 |
| 24-May-19 | 39 | 0.00002 | 0.0008 | 0.205 | 0.0342 | <0.005 | 0.00006 | <0.00005 | <0.0015 | 0.980 | <0.00002 | 0.47 | <0.000025 | 0.13 | 0.0190 | 3.4 | <0.0000025 | <0.00003 | 0.00006 | 0.000329 | 0.00016 | <0.001 | <0.001 |
| **Cell Terminated** | | | | | | | | | | | | | | | | | | | | | | | |
| **Loads** | **mg/kg** | | | | | | | | | | | | | | | | | | | | | | |
| 24-Aug-18 | 0 | 0.000019 | 0.002584 | 0.779 | 0.06042 | 0.0019 | 0.0001824 | 0.005282 | 0.01406 | 3.4504 | 0.0000418 | 0.4446 | 0.0000228 | 3.021 | 0.07258 | 1.406 | 0.00002394 | 0.0006764 | 0.0000418 | 0.00006422 | 0.0001482 | 0.00038 | 0.00038 |
| 31-Aug-18 | 1 | 0.0000135 | 0.00207 | 0.7965 | 0.020385 | 0.00225 | 0.0004905 | 0.00108 | 0.000675 | 2.889 | 0.0000225 | 0.576 | 0.00001125 | 2.772 | 0.06075 | 2.43 | 0.0000045 | 0.0005445 | 0.00001125 | 0.00027495 | 0.0003285 | 0.00045 | 0.00045 |
| 07-Sep-18 | 2 | 0.0000176 | 0.001232 | 0.4158 | 0.015312 | 0.0088 | 0.0005412 | 0.000396 | 0.00066 | 1.7336 | 0.0000176 | 0.5324 | 0.000011 | 1.4432 | 0.02948 | 1.892 | 0.00000264 | 0.0003036 | 0.000044 | 0.00026356 | 0.0003696 | 0.00044 | 0.00044 |
| 14-Sep-18 | 3 | 0.0000088 | 0.000792 | 0.25124 | 0.014476 | 0.0132 | 0.0003476 | 0.00022 | 0.00066 | 1.0648 | 0.0000176 | 0.3916 | 0.000011 | 0.6512 | 0.019888 | 0.792 | 0.0000022 | 0.0001716 | 0.0000264 | 0.00024772 | 0.0003432 | 0.00044 | 0.00044 |
| 21-Sep-18 | 4 | | | | | | | | | | | | | | | | | | | | | | |
| 28-Sep-18 | 5 | 0.0000174 | 0.00087 | 0.224895 | 0.017226 | 0.002175 | 0.00014355 | 0.000348 | 0.0006525 | 0.93525 | 0.0000087 | 0.4089 | 0.000010875 | 0.3654 | 0.016617 | 1.044 | 1.0875E-06 | 0.0000957 | 0.0000435 | 0.00029841 | 0.0003915 | 0.000435 | 0.000435 |
| 05-Oct-18 | 6 | | | | | | | | | | | | | | | | | | | | | | |
| 12-Oct-18 | 7 | 0.00001305 | 0.000783 | 0.204015 | 0.0157905 | 0.002175 | 0.0000696 | 0.0002175 | 0.0006525 | 0.8091 | 0.0000087 | 0.38715 | 0.000010875 | 0.2436 | 0.014703 | 1.1745 | 1.0875E-06 | 0.0000522 | 0.00010875 | 0.00033669 | 0.00032625 | 0.000435 | 0.000435 |
| 19-Oct-18 | 8 | | | | | | | | | | | | | | | | | | | | | | |
| 26-Oct-18 | 9 | 0.00000435 | 0.0006525 | 0.22707 | 0.019662 | 0.002175 | 0.00008265 | 0.0001305 | 0.0006525 | 0.98745 | 0.0000087 | 0.27405 | 0.000010875 | 0.2349 | 0.0151815 | 1.7835 | 1.0875E-06 | 0.00005655 | 0.00016965 | 0.000408465 | 0.00033495 | 0.000435 | 0.000435 |
| 02-Nov-18 | 10 | | | | | | | | | | | | | | | | | | | | | | |
| 09-Nov-18 | 11 | 0.00000445 | 0.0008455 | 0.26077 | 0.019491 | 0.002225 | 0.0000445 | 0.000178 | 0.0006675 | 0.8544 | 0.0000089 | 0.2848 | 0.000011125 | 0.20025 | 0.021716 | 3.2485 | 0.00000267 | 0.0000267 | 0.00006675 | 0.0006586 | 0.00015575 | 0.000445 | 0.000445 |
| 16-Nov-18 | 12 | | | | | | | | | | | | | | | | | | | | | | |
| 23-Nov-18 | 13 | 0.0000022 | 0.000704 | 0.21428 | 0.01672 | 0.0022 | 0.0000616 | 0.000088 | 0.00066 | 0.8316 | 0.0000088 | 0.2948 | 0.000011 | 0.1364 | 0.01848 | 3.036 | 0.0000022 | 0.0000836 | 0.000011 | 0.0005544 | 0.0001584 | 0.00044 | 0.00044 |
| 30-Nov-18 | 14 | | | | | | | | | | | | | | | | | | | | | | |
| 07-Dec-18 | 15 | 0.000002175 | 0.000609 | 0.200535 | 0.0190965 | 0.002175 | 0.0000522 | 0.000087 | 0.0006525 | 0.83955 | 0.0000087 | 0.30885 | 0.000010875 | 0.1044 | 0.0181395 | 3.132 | 1.0875E-06 | 0.0000261 | 0.000010875 | 0.0004785 | 0.00012615 | 0.000435 | 0.000435 |
| 14-Dec-18 | 16 | | | | | | | | | | | | | | | | | | | | | | |
| 21-Dec-18 | 17 | 0.0000044 | 0.000484 | 0.15708 | 0.016148 | 0.0022 | 0.0000352 | 0.000022 | 0.00066 | 0.6732 | 0.0000088 | 0.2464 | 0.000011 | 0.0836 | 0.017468 | 3.564 | 0.0000011 | 0.0000308 | 0.000011 | 0.0004576 | 0.00011 | 0.00044 | 0.00044 |
| 28-Dec-18 | 18 | | | | | | | | | | | | | | | | | | | | | | |
| 04-Jan-19 | 19 | 0.00000225 | 0.000495 | 0.16965 | 0.017865 | 0.00225 | 0.0000855 | 0.00009 | 0.000675 | 0.747 | 0.000009 | 0.225 | 0.00001125 | 0.0945 | 0.0162 | 4.23 | 0.000001125 | 0.000018 | 0.00001125 | 0.0003807 | 0.000126 | 0.00045 | 0.00045 |
| 11-Jan-19 | 20 | | | | | | | | | | | | | | | | | | | | | | |
| 18-Jan-19 | 21 | 0.00000435 | 0.0005655 | 0.150945 | 0.0157905 | 0.002175 | 0.0026796 | 0.0000435 | 0.0006525 | 0.63945 | 0.0000087 | 0.2436 | 0.000010875 | 0.087 | 0.014181 | 2.871 | 1.0875E-06 | 0.0000261 | 0.000010875 | 0.000411945 | 0.0001218 | 0.000435 | 0.000435 |
| 25-Jan-19 | 22 | | | | | | | | | | | | | | | | | | | | | | |
| 01-Feb-19 | 23 | 0.000308 | 0.000836 | 0.15972 | 0.015664 | 0.0022 | 0.00011 | 0.000132 | 0.00066 | 0.572 | 0.0000088 | 0.2464 | 0.000011 | 0.0968 | 0.015312 | 3.784 | 0.0000011 | 0.0000572 | 0.000011 | 0.00037312 | 0.0000924 | 0.0088 | 0.00044 |
| 08-Feb-19 | 24 | | | | | | | | | | | | | | | | | | | | | | |
| 15-Feb-19 | 25 | 0.0000022 | 0.000396 | 0.13948 | 0.01584 | 0.0022 | 0.0000396 | 0.000022 | 0.00066 | 0.6336 | 0.0000088 | 0.2728 | 0.000011 | 0.11 | 0.01166 | 3.432 | 0.0000011 | 0.000022 | 0.000022 | 0.00027016 | 0.0000968 | 0.00044 | 0.00044 |
| 22-Feb-19 | 26 | | | | | | | | | | | | | | | | | | | | | | |
| 01-Mar-19 | 27 | 0.0000044 | 0.000484 | 0.12496 | 0.019932 | 0.0022 | 0.0001188 | 0.000088 | 0.00066 | 0.5456 | 0.000044 | 0.2156 | 0.000011 | 0.1056 | 0.011132 | 2.376 | 0.0000011 | 0.0000132 | 0.000022 | 0.00024508 | 0.0000836 | 0.00044 | 0.00044 |
| 08-Mar-19 | 28 | | | | | | | | | | | | | | | | | | | | | | |
| 15-Mar-19 | 29 | 0.0000267 | 0.000356 | 0.123265 | 0.016465 | 0.002225 | 0.0000445 | 0.0000445 | 0.0006675 | 0.534 | 0.0000089 | 0.2047 | 0.000011125 | 0.0534 | 0.010057 | 2.5365 | 1.1125E-06 | 0.00003115 | 0.00013795 | 0.000241635 | 0.00007565 | 0.000445 | 0.000445 |
| 22-Mar-19 | 30 | | | | | | | | | | | | | | | | | | | | | | |
| 29-Mar-19 | 31 | 0.000002225 | 0.000445 | 0.11392 | 0.01468945 | 0.002225 | 0.00003115 | 0.00002225 | 0.0006675 | 0.5251 | 0.0000089 | 0.21805 | 0.000011125 | 0.06675 | 0.011214 | 3.8715 | 1.1125E-06 | 0.00001335 | 0.000011125 | 0.000195355 | 0.00008455 | 0.000445 | 0.000445 |
| 05-Apr-19 | 32 | | | | | | | | | | | | | | | | | | | | | | |
| 12-Apr-19 | 33 | 0.000002425 | 0.000388 | 0.12222 | 0.016005 | 0.002425 | 0.0000873 | 0.00002425 | 0.0007275 | 0.53835 | 0.0000097 | 0.2619 | 0.000012125 | 0.05335 | 0.0145985 | 3.104 | 0.00000291 | 0.00007275 | 0.000012125 | 0.000389455 | 0.0000873 | 0.000485 | 0.000485 |
| 19-Apr-19 | 34 | | | | | | | | | | | | | | | | | | | | | | |
| 26-Apr-19 | 35 | 0.0000176 | 0.000396 | 0.10736 | 0.0132 | 0.0022 | 0.0000836 | 0.000022 | 0.00066 | 0.5104 | 0.0000088 | 0.2024 | 0.000011 | 0.066 | 0.009416 | 2.508 | 0.0000022 | 0.0000352 | 0.000011 | 0.00024288 | 0.0000704 | 0.00044 | 0.00044 |
| 03-May-19 | 36 | | | | | | | | | | | | | | | | | | | | | | |
| 10-May-19 | 37 | 0.0000089 | 0.000356 | 0.11481 | 0.0121485 | 0.002225 | 0.00003115 | 0.0000445 | 0.0006675 | 0.5162 | 0.0000089 | 0.23585 | 0.000011125 | 0.06675 | 0.0106355 | 3.115 | 0.000002225 | 0.00001335 | 0.000011125 | 0.00022161 | 0.000089 | 0.000445 | 0.000445 |
| 17-May-19 | 38 | 0.00002225 | 0.000356 | 0.101905 | 0.0230065 | 0.002225 | 0.0000267 | 0.00002225 | 0.0006675 | 0.4984 | 0.0000089 | 0.2403 | 0.000011125 | 0.05785 | 0.0100125 | 2.403 | 1.1125E-06 | 0.0000445 | 0.00002225 | 0.000173105 | 0.00008455 | 0.000445 | 0.000445 |
| 24-May-19 | 39 | 0.0000088 | 0.000352 | 0.0902 | 0.015048 | 0.0022 | 0.0000264 | 0.000022 | 0.00066 | 0.4312 | 0.0000088 | 0.2068 | 0.000011 | 0.0572 | 0.00836 | 1.496 | 0.0000011 | 0.0000132 | 0.0000264 | 0.00014476 | 0.0000704 | 0.00044 | 0.00044 |

**Appendix 4-6: Kinetic Test Results**
**HC 5**

| Date | Cycle | Volume mL | | pH | Cond. | Acidity | Acidity | Alkalinity | Sulphate | Chloride | Fluoride | Hardness | Al | Sb | As | Ba | Be | Bi | B | Cd | Ca | Cr | Co | Cu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. | Input | Output | | | (pH 4.5) | (pH 8.3) | | | | | CaCO3 | | | | | | | | | | | | |
| | | | | | umhos/cm | mgCaCO3/L | mgCaCO3/L | mgCaCO3/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 |
| 24-Aug-18 | 0 | 500 | 385 | 7.86 | 438 | #N/A | 4.1 | 40.3 | 73 | 32 | 0.12 | 165 | 0.026 | 0.0002 | 0.0123 | 0.00764 | <0.0000035 | <0.0000035 | 0.018 | 0.000024 | 61.4 | <0.000015 | 0.000821 | 0.00037 |
| 31-Aug-18 | 1 | 500 | 450 | 7.65 | 269 | #N/A | 3.3 | 14.4 | 54 | 26 | 0.11 | 98.0 | 0.134 | 0.0003 | 0.0217 | 0.00366 | <0.0000035 | <0.0000035 | 0.016 | 0.000003 | 36.0 | <0.000015 | 0.000028 | 0.00042 |
| 07-Sep-18 | 2 | 500 | 430 | 7.69 | 147 | #N/A | 2.9 | 15.7 | 33 | 7 | 0.09 | 54.2 | 0.212 | 0.0003 | 0.0186 | 0.00190 | <0.0000035 | <0.0000035 | 0.017 | <0.0000015 | 19.9 | <0.000015 | 0.000019 | 0.00009 |
| 14-Sep-18 | 3 | 500 | 440 | 7.72 | 104 | #N/A | 1.7 | 14.8 | 25 | 3 | 0.07 | 34.7 | 0.143 | 0.0002 | 0.0158 | 0.00116 | <0.0000035 | <0.0000035 | 0.008 | 0.000008 | 12.8 | 0.00011 | 0.000019 | 0.00017 |
| 21-Sep-18 | 4 | 500 | 435 | 7.74 | 89 | #N/A | 2.4 | 14.7 | 21 | | | | | | | | | | | | | | | |
| 28-Sep-18 | 5 | 500 | 450 | 7.87 | 81 | #N/A | 1.3 | 20.1 | 17 | 1 | <0.03 | 34.2 | 0.169 | 0.0002 | 0.0163 | 0.00102 | <0.0000035 | <0.0000035 | 0.008 | <0.0000015 | 12.6 | <0.000015 | 0.000016 | 0.00034 |
| 05-Oct-18 | 6 | 500 | 435 | 7.69 | 75 | #N/A | 1.9 | 14.3 | 14 | | | | | | | | | | | | | | | |
| 12-Oct-18 | 7 | 500 | 415 | 7.79 | 83 | #N/A | 4.2 | 15.9 | 18 | <0.5 | <0.03 | 32.4 | 0.158 | <0.0001 | 0.0142 | 0.00104 | <0.0000035 | <0.0000035 | 0.006 | <0.0000015 | 12.1 | 0.00021 | 0.000099 | 0.00150 |
| 19-Oct-18 | 8 | 500 | 440 | 7.72 | 69 | #N/A | 1.6 | 13.5 | 14 | | | | | | | | | | | | | | | |
| 26-Oct-18 | 9 | 500 | 445 | 7.74 | 69 | #N/A | 1.3 | 13.6 | 16 | <0.5 | <0.03 | 31.0 | 0.151 | <0.0001 | 0.0096 | 0.00089 | <0.0000035 | <0.0000035 | 0.005 | <0.0000015 | 11.6 | <0.000015 | 0.000024 | 0.00191 |
| 02-Nov-18 | 10 | 500 | 440 | 7.78 | 68 | #N/A | 1.5 | 13.4 | 15 | | | | | | | | | | | | | | | |
| 09-Nov-18 | 11 | 500 | 450 | 7.78 | 66 | #N/A | 2.2 | 13.1 | 14 | <0.5 | <0.03 | 24.4 | 0.119 | <0.0001 | 0.0110 | 0.00074 | <0.0000035 | <0.0000035 | 0.004 | 0.000005 | 9.09 | 0.00004 | 0.000014 | 0.00032 |
| 16-Nov-18 | 12 | 500 | 425 | 7.63 | 76 | #N/A | 1.1 | 12.5 | 16 | | | | | | | | | | | | | | | |
| 23-Nov-18 | 13 | 500 | 440 | 7.91 | 77 | #N/A | 1.7 | 14.0 | 14 | <0.5 | <0.03 | 29.1 | 0.161 | <0.0001 | 0.0114 | 0.00077 | <0.0000035 | <0.0000035 | 0.003 | <0.0000015 | 10.9 | <0.000015 | 0.000007 | 0.00026 |
| 30-Nov-18 | 14 | 500 | 430 | 7.85 | 77 | #N/A | 1.5 | 15.3 | 15 | | | | | | | | | | | | | | | |
| 07-Dec-18 | 15 | 500 | 440 | 7.72 | 79 | #N/A | 3.3 | 15.7 | 16 | <0.5 | <0.03 | 31.9 | 0.149 | <0.0001 | 0.0115 | 0.00085 | <0.0000035 | <0.0000035 | 0.004 | 0.000005 | 12.0 | <0.000015 | 0.000005 | 0.0168 |
| 14-Dec-18 | 16 | 500 | 440 | 7.92 | 84 | #N/A | 2.6 | 15.6 | 19 | | | | | | | | | | | | | | | |
| 21-Dec-18 | 17 | 500 | 435 | 7.72 | 101 | #N/A | 3.3 | 14.2 | 26 | <0.5 | <0.03 | 38.9 | 0.100 | <0.0001 | 0.0219 | 0.00105 | <0.0000035 | <0.0000035 | <0.001 | <0.0000015 | 14.8 | <0.000015 | <0.000002 | 0.00045 |
| 28-Dec-18 | 18 | 500 | 440 | 7.61 | 108 | #N/A | 1.7 | 11.3 | 31 | | | | | | | | | | | | | | | |
| 04-Jan-19 | 19 | 500 | 440 | 7.74 | 101 | #N/A | 3.0 | 12.9 | 29 | <0.5 | <0.03 | 43.7 | 0.114 | <0.0001 | 0.0447 | 0.00130 | <0.0000035 | <0.0000035 | 0.003 | <0.0000015 | 16.7 | 0.00003 | 0.000041 | 0.00042 |
| 11-Jan-19 | 20 | 500 | 435 | 7.46 | 99 | #N/A | 2.7 | 12.9 | 33 | | | | | | | | | | | | | | | |
| 18-Jan-19 | 21 | 500 | 435 | 7.57 | 89 | #N/A | 1.5 | 12.1 | 32 | <0.5 | <0.03 | 42.7 | 0.112 | <0.0001 | 0.0503 | 0.00105 | <0.0000035 | <0.0000035 | 0.003 | <0.0000015 | 16.3 | <0.000015 | 0.000014 | 0.00012 |
| 25-Jan-19 | 22 | 500 | 440 | 7.65 | 104 | #N/A | 1.6 | 11.3 | 29 | | | | | | | | | | | | | | | |
| 01-Feb-19 | 23 | 500 | 440 | 7.61 | 103 | #N/A | 2.7 | 12.9 | 28 | <0.5 | <0.03 | 39.8 | 0.093 | <0.0001 | 0.0426 | 0.00098 | <0.0000035 | <0.0000035 | 0.003 | <0.0000015 | 15.2 | <0.000015 | 0.000019 | 0.00062 |
| 08-Feb-19 | 24 | 500 | 440 | 7.67 | 103 | #N/A | 2.6 | 12.4 | 29 | | | | | | | | | | | | | | | |
| 15-Feb-19 | 25 | 500 | 440 | 7.56 | 101 | #N/A | 1.8 | 11.8 | 30 | <0.5 | <0.03 | 43.0 | 0.090 | <0.0001 | 0.0394 | 0.00113 | <0.0000035 | <0.0000035 | 0.008 | 0.000025 | 16.5 | 0.00007 | 0.000028 | 0.00029 |
| 22-Feb-19 | 26 | 500 | 425 | 7.74 | 117 | #N/A | 3.0 | 14.2 | 36 | | | | | | | | | | | | | | | |
| 01-Mar-19 | 27 | 500 | 435 | 7.48 | 113 | #N/A | 2.4 | 14.1 | 34 | <0.5 | <0.03 | 46.9 | 0.066 | <0.00045 | 0.0231 | 0.00107 | <0.0000035 | <0.0000035 | 0.003 | <0.0000015 | 18.1 | <0.00004 | 0.000087 | 0.0004 |
| 08-Mar-19 | 28 | 500 | 435 | 7.64 | 107 | #N/A | 2.8 | 12.2 | 36 | | | | | | | | | | | | | | | |
| 15-Mar-19 | 29 | 500 | 450 | 7.57 | 99 | #N/A | 2.0 | 12.1 | 35 | <0.5 | <0.03 | 44.1 | 0.065 | <0.00045 | 0.0182 | 0.00102 | <0.0000035 | <0.0000035 | 0.003 | 0.000007 | 17.0 | <0.00004 | 0.000040 | 0.0023 |
| 22-Mar-19 | 30 | 500 | 435 | 7.76 | 109 | #N/A | 2.7 | 13.0 | 35 | | | | | | | | | | | | | | | |
| 29-Mar-19 | 31 | 500 | 435 | 7.43 | 108 | #N/A | 2.4 | 13.8 | 33 | <0.5 | <0.03 | 47.1 | 0.063 | <0.00045 | 0.0140 | 0.00104 | <0.0000035 | <0.0000035 | 0.003 | 0.000017 | 18.2 | <0.00004 | 0.000087 | 0.0008 |
| 05-Apr-19 | 32 | 500 | 430 | 7.75 | 108 | #N/A | 5.3 | 16.5 | 34 | | | | | | | | | | | | | | | |
| 12-Apr-19 | 33 | 500 | 480 | 7.51 | 115 | #N/A | 1.6 | 16.5 | 37 | <0.5 | <0.03 | 46.0 | 0.080 | <0.00045 | 0.0181 | 0.00096 | <0.0000035 | <0.0000035 | 0.002 | <0.0000015 | 17.8 | <0.00004 | 0.000017 | 0.0006 |
| 19-Apr-19 | 34 | 500 | 430 | 7.52 | 106 | #N/A | 2.2 | 12.3 | 36 | | | | | | | | | | | | | | | |
| 26-Apr-19 | 35 | 500 | 430 | 7.64 | 103 | #N/A | 2.5 | 11.7 | 34 | <0.5 | <0.03 | 46.4 | 0.059 | <0.00045 | 0.0094 | 0.00115 | <0.0000035 | <0.0000035 | 0.003 | 0.000003 | 18.0 | <0.00004 | 0.000135 | 0.0006 |
| 03-May-19 | 36 | 500 | 440 | 7.91 | 97 | #N/A | 2.3 | 10.2 | 33 | | | | | | | | | | | | | | | |
| 10-May-19 | 37 | 500 | 430 | 7.52 | 97 | #N/A | 1.7 | 10.2 | 30 | <0.5 | <0.03 | 42.1 | 0.059 | <0.00045 | 0.0120 | 0.00103 | <0.0000035 | <0.0000035 | 0.003 | 0.000005 | 16.3 | <0.00004 | 0.000080 | 0.0008 |
| 17-May-19 | 38 | 500 | 435 | 7.49 | 96 | #N/A | 2.5 | 10.8 | 29 | <0.5 | <0.03 | 39.5 | 0.063 | <0.00045 | 0.0135 | 0.00090 | <0.0000035 | <0.0000035 | <0.001 | 0.000006 | 15.3 | <0.00004 | 0.000060 | 0.0004 |
| 24-May-19 | 39 | 500 | 435 | 7.53 | 90 | #N/A | 3.1 | 11.1 | 29 | <0.5 | <0.03 | 37.5 | 0.054 | <0.00045 | 0.0093 | 0.00089 | <0.0000035 | <0.0000035 | 0.003 | <0.0000015 | 14.5 | <0.00004 | 0.000111 | 0.0008 |
| **Cell Terminated** | | | | | | | | | | | | | | | | | | | | | | | | |
| **Loads** | **mg/kg** | | | | | | | | | | | | | | | | | | | | | | | |
| 24-Aug-18 | 0 | | | 7.86 | | | | | 28.105 | 12.32 | 0.0462 | 63.525 | 0.01001 | 0.000077 | 0.0047355 | 0.0029414 | 1.3475E-06 | 1.3475E-06 | 0.00693 | 0.00000924 | 23.639 | 0.000005775 | 0.000316085 | 0.00014245 |
| 31-Aug-18 | 1 | | | 7.65 | | | | | 24.3 | 11.7 | 0.0495 | 44.1 | 0.0603 | 0.000135 | 0.009765 | 0.001647 | 0.000001575 | 0.000001575 | 0.0072 | 0.00000135 | 16.2 | 0.00000675 | 0.0000126 | 0.000189 |
| 07-Sep-18 | 2 | | | 7.69 | | | | | 14.19 | 3.01 | 0.0387 | 23.306 | 0.09116 | 0.000129 | 0.007998 | 0.000817 | 0.000001505 | 0.000001505 | 0.00731 | 0.000000645 | 8.557 | 0.00000645 | 0.00000817 | 0.0000387 |
| 14-Sep-18 | 3 | | | 7.72 | | | | | 11 | 1.32 | 0.0308 | 15.268 | 0.06292 | 0.000088 | 0.006952 | 0.0005104 | 0.00000154 | 0.00000154 | 0.00352 | 0.00000352 | 5.632 | 0.0000484 | 0.00000836 | 0.0000748 |
| 21-Sep-18 | 4 | | | 7.74 | | | | | 9.135 | | | | | | | | | | | | | | | |
| 28-Sep-18 | 5 | | | 7.87 | | | | | 7.65 | 0.45 | 0.0135 | 15.39 | 0.07605 | 0.00009 | 0.007335 | 0.000459 | 0.000001575 | 0.000001575 | 0.0036 | 0.000000675 | 5.67 | 0.00000675 | 0.0000072 | 0.000153 |
| 05-Oct-18 | 6 | | | 7.69 | | | | | 6.09 | | | | | | | | | | | | | | | |
| 12-Oct-18 | 7 | | | 7.79 | | | | | 7.47 | 0.2075 | 0.01245 | 13.446 | 0.06557 | 0.0000415 | 0.005893 | 0.0004316 | 1.4525E-06 | 1.4525E-06 | 0.00249 | 6.225E-07 | 5.0215 | 0.00008715 | 0.000041085 | 0.0006225 |
| 19-Oct-18 | 8 | | | 7.72 | | | | | 6.16 | | | | | | | | | | | | | | | |
| 26-Oct-18 | 9 | | | 7.74 | | | | | 7.12 | 0.2225 | 0.01335 | 13.795 | 0.067195 | 0.0000445 | 0.004272 | 0.00039605 | 1.5575E-06 | 1.5575E-06 | 0.002225 | 6.675E-07 | 5.162 | 0.000006675 | 0.00001068 | 0.00084995 |
| 02-Nov-18 | 10 | | | 7.78 | | | | | 6.6 | | | | | | | | | | | | | | | |
| 09-Nov-18 | 11 | | | 7.78 | | | | | 6.3 | 0.225 | 0.0135 | 10.98 | 0.05355 | 0.000045 | 0.00495 | 0.000333 | 0.000001575 | 0.000001575 | 0.0018 | 0.00000225 | 4.0905 | 0.000018 | 0.0000063 | 0.000144 |
| 16-Nov-18 | 12 | | | 7.63 | | | | | 6.8 | | | | | | | | | | | | | | | |
| 23-Nov-18 | 13 | | | 7.91 | | | | | 6.16 | 0.22 | 0.0132 | 12.804 | 0.07084 | 0.000044 | 0.005016 | 0.0003388 | 0.00000154 | 0.00000154 | 0.00132 | 0.00000066 | 4.796 | 0.0000066 | 0.00000308 | 0.0001144 |
| 30-Nov-18 | 14 | | | 7.85 | | | | | 6.45 | | | | | | | | | | | | | | | |
| 07-Dec-18 | 15 | | | 7.72 | | | | | 7.04 | 0.22 | 0.0132 | 14.036 | 0.06556 | 0.000044 | 0.00506 | 0.000374 | 0.00000154 | 0.00000154 | 0.00176 | 0.0000022 | 5.28 | 0.0000066 | 0.0000022 | 0.007392 |
| 14-Dec-18 | 16 | | | 7.92 | | | | | 8.36 | | | | | | | | | | | | | | | |
| 21-Dec-18 | 17 | | | 7.72 | | | | | 11.31 | 0.2175 | 0.01305 | 16.9215 | 0.0435 | 0.0000435 | 0.0095265 | 0.00045675 | 1.5225E-06 | 1.5225E-06 | 0.000435 | 6.525E-07 | 6.438 | 0.000006525 | 0.00000087 | 0.00019575 |
| 28-Dec-18 | 18 | | | 7.61 | | | | | 13.64 | | | | | | | | | | | | | | | |
| 04-Jan-19 | 19 | | | 7.74 | | | | | 12.76 | 0.22 | 0.0132 | 19.228 | 0.05016 | 0.000044 | 0.019668 | 0.000572 | 0.00000154 | 0.00000154 | 0.00132 | 0.00000066 | 7.348 | 0.0000132 | 0.00001804 | 0.0001848 |
| 11-Jan-19 | 20 | | | 7.46 | | | | | 14.355 | | | | | | | | | | | | | | | |
| 18-Jan-19 | 21 | | | 7.57 | | | | | 13.92 | 0.2175 | 0.01305 | 18.5745 | 0.04872 | 0.0000435 | 0.0218805 | 0.00045675 | 1.5225E-06 | 1.5225E-06 | 0.001305 | 6.525E-07 | 7.0905 | 0.000006525 | 0.00000609 | 0.0000522 |
| 25-Jan-19 | 22 | | | 7.65 | | | | | 12.76 | | | | | | | | | | | | | | | |
| 01-Feb-19 | 23 | | | 7.61 | | | | | 12.32 | 0.22 | 0.0132 | 17.512 | 0.04092 | 0.000044 | 0.018744 | 0.0004312 | 0.00000154 | 0.00000154 | 0.00132 | 0.00000066 | 6.688 | 0.0000066 | 0.00000836 | 0.0002728 |
| 08-Feb-19 | 24 | | | 7.67 | | | | | 12.76 | | | | | | | | | | | | | | | |
| 15-Feb-19 | 25 | | | 7.56 | | | | | 13.2 | 0.22 | 0.0132 | 18.92 | 0.0396 | 0.000044 | 0.017336 | 0.0004972 | 0.00000154 | 0.00000154 | 0.00352 | 0.000011 | 7.26 | 0.0000308 | 0.00001232 | 0.0001276 |
| 22-Feb-19 | 26 | | | 7.74 | | | | | 15.3 | | | | | | | | | | | | | | | |
| 01-Mar-19 | 27 | | | 7.48 | | | | | 14.79 | 0.2175 | 0.01305 | 20.4015 | 0.02871 | 0.00019575 | 0.0100485 | 0.00046545 | 1.5225E-06 | 1.5225E-06 | 0.001305 | 6.525E-07 | 7.8735 | 0.0000174 | 0.000037845 | 0.000174 |
| 08-Mar-19 | 28 | | | 7.64 | | | | | 15.66 | | | | | | | | | | | | | | | |
| 15-Mar-19 | 29 | | | 7.57 | | | | | 15.75 | 0.225 | 0.0135 | 19.845 | 0.02925 | 0.0002025 | 0.00819 | 0.000459 | 0.000001575 | 0.000001575 | 0.00135 | 0.00000315 | 7.65 | 0.000018 | 0.000018 | 0.001035 |
| 22-Mar-19 | 30 | | | 7.76 | | | | | 15.225 | | | | | | | | | | | | | | | |
| 29-Mar-19 | 31 | | | 7.43 | | | | | 14.355 | 0.2175 | 0.01305 | 20.4885 | 0.027405 | 0.00019575 | 0.00609 | 0.0004524 | 1.5225E-06 | 1.5225E-06 | 0.001305 | 0.000007395 | 7.917 | 0.0000174 | 0.000037845 | 0.000348 |
| 05-Apr-19 | 32 | | | 7.75 | | | | | 14.62 | | | | | | | | | | | | | | | |
| 12-Apr-19 | 33 | | | 7.51 | | | | | 17.76 | 0.24 | 0.0144 | 22.08 | 0.0384 | 0.000216 | 0.008688 | 0.0004608 | 0.00000168 | 0.00000168 | 0.00096 | 0.00000072 | 8.544 | 0.0000192 | 0.00000816 | 0.000288 |
| 19-Apr-19 | 34 | | | 7.52 | | | | | 15.48 | | | | | | | | | | | | | | | |
| 26-Apr-19 | 35 | | | 7.64 | | | | | 14.62 | 0.215 | 0.0129 | 19.952 | 0.02537 | 0.0001935 | 0.004042 | 0.0004945 | 0.000001505 | 0.000001505 | 0.00129 | 0.00000129 | 7.74 | 0.0000172 | 0.00005805 | 0.000258 |
| 03-May-19 | 36 | | | 7.91 | | | | | 14.52 | | | | | | | | | | | | | | | |
| 10-May-19 | 37 | | | 7.52 | | | | | 12.9 | 0.215 | 0.0129 | 18.103 | 0.02537 | 0.0001935 | 0.00516 | 0.0004429 | 0.000001505 | 0.000001505 | 0.00129 | 0.00000215 | 7.009 | 0.0000172 | 0.0000344 | 0.000344 |
| 17-May-19 | 38 | | | 7.49 | | | | | 12.615 | 0.2175 | 0.01305 | 17.1825 | 0.027405 | 0.00019575 | 0.0058725 | 0.0003915 | 1.5225E-06 | 1.5225E-06 | 0.000435 | 0.00000261 | 6.6555 | 0.0000174 | 0.0000261 | 0.000174 |
| 24-May-19 | 39 | | | 7.53 | | | | | 12.615 | 0.2175 | 0.01305 | 16.3125 | 0.02349 | 0.00019575 | 0.0040455 | 0.00038715 | 1.5225E-06 | 1.5225E-06 | 0.001305 | 6.525E-07 | 6.3075 | 0.0000174 | 0.000048285 | 0.000348 |

**Appendix 4-6: Kinetic Test Results**
**HC 5**

| Date | Cycle No. | Fe | Pb | Li | Mg | Mn | Hg | Mo | Ni | P | K | Se | Si | Ag | Na | Sr | S | Tl | Sn | Ti | U | V | Zn | Zr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | mg/L | mg/L | mg/L | mg/L | mg/L | ug/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L |
| 24-Aug-18 | 0 | <0.0035 | <0.000005 | 0.0098 | 2.97 | 0.245 | <0.005 | 0.00023 | 0.0131 | 0.006 | 13.8 | 0.00020 | 1.06 | <0.000025 | 7.82 | 0.447 | 31.0 | 0.000019 | 0.00192 | <0.000025 | 0.000590 | 0.00005 | <0.001 | <0.001 |
| 31-Aug-18 | 1 | <0.0035 | <0.000005 | 0.0055 | 1.99 | 0.0355 | <0.005 | 0.00153 | 0.0006 | 0.006 | 8.27 | 0.00024 | 1.19 | <0.000025 | 5.82 | 0.290 | 22.8 | 0.000006 | 0.00123 | <0.000025 | 0.000400 | 0.00034 | <0.001 | <0.001 |
| 07-Sep-18 | 2 | <0.0035 | 0.00006 | 0.0033 | 1.08 | 0.0197 | <0.005 | 0.00121 | 0.0003 | <0.0015 | 5.79 | 0.00017 | 1.25 | <0.000025 | 2.94 | 0.150 | 14.1 | <0.0000025 | 0.00064 | 0.00027 | 0.000287 | 0.00045 | <0.001 | <0.001 |
| 14-Sep-18 | 3 | <0.0035 | 0.00002 | 0.0022 | 0.673 | 0.0183 | 0.03 | 0.00071 | 0.0002 | <0.0015 | 3.39 | 0.00013 | 0.91 | <0.000025 | 1.40 | 0.102 | 7.5 | <0.0000025 | 0.00031 | 0.00005 | 0.000198 | 0.00050 | <0.001 | <0.001 |
| 21-Sep-18 | 4 | | | | | | | | | | | | | | | | | | | | | | | |
| 28-Sep-18 | 5 | <0.0035 | 0.00006 | 0.0024 | 0.645 | 0.0215 | <0.005 | 0.00031 | 0.0004 | <0.0015 | 2.83 | 0.00010 | 1.08 | <0.000025 | 0.84 | 0.0857 | 6.3 | <0.0000025 | 0.00020 | 0.00015 | 0.000286 | 0.00059 | <0.001 | <0.001 |
| 05-Oct-18 | 6 | | | | | | | | | | | | | | | | | | | | | | | |
| 12-Oct-18 | 7 | 0.016 | 0.00005 | 0.0021 | 0.535 | 0.0224 | <0.005 | 0.00015 | 0.0003 | <0.0015 | 2.28 | 0.00008 | 0.97 | <0.000025 | 0.54 | 0.0774 | 5.9 | <0.0000025 | 0.00014 | 0.00020 | 0.000248 | 0.00049 | <0.001 | <0.001 |
| 19-Oct-18 | 8 | | | | | | | | | | | | | | | | | | | | | | | |
| 26-Oct-18 | 9 | 0.011 | 0.00003 | 0.0016 | 0.495 | 0.0237 | <0.005 | 0.00023 | 0.0002 | <0.0015 | 2.36 | 0.00009 | 0.71 | <0.000025 | 0.40 | 0.0549 | 5.8 | <0.0000025 | 0.00014 | 0.00047 | 0.000196 | 0.00056 | <0.001 | <0.001 |
| 02-Nov-18 | 10 | | | | | | | | | | | | | | | | | | | | | | | |
| 09-Nov-18 | 11 | <0.0035 | 0.00002 | 0.0016 | 0.415 | 0.0205 | <0.005 | 0.00008 | 0.0002 | <0.0015 | 1.53 | 0.00005 | 0.69 | <0.000025 | 0.30 | 0.0517 | 4.6 | <0.0000025 | 0.00005 | <0.000025 | 0.000219 | 0.00039 | <0.001 | <0.001 |
| 16-Nov-18 | 12 | | | | | | | | | | | | | | | | | | | | | | | |
| 23-Nov-18 | 13 | 0.009 | 0.00002 | 0.0016 | 0.432 | 0.0196 | <0.005 | 0.00011 | <0.00005 | 0.004 | 1.57 | 0.00007 | 0.78 | <0.000025 | 0.34 | 0.0526 | 5.8 | 0.000005 | 0.00007 | 0.00035 | 0.000262 | 0.00044 | <0.001 | <0.001 |
| 30-Nov-18 | 14 | | | | | | | | | | | | | | | | | | | | | | | |
| 07-Dec-18 | 15 | <0.0035 | <0.000005 | 0.0016 | 0.442 | 0.0135 | <0.005 | 0.00008 | 0.0002 | <0.0015 | 1.74 | 0.00006 | 0.86 | <0.000025 | 0.25 | 0.0558 | 6.2 | <0.0000025 | 0.00018 | <0.000025 | 0.000296 | 0.00035 | <0.001 | <0.001 |
| 14-Dec-18 | 16 | | | | | | | | | | | | | | | | | | | | | | | |
| 21-Dec-18 | 17 | <0.0035 | <0.000005 | 0.0014 | 0.469 | 0.00694 | <0.005 | 0.00016 | 0.0001 | <0.0015 | 1.61 | <0.00002 | 0.62 | <0.000025 | 0.20 | 0.0657 | 9.8 | <0.0000025 | 0.00006 | <0.000025 | 0.000400 | 0.00024 | <0.001 | <0.001 |
| 28-Dec-18 | 18 | | | | | | | | | | | | | | | | | | | | | | | |
| 04-Jan-19 | 19 | <0.0035 | <0.000005 | 0.0015 | 0.504 | 0.00808 | <0.005 | 0.00026 | 0.0003 | <0.0015 | 1.80 | <0.00002 | 0.58 | <0.000025 | 0.24 | 0.0629 | 12.5 | <0.0000025 | 0.00003 | 0.00006 | 0.000329 | 0.00028 | <0.001 | <0.001 |
| 11-Jan-19 | 20 | | | | | | | | | | | | | | | | | | | | | | | |
| 18-Jan-19 | 21 | <0.0035 | 0.00004 | 0.0017 | 0.477 | 0.00726 | <0.005 | 0.00021 | 0.0001 | <0.0015 | 1.62 | 0.00005 | 0.62 | <0.000025 | 0.25 | 0.0572 | 10.1 | <0.0000025 | 0.00005 | 0.00008 | 0.000350 | 0.00026 | <0.001 | <0.001 |
| 25-Jan-19 | 22 | | | | | | | | | | | | | | | | | | | | | | | |
| 01-Feb-19 | 23 | <0.0035 | <0.000005 | 0.0022 | 0.467 | 0.00842 | <0.005 | 0.00097 | 0.0002 | <0.0015 | 1.31 | 0.00004 | 0.59 | <0.000025 | 0.23 | 0.0550 | 11.7 | <0.0000025 | 0.00004 | 0.00017 | 0.000364 | 0.00019 | <0.001 | <0.001 |
| 08-Feb-19 | 24 | | | | | | | | | | | | | | | | | | | | | | | |
| 15-Feb-19 | 25 | <0.0035 | <0.000005 | 0.0014 | 0.426 | 0.0109 | <0.005 | 0.00011 | 0.0003 | <0.0015 | 1.50 | <0.00002 | 0.59 | <0.000025 | 0.26 | 0.0460 | 12.6 | <0.0000025 | <0.00005 | 0.00004 | 0.000218 | 0.00018 | <0.001 | <0.001 |
| 22-Feb-19 | 26 | | | | | | | | | | | | | | | | | | | | | | | |
| 01-Mar-19 | 27 | <0.0035 | <0.000005 | 0.0014 | 0.420 | 0.0277 | <0.005 | 0.00094 | 0.0009 | <0.0015 | 1.41 | 0.00004 | 0.57 | <0.000025 | 0.24 | 0.0518 | 12.0 | <0.0000025 | <0.00003 | <0.000025 | 0.000228 | 0.00007 | <0.001 | <0.001 |
| 08-Mar-19 | 28 | | | | | | | | | | | | | | | | | | | | | | | |
| 15-Mar-19 | 29 | <0.0035 | <0.000005 | 0.0013 | 0.379 | 0.0246 | <0.005 | 0.00007 | 0.0005 | <0.0015 | 1.33 | 0.00005 | 0.51 | <0.000025 | 0.13 | 0.0444 | 12.7 | <0.0000025 | <0.00003 | <0.000025 | 0.000194 | 0.00010 | <0.001 | <0.001 |
| 22-Mar-19 | 30 | | | | | | | | | | | | | | | | | | | | | | | |
| 29-Mar-19 | 31 | 0.014 | 0.00011 | 0.0016 | 0.391 | 0.03195 | <0.005 | 0.00005 | 0.0008 | <0.0015 | 1.40 | 0.00004 | 0.51 | <0.000025 | 0.15 | 0.0447 | 14.5 | <0.0000025 | 0.00011 | <0.000025 | 0.000164 | 0.00005 | <0.001 | <0.001 |
| 05-Apr-19 | 32 | | | | | | | | | | | | | | | | | | | | | | | |
| 12-Apr-19 | 33 | <0.0035 | <0.000005 | 0.0011 | 0.358 | 0.0103 | <0.005 | 0.00014 | 0.0002 | <0.0015 | 1.22 | <0.00002 | 0.51 | <0.000025 | 0.13 | 0.0435 | 10.8 | 0.000006 | 0.00007 | <0.000025 | 0.000244 | 0.00010 | <0.001 | <0.001 |
| 19-Apr-19 | 34 | | | | | | | | | | | | | | | | | | | | | | | |
| 26-Apr-19 | 35 | <0.0035 | <0.000005 | 0.0014 | 0.367 | 0.0357 | <0.005 | 0.00019 | 0.0011 | <0.0015 | 1.42 | 0.00005 | 0.51 | <0.000025 | 0.17 | 0.0409 | 13.5 | 0.000005 | 0.00007 | <0.000025 | 0.000148 | 0.00005 | <0.001 | <0.001 |
| 03-May-19 | 36 | | | | | | | | | | | | | | | | | | | | | | | |
| 10-May-19 | 37 | 0.007 | <0.000005 | 0.0011 | 0.327 | 0.0205 | <0.005 | 0.00005 | 0.0007 | <0.0015 | 1.28 | 0.00004 | 0.46 | <0.000025 | 0.17 | 0.0337 | 11.7 | 0.000006 | <0.00003 | <0.000025 | 0.000111 | 0.00005 | <0.001 | <0.001 |
| 17-May-19 | 38 | <0.0035 | <0.000005 | 0.0011 | 0.301 | 0.0154 | <0.005 | 0.00005 | 0.0004 | <0.0015 | 1.26 | 0.00006 | 0.47 | <0.000025 | 0.15 | 0.0319 | 10.5 | 0.000005 | 0.00007 | <0.000025 | 0.000093 | 0.00005 | <0.001 | <0.001 |
| 24-May-19 | 39 | <0.0035 | 0.00002 | 0.0013 | 0.315 | 0.0224 | <0.005 | 0.00007 | 0.0009 | <0.0015 | 1.24 | 0.00005 | 0.47 | <0.000025 | 0.16 | 0.0299 | 9.8 | <0.0000025 | <0.00003 | <0.000025 | 0.000089 | 0.00003 | <0.001 | <0.001 |
| **Cell Terminated** | | | | | | | | | | | | | | | | | | | | | | | | |
| **Loads** | **mg/kg** | | | | | | | | | | | | | | | | | | | | | | | |
| 24-Aug-18 | 0 | 0.0013475 | 0.000001925 | 0.003773 | 1.14345 | 0.094325 | 0.001925 | 0.00008855 | 0.0050435 | 0.00231 | 5.313 | 0.000077 | 0.4081 | 0.000009625 | 3.0107 | 0.172095 | 11.935 | 0.000007315 | 0.0007392 | 0.000009625 | 0.00022715 | 0.00001925 | 0.000385 | 0.000385 |
| 31-Aug-18 | 1 | 0.001575 | 0.00000225 | 0.002475 | 0.8955 | 0.015975 | 0.00225 | 0.0006885 | 0.00027 | 0.0027 | 3.7215 | 0.000108 | 0.5355 | 0.00001125 | 2.619 | 0.1305 | 10.26 | 0.0000027 | 0.0005535 | 0.00001125 | 0.00018 | 0.000153 | 0.00045 | 0.00045 |
| 07-Sep-18 | 2 | 0.001505 | 0.0000258 | 0.001419 | 0.4644 | 0.008471 | 0.00215 | 0.0005203 | 0.000129 | 0.000645 | 2.4897 | 0.0000731 | 0.5375 | 0.00001075 | 1.2642 | 0.0645 | 6.063 | 0.000001075 | 0.0002752 | 0.0001161 | 0.00012341 | 0.0001935 | 0.00043 | 0.00043 |
| 14-Sep-18 | 3 | 0.00154 | 0.0000088 | 0.000968 | 0.29612 | 0.008052 | 0.0132 | 0.0003124 | 0.000088 | 0.00066 | 1.4916 | 0.0000572 | 0.4004 | 0.000011 | 0.616 | 0.04488 | 3.3 | 0.0000011 | 0.0001364 | 0.000022 | 0.00008712 | 0.00022 | 0.00044 | 0.00044 |
| 21-Sep-18 | 4 | | | | | | | | | | | | | | | | | | | | | | | |
| 28-Sep-18 | 5 | 0.001575 | 0.000027 | 0.00108 | 0.29025 | 0.009675 | 0.00225 | 0.0001395 | 0.00018 | 0.000675 | 1.2735 | 0.000045 | 0.486 | 0.00001125 | 0.378 | 0.038565 | 2.835 | 0.000001125 | 0.00009 | 0.0000675 | 0.0001287 | 0.0002655 | 0.00045 | 0.00045 |
| 05-Oct-18 | 6 | | | | | | | | | | | | | | | | | | | | | | | |
| 12-Oct-18 | 7 | 0.00664 | 0.00002075 | 0.0008715 | 0.222025 | 0.009296 | 0.002075 | 0.00006225 | 0.0001245 | 0.0006225 | 0.9462 | 0.0000332 | 0.40255 | 0.000010375 | 0.2241 | 0.032121 | 2.4485 | 1.0375E-06 | 0.0000581 | 0.000083 | 0.00010292 | 0.00020335 | 0.000415 | 0.000415 |
| 19-Oct-18 | 8 | | | | | | | | | | | | | | | | | | | | | | | |
| 26-Oct-18 | 9 | 0.004895 | 0.00001335 | 0.000712 | 0.220275 | 0.0105465 | 0.002225 | 0.00010235 | 0.000089 | 0.0006675 | 1.0502 | 0.00004005 | 0.31595 | 0.000011125 | 0.178 | 0.0244305 | 2.581 | 1.1125E-06 | 0.0000623 | 0.00020915 | 0.00008722 | 0.0002492 | 0.000445 | 0.000445 |
| 02-Nov-18 | 10 | | | | | | | | | | | | | | | | | | | | | | | |
| 09-Nov-18 | 11 | 0.001575 | 0.000009 | 0.00072 | 0.18675 | 0.009225 | 0.00225 | 0.000036 | 0.00009 | 0.000675 | 0.6885 | 0.0000225 | 0.3105 | 0.00001125 | 0.135 | 0.023265 | 2.07 | 0.000001125 | 0.0000225 | 0.00001125 | 0.00009855 | 0.0001755 | 0.00045 | 0.00045 |
| 16-Nov-18 | 12 | | | | | | | | | | | | | | | | | | | | | | | |
| 23-Nov-18 | 13 | 0.00396 | 0.0000088 | 0.000704 | 0.19008 | 0.008624 | 0.0022 | 0.0000484 | 0.000022 | 0.00176 | 0.6908 | 0.0000308 | 0.3432 | 0.000011 | 0.1496 | 0.023144 | 2.552 | 0.0000022 | 0.0000308 | 0.000154 | 0.00011528 | 0.0001936 | 0.00044 | 0.00044 |
| 30-Nov-18 | 14 | | | | | | | | | | | | | | | | | | | | | | | |
| 07-Dec-18 | 15 | 0.00154 | 0.0000022 | 0.000704 | 0.19448 | 0.00594 | 0.0022 | 0.0000352 | 0.000088 | 0.00066 | 0.7656 | 0.0000264 | 0.3784 | 0.000011 | 0.11 | 0.024552 | 2.728 | 0.0000011 | 0.0000792 | 0.000011 | 0.00013024 | 0.000154 | 0.00044 | 0.00044 |
| 14-Dec-18 | 16 | | | | | | | | | | | | | | | | | | | | | | | |
| 21-Dec-18 | 17 | 0.0015225 | 0.000002175 | 0.000609 | 0.204015 | 0.0030189 | 0.002175 | 0.0000696 | 0.0000435 | 0.0006525 | 0.70035 | 0.0000087 | 0.2697 | 0.000010875 | 0.087 | 0.0285795 | 4.263 | 1.0875E-06 | 0.0000261 | 0.000010875 | 0.000174 | 0.0001044 | 0.000435 | 0.000435 |
| 28-Dec-18 | 18 | | | | | | | | | | | | | | | | | | | | | | | |
| 04-Jan-19 | 19 | 0.00154 | 0.0000022 | 0.00066 | 0.22176 | 0.0035552 | 0.0022 | 0.0001144 | 0.000132 | 0.00066 | 0.792 | 0.0000088 | 0.2552 | 0.000011 | 0.1056 | 0.027676 | 5.5 | 0.0000011 | 0.0000132 | 0.0000264 | 0.00014476 | 0.0001232 | 0.00044 | 0.00044 |
| 11-Jan-19 | 20 | | | | | | | | | | | | | | | | | | | | | | | |
| 18-Jan-19 | 21 | 0.0015225 | 0.0000174 | 0.0007395 | 0.207495 | 0.0031581 | 0.002175 | 0.00009135 | 0.0000435 | 0.0006525 | 0.7047 | 0.00002175 | 0.2697 | 0.000010875 | 0.10875 | 0.024882 | 4.3935 | 1.0875E-06 | 0.00002175 | 0.0000348 | 0.00015225 | 0.0001131 | 0.000435 | 0.000435 |
| 25-Jan-19 | 22 | | | | | | | | | | | | | | | | | | | | | | | |
| 01-Feb-19 | 23 | 0.00154 | 0.0000022 | 0.000968 | 0.20548 | 0.0037048 | 0.0022 | 0.0004268 | 0.000088 | 0.00066 | 0.5764 | 0.0000176 | 0.2596 | 0.000011 | 0.1012 | 0.0242 | 5.148 | 0.0000011 | 0.0000176 | 0.0000748 | 0.00016016 | 0.0000836 | 0.00044 | 0.00044 |
| 08-Feb-19 | 24 | | | | | | | | | | | | | | | | | | | | | | | |
| 15-Feb-19 | 25 | 0.00154 | 0.0000022 | 0.000616 | 0.18744 | 0.004796 | 0.0022 | 0.0000484 | 0.000132 | 0.00066 | 0.66 | 0.0000088 | 0.2596 | 0.000011 | 0.1144 | 0.02024 | 5.544 | 0.0000011 | 0.000022 | 0.0000176 | 0.00009592 | 0.0000792 | 0.00044 | 0.00044 |
| 22-Feb-19 | 26 | | | | | | | | | | | | | | | | | | | | | | | |
| 01-Mar-19 | 27 | 0.0015225 | 0.000002175 | 0.000609 | 0.1827 | 0.0120495 | 0.002175 | 0.0004089 | 0.0003915 | 0.0006525 | 0.61335 | 0.0000174 | 0.24795 | 0.000010875 | 0.1044 | 0.022533 | 5.22 | 1.0875E-06 | 0.00001305 | 0.000010875 | 0.00009918 | 0.00003045 | 0.000435 | 0.000435 |
| 08-Mar-19 | 28 | | | | | | | | | | | | | | | | | | | | | | | |
| 15-Mar-19 | 29 | 0.001575 | 0.00000225 | 0.000585 | 0.17055 | 0.01107 | 0.00225 | 0.0000315 | 0.000225 | 0.000675 | 0.5985 | 0.0000225 | 0.2295 | 0.00001125 | 0.0585 | 0.01998 | 5.715 | 0.000001125 | 0.0000135 | 0.00001125 | 0.0000873 | 0.000045 | 0.00045 | 0.00045 |
| 22-Mar-19 | 30 | | | | | | | | | | | | | | | | | | | | | | | |
| 29-Mar-19 | 31 | 0.00609 | 0.00004785 | 0.000696 | 0.170085 | 0.01389825 | 0.002175 | 0.00002175 | 0.000348 | 0.0006525 | 0.609 | 0.0000174 | 0.22185 | 0.000010875 | 0.06525 | 0.0194445 | 6.3075 | 1.0875E-06 | 0.00004785 | 0.000010875 | 0.00007134 | 0.00002175 | 0.000435 | 0.000435 |
| 05-Apr-19 | 32 | | | | | | | | | | | | | | | | | | | | | | | |
| 12-Apr-19 | 33 | 0.00168 | 0.0000024 | 0.000528 | 0.17184 | 0.004944 | 0.0024 | 0.0000672 | 0.000096 | 0.00072 | 0.5856 | 0.0000096 | 0.2448 | 0.000012 | 0.0624 | 0.02088 | 5.184 | 0.00000288 | 0.0000336 | 0.000012 | 0.00011712 | 0.000048 | 0.00048 | 0.00048 |
| 19-Apr-19 | 34 | | | | | | | | | | | | | | | | | | | | | | | |
| 26-Apr-19 | 35 | 0.001505 | 0.00000215 | 0.000602 | 0.15781 | 0.015351 | 0.00215 | 0.0000817 | 0.000473 | 0.000645 | 0.6106 | 0.0000215 | 0.2193 | 0.00001075 | 0.0731 | 0.017587 | 5.805 | 0.00000215 | 0.0000301 | 0.00001075 | 0.00006364 | 0.0000215 | 0.00043 | 0.00043 |
| 03-May-19 | 36 | | | | | | | | | | | | | | | | | | | | | | | |
| 10-May-19 | 37 | 0.00301 | 0.00000215 | 0.000473 | 0.14061 | 0.008815 | 0.00215 | 0.0000215 | 0.000301 | 0.000645 | 0.5504 | 0.0000172 | 0.1978 | 0.00001075 | 0.0731 | 0.014491 | 5.031 | 0.00000258 | 0.0000129 | 0.00001075 | 0.00004773 | 0.0000215 | 0.00043 | 0.00043 |
| 17-May-19 | 38 | 0.0015225 | 0.000002175 | 0.0004785 | 0.130935 | 0.006699 | 0.002175 | 0.00002175 | 0.000174 | 0.0006525 | 0.5481 | 0.0000261 | 0.20445 | 0.000010875 | 0.06525 | 0.0138765 | 4.5675 | 0.000002175 | 0.00003045 | 0.000010875 | 0.000040455 | 0.00002175 | 0.000435 | 0.000435 |
| 24-May-19 | 39 | 0.0015225 | 0.0000087 | 0.0005655 | 0.137025 | 0.009744 | 0.002175 | 0.00003045 | 0.0003915 | 0.0006525 | 0.5394 | 0.00002175 | 0.20445 | 0.000010875 | 0.0696 | 0.0130065 | 4.263 | 1.0875E-06 | 0.00001305 | 0.000010875 | 0.000038715 | 0.00001305 | 0.000435 | 0.000435 |

# *Appendix 4-7: Field Bin Leachate Results*

Atlantic Gold

**Appendix 4-7: Field Bin Leachate Results**

| Parameter | Units | CCME WQG | | FB3 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Short Term | Long Term | 2018-09-27 12:30:00 PM | 2018-10-24 2:07:00 PM | 2019-03-29 11:53:00 AM | 2019-04-18 1:30:00 PM | 2019-04-29 2:00:00 PM | 2019-05-29 10:10:00 AM | 2019-06-12 12:00:00 AM | 2019-07-03 2:10:00 PM |
| **Calculated Parameters** | | | | | | | | | | | |
| Anion Sum | me/L | - | - | 10.1 | 3.48 | 1.04 | 1.18 | 1.32 | 2.35 | 1.7 | 2.26 |
| Bicarb. Alkalinity (calc. as $CaCO_3$) | mg/L | - | - | 56 | 29 | 13 | 22 | 27 | 28 | 26 | 21 |
| Calculated TDS | mg/L | - | - | 630 | 210 | 65 | 72 | 79 | 150 | 110 | 150 |
| Carb. Alkalinity (calc. as $CaCO_3$) | mg/L | - | - | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| Cation Sum | me/L | - | - | 9.97 | 3.3 | 1.03 | 1.16 | 1.27 | 2.39 | 1.6 | 2.22 |
| Hardness ($CaCO_3$) | mg/L | - | - | 450 | 150 | 49 | 52 | 58 | 110 | 75 | 110 |
| Ion Balance (% Difference) | % | - | - | 0.8 | 2.65 | 0.48 | 0.85 | 1.93 | 0.84 | 3.03 | 0.89 |
| Langelier Index (@ 20C) | N/A | - | - | -0.14 | -1.01 | -1.88 | -1.32 | -0.83 | -0.746 | -1.38 | -1.08 |
| Langelier Index (@ 4C) | N/A | - | - | -0.388 | -1.26 | -2.13 | -1.57 | -1.08 | -0.996 | -1.63 | -1.33 |
| Saturation pH (@ 20C) | N/A | - | - | 7.53 | 8.19 | 8.93 | 8.7 | 8.56 | 8.29 | 8.48 | 8.45 |
| Saturation pH (@ 4C) | N/A | - | - | 7.78 | 8.44 | 9.18 | 8.95 | 8.81 | 8.54 | 8.73 | 8.70 |
| **Inorganics** | | | | | | | | | | | |
| Acidity | mg/L | - | - | 6.2 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 |
| Total Alkalinity (Total as $CaCO_3$) | mg/L | - | - | 56 | 29 | 13 | 22 | 27 | 28 | 26 | 21 |
| Dissolved Chloride (Cl-) | mg/L | 640 | 120 | 130 | 56 | 4.5 | 5.5 | 4.6 | 5.5 | 3.3 | 3.9 |
| Colour | TCU | - | - | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 |
| Dissolved Fluoride (F-) | mg/L | - | 0.12 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 |
| Nitrate (N) | mg/L | - | - | 0.54 | 0.056 | <0.05 | <0.05 | 0.1 | 0.075 | <0.05 | 0.088 |
| Nitrate + Nitrite (N) | mg/L | - | - | 0.6 | 0.073 | <0.05 | <0.05 | 0.1 | 0.075 | 0.063 | 0.13 |
| Nitrite (N) | mg/L | - | - | 0.058 | 0.018 | <0.01 | <0.01 | <0.01 | <0.01 | 0.015 | 0.042 |
| Nitrogen (Ammonia Nitrogen) | mg/L | - | - | 0.067 | 0.065 | <0.05 | <0.05 | 0.081 | 0.1 | <0.05 | 0.061 |
| Total Organic Carbon (C) | mg/L | - | - | 1.6 | 1.6 | 0.63 | 0.71 | 0.76 | 1.2 | 1.3 | 0.74 |
| Orthophosphate (P) | mg/L | - | - | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| pH | pH | 6.5-9.0 | - | 7.39 | 7.18 | 7.05 | 7.38 | 7.73 | 7.55 | 7.1 | 7.37 |
| Reactive Silica ($SiO_2$) | mg/L | - | - | 3.2 | 2.1 | 0.61 | 1.1 | 1.4 | 2.1 | 2 | 2.1 |
| Dissolved Sulphate ($SO_4$) | mg/L | - | - | 250 | 63 | 31 | 29 | 31 | 78 | 52 | 83 |
| Turbidity | NTU | - | - | 820 | 4.1 | 1.2 | 5.4 | 29 | 2.2 | 1.3 | 0.69 |
| Conductivity | µS/cm | - | - | 990 | 360 | 110 | 120 | 150 | 230 | 170 | 210 |
| Bromide (Br-) | mg/L | - | - | 18 | 1.6 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| **Nutritional Parameters** | | | | | | | | | | | |
| Total Nitrogen (N) | mg/L | | | 1.43 | 0.225 | 0.13 | | 0.278 | 0.385 | 0.36 | 0.356 |
| **Metals** | | | | | | | | | | | |
| Dissolved Aluminum (Al)[a] | µg/L | - | 100 | 6.5 | 17 | <5.0 | 11 | 11 | 130 | 14 | 11 |
| Dissolved Antimony (Sb) | µg/L | - | - | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | 1 |
| Dissolved Arsenic (As) | µg/L | - | 5 | 6.4 | 3.2 | 1.6 | 2.2 | 3.4 | 3.5 | 3.9 | 2.4 |
| Dissolved Barium (Ba) | µg/L | - | - | 22 | 5.3 | 1 | 1.5 | 1.7 | 3.1 | 2.4 | 3.1 |
| Dissolved Beryllium (Be) | µg/L | - | - | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| Dissolved Bismuth (Bi) | µg/L | - | - | <2.0 | <2.0 | <2.0 | <2.0 | <2.0 | <2.0 | <2.0 | <2.0 |
| Dissolved Boron (B) | µg/L | 29000 | 1500 | <50 | <50 | <50 | <50 | <50 | <50 | <50 | <50 |
| Dissolved Cadmium (Cd) | µg/L | 1 | 0.09 | 0.088 | 0.015 | <0.01 | <0.01 | <0.01 | 0.043 | <0.01 | 0.015 |
| Dissolved Calcium (Ca) | µg/L | - | - | 160000 | 54000 | 19000 | 19000 | 21000 | 42000 | 28000 | 40000 |
| Dissolved Chromium (Cr) | µg/L | - | 1 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| Dissolved Cobalt (Co) | µg/L | - | - | 40 | 5.2 | 0.92 | 1.3 | 1.1 | 2.3 | 1.4 | 2.3 |
| Dissolved Copper (Cu)[b] | µg/L | - | 2 | <2.0 | <2.0 | <0.50 | 0.84 | <0.50 | 0.89 | 0.63 | 0.74 |
| Dissolved Iron (Fe) | µg/L | - | 300 | <50 | <50 | <50 | <50 | <50 | <50 | <50 | 57 |
| Dissolved Lead (Pb)[b] | µg/L | - | 1 | <0.50 | <0.50 | <0.50 | <0.50 | <0.50 | <0.50 | <0.50 | <0.50 |
| Dissolved Magnesium (Mg) | µg/L | - | - | 11000 | 3500 | 530 | 890 | 1000 | 2000 | 1300 | 1600 |
| Dissolved Manganese (Mn) | µg/L | - | - | 1400 | 220 | 45 | 70 | 52 | 110 | 57 | 110 |
| Dissolved Molybdenum (Mo) | µg/L | - | 73 | <2.0 | <2.0 | <2.0 | 2.8 | <2.0 | <2.0 | <2.0 | <2.0 |
| Dissolved Nickel (Ni)[b] | µg/L | - | 25 | 230 | 38 | 6.6 | 9.2 | 9.6 | 19 | 14 | 23 |
| Dissolved Phosphorus (P) | µg/L | - | - | <100 | <100 | <100 | <100 | <100 | <100 | <100 | <100 |
| Dissolved Potassium (K) | µg/L | - | - | 13000 | 3600 | 650 | 1200 | 1500 | 2400 | 1800 | 2200 |
| Dissolved Selenium (Se) | µg/L | - | 1 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <0.50 | <0.50 | <0.50 |
| Dissolved Silver (Ag) | µg/L | - | 0.25 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 |
| Dissolved Sodium (Na) | µg/L | - | - | 13000 | 4900 | 790 | 1900 | 1700 | 1700 | 1100 | 1100 |
| Dissolved Strontium (Sr) | µg/L | - | - | 1400 | 510 | 140 | 160 | 170 | 340 | 220 | 290 |
| Dissolved Thallium (Tl) | µg/L | - | 0.8 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 |
| Dissolved Tin (Sn) | µg/L | - | - | 14 | 3.2 | <2.0 | <2.0 | <2.0 | <2.0 | <2.0 | <2.0 |
| Dissolved Titanium (Ti) | µg/L | - | - | <2.0 | <2.0 | <2.0 | <2.0 | <2.0 | <2.0 | <2.0 | <2.0 |
| Dissolved Uranium (U) | µg/L | 33 | 15 | 1.5 | 0.87 | 0.17 | 0.47 | 0.52 | 1.2 | 0.65 | 0.57 |
| Dissolved Vanadium (V) | µg/L | - | - | <2.0 | <2.0 | <2.0 | <2.0 | <2.0 | <2.0 | <2.0 | <2.0 |
| Dissolved Zinc (Zn) | µg/L | 37 | 7 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 |

**Notes:**
Values shaded in light grey are above the long-term CCME guideline; no values are above the short-term CCME guidelines
[a]Aluminum guideline is based on pH > 6.5
[b]Hardness dependent guidelines are based on a hardness of 10 mg/L
CCME – Canadian Council for Ministers of the Environment; WQG – Water quality guideline for the protection of aquatic life

# *Appendix 4-8: Tailings Static Test Results*

Atlantic Gold

**Appendix 4-8: Tailings Static Test Results**

| **Sample ID** | **Paste** | **TIC** | **CaNP** | **S(T)** | **S($SO_4$)** | **S($S^{-2}$)** | **Insoluble S** | **TAP** | **SAP** | **Modified NP** | **Net Modified** | **NPR** | **Fizz Test** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *pH* | *%* | *kg $CaCO_3$/t* | *%* | *%* | *%* | *%* | *kg $CaCO_3$/t* | *kg $CaCO_3$/t* | *kg $CaCO_3$/t* | *NP* | *ModNP/TAP* | |
| Method Code | Sobek | CSB02V | Calc. | CSA06V | CSA07V | CSA08D | Calc. | Calc. | Calc. | Modified | Calc. | Calc. | Sobek |
| LOD | 0.20 | 0.01 | #N/A | 0.005 | 0.01 | 0.01 | N/A | N/A | N/A | 0.5 | N/A | N/A | N/A |
| FMS 2017 Tailings - Test 8 | 8.28 | 0.13 | 10.8 | 0.213 | <0.01 | 0.02 | 0.19 | 6.66 | 0.6 | 13.9 | 13.3 | 2.1 | Slight |
| FMS 2017 Tailings - Test 42 | 8.33 | 0.15 | 12.5 | 0.085 | <0.01 | 0.01 | 0.08 | 2.66 | 0.3 | 14.9 | 14.6 | 5.6 | Slight |
| FMS 2018 Tailings - Test 6 | 8.09 | 0.13 | 10.8 | 0.249 | <0.01 | 0.25 | N/A | 7.8 | 7.8 | 12.1 | 4.3 | 0.55502008 | None |
| FMS 2018 Tailings - Test 10 | 8.23 | 0.13 | 10.8 | 0.195 | <0.01 | 0.20 | N/A | 6.1 | 6.1 | 12.2 | 6.1 | 1.002051282 | None |
| **Duplicates** | | | | | | | | | | | | | |
| FMS 2017 Tailings - Test 8 | | | | | <0.01 | | | | | | | | |
| FMS 2018 Tailings - Test 6 | | | | 0.25 | | | | | | | | | |
| FMS 2018 Tailings - Test 10 | | 0.14 | | | | | | | | | | | |
| **QC** | | | | | | | | | | | | | |
| GTS-2A | | | | 0.326 | | | | | | | | | |
| RTS-3A | | | | | 1.06 | 2.31 | | | | | | | |
| SY4 | | 0.91 | | | | | | | | | | | |
| NBM-1 | | | | | | | | | | 40.9 | | | Slight |
| | | | | | | | | | | | | | |
| Expected Values | | 0.91 | | 0.341 | 0.98 | 2.46 | | | | 40.4 | | | Slight |
| Tolerance +/- | | 0.07 | | 0.01 | 0.12 | 0.25 | | | | 2.2 | | | |

**Note:**

AP = Acid potential in tonnes CaCO3 equivalent per 1000 tonnes of material. TAP is determined from the total S content; SAP is determined from the measured sulphide sulphur content.

NP = Neutralization potential in tonnes CaCO3 equivalent per 1000 tonnes of material.

NET Modified NP = Modified NP - AP

Carbonate NP is calculated from TIC originating from carbonate minerals and is expressed in kg CaCO3/tonne.

Sulphate Sulphur determined by 25% HCl Leach with S by ICP Finish.

2017 samples: Sulphide Sulphur determined by Sobek 1:7 Nitric Acid Leach with S by ICP Finish.

Insoluble S is acid insoluble S (Total S - (Sulphate S + Sulphide S)).

2018 samples: Sulphide Sulphur calculated as (Total S - Sulphate S)

**Appendix 4-8: Tailings Static Test Results**

| Sample ID | Ag | Al | As | Ba | Be | Bi | Ca | Cd | Ce | Co | Cr | Cs | Cu | Fe | Ga | Ge | Hf |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ppm | % | ppm | ppm | ppm | ppm | % | ppm | ppm | ppm | ppm | ppm | ppm | % | ppm | ppm | ppm |
| Method Code | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B |
| LOD | 0.01 | 0.01 | 1 | 5 | 0.1 | 0.02 | 0.01 | 0.01 | 0.05 | 0.1 | 1 | 0.05 | 0.5 | 0.01 | 0.1 | 0.1 | 0.05 |
| FMS 2017 Tailings - Test 8 | 0.03 | 2.31 | 176 | 48 | 0.6 | 0.18 | 0.5 | 0.07 | 57.4 | 7.9 | 50 | 3.42 | 4.2 | 4.53 | 6.7 | 0.1 | 0.39 |
| FMS 2017 Tailings - Test 42 | 0.01 | 2.33 | 43 | 46 | 0.7 | 0.15 | 0.55 | 0.04 | 56.3 | 6 | 50 | 3.1 | 3.6 | 4.43 | 6.7 | 0.1 | 0.4 |
| FMS 2018 Tailings - Test 6 | 0.03 | 2.35 | 335 | 41 | 0.4 | 0.17 | 0.61 | 0.05 | 62.57 | 12.7 | 49 | 2.47 | 5.4 | 4.51 | 6.8 | 0.2 | 0.3 |
| FMS 2018 Tailings - Test 10 | 0.03 | 2.18 | 225 | 128 | 0.7 | 0.09 | 0.48 | 0.52 | 35.13 | 4.6 | 52 | 4.09 | 9.6 | 3.4 | 7.7 | 0.1 | 0.16 |
| **QC** | | | | | | | | | | | | | | | | | |
| CH4 | 2.09 | 1.89 | 10 | 279 | 0.1 | 0.45 | 0.57 | 1.18 | 27 | 23.6 | 108 | 2.53 | 1900 | 4.86 | 8.7 | 0.2 | 0.38 |
| Certified Values | 2.10 | 1.85 | 8.14 | 293 | 0.108 | 0.51 | 0.61 | 1.17 | 28.18 | 23.56 | 103.8 | 2.6 | 2000 | 4.79 | 9.139 | 0.213 | 0.292 |
| Tolerance (%) | 28.57 | 11.35 | 40.72 | 14.3 | 241.3 | 19.7 | 14.1 | 12.1 | 16.1 | 11.1 | 12.4 | 14.8 | 10.1 | 10.52 | 12.9 | 127.4 | 52.8 |
| *AUCCA* | 0.0530 | 8.15 | 4.80 | 628 | 2.10 | 0.16 | 2.57 | 0.09 | 63.0 | 17.3 | 92 | 4.9 | 28.0 | 3.92 | 17.50 | 1.40 | 5.30 |

| Sample ID | Hg | In | K | La | Li | Lu | Mg | Mn | Mo | Na | Nb | Ni | P | Pb | Rb | S | Sb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ppm | ppm | % | ppm | ppm | ppm | % | ppm | ppm | % | ppm | ppm | % | ppm | ppm | % | ppm |
| Method Code | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B |
| LOD | 0.01 | 0.02 | 0.01 | 0.1 | 1 | 0.01 | 0.01 | 2 | 0.05 | 0.01 | 0.05 | 0.5 | 0.005 | 0.2 | 0.2 | 0.01 | 0.05 |
| FMS 2017 Tailings - Test 8 | <0.01 | <0.02 | 0.43 | 26.8 | 42 | 0.17 | 1.3 | 587 | 0.73 | 0.02 | 0.38 | 25.2 | 0.04 | 6.4 | 27.9 | 0.22 | 0.13 |
| FMS 2017 Tailings - Test 42 | <0.01 | <0.02 | 0.4 | 27.2 | 45 | 0.17 | 1.32 | 621 | 0.69 | 0.02 | 0.35 | 20.2 | 0.04 | 4.7 | 25.3 | 0.08 | 0.05 |
| FMS 2018 Tailings - Test 6 | 0.01 | <0.02 | 0.34 | 29.4 | 42 | 0.15 | 1.23 | 556 | 1.73 | 0.02 | 0.35 | 38.9 | 0.05 | 4.4 | 22.8 | 0.26 | 0.36 |
| FMS 2018 Tailings - Test 10 | 0.02 | 0.02 | 1.04 | 16.5 | 42 | 0.05 | 1.07 | 369 | 0.88 | 0.04 | 1.08 | 15.9 | 0.04 | 29.2 | 67.6 | 0.15 | 0.35 |
| **QC** | | | | | | | | | | | | | | | | | |
| CH4 | 0.03 | 0.1 | 1.39 | 13.4 | 12 | 0.06 | 1.22 | 322 | 3.42 | 0.06 | 0.37 | 49.5 | 0.06 | 8.7 | 68.1 | 0.67 | 0.44 |
| Certified Values | #N/A | 0.096 | 1.43 | 14 | 12.6 | 0.07 | 1.18 | 324.4 | 3.05 | 0.062 | 0.346 | 49.57 | 0.072 | 8.24 | 67.039 | 0.63 | 0.335 |
| Tolerance (%) | #N/A | 62.1 | 11.74 | 11.8 | 29.84 | 45.71 | 12.3 | 11.5 | 26.07 | 50.3 | 75 | 12.52 | 27.4 | 16.1 | 10.75 | 28.57 | 47.3 |
| *AUCCA* | 0.050 | 0.056 | 2.32 | 31.0 | 24.0 | 0.31 | 1.50 | 775 | 1.10 | 2.43 | 12 | 47.0 | 0.066 | 17.0 | 84.0 | 0.062 | 0.40 |

| Sample ID | Sc | Se | Sn | Sr | Ta | Tb | Te | Th | Ti | Tl | U | V | W | Y | Yb | Zn | Zr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | % | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm |
| Method Code | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B | ICM14B |
| LOD | 0.1 | 1 | 0.3 | 0.5 | 0.05 | 0.02 | 0.05 | 0.1 | 0.01 | 0.02 | 0.05 | 1 | 0.1 | 0.05 | 0.1 | 1 | 0.5 |
| FMS 2017 Tailings - Test 8 | 3.4 | <1 | 0.6 | 10.7 | <0.05 | 0.77 | <0.05 | 8.7 | 0.06 | 0.21 | 0.89 | 29 | 0.2 | 18.9 | 1.4 | 90 | 14.4 |
| FMS 2017 Tailings - Test 42 | 3.3 | <1 | 0.7 | 11.6 | <0.05 | 0.78 | <0.05 | 8.7 | 0.06 | 0.18 | 0.94 | 28 | 0.1 | 19.1 | 1.4 | 88 | 14.6 |
| FMS 2018 Tailings - Test 6 | 3 | <1 | 0.8 | 11.1 | <0.05 | 0.76 | 0.06 | 8.6 | 0.05 | 0.17 | 0.82 | 29 | 0.2 | 17.91 | 1.3 | 96 | 9.9 |
| FMS 2018 Tailings - Test 10 | 6.1 | <1 | 1.3 | 12.4 | <0.05 | 0.36 | <0.05 | 4.9 | 0.16 | 0.41 | 0.7 | 56 | 0.3 | 5.62 | 0.4 | 209 | 5.4 |
| **QC** | | | | | | | | | | | | | | | | | |
| CH4 | 8.2 | 2 | 1 | 9.6 | <0.05 | 0.28 | 0.43 | 2 | 0.22 | 0.39 | 0.29 | 84 | 2 | 5.85 | 0.5 | 197 | 16.1 |
| Certified Values | 8.53 | 1.57 | 0.6 | 9.38 | <0.05 | 0.272 | 0.422 | 2.239 | 0.21 | 0.398 | 0.291 | 79.27 | 2.15 | 5.66 | 0.5 | 200 | 13.95 |
| Tolerance (%) | 13.1 | 169.6 | 134.5 | 23.3 | 250 | 28.4 | 39.6 | 21.2 | 23.3 | 22.6 | 52.9 | 13.2 | 49.28 | 12.2 | 60 | 11.3 | 18.96 |
| *AUCCA* | 14.000 | 0.090 | 2.10 | 320 | 1 | 0.9 | - | 11 | 0.384 | 0.900 | 2.70 | 97 | 1.90 | 21 | 2.0 | 67.0 | 193.0 |

**Notes:**
AUCCA = average upper continental crust abundance (Rudnick and Gao, 2014);
Values greater than 3x the AUCCC are shaded in light grey; values greater than 10x the AUCCC are shaded in dark grey.

**Appendix 4-8: Tailings Static Test Results**

| **Sample ID** | | | **CCME WQG** | | **FMS 2017 Tailings** | **FMS 2017 Tailings** | **FMS 2018 Tailings** | **FMS 2018 Tailings** |
|---|---|---|---|---|---|---|---|---|
| | | | **Short Term** | **Long Term** | **Test 8** | **Test 42** | **Test 6** | **Test 10** |
| **Parameter** | **Method** | **Units** | | | | | | |
| Volume Nanopure Water | | mL | - | - | 750 | 750 | 750 | 750 |
| Sample Weight | | g | - | - | 250 | 250 | 250 | 250 |
| pH | meter | - | 6.5-9 | - | 8.09 | 8.15 | 7.95 | 7.93 |
| Redox | meter | mV | - | - | 336 | 346 | 322 | 317 |
| Conductivity | meter | µS/cm | - | - | 134 | 123 | 157 | 178 |
| Acidity (to pH 4.5) | titration | mg $CaCO_3$/L | - | - | #N/A | #N/A | #N/A | #N/A |
| Total Acidity (to pH 8.3) | titration | mg $CaCO_3$/L | - | - | 1.5 | 1.2 | 6.3 | 5.8 |
| Alkalinity | titration | mg $CaCO_3$/L | - | - | 35.5 | 30.4 | 50.6 | 55.5 |
| Chloride | Colour | mg/L | 640 | 120 | 2 | 2 | 2 | 3 |
| Fluoride | IC | mg/L | - | 0.12 | 0.11 | 0.10 | 0.16 | 0.17 |
| Sulphate | Turbidity | mg/L | - | - | 18 | 16 | 29 | 30 |
| **Ion Balance** | | | | | | | | |
| Major Anions | Calc | meq/L | - | - | 1.15 | 1.01 | 1.68 | 1.83 |
| Major Cations | Calc | meq/L | - | - | 1.11 | 1.00 | 1.58 | 1.76 |
| Difference | Calc | meq/L | - | - | 0.04 | 0.00 | 0.10 | 0.07 |
| Balance (%) | Calc | % | - | - | 1.7% | 0.0% | 3.0% | 2.0% |
| **Dissolved Metals** | | | | | | | | |
| Hardness $CaCO_3$ | | mg/L | - | - | 46.8 | 39.8 | 61.9 | 62.9 |
| Aluminum Al[a] | ICP-MS | mg/L | - | 0.1 | 0.150 | 0.226 | 0.126 | 0.128 |
| Antimony Sb | ICP-MS | mg/L | - | - | 0.0005 | 0.0004 | < 0.0009 | < 0.0009 |
| Arsenic As | ICP-MS | mg/L | - | 0.005 | 0.0131 | 0.0189 | 0.0126 | 0.0066 |
| Barium Ba | ICP-MS | mg/L | - | - | 0.00130 | 0.00099 | 0.00377 | 0.00424 |
| Beryllium Be | ICP-MS | mg/L | - | - | < 0.000007 | 0.000007 | < 0.000007 | < 0.000007 |
| Bismuth Bi | ICP-MS | mg/L | - | - | < 0.000007 | < 0.000007 | < 0.000007 | < 0.000007 |
| Boron B | ICP-MS | mg/L | 29 | 1.5 | 0.008 | 0.007 | 0.012 | 0.015 |
| Cadmium Cd | ICP-MS | mg/L | 0.001 | 0.00009 | < 0.000003 | < 0.000003 | 0.000005 | 0.000005 |
| Calcium Ca | ICP-MS | mg/L | - | - | 17.9 | 15.4 | 21.7 | 22.1 |
| Chromium Cr | ICP-MS | mg/L | - | 0.001 | 0.00019 | 0.00077 | 0.00015 | 0.00013 |
| Cobalt Co | ICP-MS | mg/L | - | - | 0.000036 | 0.000044 | 0.000032 | 0.000023 |
| Copper Cu[b] | ICP-MS | mg/L | - | 0.002 | 0.00045 | 0.00038 | 0.0007 | 0.0014 |
| Iron Fe | ICP-MS | mg/L | - | 0.3 | 0.039 | 0.061 | 0.020 | 0.050 |
| Lead Pb[b] | ICP-MS | mg/L | - | 0.001 | 0.00005 | 0.00005 | 0.00003 | 0.00002 |
| Lithium Li | ICP-MS | mg/L | - | - | 0.0036 | 0.0024 | 0.0022 | 0.0024 |
| Magnesium Mg | ICP-MS | mg/L | - | - | 0.546 | 0.349 | 1.88 | 1.88 |
| Manganese Mn | ICP-MS | mg/L | - | - | 0.00589 | 0.00164 | 0.0121 | 0.0108 |
| Mercury Hg | ICP-MS | µg/L | - | 0.026 | < 0.01 | < 0.01 | < 0.01 | 0.02 |
| Molybdenum Mo | ICP-MS | mg/L | - | 0.073 | 0.00251 | 0.00187 | 0.00571 | 0.0135 |
| Nickel Ni[b] | ICP-MS | mg/L | - | 0.025 | 0.0003 | 0.0002 | 0.0004 | 0.0005 |
| Phosphorus P | ICP-MS | mg/L | - | - | 0.022 | 0.020 | < 0.003 | < 0.003 |
| Potassium K | ICP-MS | mg/L | - | - | 3.66 | 3.78 | 8.74 | 13.6 |
| Selenium Se | ICP-MS | mg/L | - | 0.001 | 0.00018 | 0.00021 | 0.00033 | 0.00013 |
| Silicon Si | ICP-MS | mg/L | - | - | 1.33 | 1.46 | 1.78 | 1.55 |
| Silver Ag | ICP-MS | mg/L | - | 0.00025 | < 0.00005 | < 0.00005 | < 0.00005 | < 0.00005 |
| Sodium Na | ICP-MS | mg/L | - | - | 1.45 | 1.97 | 2.45 | 3.04 |
| Strontium Sr | ICP-MS | mg/L | - | - | 0.0591 | 0.0452 | 0.0840 | 0.100 |
| Sulphur (S) | ICP-MS | mg/L | - | - | 6.6 | 6.2 | 12.1 | 12.0 |
| Thallium Tl | ICP-MS | mg/L | - | 0.0008 | 0.000007 | 0.000006 | 0.000005 | < 0.000005 |
| Tin Sn | ICP-MS | mg/L | - | - | 0.00005 | 0.00004 | 0.00011 | 0.00024 |
| Titanium Ti | ICP-MS | mg/L | - | - | 0.00059 | 0.00094 | 0.00052 | 0.00066 |
| Uranium U | ICP-MS | mg/L | 0.033 | 0.015 | 0.000349 | 0.000332 | 0.000250 | 0.000226 |
| Vanadium V | ICP-MS | mg/L | - | - | 0.00028 | 0.00051 | 0.00018 | 0.00015 |
| Zinc Zn | ICP-MS | mg/L | 0.037 | 0.007 | < 0.002 | < 0.002 | < 0.002 | < 0.002 |
| Zirconium Zr | ICP-MS | mg/L | - | - | < 0.002 | < 0.002 | < 0.002 | < 0.002 |

**Notes:**
Values shaded in light grey are above the long-term CCME guideline; no values are above the short-term CCME guidelines
[a]Aluminum guideline is based on pH > 6.5
[b]Hardness dependent guidelines are based on a hardness of 10 mg/L
CCME – Canadian Council for Ministers of the Environment; WQG – Water quality guideline for the protection of aquatic life

# Appendix 4-9: Saturated Column Leachate Results

Atlantic Gold

**Appendix 4-9: Saturated Column Leachate Results**

| | | mL | mL | pH | uS/cm | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Stn.Code** | **Collect Date/Time** | **Vol-Leachate-LE** | **Vol-Eff-LE** | **pH-LE** | **Cond-LE** | **T-Alk-LE** | **NH3** | **NO2-N** | **NO3-N** | **TD-P** | **DOC** | **SO4** | **D-Br** | **D-Cl** |
| INFLUENT | 2019-02-06 10:40 | 100 | | 7.95 | 314 | 79 | 0.352 | 0.0048 | 0.0480 | *<0.0020* | 11.4 | 47.1 | *<0.050* | 15.0 |
| FMS_TEST10 | 2019-03-07 10:50 | 165 | | 8.06 | 480 | 119 | 0.0518 | *<0.0010* | *<0.0050* | 0.0061 | 4.56 | 95.9 | *<0.050* | 16.2 |
| FMS_TEST10 | 2019-03-21 14:05 | 189 | 7 | 8.07 | 440 | 135 | 0.128 | *<0.0010* | *<0.0050* | 0.0043 | 6.32 | 75.3 | *<0.050* | 16.2 |
| FMS_TEST10 | 2019-04-04 15:45 | 203 | 13 | 8.05 | 417 | 126 | 0.192 | *<0.0010* | *<0.0050* | 0.0041 | 11.8 | 61.9 | *<0.050* | 15.8 |
| FMS_TEST10 | 2019-04-17 14:00 | 214 | | 8.15 | 410 | 145 | 0.202 | 0.0012 | *<0.0050* | 0.0035 | 11.7 | 56.7 | *<0.050* | 16.3 |
| FMS_TEST10 | 2019-05-02 14:30 | 225 | | 8.05 | 401 | 142 | 0.206 | 0.0020 | *<0.0050* | 0.0041 | 10.5 | 49.3 | *<0.050* | 15.6 |
| FMS_TEST10 | 2019-05-16 14:30 | 216 | 3 | 8.06 | 387 | 149 | 0.226 | 0.0024 | *<0.0050* | 0.0046 | 7.81 | 47.8 | *<0.050* | 16.1 |
| FMS_TEST10 | 2019-06-13 15:30 | 221 | | 8.13 | 397 | 154 | 0.230 | *<0.0010* | *<0.0050* | 0.0031 | 6.35 | 46.8 | *<0.050* | 15.9 |
| FMS_TEST10 | 2019-07-11 15:00 | 235 | | 8.31 | 411 | 161 | 0.239 | *<0.0010* | *<0.0050* | 0.0021 | 4.38 | 49.6 | *<0.050* | 15.8 |

| | | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Stn.Code** | **Collect Date/Time** | **D-F** | **D-Ag** | **D-Al** | **D-As** | **D-B** | **D-Ba** | **D-Be** | **D-Bi** | **D-Ca** | **D-Cd** | **D-Co** | **D-Cr** | **D-Cs** |
| INFLUENT | 2019-02-06 10:40 | 0.284 | *<0.0000050* | 0.0944 | 0.0119 | 0.021 | 0.00664 | *<0.000010* | *<0.0000050* | 24.7 | *<0.0000050* | 0.0000094 | *<0.00010* | 0.000216 |
| FMS_TEST10 | 2019-03-07 10:50 | 0.442 | *<0.0000050* | 0.0260 | 0.0134 | 0.054 | 0.0149 | *<0.000010* | *<0.0000050* | 37.9 | *<0.000030* | 0.0000839 | *<0.00010* | 0.000356 |
| FMS_TEST10 | 2019-03-21 14:05 | 0.511 | *<0.0000050* | 0.0199 | 0.0155 | 0.058 | 0.0128 | *<0.000010* | *<0.0000050* | 39.1 | *<0.000015* | 0.0000077 | *<0.00010* | 0.000286 |
| FMS_TEST10 | 2019-04-04 15:45 | 0.544 | *<0.0000050* | 0.0176 | 0.0196 | 0.054 | 0.0116 | *<0.000010* | *<0.0000050* | 34.6 | *<0.000025* | 0.0000085 | *<0.00010* | 0.000287 |
| FMS_TEST10 | 2019-04-17 14:00 | 0.625 | *<0.0000050* | 0.0147 | 0.0226 | 0.058 | 0.0126 | *<0.000010* | *<0.0000050* | 35.5 | *<0.0000050* | 0.0000091 | *<0.00010* | 0.000308 |
| FMS_TEST10 | 2019-05-02 14:30 | 0.619 | *<0.0000050* | 0.0133 | 0.0247 | 0.053 | 0.0103 | *<0.000010* | *<0.0000050* | 29.6 | *<0.000015* | 0.0000091 | *<0.00010* | 0.000275 |
| FMS_TEST10 | 2019-05-16 14:30 | 0.670 | *<0.0000050* | 0.0135 | 0.0278 | 0.052 | 0.00969 | *<0.000010* | *<0.0000050* | 27.9 | *<0.000020* | 0.0000124 | *<0.00010* | 0.000270 |
| FMS_TEST10 | 2019-06-13 15:30 | 0.650 | *<0.0000050* | 0.0125 | 0.0309 | 0.059 | 0.0108 | *<0.000010* | *<0.0000050* | 29.0 | *<0.000020* | 0.0000360 | *<0.00010* | 0.000294 |
| FMS_TEST10 | 2019-07-11 15:00 | 0.724 | *<0.0000050* | 0.0103 | 0.0349 | 0.062 | 0.0113 | *<0.000010* | *<0.0000050* | 32.2 | *<0.000050* | 0.0000481 | *<0.00010* | 0.000280 |

| | | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Stn.Code** | **Collect Date/Time** | **D-Cu** | **D-Fe** | **D-Hg** | **D-K** | **D-Li** | **D-Mg** | **D-Mn** | **D-Mo** | **D-Na** | **D-Ni** | **D-P** | **D-Pb** | **D-Rb** | **D-S** |
| INFLUENT | 2019-02-06 10:40 | *<0.00010* | *<0.0010* | *<0.0000050* | 32.0 | 0.00587 | 3.47 | 0.0182 | 0.0160 | 11.2 | 0.000762 | *<0.050* | *<0.0000050* | 0.0218 | 20.3 |
| FMS_TEST10 | 2019-03-07 10:50 | 0.00016 | *<0.0010* | *<0.0000050* | 46.1 | 0.00705 | 5.99 | 0.0498 | 0.0598 | 18.1 | 0.00202 | *<0.050* | 0.0000085 | 0.0237 | 34.7 |
| FMS_TEST10 | 2019-03-21 14:05 | *<0.00010* | *<0.0010* | *<0.0000050* | 44.0 | 0.00950 | 5.87 | 0.0611 | 0.0564 | 19.1 | 0.000792 | *<0.050* | *<0.0000050* | 0.0240 | 28.9 |
| FMS_TEST10 | 2019-04-04 15:45 | *<0.00010* | 0.0021 | *<0.0000050* | 41.4 | 0.0119 | 5.17 | 0.0665 | 0.0585 | 19.3 | 0.000401 | *<0.050* | *<0.0000050* | 0.0228 | 26.5 |
| FMS_TEST10 | 2019-04-17 14:00 | *<0.00010* | 0.0042 | *<0.0000050* | 41.6 | 0.0127 | 4.96 | 0.0761 | 0.0633 | 19.7 | 0.000327 | *<0.050* | *<0.0000050* | 0.0245 | 21.4 |
| FMS_TEST10 | 2019-05-02 14:30 | *<0.00010* | 0.0044 | *<0.0000050* | 38.7 | 0.0134 | 4.33 | 0.0799 | 0.0629 | 19.8 | 0.000293 | *<0.050* | *<0.0000050* | 0.0219 | 21.0 |
| FMS_TEST10 | 2019-05-16 14:30 | *<0.00010* | 0.0082 | *<0.0000050* | 38.5 | 0.0142 | 4.20 | 0.0807 | 0.0567 | 20.8 | 0.000277 | *<0.050* | *<0.0000050* | 0.0217 | 19.6 |
| FMS_TEST10 | 2019-06-13 15:30 | *<0.00010* | 0.0050 | *<0.0000050* | 40.0 | 0.0167 | 4.13 | 0.0918 | 0.0548 | 22.3 | 0.000834 | *<0.050* | *<0.0000050* | 0.0238 | 17.6 |
| FMS_TEST10 | 2019-07-11 15:00 | *<0.00010* | 0.0022 | *<0.0000050* | 40.6 | 0.0164 | 3.99 | 0.114 | 0.0526 | 22.5 | 0.000620 | *<0.050* | *<0.0000050* | 0.0233 | 19.2 |

| | | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Stn.Code** | **Collect Date/Time** | **D-Sb** | **D-Se** | **D-Si** | **D-Sn** | **D-Sr** | **D-Te** | **D-Th** | **D-Ti** | **D-Tl** | **D-U** | **D-V** | **D-W** | **D-Zn** | **D-Zr** |
| INFLUENT | 2019-02-06 10:40 | 0.000305 | 0.000276 | 1.66 | 0.000563 | 0.160 | *<0.00020* | *<0.00010* | *<0.00030* | 0.0000061 | 0.000157 | 0.000109 | 0.00031 | 0.0101 | *<0.000060* |
| FMS_TEST10 | 2019-03-07 10:50 | 0.000572 | 0.000229 | 2.91 | 0.000345 | 0.319 | *<0.00020* | *<0.00010* | *<0.00030* | 0.0000085 | 0.00104 | 0.000082 | 0.00016 | 0.0016 | *<0.000060* |
| FMS_TEST10 | 2019-03-21 14:05 | 0.000357 | 0.000342 | 3.44 | 0.000276 | 0.302 | *<0.00020* | *<0.00010* | *<0.00030* | *<0.0000020* | 0.000610 | 0.000099 | 0.00015 | *<0.0010* | *<0.000060* |
| FMS_TEST10 | 2019-04-04 15:45 | 0.000317 | 0.000255 | 3.63 | 0.000277 | 0.258 | *<0.00020* | *<0.00010* | *<0.00030* | *<0.0000020* | 0.000368 | 0.000086 | 0.00018 | *<0.0010* | *<0.000060* |
| FMS_TEST10 | 2019-04-17 14:00 | 0.000270 | 0.000142 | 3.71 | 0.000283 | 0.281 | *<0.00020* | *<0.00010* | *<0.00030* | *<0.0000020* | 0.000349 | 0.000074 | 0.00019 | *<0.0010* | *<0.000060* |
| FMS_TEST10 | 2019-05-02 14:30 | 0.000246 | 0.000183 | 4.18 | 0.000267 | 0.242 | *<0.00020* | *<0.00010* | *<0.00030* | *<0.0000020* | 0.000258 | 0.000058 | 0.00018 | *<0.0010* | *<0.000060* |
| FMS_TEST10 | 2019-05-16 14:30 | 0.000221 | 0.000135 | 4.38 | 0.000228 | 0.216 | *<0.00020* | *<0.00010* | *<0.00030* | *<0.0000020* | 0.000228 | *<0.000050* | 0.00017 | *<0.0010* | *<0.000060* |
| FMS_TEST10 | 2019-06-13 15:30 | 0.000186 | 0.000115 | 4.86 | 0.000190 | 0.215 | *<0.00020* | *<0.00010* | *<0.00030* | *<0.0000020* | 0.000276 | 0.000071 | 0.00016 | *<0.0010* | *<0.00020* |
| FMS_TEST10 | 2019-07-11 15:00 | 0.000174 | 0.000068 | 4.71 | 0.000155 | 0.218 | *<0.00020* | *<0.00010* | *<0.00030* | *<0.0000020* | 0.000280 | 0.000074 | 0.00013 | *<0.0010* | *<0.00020* |

**Notes:**
Values in blue italics are below detection limit.

# Appendix F.3

Fifteen Mile Stream Project Mine Rock Management Plan,
Lorax Environmental Services Ltd.

# Fifteen Mile Stream Project
# Mine Rock Management Plan

**Prepared for:**
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**Project No. A550-4**

**9 September 2020**

# Document Revision Record

| Date | Nature of Change | Page Inserted, Replaced, Revised or Cancelled | Signature |
|---|---|---|---|
| April 8, 2020 | Draft v.1 | | Lorax |
| September 9, 2020 | Final v.1 | | Lorax |
| | | | |
| | | | |

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# 1. Introduction

## 1.1 Project Background

The Fifteen Mile Stream (FMS) project is a proposed gold mine owned by Atlantic Mining Nova Scotia Inc. (AMNS) a wholly owned subsidiary of St. Barbara Limited. The property is located in the Moose River Gold Mines District, around 100 km northeast of Halifax, Nova Scotia, and 35 km northeast of the currently operating Touquoy gold mine. The FMS project includes three zones – the Egerton Zone, the Hudson Zone, and the Plenty Zone. The Environmental Impact Statement (EIS) currently only includes development of the Egerton Zone. Based on a cut-off grade of 0.3 g/t Au, the total measured and indicated mineral resource estimates for the Egerton Zone is 14.57 Mt at a grade of 1.16 g/t Au (Atlantic Gold, 2019). The project is expected to produce 543,500 oz. of gold from this zone over the life of mine.

Geologically, the FMS deposit falls into the Meguma Terrane which hosts various gold deposits in southern and central Nova Scotia. The main geological units at the site are argillite and greywacke; however, these units are interbedded and intermediate classifications are included in between these two endmembers. Lithological codes for the main units encountered on site include ***AR*** (argillite with <5% greywacke), ***AG*** (argillite with 5-49% greywacke), ***GA*** (greywacke with 20-50% argillite), and ***GW*** (greywacke with <20% argillite). Rock with a higher proportion of argillite beds generally have a higher risk of ARD due to the higher overall sulphide content and lower neutralization potential of this unit (Lorax, 2019a).

This Mine Rock Management Plan has been prepared in support of the EIS as the need for management and monitoring of metal leaching/acid rock drainage (ML/ARD) produced by FMS mine rock and tailings is expected. This Mine Rock Management Plan is intended to be a living document and will be updated as additional geochemical data become available and/or based on the requirements by regulatory agencies.

Mine rock is herein defined as ore and waste material that is produced by blasting. While ore is either directly processed or temporarily stockpiled for later processing, waste material may be permanently stored in a Waste Rock Storage Area (WRSA) or used as construction material for site infrastructure if it meets material specifications and is classified as non-Potentially Acid Generating (NPAG).

Tailings are the fine-grained waste product of the gold concentration process which will occur at the FMS processing plant. The gold concentrate produced at site will then be transported to the Touquoy processing facility where the final processing to gold doré will take place. The tailings produced at the FMS facility will be deposited in an above-ground tailings management facility (TMF) where the bulk of the material will be stored under water-saturated conditions during operations. The TMF will then be drained after mine closure and a portion of the tailings will become exposed to atmospheric conditions. The well-mixed nature of the tailings materials along with the saturated storage conditions need to be considered when assessing the ARD potential within the TMF. The location and site layout of the FMS project are shown in Figure 1-1.

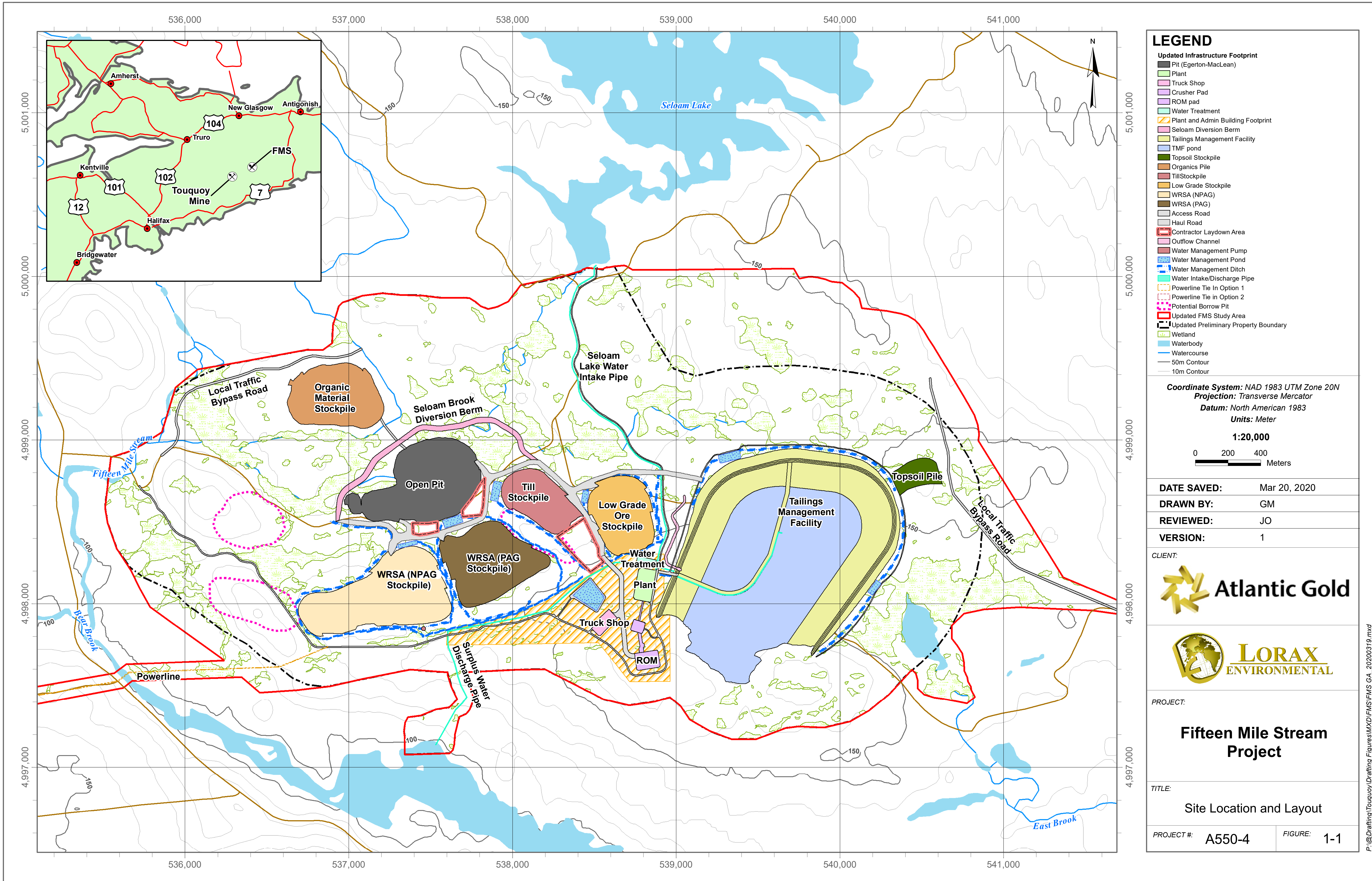
## 1.2 Scope and Purpose

The purpose of this Mine Rock Management Plan is to formalize monitoring procedures in place at the mine as well as to provide guidance to AMNS with respect to best practice ML/ARD mitigation strategies that may be considered should the results from the monitoring program indicate mitigation is necessary. To that end, this document is intended to serve as a geochemical reference guide for the various different activities at the mine that have a direct or indirect impact on ML/ARD-related processes. Ultimately, the Plan will allow for proactive material handling and contaminant source control to minimize mining effects on water quality and protect the downstream aquatic environment. Specific components to be discussed in this Plan include:

- ML/ARD monitoring and analysis in support of the understanding of the site’s waste rock and ore classifications;
- Material handling strategies for potentially acid generating (PAG) and NPAG materials;
- Definition of materials suitable for construction of site infrastructure; and
- Verification sampling and monitoring of mine rock and tailings to test the effectiveness of the implemented mitigation measures.

## 1.3 Report Structure

Following the introduction and background provided in this chapter, Chapter 2 provides an overview of the classification of ML/ARD potential at FMS. Chapter 3 covers the specific roles and responsibilities of personnel involved in ML/ARD management. Chapter 4 summarizes the monitoring and management requirements for waste rock and tailings and lastly, Chapter 5 outlines the reporting requirements.


LEGEND
Updated Infrastructure Footprint
Pit (Egerton-MacLean)
Plant
Truck Shop
Crusher Pad
ROM pad
Water Treatment
Plant and Admin Building Footprint
Seloam Diversion Berm
Tailings Management Facility
TMF pond
Topsoil Stockpile
Organics Pile
TillStockpile
Low Grade Stockpile
WRSA (NPAG)
WRSA (PAG)
Access Road
Haul Road
Contractor Laydown Area
Outflow Channel
Water Management Pump
Water Management Pond
Water Management Ditch
Water Intake/Discharge Pipe
Powerline Tie In Option 1
Powerline Tie in Option 2
Potential Borrow Pit
Updated FMS Study Area
Updated Preliminary Property Boundary
Wetland
Waterbody
Watercourse
50m Contour
10m Contour
Coordinate System: NAD 1983 UTM Zone 20N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter
1:20,000
0 200 400
Meters
DATE SAVED: Mar 20, 2020
DRAWN BY: GM
REVIEWED: JO
VERSION: 1
CLIENT:
Atlantic Gold
LORAX ENVIRONMENTAL
PROJECT:
Fifteen Mile Stream Project
TITLE:
Site Location and Layout
PROJECT #: A550-4
FIGURE: 1-1
P:\@Drafting\Touquoy\Drafting Figures\MXD\FMS\FMS GA_20200319.mxd
Amherst
New Glasgow
Antigonish
Truro
104
FMS
Kentville
101
102
Touquoy Mine
7
12
Halifax
Bridgewater
536,000
537,000
538,000
539,000
540,000
541,000
5,001,000
5,000,000
4,999,000
4,998,000
4,997,000
N
Seloam Lake
Seloam Lake Water Intake Pipe
Local Traffic Bypass Road
Organic Material Stockpile
Seloam Brook Diversion Berm
Open Pit
Till Stockpile
Low Grade Ore Stockpile
Tailings Management Facility
Topsoil Pile
Fifteen Mile Stream
WRSA (PAG Stockpile)
WRSA (NPAG Stockpile)
Water Treatment
Plant
Truck Shop
ROM
Surplus Water Discharge Pipe
Powerline
Bear Brook
East Brook
150
100

# 2. Classification of Acid Rock Drainage Potential

The ML/ARD potential of the various geologic materials at FMS has been previously assessed through geochemical testing (Lorax, 2019a). Both static and kinetic tests were conducted on the FMS mine rock and tailings. The results indicate that, although the sulphide contents at FMS are relatively low, there is potential for ML/ARD. This is recognized in the mine plan which provides for separate PAG and NPAG WRSAs. As such, operational ML/ARD monitoring is warranted to the demonstrate the performance of the planned material handling strategies.

The ML/ARD potential of operational monitoring samples will be classified using acid-base accounting (ABA) results. These analyses are expected to be performed both on-site for selected parameters as well as externally at an accredited laboratory. It should be noted that the on-site laboratory may be located at the Touquoy mine site.

## 2.1 Neutralization Potential (NP) Determination

The geochemical characterization program included both modified Sobek neutralization potential (modified NP) and carbonate neutralization potential (CaNP) (Lorax, 2019a). Modified NP provides a bulk measurement of NP. The CaNP is calculated from the total inorganic carbon (TIC) content as it is assumed that the inorganic C is present as carbonate minerals. For the purpose of this Plan it is recommended that the modified NP is used for classification of the samples. This metric is determined through a titration-based method conducted at room temperature that is not mineral-specific. Therefore, the modified NP inherently accounts for the buffering capacity from non-carbonate minerals as well as the reduced neutralization potential of Fe- and Mn-bearing carbonates (*e.g.*, ankerite, siderite). Silicate minerals that may act as neutralizing agents once carbonate phases are depleted include biotite, chlorite, and certain clay minerals.

## 2.2 Acid Potential (AP) Determination

The acid generating potential of a rock sample is estimated based on its sulphur content. The amount of acidity generated per mass of sulphur depends in large part on the mineralogy and solid phase speciation of sulphur. That is, different sulphide and sulphate minerals produce different amounts of acidity when weathered. The sulphide mineralogy of the FMS samples includes pyrite, pyrrhotite, chalcopyrite, and arsenopyrite, all of which generate acidity in response to oxidative weathering. Due to the lack of acidic sulphate salts in the FMS mine materials, acid potential (AP) is calculated on the basis of the sulphide sulphur content in a given sample (Lorax, 2019a). Sulphide sulphur is, in turn, conservatively calculated by subtracting the sulphate sulphur (by carbonate leach) from the total sulphur value.

The AP for the FMS mine rock is then calculated as:

$$AP\ (kg\ CaCO_3/tonne) = 31.25 \times sulphide\text{-}S\ (wt.\ \%)$$

This conversion stoichiometrically accounts for the amount of acidity released per 1% of pyrite contained in the rock material and assumes that all sulphide is available for oxidation. The AP is given in units of kg $CaCO_3$/tonne to allow the direct comparison with NP.

### 2.3 PAG Definition

The likelihood for a sample to generate acidity can be quantified by the comparison of NP and AP. The net potential ratio (NPR = NP/AP) represents a measure that is commonly used to identify whether a sample is PAG or NPAG. Typically, in agreement with recommendations made in Price (2009), a sample can be considered PAG if the NPR falls below a value of 2, while samples with NPR $\geq$ 2 can be considered NPAG. In other words, according to this classification the NP has to be at least twice as high as the AP in order to render a sample NPAG. This approach is conservative and accounts for the potential partial occlusion of carbonate (and other acid-buffering) minerals.

The spatial discretization of the PAG proportions was conducted through the incorporation of NPR values from the initial geochemical characterization (Lorax, 2019a) into the site's geologic block model. NPR values were interpolated across the deposit, as would be done for gold grades, and the model output was provided to the mine planning team for the calculation of PAG and NPAG tonnages. The resulting estimated proportions of PAG rock were around 12.5% of the total waste rock tonnage produced (Lorax, 2019b).

# 3. Planning

## 3.1 Roles and Responsibilities

A summary of the roles and responsibilities for the ML/ARD management sampling programs are provided in Table 3-1. Mine rock sample collection and material management should be undertaken by the mine Geologist and Mine Operations. Tailings sampling will be conducted by the metallurgists at site. The on-site analyses will include rinse pH, total S and NP. These analyses will be conducted by personnel in the on-site laboratory. The pH and conductivity monitoring of waste rock and tailings contact water should be conducted by environmental field technicians as part of a large water quality monitoring program at site. Ultimately, the Environmental Superintendent will review the ML/ARD results from the sampling programs and report to Nova Scotia Environment (NSE), if required.

**Table 3-1:**
**Summary of Roles and Responsibilities**

| Department/Title | Roles and Responsibilities |
| --- | --- |
| *Grade Control or Blast Hole Sampling* | |
| Mine Geologist | • Collect grade control samples, if possible<br>• If blast hole samples are to be collected, classify the blast material and determine the variability in geology in the blast area<br>• Determine if the sampling density is suitable to characterize the blast<br>• Communicate with Mine Operations & Engineering<br>• Oversee the ML/ARD sampling program<br>• Review and update blast materials sampling procedure in SOP<br>• Notify Environment and Mine Operations & Engineering departments if PAG identified based on on-site sulphur and NP testing. |
| Mine Operations & Engineering | • Plan blasting and oversee blasting activities<br>• Appropriate material handling for PAG and NPAG material, once classified |
| Health & Safety | • Review and audit Blast Hole Sampling procedure outlined in the SOP |
| Environment | • Review blast materials sampling procedure in SOP<br>• Ship samples to external lab for appropriate testing<br>• Review ML/ARD sampling results and communicate with Geology and Mine Operations and Engineering<br>• Report results to NSE |

**Table 3-1 (continued):**
**Summary of Roles and Responsibilities**

| Department/Title | Roles and Responsibilities |
|---|---|
| *Tailings Sampling* | |
| Chief Metallurgist | • Review and update tailings sampling procedure in SOP |
| Metallurgist | • Review and update tailings sampling procedure<br>• Assist Metallurgical Technician in the undertaking of the sampling procedure in the SOP |
| Metallurgical Technician | • Perform tailings solid sampling following the procedure outlined in the SOP |
| Health & Safety | • Review and audit Tailings Solids Sampling procedure, as outlined in the SOP |
| Environment | • Review tailings sampling procedure in SOP<br>• Review ML/ARD sampling results<br>• Report results to NSE |
| *On-Site Analyses* | |
| Laboratory Manager | • Review and update the rinse pH, total S, and NP on-site analytical procedures<br>• Assist the Laboratory Technician in undertaking the analyses<br>• Review the results of the on-site analyses and provide to Environment |
| Laboratory Technician | • Perform the rinse pH, total S, and NP analyses |
| Health & Safety | • Review and audit the analytical procedures |
| *pH and Conductivity Monitoring* | |
| Department/Area Supervisors | • Provide field technicians with necessary tools required to complete the work safely |
| Field Technician | • Collect weekly pH and conductivity measurements of drainage water pumped from the open pit (surface) mine and draining from the waste rock stockpiles<br>• Enter field results into the database |
| Health & Safety | • Review and audit Surface Water Sampling procedure |
| Environmental Superintendent | • Maintain database for inspection by NSE, if required |

## *3.2 Quality Assurance/Quality Control (QA/QC)*

QA/QC measures will be implemented during both the sampling and the geochemical analysis of the blast hole and tailings materials. One in every 10 samples analyzed for a limited parameter suite by the on-site laboratory shall be submitted to an external laboratory for full ABA and solid phase metals. The full ABA analysis will include sulphur speciation (total S, sulphate S, and sulphide S), total inorganic carbon and modified NP. These results will be compared to the on-site analyses to ensure that the results are in good agreement.

The sampling QA/QC protocol will also include the collection of a replicate sample for every 10th blast hole monitoring sample and for every 10th tailings sample. The sample collection procedure for the replicate sample should be identical to that for the original sample. Laboratory QA/QC measures will include the implementation of analytical duplicates and the use of certified reference materials.

The field pH and conductivity probe should be properly maintained and calibrated regularly. Field QA/QC for pH and conductivity monitoring should include collecting duplicate readings at one in every ten sites. In addition, the field measurements should be compared to laboratory values when water quality samples are collected at these monitoring stations.

# 4. Monitoring and Management

## 4.1 Mine Rock

### 4.1.1 In-Pit Monitoring

Waste rock will be monitored by either collecting grade control samples or blast hole cuttings from within the open pit. To allow for flexibility with respect to material classification and handling, the collection and analysis of ML/ARD monitoring samples should be conducted as early as possible. Grade control samples are therefore preferable as they are generally collected well before blasting occurs and serve to produce the final definition of ore reserves. Conversely, blast holes are drilled only shortly (1 to 3 days) before a blast is executed. This type of sample is acceptable if rapid on-site testing can provide an ARD classification for the blasted mine rock before placement in designated storage areas.

The recommended minimum sampling frequencies for in-pit mine rock and construction material include:

- One sample for every 100,000 tonnes of waste rock mined in-pit; and
- One composite sample for shake flask extraction (SFE) testing per 50,000 tonnes of construction material.

ML/ARD potential for the FMS project will be determined via on-site ABA. Parameters determined as part of the operational monitoring program should, at a minimum, include:

- Rinse pH;
- Total sulphur; and
- Modified NP.

If it is not feasible to determine modified NP rapidly on-site, an NP proxy based on total C or another solid-phase species (*e.g.*, Ca) may need to be developed.

The NPR is calculated as NP/AP. For the on-site testing, total sulphur content will be used as the basis for AP and the calculation of the NPR. For the purpose of this Mine Rock Management Plan, a sample is considered PAG if it shows an NPR < 2 in accordance with recommendations made in Price (2009).

Total sulphur alone cannot be used as a proxy for characterizing material as PAG or NPAG at the FMS site. Samples classified as NPAG (NPR > 2) have a wide range of total sulphur contents (Figure 4-1). Based on the current data, PAG samples may have total sulphur content as low as approximately 0.15%. Using this value as a proxy would misclassify a large proportion of NPAG samples as PAG material. As such, both total sulphur and NP (or an NP proxy) are required to more accurately classify the material.

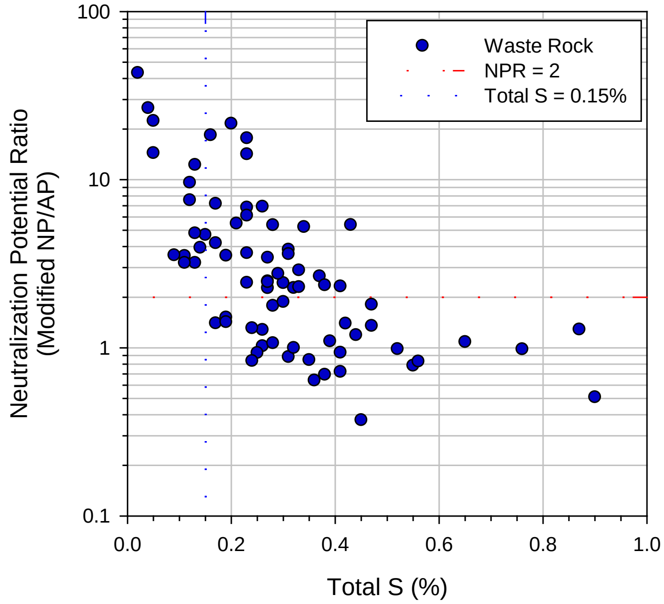



**Figure 4-1: NPR versus total S in Fifteen Mile Stream waste rock samples**

### 4.1.2 Material Handling and Management

From an environmental standpoint, three general types of material are expected to be produced during mining, namely NPAG waste rock, PAG waste rock, and ore. While ore will either be processed directly or temporarily stockpiled for later processing (if low-grade), waste material will be hauled to the WRSAs for permanent storage or used for the construction of mine infrastructure. The WRSAs were designed such that PAG and NPAG waste material are stored in separate facilities in order to better control the potential for acidic drainage and associated metal loads and mine water management. As such, material handling efforts will focus on the optimization of PAG and NPAG identification and segregation. The following provides an overview of some industry best practice measures that would apply to the FMS mine rock and tailings storage facilities.

#### *4.1.2.1 Waste Rock*

Once the geochemical character of a mining block has been determined, waste rock will be segregated accordingly and transported to the corresponding PAG and NPAG WRSAs (Figure 4-2). As mentioned previously, the timely definition of contiguous PAG zones through combined pre-mine geochemical testing along with pro-active operational

ML/ARD monitoring within the open pit will allow for increased flexibility with respect to developing material movement plans.

To further reduce the potential for the release of net acid and elevated metal loads, the following ML/ARD mitigation strategies should be considered.

Handling of Misclassified PAG Rock within NPAG WRSA

Although all efforts will be made to effectively segregate PAG and NPAG waste rock, the misclassification of a portion of the mined blast rock through unrepresentative subsampling cannot be ruled out in all cases. These cases would likely come to light during verification monitoring (see Section 4.1.3). In a sensitivity analysis, the site-wide water quality model has considered the possibility of PAG rock misplacement in the NPAG WRSA for up to 2% of the NPAG WRSA. Under the current mine plan, this accounts for approximately 8% of all PAG material being misclassified, which is conservative. Besides assessing the effect of the PAG rock being deposited in the NPAG WRSA on water quality, source control measures can be implemented to minimize the impact of PAG rock on NPAG WRSA seepage quality. Such measures include:

a. Blending of PAG and NPAG materials;
b. Encapsulation of PAG rock; and
c. Re-location of PAG rock

The objective of blending PAG and NPAG materials is to obtain an NPAG composite. The method concept is based on the principle that excess NP in the NPAG material will neutralize the acid produced by the PAG material. A good understanding of the variability in NP and AP for both PAG and NPAG material is required in order to determine the proportions of PAG and NPAG material that will consistently produce an NPAG composite. Generally, since complete mixing of PAG and NPAG rock may not be easily achievable in coarse waste rock materials and zones with higher PAG material concentrations can be expected, the blended layers pile should have a target bulk NPR of $\geq 3$.

Encapsulation is a specific type of blending option that requires PAG material to be entirely enclosed by NPAG material. This decreases the exposure of the PAG material to both water and oxygen and provides alkalinity before and after water comes in contact with the PAG zone. In order to be effective, any acidic seepage generated by the PAG material must be neutralized by the encapsulating NPAG material.

Relocation of material to the PAG WRSA may be required if verification monitoring suggests that the volumes of misplaced PAG materials are higher than expected and if in-situ mitigation strategies prove to be insufficient. The re-handling of these materials will be required to avoid effects of localized ARD development in the NPAG WRSA and associated effects on the aqueous environment.

Placement of Synthetic or Natural Cover on PAG WRSA

Covers over PAG material limit ML/ARD by reducing the exposure of the PAG material to water and oxygen. These can include geosynthetic covers or geomembranes as well as natural covers made of low hydraulic conductivity material such as till or clay or store and release covers. The covers must be carefully constructed in order to meet the design objectives and may require regular inspection for potential damage. Decisions around cover design may be made as more information around PAG balance and reactivity becomes available via operational ML/ARD monitoring.

The benefits of cover placement are twofold. First, the cover will shed precipitation and thereby reduce the infiltration rate and net percolation within the WRSA. The resulting lower seepage rates will result in a reduction of the overall geochemical load being released from the WRSA which facilitates water management or treatment, if necessary. Second, both synthetic and natural covers may be designed to act as an oxygen barrier that slows the diffusion of oxygen into the waste pile. Once pore water oxygen is depleted by sulphide oxidation, the slow replenishment of oxygen through the cover will result in a lower proportion of the WRSA being exposed to oxygen. As such, the risk for ARD developing throughout the pile is reduced.

#### *4.1.2.2 Ore*

Material classified as ore will either be processed directly or transported to the low-grade ore stockpile for temporary storage. Based on the current knowledge of FMS ore, these materials contain sufficient NP to buffer acidity at circum-neutral pH levels for the duration of the operating mine life until re-handling and processing is initiated prior to closure. Therefore, no special handling considerations are currently proposed. Should continued operational monitoring indicate contiguous areas of low-NP PAG material, a geochemical investigation into the lag time to onset of ARD and potential mitigation measures will be triggered. In addition, if unforeseen circumstances render the low-grade ore stockpile uneconomic, effectively rendering it a permanent waste rock facility, then ARD mitigation measures will need to be re-evaluated and implemented as necessary. To pro-actively manage for such a scenario, the placement of the ore stockpile in proximity to the PAG WRSA may be beneficial for water management purposes and for the implementation of post-closure strategies such as cover placement.

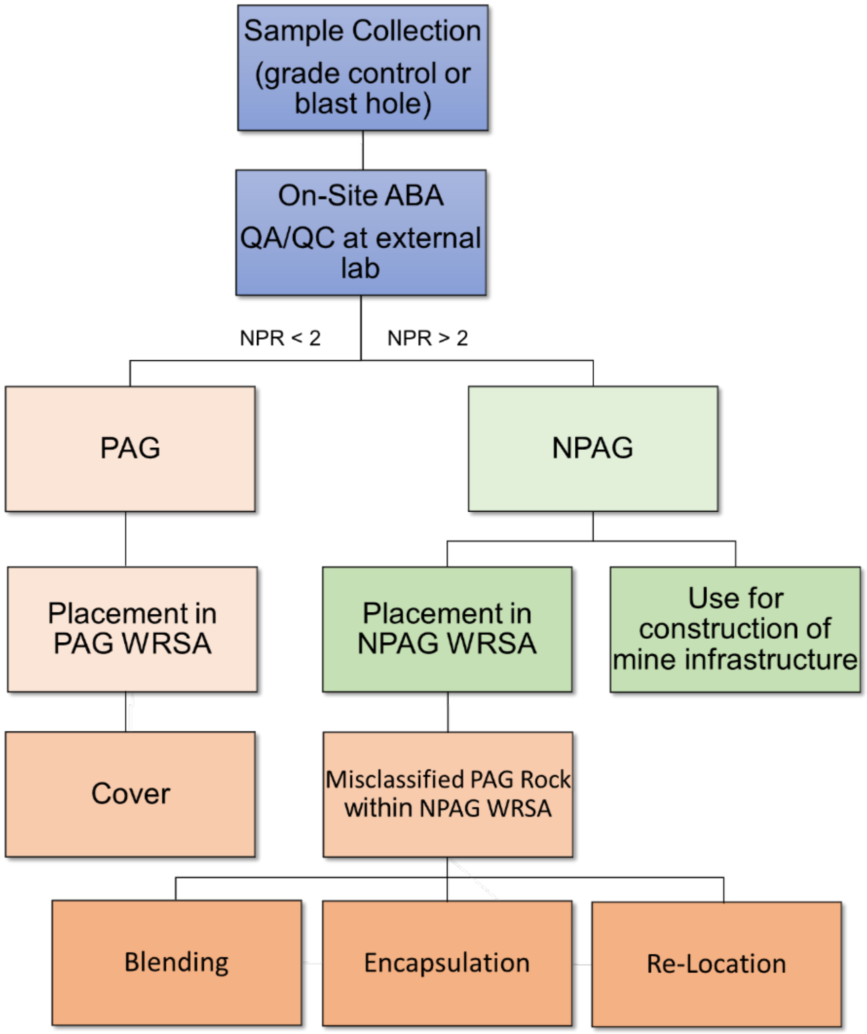



**Figure 4-2: In-Pit Material Handling Decision Tree**

### 4.1.3 Verification Monitoring

Confirmatory sampling of placed waste rock and ore should be conducted in the WRSAs and in areas where waste rock is used for construction. This sampling program will comprise surface sampling along freshly placed material and will ensure that proper material handling protocols have been implemented and that placement of PAG material has been properly managed. A sampling frequency of one sample per every 400,000 tonnes of material placed is recommended. These samples should be submitted for ABA and aqua-regia digestible metals.

In addition to mine rock sampling, regular surface water monitoring of the waste rock collection ponds as well opportunistic sampling of surface seeps is recommended as part of the verification monitoring for the site. Any ML/ARD influence on the pond water quality would be indicated by a decrease in pH and/or an increase in sulphate and metal concentrations. Such water monitoring will allow for the early detection of waste rock zones that have turned acidic and may trigger adaptive management.

## *4.2 Tailings*

### 4.2.1 Monitoring

The recommended monitoring frequency for tailings samples is one sample for every 100,000 tonnes of ore processed. Tailings slurry samples will be collected from the tailings screen at the mill. The slurry is then filtered, and the tailings solids are submitted to the lab for analysis. These samples should be analyzed for ABA at a minimum. Analysis for aqua-regia digestible metals is also recommended. Note that kinetic testing in the form of saturated columns is currently being operated at the Lorax laboratory in order to quantify metal leaching rates under suboxic conditions. These experiments were used as the basis for source term and water quality model predictions.

### 4.2.2 Material Handling and Management

The tailings slurry will be deposited in the TMF and a water cover will be maintained over the bulk of the tailings volume during operations, with tailings beaches being intermittently exposed to the atmosphere. In post-closure, the TMF will be drained and the majority of the tailings in the upper TMF zones will be subject to oxidative weathering. During operations, the ML/ARD risk from the FMS tailings is expected to be limited due to predominantly water-saturated storage within the TMF. Further, the geochemical assessment of tailings produced by metallurgical testing showed that materials produced by conventional ore processing, which is the designated method for FMS ore, have NPAG character (Lorax, 2019b). As opposed to blast rock, the acid-producing and acid-consuming phases in the tailings slurry will be well mixed which generally bears a lower risk of localized ARD. In combination, the presently available information suggests that the risk for ARD from exposed tailings is low, even under oxidizing conditions.

Operational experience at Touquoy will be used to develop management strategies for the FMS tailings, if needed. Nevertheless, should operational monitoring unexpectedly show larger quantities of PAG tailings being deposited in the TMF, the following mitigation strategies similar to those already discussed in Section 4.1.2.1 should be considered:

- Covering of PAG with NPAG tailings in the long-term; and
- Synthetic or natural dry covers on TMF.

In addition, potential mitigation options specific to tailings that may be implemented, if required, are:

- Increased addition of lime; and
- Subaqueous storage.

Increased Addition of Lime

Increasing the amount of lime added to the tailings will increase the neutralization potential of the tailings stream. The volume of lime added must be sufficient to neutralize the acid generating potential of the tailings to increase the NPR > 2.

Subaqueous Storage

Storage of PAG material under water cover reduces sulphide mineral oxidation by decreasing the availability of dissolved oxygen; however, there may be impacts to water quality through pH and/or redox-dependent processes. In order to maintain a continual water cover over the PAG material, consideration must be given to the design of the storage facility's water balance and long-term geotechnical stability. If monitoring suggests that the tailings stream has PAG character for extended periods of time, preferential deposition in the saturated zones of the TMF should be considered.

# 5. Implementation and Reporting

## 5.1 Record Keeping and Tracking

The Environmental Superintendent or designate is responsible for the implementation of the Mine Rock Management Plan with support from Mine Engineering, Geology, and Mill Metallurgy. The laboratory chain of custody (COC) and raw data files from the laboratory should be kept on file. Field notes and both on-site and external laboratory test results should be compiled into an electronic database. The Environmental Superintendent or designate will be responsible for the maintenance of the original records and database. Records of ML/ARD assessment testwork and weekly pH measurements for drainage water quality must be available on site for inspection by NSE.

Tracking of lithologies (argillite- versus greywacke-dominated) for the individual blasts is recommended where possible due to the known different geochemical behaviour of the two rock type end-members. A record of the volume, material type, and material placement should be maintained by Mine Operations & Engineering and updated on a regular basis. A copy of the record should be provided to Atlantic Gold's environmental department on a monthly basis. Investigation and corrective action will be undertaken if monitoring data indicates that actual geochemical characteristics are significantly different than expected based on the geochemical characterization testwork conducted to date.

### 5.1.1 Monitoring Reporting

A summary of the ML/ARD results and material placement should be provided in the Annual Report. An analysis of the new sampling results should be included and any notable deviations from previous years should be discussed.

### 5.1.2 Incident Reporting

If test results indicate that currently acid-generating (AG) rock, identified by means of rinse pH measurements, is encountered, NSE will be notified. The location and volume of AG material should be estimated and recorded. At a minimum, an AG sample would trigger confirmatory analysis. Additional monitoring, mitigation, and/or relocation to the PAG WRSA may be required.

# 6. Closure

This report was prepared by Lorax Environmental Services Ltd. for the exclusive use of Atlantic Mining Nova Scotia Inc. This initial plan has been developed to outline ML/ARD monitoring measures and management options that can be considered for the Fifteen Mile Stream project. Please contact the undersigned should you have any questions or comments or require additional information in support of this work.

Sincerely,
**LORAX ENVIRONMENTAL SERVICES LTD.**

Prepared by:

| | |
|---|---|
| ***Original Signed By*** | ***Original Signed By*** |
| **Jennifer Stevenson, M.Sc., G.I.T.**<br>Environmental Scientist | **Timo Kirchner, M.Sc., P.Geo.**<br>Environmental Geoscientist |

**Reviewed by:**

***Original Signed By***

**Bruce Mattson, M.Sc., P.Geo.**
Senior Environmental Geoscientist.

# References


Atlantic Gold Corporation (2019). Moose River Consolidated Mine, Nova Scotia, Canada, NI 43-101 Technical Report. March 25, 2019.

Lorax (2019a). Fifteen Mile Stream Project – ML/ARD Assessment Report. Technical report prepared for Atlantic Mining NS Corp. August 28, 2019.

Lorax (2019b). Fifteen Mile Stream Project: Geochemical Source Term Predictions. Technical report prepared for Atlantic Mining NS Corp.; September 18, 2019.

Price, W.A. (2009). Prediction Manual of Drainage Chemistry from Sulphidic Geologic Materials. Canadian Mine Environment Neutral Drainage (MEND). Report 1.20.1.

Atlantic Gold

# Appendix G.1

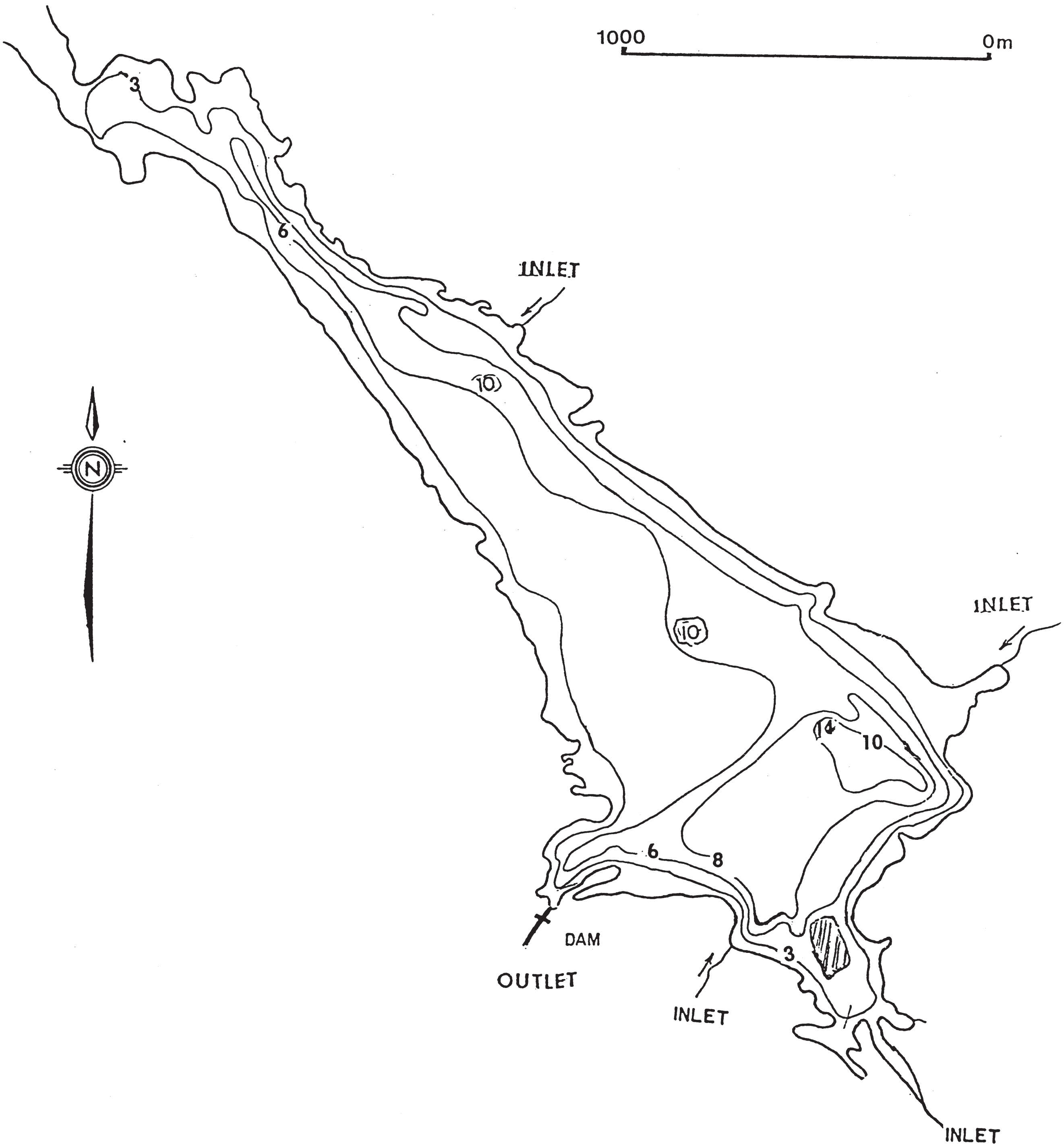
## Seloam and Antidam Bathymetry Lake Inventory Maps from Nova Scotia Department of Fisheries and Aquaculture

Retrieved from: https://novascotia.ca/fish/sportfishing/our-lakes/lake-inventory/

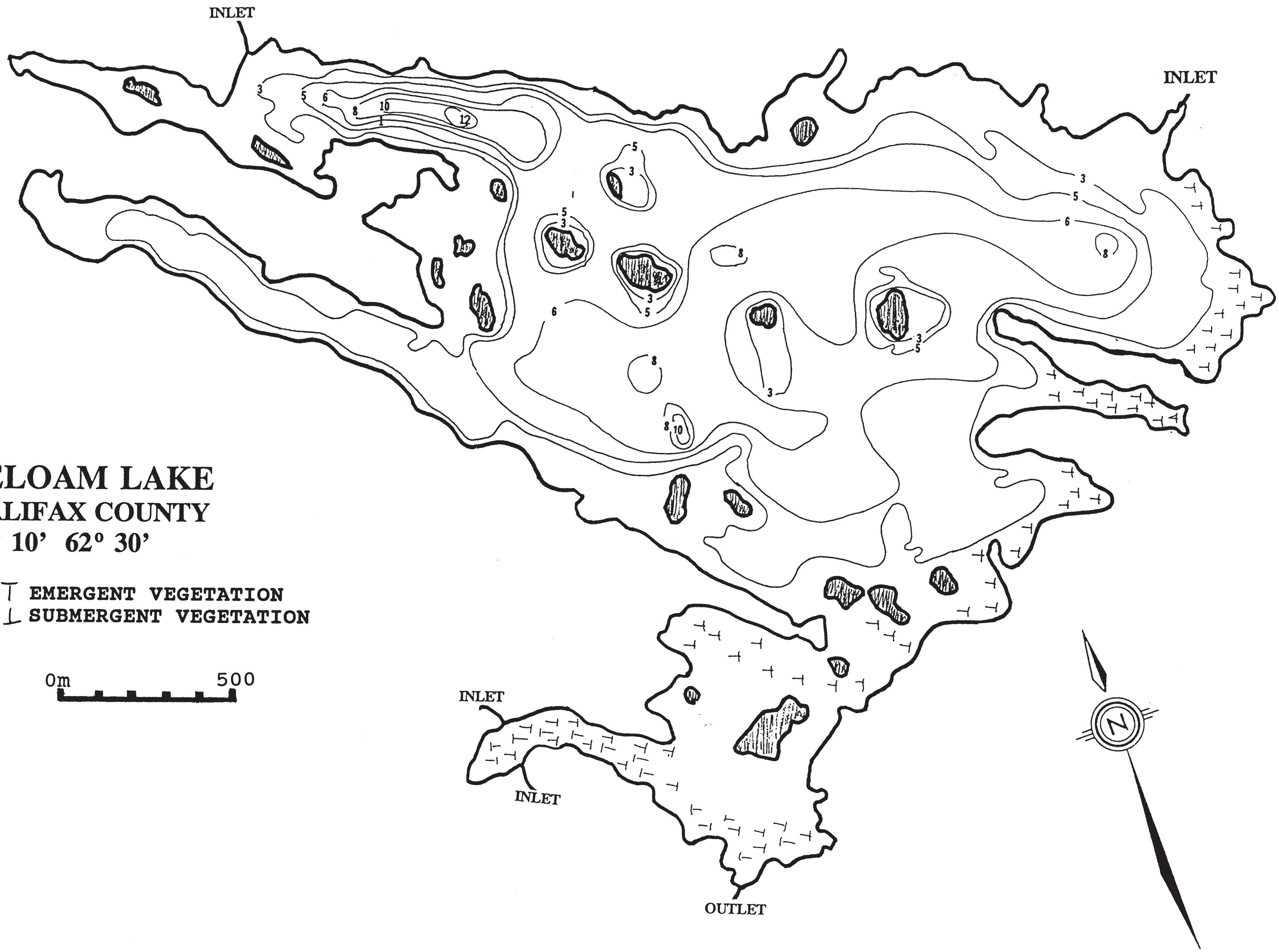
# ANTIDAM FLOWAGE

HALIFAX CO.

45° 07" N 62° 30" W



# SELOAM LAKE
## HALIFAX COUNTY
## 45° 10' 62° 30'



# Appendix G.2

Benthic Invertebrate Species in Freshwater Surber Samples
- Fifteen Mile Stream,
Envirosphere Consultants Limited

# BENTHIC INVERTEBRATE SPECIES COMPOSITION IN FRESHWATER SURBER SAMPLES— FIFTEEN MILE STREAM

Lab Number: L2018-77

February 2019

Report to:

McCallum Environmental Ltd., Bedford, Nova Scotia

Prepared by:

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BENTHIC INVERTEBRATE SPECIES COMPOSITION IN
FRESHWATER SURBER SAMPLES—FIFTEEN MILE STREAM
for
McCallum Environmental Ltd., Bedford, Nova Scotia

FEBRUARY 2019

## INTRODUCTION

McCallum Environmental Ltd. personnel collected freshwater benthic invertebrate samples from eighteen sample stations, from October 5 – 23, 2018. Samples were preserved in 70% Isopropyl alcohol; and subsequently shipped

to Envirosphere Consultants Limited, Windsor, Nova Scotia, for sorting, identification and enumeration of benthic invertebrates. Samples were received on October 30, 2018. The results of the analysis are presented in this report.

## METHODS

### SIEVING OF WHOLE SEDIMENTS

Aquatic benthic invertebrate samples from the streambed were collected using a Surber sampler (30.5 x 30.5 cm). The sediment samples were provided preserved (70% Isopropyl alcohol) in large Ziploc bags. Prior to sorting, samples were rinsed on an 0.5 mm sieve to remove preservative. All samples were processed at 100% with the exception of sites FIA 2.3, 3.2, 3.3 and 4.1, which were sub-sampled.

### SUB-SAMPLING OF WHOLE SAMPLES

Sub-sampling ensures efficient processing time and selection of adequate numbers of organisms for analysis (i.e. 300+ organisms). Depending on the sample volume and the expected number of organisms present, samples designated for sub-sampling are manually divided to give equal portions, which are specific fractions of the original sample (e.g. 1/2). All fractions produced during sub-sampling are weighed and verified to be equivalent (i.e. within 0.5 to 1.0 g). Final counts and biomass for the sub-samples are extrapolated to 100%, based on the sub-sample percentage. Sub-sampling can affect measures of animal abundance and biomass by increasing variability, and may lead to slightly reduced estimates of taxon richness compared to whole samples.

### SORTING AND IDENTIFICATION

Samples were examined at 6 - 6.4x magnification on a stereomicroscope, with a final brief check at 16x and all organisms were removed. Removal efficiency for lab personnel is checked by resorting 10% of samples to ensure a sorting efficiency of 90% or better (see Attachment 1). Organisms were subsequently stored in labeled vials in 70% Isopropyl alcohol. Wet weight biomass (grams per sample) was estimated by weighing animals to the nearest milligram at the time of sorting, after blotting to remove surface water.

Organisms were identified to an appropriate taxonomic level, typically to genus, using conventional literature for the groups involved (see Attachment 2). Organisms were identified by Heather Levy (B.Sc. Hons.) and verified by Valerie Kendall (M.Env.Sc.) of Envirosphere Consultants Ltd. Abundance of each taxonomic group, number of taxanomic groups (taxa richness), and wet weight biomass were estimated from the data.

## RESULTS AND DISCUSSION

Sample descriptions for samples, as received, are presented in Table 1. Identifications, abundance, taxon richness, and biomass measures are presented in Table 2. Abundance, taxon richness and biomass are expressed on a per sample basis.

Samples from FIA sites contained freshwater animals with major organism groups represented, primarily Diptera (midgefly larvae (Chironomidae and Ceratopogonidae)), Ephemeroptera (mayfly larvae), Trichoptera (caddisfly larvae), Coleoptera (aquatic beetles) and Oligochaetes (aquatic worms) were most numerous. Minor numbers of other groups such as Plecoptera (stonefly larvae), Collembola (springtails), Hemiptera (aphids), Lepidoptera (moth and butterfly larvae), Megaloptera (alderfly and dobsonfly larvae), Odonata (dragonfly and damselfly larvae), Hydrachnidia (water mites), other Diptera (Athericidae, Dolichopodidae, Empididae, Simuliidae and Tipulidae) and Mollusca (bivalves Pisidiidae; gastropods *Planorbula, Physa* and *Ferrissia*). Communities had a low to high diversity of organisms (8 –33 taxa per sample); low to high abundances (759 – 16,786 individuals per metre squared); and low to high biomasses (0.56 – 26.1 grams per metre squared) (Table 2).

Samples from Antidam sites 1 to 6 contained few animals. Oligochaetes and midgefly larvae (Chironomidae) were most numerous and present at five and three of six sites, respectively. Mollusca (bivalves) and Ephemeroptera (mayfly larvae) were present at only one of the six sites. Communities had a low diversity of organisms (1 – 3 taxa per sample); low abundances (11 – 495 individuals per metre squared); and low biomasses (<0.01 – 0.21 grams per metre squared) (Table 2).

### Limiting Conditions

The quality of the results presented in this report are dependent both on our analysis, and on the quality of samples as provided to Envirosphere Consultants Limited by the client. The analyses are based on practices normally accepted in the analysis of marine and freshwater benthic invertebrate samples, and with suitable controls for quality assurance. No other warranty is made.

Table 1. Characteristics of samples, McCallum Environmental Ltd., Fifteen Mile Stream, October 5 – 23, 2018.

| | |
|---|---|
| FIA 1.1 | Fines with organic matter (moss and leaf debris). |
| FIA 1.2 | Fine-grained sand with organic matter (detritus, leaf, woody and grass debris). |
| FIA 1.3 | Coarse to medium-grained sand with silt and organic debris (roots, woody and plant). |
| FIA 2.1 | Coarse to fine sand with silt and organic matter (grass and woody debris). |
| FIA 2.2 | Fines and organic matter (woody, leaf and detritus). |
| FIA 2.3 | Fines with organic matter (leaf and root debris). |
| FIA 3.1 | Coarse to fine gravel with sand and woody debris. Bits of glass refuse were also in the sample. |
| FIA 3.2 | Silt with organic matter (plant and woody debris). |
| FIA 3.3 | Fines with organic matter (leaf and plant debris). |
| FIA 4.1 | Organic matter (grasses, roots, algae, leaf and woody debris). |
| FIA 4.2 | Fines with organic matter (plant, algae and woody debris). |
| FIA 4.3 | Fines with organic matter (leaf, plant and woody debris). |
| Antidam 1 | Fines with detritus, grass and woody debris. |
| Antidam 2 | Organic matter (detritus and woody debris). |
| Antidam 3 | Fines with organic matter (grass, needles and plant debris). |
| Antidam 4 | Silt with organic matter (woody and plant debris). |
| Antidam 5 | Fine with fine to medium-grained sand, as well as organic matter (grass and needle debris). |
| Antidam 6 | Fines and coarse to medium-grained sand with organic matter (woody and plant debris). |

**Grain size classes: cobble = 6.4 cm and larger; pebble/ gravel = 4 mm to 6.4 cm; sand = 0.063 mm to 2 mm; silt = 0.004 mm to 0.063 mm; clay = <0.004 mm.**

Table 2. Abundance of benthic organisms in sediments from Fifteen Mile Stream, October 5 - 23, 2018.

| | | | | Raw Numbers | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date Sampled | | | | October 5 - 23, 2018 | | | | | | | | | | | | | | | | | |
| Phylum & | | | | FIA | | | FIA | | | FIA | | | FIA | | | Antidam | | | | | |
| Class | Order | Family | *Genus & Species* | 1.1 | 1.2 | 1.3 | 2.1 | 2.2 | 2.3 | 3.1 | 3.2 | 3.3 | 4.1 | 4.2 | 4.3 | 1 | 2 | 3 | 4 | 5 | 6 |
| Arthropoda Insecta | | | | | | | | | | | | | | | | | | | | | |
| | Diptera | | | | | | | | | | | | | | | | | | | | |
| | | Athericidae | | | | | | | | | | | | | | | | | | | |
| | | | *Atherix* | 0 | 11 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Ceratopogonidae | | 0 | 77 | 77 | 1419 | 22 | 220 | 11 | 88 | 66 | 132 | 253 | 77 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Chironomidae* | | 2002 | 88 | 3322 | 561 | 2376 | 2728 | 1859 | 10098 | 8096 | 12540 | 1287 | 561 | 0 | 0 | 11 | 55 | 0 | 11 |
| | | Dolichopodidae | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 33 |
| | | Empididae | | | | | | | | | | | | | | | | | | | |
| | | | *Hemerodromia* | 22 | 902 | 33 | 11 | 11 | 132 | 0 | 0 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Simuliidae* | | 0 | 22 | 11 | 0 | 0 | 0 | 0 | 0 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Tipulidae | | | | | | | | | | | | | | | | | | | |
| | | | *Antocha* | 55 | 165 | 0 | 0 | 44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | *Limnophila?* | 0 | 0 | 11 | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | *Tipula* | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | Unidentified | 11 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Ephemeroptera | | | | | | | | | | | | | | | | | | | | |
| | | Baetidae | | 0 | 22 | 44 | 0 | 0 | 0 | 0 | 22 | 176 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Caenidae | | | | | | | | | | | | | | | | | | | |
| | | | *Caenis* | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Ephemerellidae | | | | | | | | | | | | | | | | | | | |
| | | | *Eurylophella* | 33 | 231 | 44 | 0 | 33 | 0 | 176 | 528 | 506 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Heptegeniidae | | | | | | | | | | | | | | | | | | | |
| | | | *Maccaffertium* | 110 | 583 | 0 | 0 | 363 | 0 | 11 | 66 | 88 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | Unidentified | 0 | 286 | 0 | 0 | 44 | 176 | 22 | 308 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Leptophlebiidae | | | | | | | | | | | | | | | | | | | |
| | | | *Leptophlebia* | 22 | 66 | 33 | 0 | 0 | 0 | 33 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | Unidentified | 187 | 869 | 55 | 0 | 33 | 44 | 121 | 396 | 418 | 132 | 11 | 11 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Unidentified | | 0 | 0 | 22 | 11 | 583 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 0 |
| | Plecoptera | | | | | | | | | | | | | | | | | | | | |
| | Unidentified (juveniles) | | | 0 | 33 | 11 | 0 | 33 | 0 | 22 | 792 | 88 | 88 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Trichoptera | | | | | | | | | | | | | | | | | | | | |
| | | Brachycentridae | | | | | | | | | | | | | | | | | | | |
| | | | *Brachycentrus* | 44 | 55 | 0 | 0 | 44 | 88 | 11 | 286 | 374 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Dipseudopsidae | | | | | | | | | | | | | | | | | | | |
| | | | *Phylocentropus* | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Helicopsychidae | | | | | | | | | | | | | | | | | | | |
| | | | *Helicopsyche* | 0 | 121 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Hydropsychidae | | | | | | | | | | | | | | | | | | | |

Table 2. Abundance of benthic organisms in sediments from Fifteen Mile Stream, October 5 - 23, 2018.

| | | | | Raw Numbers | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date Sampled | | | | October 5 - 23, 2018 | | | | | | | | | | | | | | | | | |
| Phylum & Class | Order | Family | Genus & Species | FIA | | | FIA | | | FIA | | | FIA | | | Antidam | | | | | |
| | | | | 1.1 | 1.2 | 1.3 | 2.1 | 2.2 | 2.3 | 3.1 | 3.2 | 3.3 | 4.1 | 4.2 | 4.3 | 1 | 2 | 3 | 4 | 5 | 6 |
| | | | *Cheumatopsyche* | 0 | 0 | 0 | 0 | 88 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | *Hydropsyche* | 33 | 528 | 33 | 0 | 1628 | 572 | 22 | 462 | 44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Hydroptilidae | | | | | | | | | | | | | | | | | | | |
| | | | *Ochrotrichia*? | 66 | 220 | 99 | 55 | 11 | 44 | 11 | 286 | 44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | *Oxyethira* | 33 | 0 | 99 | 0 | 77 | 396 | 88 | 88 | 110 | 308 | 22 | 11 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Leptoceridae | | | | | | | | | | | | | | | | | | | |
| | | | *Mystacides* | 11 | 0 | 11 | 11 | 0 | 0 | 0 | 0 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | *Oecetis* | 44 | 33 | 0 | 0 | 143 | 176 | 55 | 176 | 308 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Limnephilidae | | | | | | | | | | | | | | | | | | | |
| | | | Sp A | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Philopotamidae | | | | | | | | | | | | | | | | | | | |
| | | | *Chimarra* | 0 | 11 | 0 | 11 | 561 | 132 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Phryganidae | | | | | | | | | | | | | | | | | | | |
| | | | *Ptilostomis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 11 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | Unidentified | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Polycentropodidae | | | | | | | | | | | | | | | | | | | |
| | | | *Cyrnellus?* | 110 | 187 | 11 | 0 | 88 | 704 | 0 | 44 | 44 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | *Neureclipsis* | 0 | 0 | 0 | 0 | 132 | 88 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | *Nyctiophylax* | 33 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | *Polycentropus* | 33 | 55 | 11 | 0 | 253 | 88 | 11 | 594 | 110 | 88 | 198 | 11 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | unidentified | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Rhyacophilidae | | | | | | | | | | | | | | | | | | | |
| | | | *Rhyacophila* | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Pupae | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Unidentified | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Coleoptera | | | | | | | | | | | | | | | | | | | | |
| | | Dytiscidae | | | | | | | | | | | | | | | | | | | |
| | | | *Potamonectes* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 44 | 11 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Elmidae | | | | | | | | | | | | | | | | | | | |
| | | | Adult | 242 | 0 | 0 | 22 | 407 | 440 | 22 | 242 | 132 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | *Promoresia* | 1144 | 858 | 0 | 0 | 693 | 3960 | 99 | 1672 | 2618 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | *Stenelmis* | 33 | 99 | 0 | 0 | 33 | 88 | 165 | 88 | 660 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Unidentified | | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Collembola | | | | | | | | | | | | | | | | | | | | |
| | | Isotomoidea | | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Hemiptera | | | | | | | | | | | | | | | | | | | | |
| | | Aphididae | | 0 | 0 | 0 | 0 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Lepidoptera | | | | | | | | | | | | | | | | | | | | |

Table 2. Abundance of benthic organisms in sediments from Fifteen Mile Stream, October 5 - 23, 2018.

| | | | | Raw Numbers | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date Sampled | | | | October 5 - 23, 2018 | | | | | | | | | | | | | | | | | |
| Phylum & Class | Order | Family | *Genus & Species* | FIA | | | FIA | | | FIA | | | FIA | | | Antidam | | | | | |
| | | | | 1.1 | 1.2 | 1.3 | 2.1 | 2.2 | 2.3 | 3.1 | 3.2 | 3.3 | 4.1 | 4.2 | 4.3 | 1 | 2 | 3 | 4 | 5 | 6 |
| | | | Sp A | 0 | 0 | 0 | 0 | 0 | 0 | 44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Megaloptera | | | | | | | | | | | | | | | | | | | | |
| | | Corydalidae | | | | | | | | | | | | | | | | | | | |
| | | | *Nigronia* | 44 | 11 | 0 | 0 | 22 | 44 | 0 | 88 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Sialidae | | | | | | | | | | | | | | | | | | | |
| | | | *Sialis* | 0 | 0 | 0 | 55 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Odonata | | | | | | | | | | | | | | | | | | | | |
| | | Aeshnidae | | | | | | | | | | | | | | | | | | | |
| | | | *Boyeria* | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 11 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Calopterygidae | | | | | | | | | | | | | | | | | | | |
| | | | *Calopteryx* | 0 | 0 | 0 | 0 | 0 | 44 | 33 | 88 | 88 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Coengrionidae | | 0 | 0 | 0 | 0 | 44 | 0 | 0 | 22 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Corduliidea | | | | | | | | | | | | | | | | | | | |
| | | | *Tetragoneuria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 22 | 0 | 0 | 22 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Gomphidae | | | | | | | | | | | | | | | | | | | |
| | | | *Hagenius* | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | *Gomphus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | *Stylogomphus?* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | Nymph | 0 | 0 | 0 | 0 | 0 | 0 | 44 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Unidentified | | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Athropoda Archnida | | | | | | | | | | | | | | | | | | | | | |
| | Trombidiformes | | | | | | | | | | | | | | | | | | | | |
| | | Hydrachnidae | | | | | | | | | | | | | | | | | | | |
| | | | Sp A | 33 | 22 | 33 | 33 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | Sp B | 22 | 99 | 0 | 0 | 0 | 0 | 0 | 44 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | Sp C | 0 | 33 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | Sp D | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | Sp E | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | Sp F | 0 | 0 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | Sp G | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | Sp H | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | Sp I | 0 | 0 | 0 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | Sp J | 0 | 0 | 0 | 0 | 0 | 0 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mollusca Bivalvia | | | | | | | | | | | | | | | | | | | | | |
| | Veneroida | | | | | | | | | | | | | | | | | | | | |
| | | Pisidiidae | | 11 | 66 | 11 | 0 | 22 | 0 | 0 | 22 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 0 |
| Mollusca Gastropoda | | | | | | | | | | | | | | | | | | | | | |
| | Basommatophora | | | | | | | | | | | | | | | | | | | | |


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Table 2. Abundance of benthic organisms in sediments from Fifteen Mile Stream, October 5 - 23, 2018.

| | | | | Raw Numbers | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date Sampled | | | | October 5 - 23, 2018 | | | | | | | | | | | | | | | | | |
| Phylum & Class | Order | Family | *Genus & Species* | FIA | | | FIA | | | FIA | | | FIA | | | Antidam | | | | | |
| | | | | 1.1 | 1.2 | 1.3 | 2.1 | 2.2 | 2.3 | 3.1 | 3.2 | 3.3 | 4.1 | 4.2 | 4.3 | 1 | 2 | 3 | 4 | 5 | 6 |
| | | Ancylidae | | | | | | | | | | | | | | | | | | | |
| | | | Ferrissia (limpet) | 0 | 0 | 0 | 0 | 0 | 0 | 55 | 88 | 176 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Planorbidae | | | | | | | | | | | | | | | | | | | |
| | | | *Planorbula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Physidae | | | | | | | | | | | | | | | | | | | |
| | | | *Physa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Annelida Clitellata | | | | | | | | | | | | | | | | | | | | | |
| | Aquatic Worms (Oligochaeta) | | | | | | | | | | | | | | | | | | | | |
| | | | | 33 | 374 | 33 | 0 | 0 | 132 | 132 | 154 | 88 | 44 | 704 | 11 | 121 | 22 | 0 | 11 | 99 | 451 |
| SUMMARY | | | | | | | | | | | | | | | | | | | | | |
| Abundance #/m$^2$ | | | | 4433 | 6171 | 4059 | 2233 | 7865 | 10307 | 3113 | 16786 | 14454 | 13376 | 2607 | 759 | 121 | 22 | 11 | 77 | 110 | 495 |
| Taxa Richness | | | | 27 | 33 | 24 | 13 | 31 | 21 | 27 | 27 | 29 | 8 | 15 | 12 | 1 | 1 | 1 | 3 | 2 | 3 |
| Biomass (grams/m$^2$) | | | | 3.70 | 5.35 | 0.66 | 0.56 | 26.1 | 11.2 | 2.38 | 10.3 | 13.7 | 4.46 | 1.8 | 8.07 | 0.05 | 0.01 | <0.01 | 0.21 | 0.01 | 0.13 |
| Excluded and Non-aquatic Taxa (not included in analyses). | | | | | | | | | | | | | | | | | | | | | |
| Cladocera | | | | 0 | 0 | 0 | 0 | 0 | 0 | 66 | 0 | 286 | 0 | TNTC | 165 | 0 | 0 | 0 | 0 | 0 | 0 |
| Copepoda | | | | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 132 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Diptera adult | | | | 0 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Homoptera (cast) | | | | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 0 |
| Odonata (cast) | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ostracod | | | | 0 | 0 | 0 | 0 | 0 | 176 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

*Larvae and pupae stages are combined.


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# ATTACHMENT 1 – SORTING EFFICIENCY

Envirosphere CONSULTANTS LIMITED

## Sorting Efficiency Report

Client Name/Address:

Sample Information: Fifteen Mile Stream
L2018-77

Sorted by: Joy Baker
Checked by: Heather Levy
Approved by: [illegible]

Date: January - February 2019
Date Checked: February 9, 2019
Date: Feb 11/19

| SAMPLE NUMBER | STATED NUMBER OF ORGANISMS (A) | NUMBER OF ADDITIONAL ORGANISMS FOUND (B) | SORTING EFFICIENCY (%) (A/(A+B)) X 100 | SORTED BY (Initials) |
|---|---|---|---|---|
| 1. Antidam 6 100% | 45 | 3 | 93.8% | |
| 2. FIA 3.2 50% | 763 | 33 | 95.9% | |
| 3. | | | | |
| 4. | | | | |
| 5. | | | | |
| 6. | | | | |
| 7. | | | | |
| 8. | | | | |
| 9. | | | | |
| 10. | | | | |

Comments:

M:\myfiles\ENVIROSPHERE Benthic Lab\QA_QC forms\Sorting Efficiency Report Form\Sorting Efficiency Report Form.docx

## ATTACHMENT 2 – TAXONOMIC LITERATURE

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