Technical Data Report: Hardrock Project – Water Balance and Water Quality Model

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Sign-off Sheet

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Executive Summary

This Report entitled "Technical Data Report: Hardrock Project – Water Balance and Water Quality Model" was conducted to provide an evaluation of the water management requirements for the Project through construction, operation, and closure. The evaluation considers both the quantity and quality of water under management and is used to support the feasibility level design and water management plan for the Project, and for the prediction of potential environmental effects for use in the environmental assessment (EA). The specific objectives of the Project water balance and water quality modelling are to:

- evaluate the quantity and quality of groundwater and surface water discharge to the open pit during operation, active closure, and post-closure conditions
- evaluate the quantity and quality of groundwater recharge and surface water runoff associated with Project infrastructure, including waste rock storage areas (WRSAs) and the ore stockpile during operation and closure
- evaluate the quantity and quality of groundwater discharge and surface water runoff associated with the tailings management facility (TMF) during operation and closure
- address water management needs to meet water demand with a focus on the reuse of water to meet mill demand and to reduce the volume of water under management
- predict the quantity and quality of water that will be discharged to the environment during operation and closure and to allow the determination of treatment requirements based on the results of the "Technical Data Report: Hardrock Project - Assimilative Capacity Study of Southwest Arm of Kenogamisis Lake" (Assimilative Capacity TDR) (Stantec 2017e).

The water balance and water quality predictions for the Hardrock Project (the Project) were modelled using GoldSim™. Key Project components such as the open pit and associated historical underground workings, WRSA) and ore stockpile, process plant, and TMF are included in the model. The model was run dynamically on a monthly time step for climate normal, 25-year wet, and 25-year dry conditions for the construction, operation, and closure phases.

The water quality model included major ions and parameters regulated by the *Metal Mining Effluent Regulations of the Fisheries Act* (MMER), *Ontario Regulation 560/94* (O. Reg. 560/94) and by the *Ontario Provincial Water Quality Objectives* (PWQO).

Project components including the WRSA, ore stockpile, contact water collection ponds, open pit, historical underground workings, the process plant, and the TMF reclaim pond were modeled as fully mixed reactors at each time step. Mass inputs for these components were defined from:

- field kinetic tests scaled-up to represent Project WRSA volumes
- metallurgical and cyanide detoxification tests for dissolution/precipitation of elements in the process plant
- solution aging tests to account for natural degradation occurring in the TMF reclaim pond
- humidity cells for exposed tailings adjusted for temperature and oxidation depth
- subaqueous column tests for TMF seepage
- site-specific surface water and groundwater quality

In completing the water quality study, the following conservative assumptions were incorporated into the modelling:

- infiltration rates used for the WRSAs are high and do not consider any reductions that will be achieved by drainage controls to be implemented during detailed design and progressive rehabilitation
- the use of 25-year wet and 25-year dry climatic conditions continuously for 100 years represents precipitation extremes
- the decrease in mineral leaching rates over time is not considered beyond the two years of geochemical data available (2014-2015)
- no attenuation of elements within waste rock, tailings and overburden was considered in the model due to geochemical reactions resulting in an over prediction in water quality concentrations
- no attenuation of elements was assumed along groundwater pathways from the historical tailings, WRSAs, ore stockpile, and overburden storage area to the open pit due to either physical flow processes or geochemical reactions
- For parameters that were below the method detection limits a value of half of the detection limit was used in the modelling. This typically results in the over prediction of concentrations due to elevated detection limits.

Water quality predictions were generated and are presented below for the key Project locations where management of contact water would be required during operation and closure. The results are summarized below for the key Project locations:

Historical Underground Workings and Open Pit

Dewatering of the historical underground workings will begin prior to the operation phase. This water was assumed to be discharged to the environment following treatment, as required, and used to meet the mill demand during the initial commissioning period until adequate reclaim water is available within the TMF. During operation, the historical underground workings will be used as a storage reservoir for water and gradually dewatered to maintain water levels at approximately 25 metres (m) below the active mining level. Total dewatering rates range from 145,109 cubic metres (m^3)/month (202 m^3/hour (hr) or 55 litres per second (L/s)) to a maximum of 445,865 m^3/month (619 m^3/hr or 172 L/s) with an average of 281,336 m^3/month (391 m^3/hr or 109 L/s). Groundwater inflow to the open pit and historical underground workings accounts for approximately 61% of the average monthly dewatering volume. Water from the historical underground workings will be pumped to pond M1 and used to meet mill demand during operation, with the excess water sent to the effluent treatment plant (ETP) prior to discharge to the Southwest Arm of Kenogamisis Lake.

Once mining is completed and dewatering is terminated, the open pit and historical underground workings will fill from groundwater inflow, direct precipitation, surface water runoff, and water transferred from the pond M1 and the TMF. Fresh water will also be added from Kenogamisis Lake until the pit lake is filled. Filling of the open pit is estimated to take 16 years under climate normal conditions after closure (end of Project Year 31, Model Year 32) and will form a permanently stratified pit lake. Discharge from the pit lake will flow to the Southwest Arm of Kenogamisis Lake with discharge rates ranging from 65,900 m^3/month (92 m^3/hr or 25 L/s) to 440,900 m^3/month (604 m^3/hr or 168 L/s) under climatic normal conditions.

Discharge water quality from the pit lake at closure is represented by the upper layer (epilimnion) because the lower layer becomes chemically disconnected from the epilimnion in the permanently stratified pit lake. Water quality at the end of model simulations demonstrate the maximum concentrations of arsenic, cobalt, antimony, and uranium are 42 micrograms per litre (µg/L), 2.2 µg/L, 38 µg/L and 7.3 µg/L, respectively and above the PWQO/Interim PWQOs. The effect of discharging water from the pit lake is considered in the surface water effects assessment and concludes that the PWQO will be met within a small mixing zone. Actual predictions of mixing zones and discharge criteria will be developed through monitoring during the closure phase.

With these conservatively modelled predictions, it is important to consider that the observed water quality from the historical underground workings that are partially backfilled with waste rock provide a reliable indication of future pit lake water quality and verification of the model results. The maximum arsenic concentration (42 µg/L) in the predicted pit lake discharge in Project Year 99 (Model Year 100) is approximately five times the median values in the historical underground workings (8 µg/L). Similarly, antimony and uranium concentrations are significantly higher in model predictions (38 µg/L and 7.3 µg/L, respectively) in comparison to the historical underground workings (0.3 µg/L and 1.2 µg/L, respectively). In addition, in the areas of the historical MacLeod and Hardrock tailings, antimony is not typically observed at concentrations above the PWQO. Therefore, comparison of historical results with the predicted concentrations indicate that the model results are likely overestimating the predicted arsenic, antimony and uranium concentrations in the pit lake discharge.

Pond M1

Pond M1 receives water during operation from collection ponds and excess water from the historical underground workings that is not required for process plant supply. During operation the water quality from pond M1 is considered as the influent water quality to the ETP and is used to evaluate treatment requirements. Excess water from pond M1 will be treated during operation prior to discharge to the Southwest Arm of Kenogamisis Lake.

No parameters are predicted above the MMER/O. Reg. 560/94 criteria from pond M1 during operation and closure. Arsenic, cobalt and uranium concentrations increase over the operation phase reaching their maximum concentration of 115 µg/L, 4.5 µg/L and 13 µg/L, respectively. Antimony reaches the maximum concentration of 105 µg/L in Project Year 11 (Model Year 12) with a slight decrease to 94 µg/L at the end of operation. Arsenic and cobalt exceed the PWQO and aluminum, antimony, arsenic and uranium exceed the Interim PWQO.

The discharge criteria to the Southwest Arm of Kenogamisis Lake are determined in the Assimilative Capacity TDR (Stantec 2017e) and consider potential effects on the receiving environment. These will be further informed by ongoing Project planning and design.

After active closure, water collected in pond M1 will be diverted to the open pit to help expedite filling of the pit. After the pit lake stratifies, water from pond M1 will be sent to the lower portions of the pit lake through Mosher No. 1 Shaft. In the lower portions of the pit lake, anoxic conditions are expected to develop and lead to conditions that will reduce metal concentrations by the formation of metal sulphides under sulphate reducing conditions.

Tailings Management Facility

Surplus water from the TMF will be reclaimed to meet mill water demands during operation with additional water required from contact water from pond M1 and dewatering water from the historical underground workings and open pit. Therefore, the TMF is not planned to discharge to the environment during operation. At the end of operation, water quality in the TMF reclaim pond is predicted to be above the MMER limits for total cyanide, but declines below the criteria within 2 months after discharge from the process plant is terminated due to natural degradation within the TMF.

During active closure and post-closure, runoff and seepage from the TMF will be directed to the lower portions of the open pit until the final elevation of the pit lake is reached. At this point, water from the TMF will be directed to the overflow spillway and out to the Goldfield Creek diversion. Average monthly discharge rates from the TMF under climate normal conditions range from 0 m^3/month during the winter months to a maximum of 208,800 m^3/month (285 m^3/hr or 79 L/s) during spring freshet conditions with an average annual discharge rate of 68,979 m^3/month (94 m^3/hr or 26 L/s). During discharge the maximum concentrations of arsenic (36 µg/L) and aluminum (120 µg/L) are predicted to be below PWQO but above the Interim PWQO value (5 µg/L) and aluminum (120 µg/L) is above the Interim PWQO of 75 µg/L. Maximum concentrations of cobalt (3.0 µg/L) in discharge are predicted to be above the PWQO of 0.9 µg/L Similar to the pit lake, final closure discharge criteria will be developed based on monitoring data collected through operation and closure when the pit lake is being filled.

The quality of seepage from the TMF was derived from subaqueous column testing. Concentrations of elements in the columns showed stabilization at weeks 20 to 25 indicating that chemical equilibrium was reached between the porewater solutions and tailings in the columns (Stantec 2016b). Average concentrations observed at that time represent post-closure conditions. Un-ionized ammonia (NH_3) and cobalt are the only parameters exceeding the PWQO. Maximum values for un-ionized ammonia and cobalt are 60 µg/L and 3 µg/L, respectively. The average arsenic concentration (66 µg/L) is below the PWQO, but above the Interim PWQO. This water quality represents a conservative estimate of seepage quality and does not account for runoff from the TMF dams and surrounding catchment which will reduce concentrations.

Abbreviations

AET	actual evapotranspiration
AMECFW	Amec Foster Wheeler Environment and Infrastructure
amsl	above mean sea level
EA	environmental assessment
ETP	effluent treatment plant
GGM	Greenstone Gold Mines GP Inc.
ID	identification
km	kilometres
kt	kilotonnes / one thousand tonnes (metric)
L	litre
LOM	life of mine
M	million
m^3	cubic metres
MacLeod	MacLeod-Mosher Mine
mg	milligram
Mg	magnesium
µg	microgram
mm	millimetre
MMER	*Metal Mining Effluent Regulations of the Fisheries Act*
O. Reg.	Ontario Regulation
PDA	Project development area
PET	potential evapotranspiration

Project	Hardrock Project
PWQO	*Provincial Water Quality Objectives*
RD	runoff distribution factor
s	second
Stantec	Stantec Consulting Ltd.
t	tonne (metric)
TMF	tailings management facility
tpd	tonnes per day
WRSA	waste rock storage area
Yr	year

1.0 INTRODUCTION AND STUDY OBJECTIVES

Greenstone Gold Mines GP Inc. (GGM, the Proponent) proposes the construction, operation, and closure of an open pit gold mine and associated ancillary activities, collectively known as the Hardrock Project (the Project). The Project is located in northwestern Ontario, approximately 275 kilometres (km) northeast of Thunder Bay, in the Municipality of Greenstone, Ward of Geraldton (Figure 1-1).

The Project components include an open pit, ore processing facilities including crushing and process plants, waste rock storage areas (WRSAs), tailings management facility (TMF), natural gas-fueled power plant, and other associated buildings and processes. Project activities include the removal or relocation of existing infrastructure currently located within the Project development area (PDA) (Figure 1-2).

Since completion of the Draft Environmental Impact Statement/Environmental Assessment (EIS/EA) in February 2016, updates to the Project have been made in response to comments from agencies, Aboriginal communities, and other stakeholders, and to address advances in Project design. The Final EIS/EA includes a description of Project refinements and the Record of Consultation that includes comments and GGM responses on the Draft EIS/EA.

1.1 STUDY OBJECTIVES

This Report, entitled "Technical Data Report: Hardrock Project – Water Balance and Water Quality Model" (Water Balance and Water Quality TDR), has been prepared to provide an evaluation of the site water management requirements for the Project through construction, operation, and closure. This revised Water Balance and Water Quality TDR considers updates to the Project, new data collected since the completion of the Draft EIS/EA, and comments received from agencies, Aboriginal communities, and other stakeholders on the Draft EIS/EA.

The evaluation considers both the quantity and quality of water under management and is used to support the feasibility level design and the "Hardrock Project - Water Management and Monitoring Plan" (WMMP) (Stantec 2017a) for the Project, and for the prediction of potential environmental effects for use in the environmental assessment (EA). The results of the modelling are also used in the development of the "Hardrock Project - Conceptual Closure Plan" (Conceptual Closure Plan) (Stantec 2017b).

The specific objectives of the Water Balance and Water Quality TDR are to:

- evaluate the quantity and quality of groundwater and surface water discharge to the open pit during operation, active closure, and post-closure conditions

- evaluate the quantity and quality of groundwater recharge and surface water runoff associated with Project infrastructure, including WRSAs and the ore stockpile during operation and closure
- evaluate the quantity and quality of groundwater discharge and surface water runoff associated with the TMF during operation and closure
- address water management needs to meet water demand with a focus on the reuse of contact water to meet mill demand and to reduce the volume of water under management
- predict the quantity and quality of water that will be discharged to the environment during operation and closure and to allow the assessment of treatment requirements based on the results of the Assimilative Capacity TDR (Stantec 2017e).

1.2 CHANGES FROM DRAFT EIS/EA

The following provides a summary of the main updates that have been incorporated into the Water Balance and Water Quality TDR since the publication of the Draft EIS/EA in February 2016 to address responses to comments from agencies, Aboriginal communities, and other stakeholders, and to address advances in Project design:

- incorporation of updated open pit inflow rates and groundwater discharge from the three-dimensional groundwater inflow
- update of storage volumes within historical underground workings based on revised open pit phases
- revisions to catchment areas and deposition schedule for WRSAs, ore stockpile, and overburden storage area
- revisions to the open pit configuration, design, and production schedule and tonnages
- balancing the open pit and underground dewatering rates to consider storage within the historical underground working during spring periods where runoff flows are high
- revision to open pit filling rates to reduce overall filling times by maximizing the use of contact water
- revision to the historical tailings areas and inclusion of the subsurface seepage collection system for the historical MacLeod high tailings.

1.3 PROJECT OVERVIEW

Mining of the Hardrock deposit has been designed as an open pit. The process plant will operate 365 days per year with a Life of Mine (LOM) of approximately 15 years. The mill throughput ranges from 24,000 tonnes per day (tpd) for approximately the first two years of operation (i.e., Mill Phase 1), increasing to 30,000 tpd for the balance of operation (i.e., Mill Phase 2).

The overall Project development schedule will consist of the following main phases, during which various Project activities will be completed:

- Construction: Years -3 to -1 with early ore stockpiling commencing after the first year of construction.
- Operation: Years 1 to 15, with the first year representing a partial year as the Project transitions from construction to operation.
- Closure:
  - Active Closure: Years 16 to 20, corresponding to the period when primary decommissioning and rehabilitation activities are carried out.
  - Post-Closure: Years 21 to 36, corresponding to a semi-passive period when the Project is monitored and the open pit is allowed to fill with water creating a pit lake.

The key components of the Project are as follows:

- open pit
- WRSAs (designated as WRSA A, WRSA B, WRSA C and WRSA D)
- topsoil and overburden storage areas
- ore stockpile
- crushing plants and mill feed ore storage area
- process plant
- TMF
- water management facilities for contact water including collection ditches and ponds
- power plant and associated infrastructure
- liquefied natural gas plant
- explosives facility
- buildings and supporting infrastructure
- water supply and associated infrastructure
- sewage treatment plant
- effluent treatment plant (ETP)
- lighting and security
- Project roads and parking areas

- watercourse crossings and habitat compensation/offsets
- Goldfield Creek diversion
- onsite pipelines
- fuel and hazardous materials
- aggregate sources
- temporary camp

Project activities include the relocation of existing infrastructure currently located within the PDA, including a portion of Highway 11, a Ministry of Transportation (MTO) Patrol Yard, and Hydro One Networks Inc. (Hydro One) facilities. Figure 1-2 shows the location and general layout of the key Project components.

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Revised: 2017-04-07 By: dharvey

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Legend

- Project Location
- Town/ Village
- City
- Highway
- District Boundary
- Municipal Boundary
- Waterbody

Notes
1. Coordinate System: NAD 1983 UTM Zone 16N
2. Base features produced under license with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2013.

Client/Project

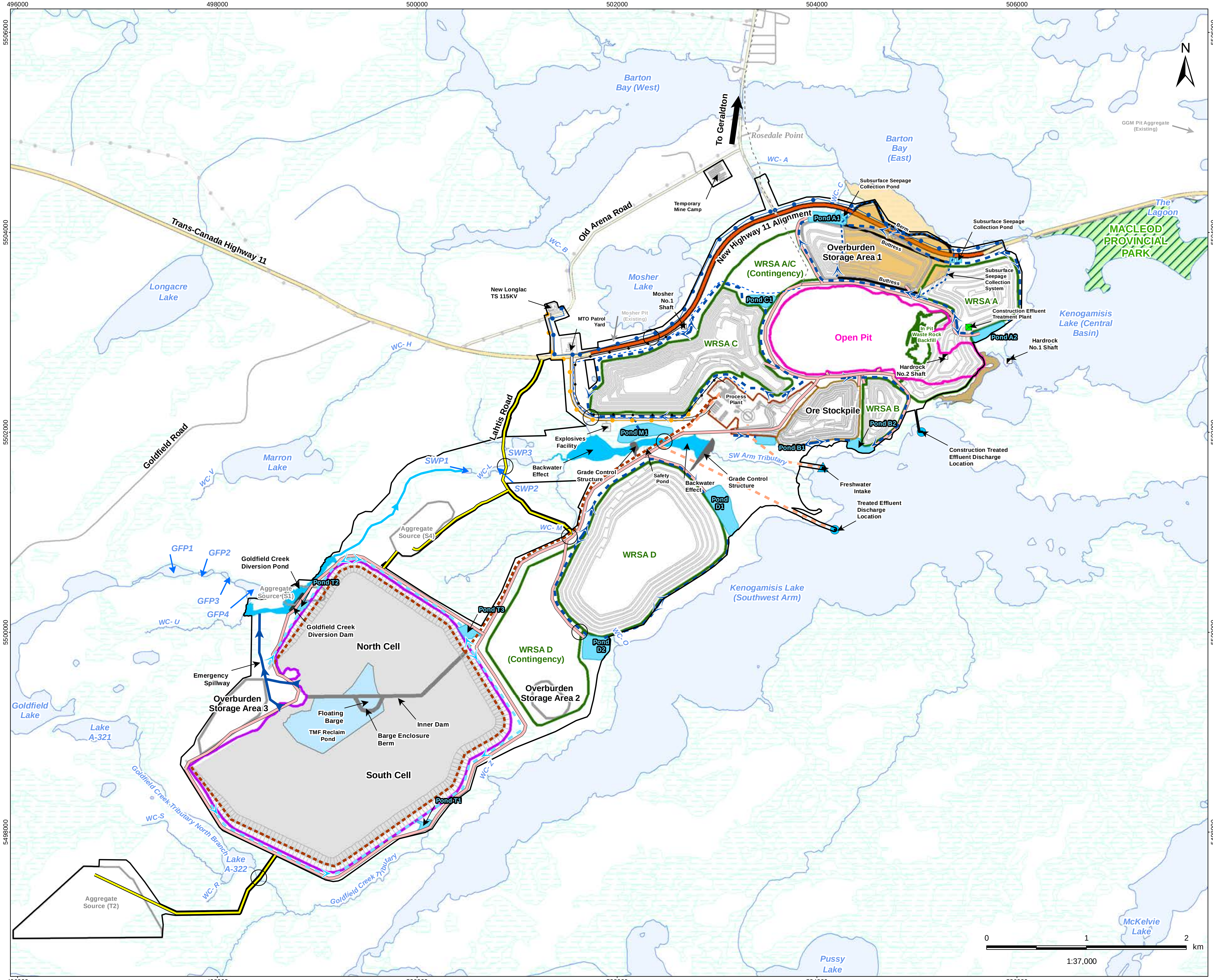
Greenstone Gold Mines GP Inc (GGM)
Hardrock Project

Figure No.

1-1

Title

Project Location



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Legend

Project Development Area

Preliminary Site Plan

- Discharge Location
- Existing Mine Shaft
- Freshwater Intake
- Construction Effluent Treatment Plant
- Watercrossing
- Access Road
- Construction Access Road
- Diversion Channel
- Emergency Spillways
- Haul Road
- Potable Water Pipeline
- Pipeline (Intake and Discharge)
- 44 kV Distribution Line
- 12.5 kV Distribution Line
- 115 kV Transmission Line
- Seepage Collection Ditch
- Subsurface Seepage Collection System
- Contact Water Collection Ditch
- Tailings Pipeline and 13.8 kV Distribution Line
- Aggregate Source
- Collection Ponds
- Open Pit- Full Extent
- Ore Stockpile
- Process Plant Area
- Tailings Management Facility
- Waste Rock Storage Area

Highway Realignment

- New Highway 11 Alignment

Existing Features*

- Highway
- Major Road
- Local Road
- Existing Power Line
- Existing Potable Water Pipeline
- Watercourse
- Provincial Park
- Waterbody
- Wetland (Eco-Site Based)

Historical Tailings Areas

- Historical Hardrock Tailings
- Historical MacLeod High Tailings
- Historical MacLeod Low Tailings

Notes

1. Coordinate System: NAD 1983 UTM Zone 16N
2. Base features produced under license with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2013.

* Existing Features have been removed in the PDA and do not reflect current conditions.

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Client/Project
Greenstone Gold Mines GP Inc. (GGM)
Hardrock Project

Figure No.
1-2

Title
Site Plan and Ultimate Footprint

2.0 KEY PROJECT ACTIVITIES

The sections below present a brief description of the Project and the overall Project components with specific emphasis on components that directly affect water management.

2.1.1 Project Development

Figure 2-1 provides an overall summary of the Project schedule along with details related to specific Project components considered in the Water Balance and Water Quality TDR.

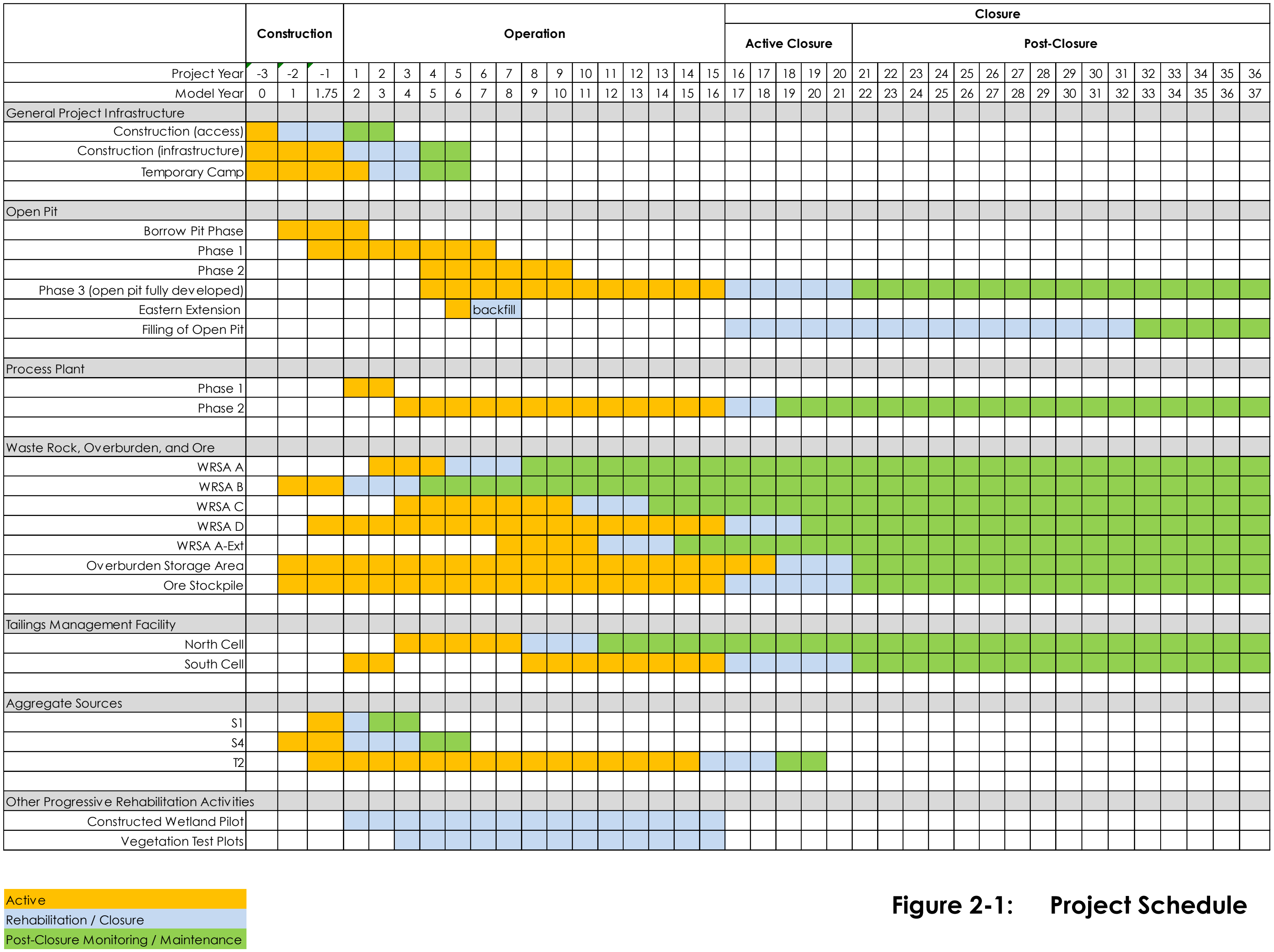


Figure 2-1: Project Schedule

2.1.2 Open Pit

Development of the open pit will occur in phases including the Borrow Pit Phase, followed by Phases 1 to 3 and the eastern extension. The Borrow Pit Phase extends from Years -2 to 1 and is designed to provide rock appropriate for early construction material, begin the stockpiling of ore for processing, and storage of waste rock. Phase 1 starts at the east portion of the open pit with each subsequent phase extending westward. Table 2-1 provides the approximate dimensions and phasing of the different subdivisions in the ultimate open pit.

Table 2-1: Summary of Approximate Dimensions of Open Pit

	Borrow Pit Phase	Open Pit, Mining Phase 1	Open Pit, Mining Phase 2	Open Pit, Mining Phase 3	Eastern Extension
Operational Period	Year -2 to 1	Year -1 to 6	Year 4 to 9	Year 4 to 15	Year 5 to 6
Maximum Surface Area (m^2)	913,829	1,204,521	1,204,521	1,204,521	152,809
Maximum Depth (m)	130	280	375	575	132

2.1.3 Waste Rock Storage Areas

Approximately 530,770 kilotonnes (kt) of waste rock will be generated over the LOM and will be managed in four primary WRSAs (A, B, C and D). A portion of WRSA A will include in-pit placement of waste rock in the eastern-most area of the open pit (Figure 1-2). The overall WRSA deposition plan is provided in Figure 2-1 and includes progressive rehabilitation of each area after deposition is completed. Progressive rehabilitation is planned to include placement of a vegetated soil cover where possible (Stantec 2017b).

Two contingency WRSAs, Contingency A/C and Contingency D (Figure 1-2), have been identified that may be used, if required, for waste rock storage. Contingency WRSAs would be used in the event that the foundation conditions of primary WRSAs, based on conditions in the field, are deemed not appropriate for anticipated capacities as mining progresses and requires design adjustments. The contingency WRSAs may also be used in the event that waste rock volumes are higher than expected or increase based on refinement to the Project plan as mining advances. Generally, waste rock deposition will proceed as follows:

- WRSA A, with a storage capacity of 43,600 kt, will be active from Year 2 to approximately Year 4.
- In-pit backfilling of waste rock in Year 6 and 7 will allow the expansion of WRSA A over the east portion of the open pit (A_Extension), which will store additional waste rock from Year 7 to Year 10. In total, the capacity of in-pit backfilling and A_Extension will be 73,500.

- WRSA B, with a storage capacity of 12,900 kt, will receive waste rock from Year -2 to Year -1.
- WRSA C, with a storage capacity of 114,300 kt, will receive waste rock from Year 3 to Year 9.
- WRSA D will receive waste rock beginning in Year -1 with increased deposition beginning in Year 3 continuing through to Year 15. The storage capacity of WRSA D is the largest at 276,800 kt, representing over half of the total waste rock volume.

The WRSA capacities noted above are the maximum design capacities considered for each WRSA. The WRSA capacities used for modelling represent the anticipated quantity of waste rock to be placed in the WRSA which may be less than the design capacities.

The waste rock will be placed directly on the existing ground surface, with foundation preparations completed for the perimeter as required for geotechnical stability purposes. Runoff and seepage will be collected through a series of collection ditches and ponds in accordance with the WMMP with collected water reporting to pond M1 for treatment prior to discharge to the environment.

2.1.4 Stockpiles

There are a number of active stockpiles that will be constructed over the LOM including an ore stockpile and overburden storage areas, which will include a separate topsoil storage area. The ore stockpile will be processed over the life of Project, while the topsoil and overburden materials will be used for progressive rehabilitation efforts. Details related to the stockpiles are provided below.

2.1.4.1 Ore Stockpiles

Ore will be hauled from the open pit to the ore stockpile, which has a capacity of approximately 33,600 kt and is designed to connect to the crusher pad to decrease cycle time for ore re-handling. The stockpile will be located on a constructed pad with perimeter contact water collection. The stockpile will be approximately 37.5 ha in size and have an overall slope of 2:1. At the end of operation, the ore stockpile and pad will be removed and the site will be rehabilitated as outlined in the Conceptual Closure Plan (Stantec, 2017b).

The ore stockpile is expected to fluctuate in size throughout operation, depending on production and operational needs. The ore stockpile capacity is more than required and will allow for variations in production and grade over time.

2.1.4.2 Topsoil and Overburden Storage Areas

Topsoil and overburden will be removed in accordance with the Conceptual Soil Management Plan (GGM 2017) for various Project components including the open pit, embankment (slope) for the WRSAs and TMF and other Project components (e.g., process plant area, building foundations, road alignments).

An estimated 7.24 million cubic metres (Mm^3) of overburden from the Project will be stockpiled over the LOM, with additional overburden generated as a result of site preparation for other Project components noted above, including WRSA and TMF perimeter foundation areas. Overburden and topsoil will be stockpiled north of the open pit within the main overburden storage area, with additional temporary storage areas located at the boundary of Contingency WRSA D and adjacent to the TMF. Other temporary overburden storage locations may be used during the construction phase, for example within the footprint of WRSA C for preparation of the mill pad. The overburden and topsoil will be used as construction, maintenance, and rehabilitation material.

Approximately 2,356 Mm^3 of topsoil will be stored at designated locations within the overburden storage areas. The stockpiled material will be used for progressive rehabilitation activities and ultimate rehabilitation during closure.

2.1.5 Historical Tailings

As part of the Project, approximately 22% of the historical MacLeod tailings and 77% of the historical Hardrock tailings will be removed in Project Year 2 to 4 (Model Year 3 to 5) and placed within the new TMF, eliminating them as an on-going source of loading in the area of the open pit.

The historical Macleod low tailings located to the north of the historical MacLeod high tailings, adjacent to Barton Bay, will remain in place with the exception of small areas immediately adjacent to the MacLeod high tailings that may need to be removed during placement of the buttressing that is proposed for the Highway 11 realignment. The historical MacLeod low tailings between Barton Bay and the Highway 11 realignment will be rehabilitated as required in accordance with O. Reg. 240/00. The remaining portion of the MacLeod high tailings will be covered with an enhanced cover designed to limit infiltration and promote runoff to the collection ponds for clarification and used as an overburden storage area. The cover system will include a drainage layer of coarse rock to help improve stability and act as a capillary break for drainage control. Overburden will then be placed in a controlled manner and runoff promoted through grading practices to reduce infiltration through the historical tailings, and as a result reduce loading to the environment.

In addition to the cover, a subsurface seepage collection system will be incorporated into the stabilization berm along the toe of the historical MacLeod high tailings during the initial construction works to collect seepage from the tailings. Seepage from the subsurface collection system will be separate from surface runoff that will be collected in the collection ditches and pumped to a construction ETP for treatment prior to discharge during construction. During operation, seepage from the subsurface collection system will either be sent to the process plant to meet mill demand or to the ETP for treatment prior to discharge to the environment.

At closure, water from the subsurface seepage collection system will either be directed to depth within the open pit, or a passive treatment system (e.g., constructed wetland) will be implemented with discharge to Barton Bay. The WMMP during closure will be refined based on actual water quantity and quality monitoring data and treatability evaluations to be completed during operation.

2.1.6 Process Plant

The process plant will include primary and secondary crushers, grinding (high pressure grinding rollers and ball milling), gravity gold recovery, gold leach and carbon-in-pulp adsorption, cyanide detoxification, carbon stripping, electrowinning, and refining. The plant is located southwest of the open pit (Figure 1-2), and planned to be constructed in two stages to accommodate changes to production rate (Mill Phase 1 and Mill Phase 2).

Ore processing will be carried out by conventional methods using a combination of gravity separation and cyanidation for gold recovery, followed by in-plant cyanide detoxification using the SO_2/air oxidation process. Tailings resulting from this process will be pumped via a pipeline to the TMF located approximately 4 km from the process plant. Mill demand water requirements will be derived primarily from water recycled from the TMF reclaim pond, WRSA seepage collection ponds, and dewatering of the open pit and historical underground workings, as needed. While Kenogamisis Lake is not planned as a primary water source for the Project, there may also be an occasional need for additional surface water supply from the lake. Approximately 40 m^3/hr of freshwater will be required during Mill Phase 1 and 50 m^3/hr will be required during Mill Phase 2.

2.1.7 Tailings Management Facility

An engineered TMF will be built using a robust downstream raise construction design to store tailings from the process plant. The TMF is required to satisfy the design criteria of 140 Mt of tailings, with an additional allowance of 5 Mt of historical tailings, for a total TMF design tonnage of 145 Mt. Deposited tailings are expected to have an average deposited dry density of 1.34 t/m^3 and volume of 108 Mm^3. The TMF will be comprised of two tailings cells, north and south, which are to be developed in phases. The first phase of TMF development in Years -2 and -1 involves the development of the south cell (including the internal dam between the south and north cells) to provide storage for the first two years of operation (Years 1 and 2). The north cell will be developed in Year 2 of operation.

As the dam construction is advanced, the seepage collection system ditches and ponds will be completed. Water collected in the seepage collection ditches and ponds will be pumped back to the TMF to build the water reserves for use in mill start up. The seepage collection system will be in operation prior to the deposition of tailings, including the historical tailings. The historical tailings will not be deposited in the TMF until a 2 m thick layer of new fresh tailings is deposited in Year 1 to 2 to reduce potential seepage losses.

The dam construction methods will be a low permeability till core along with filters and transition zones upstream of the main embankment that will be constructed of waste rock from the open pit. Dam seepage will be controlled using a variety of methods based on site-specific conditions and will consist of cut-off trenches excavated to native till or bedrock and backfilled with compacted till or grout curtains with slush grouting of bedrock.

2.1.8 Water Supply and Sewage Treatment

2.1.8.1 Service Water Supply

Water will be sourced from a connection to the Geraldton municipal water system and will be used to provide potable water and service water to the surface buildings at the Project.

The historical underground workings will provide fire water to be stored in a dedicated tank on site. Automated fire detection and protection systems will be installed for critical process areas, such as the crushing, grinding and process plant buildings and interconnecting conveyor galleries and tunnels, and certain critical components such as the power plant, warehouses and fuel storage areas. A fire hydrant network will be installed around the perimeter of the Project components and process plant site, with fire hose cabinets installed in administrative buildings and the truck maintenance facility.

2.1.8.2 Sanitary Sewage Treatment

A sewage treatment plant (STP) will be constructed in the vicinity of the process plant area (Figure 1-2) and will serve the Project offices, mine dry building as well as the process plant. Treated STP discharge will meet applicable requirements which will be confirmed during the permitting period.

The temporary camp will be connected to the Municipality of Greenstone's sanitary sewer system.

2.1.8.3 Process Water Supply

Two types of water sources are required for process water: freshwater and recycled water. The process plant will generally operate on recycled water from the TMF reclaim pond, pond M1, and historical underground workings. Freshwater may be used for cooling or specialty requirements or as gland and seal water where a high quality water supply is required. Clean fresh water with low total suspended solids will be sourced from the ETP, or an intake in the Southwest Arm of Kenogamisis Lake.

2.1.8.4 Seepage, Contact Water and Pond M1

Water inflows in the form of direct runoff and groundwater seepage to the open pit will be directed to the historical underground workings associated with the MacLeod-Cockshutt (MacLeod) (later called the MacLeod Mosher Site) and Hardrock mines via drainage shafts bored through the active pit floor. The use of the historical underground workings provides a storage reservoir for open pit seepage and run-off during mining and allows for flexibility in the water management approach, particularly during extreme events.

Water from the historical underground workings will be used to meet water demand for the process plant with excess water discharged to pond M1.

Runoff from the WRSAs will be collected in a series of perimeter contact water collection ditches which will drain by gravity to several collection ponds (ponds A1, A2, B1, B2, C1, D1, and D2) (Figure 1-2) and directed to pond M1. Runoff from the process plant and ore stockpile will be collected in pond M1. This network of collection ponds will provide primary sedimentation management and will be sited and sized to store runoff and seepage up to a 100-year storm event of 24-hour duration.

Pond M1 will be the central contact water collection pond and will be the source of influent for the ETP. Treatment is anticipated for excess contact water accumulated in pond M1. The end of pipe treatment criteria will be based on the assimilative capacity of Kenogamisis Lake and achieving *Provincial Water Quality Objectives* (PWQO) at the edge of the mixing zone. Effluent treatment will be achieved using a high density sludge metals precipitation clarifier / thickener system, or equivalent with additional treatment for ammonia if required as detailed in the WMMP. Details on the treatment process will be refined as the design progresses and as specific discharge criteria are finalized during permitting.

No discharge is proposed from the TMF during operation. Treatment of the tailings will include in-plant cyanide detoxification using the SO_2/air oxidation process, which will reduce cyanide concentrations as well as several metal/metalloids, including arsenic and antimony during mineral precipitation reactions. Further attenuation of cyanide and ammonia by natural degradation will occur within the TMF. The effects of both in-plant and in-pond detoxification and attenuation have been considered in the water quality modelling.

3.0 METHODOLOGY

To complete the water balance and water quality modelling, details related to the overall Project plan from construction, through operation and closure is required. As detailed design is completed, modifications to the Project can be expected but are unlikely to substantially change the water balance and water quality outcomes.

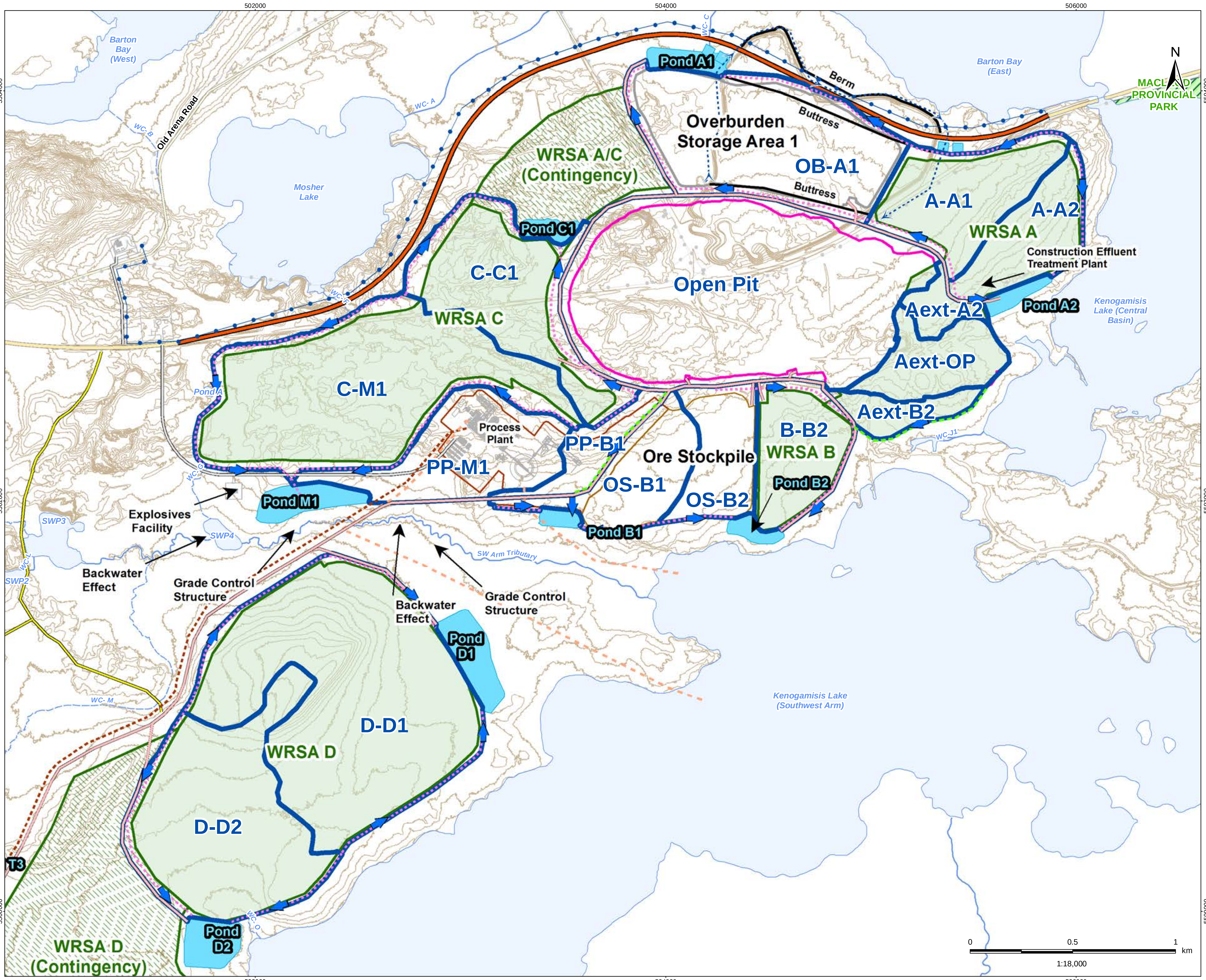
The following sections present a summary of the Project, schedule and the overall modelling approach used for the water balance and water quality modelling. Wherever possible, conservative assumptions have been included in the modelling approach for the purposes of predicting potential environmental effects.

3.1 MODELLING APPROACH

The water balance and water quality predictions for the Project were completed with GoldSim™, which is a dynamic, probabilistic simulation software developed by GoldSim Technology Group. The Project components in the water balance include: the open pit and associated historical underground workings, WRSAs, ore stockpile, overburden storage area, process plant, and TMF.

Rather than presenting the predictions on an overall watershed scale, it is assumed that the above facilities will have external drainage controls that prevent natural drainage from coming into contact with Project components and becoming contact water. This approach was selected since a detailed hydrodynamic model is being used to evaluate the effects of both direct (runoff) and indirect (groundwater) discharge to the natural environment. Details related to the contact water collection system for the open pit, process plant, and WRSAs are presented in the WMMP. Drainage and seepage controls for the TMF have been developed separately by Amec Foster Wheeler Environment and Infrastructure (AMECFW), and will include perimeter drainage and seepage collection around the TMF as well as a diversion of Goldfield Creek (AMECFW 2016).

Catchment areas for the open pit, overburden storage area, ore stockpile, WRSAs, process plant, and TMF were delineated based on the site plan (Figure 1-2). Using existing ground surface topography, the catchment areas were delineated where seepage from the bases of the WRSAs, ore stockpile and overburden storage area is expected to report to the contact water collection ditches and respective ponds and are presented in Figure 3-1. These catchment areas will not change during operation and closure. For surface water runoff, the catchment areas change slightly during operation and closure based on final WRSA, overburden storage area and ore stockpile configurations, as presented in Figure 3-2 and Figure 3-3.



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Revised: 2017-04-07 By: dharvey

Stantec

Legend

- Catchment Area

Key Project Components

- Access Road
- Construction Access Road
- Haul Road
- Pipeline (Intake and Discharge)
- 44 kV Distribution Line
- Subsurface Seepage Collection System
- Tailings Pipeline and 13.8 kV Distribution Line
- Contact Water Collection Ditch
- Temporary Site Ditch
- New Highway 11 Alignment
- Collection Ponds
- Open Pit- Full Extent
- Ore Stockpile
- Process Plant Area
- Waste Rock Storage Area
- Waste Rock Area (Contingency)

Existing Features

- Highway
- Major Road
- Local Road
- Contour (1m Intervals)
- Watercourse- Permanent
- Watercourse- Intermittent
- Provincial Park
- Waterbody

Notes

1. Coordinate System: NAD 1983 UTM Zone 16N
2. Base features produced under license with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2013.

* Existing Features have been removed in the PDA and do not reflect current conditions.

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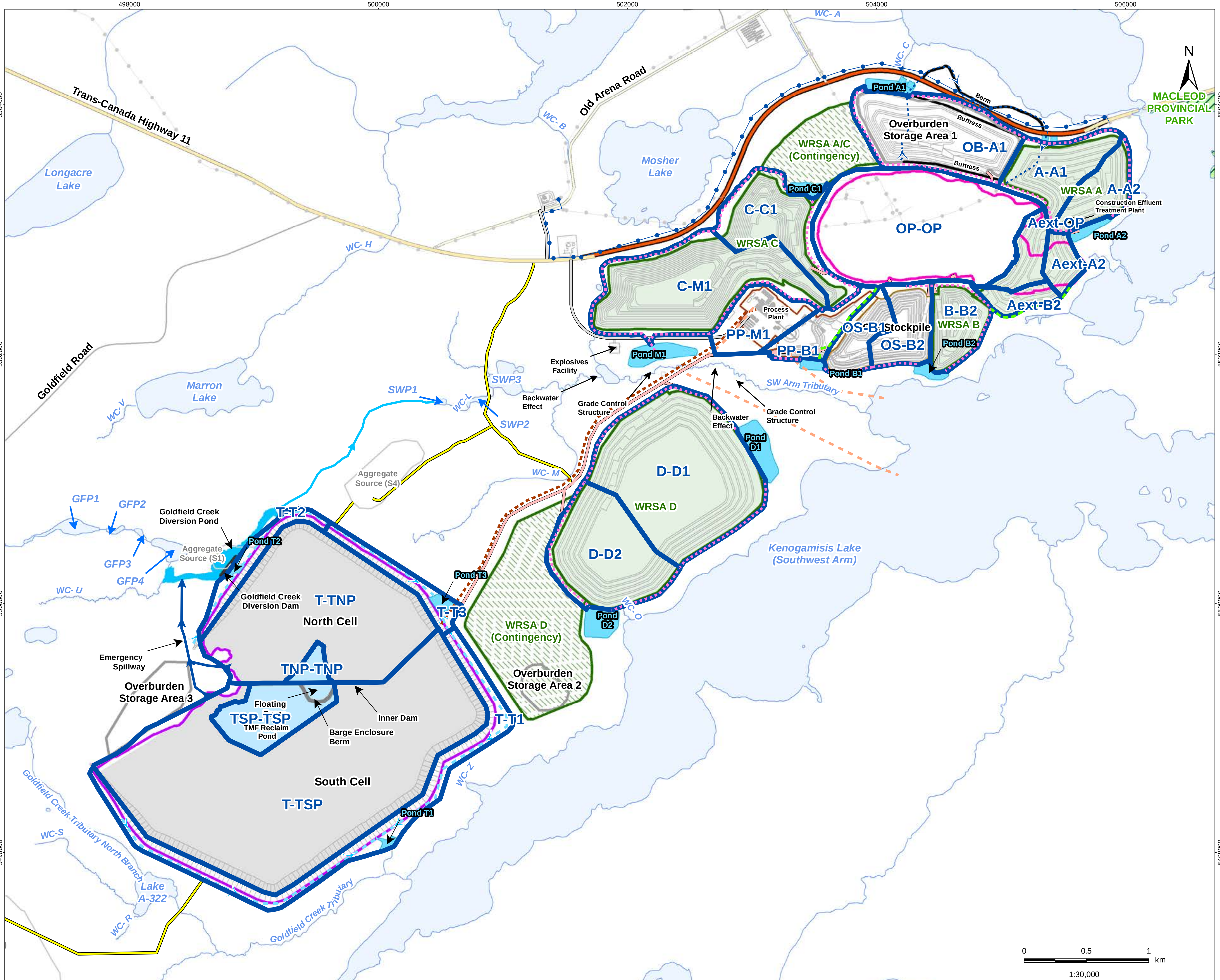
Client/Project

Greenstone Gold Mines GP Inc. (GGM)
Hardrock Project

Figure No.
3-1

Title

Catchment Area – Toe Seepage (Operation and Closure)



Stantec

Legend

Runoff Catchment Area

Key Project Components

- Access Road
- Construction Access Road
- Diversion Channel
- Emergency Spillways
- Haul Road
- Pipeline (Intake and Discharge)
- 44 kV Distribution Line
- Seepage Collection Ditch
- Subsurface Seepage Collection System
- Tailings Pipeline and Overhead Powerline
- Contact Water Collection Ditch
- Temporary Site Ditch
- New Highway 11 Alignment
- Aggregate Source
- Collection Ponds
- Open Pit- Full Extent
- Ore Stockpile
- Process Plant Area
- Tailings Management Facility
- Waste Rock Storage Area
- Waste Rock Area (Contingency)

Existing Features

- Highway
- Major Road
- Local Road
- Watercourse
- Provincial Park
- Waterbody

Notes

1. Coordinate System: NAD 1983 UTM Zone 16N
2. Base features produced under license with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2013.

* Existing Features have been removed in the PDA and do not reflect current conditions.

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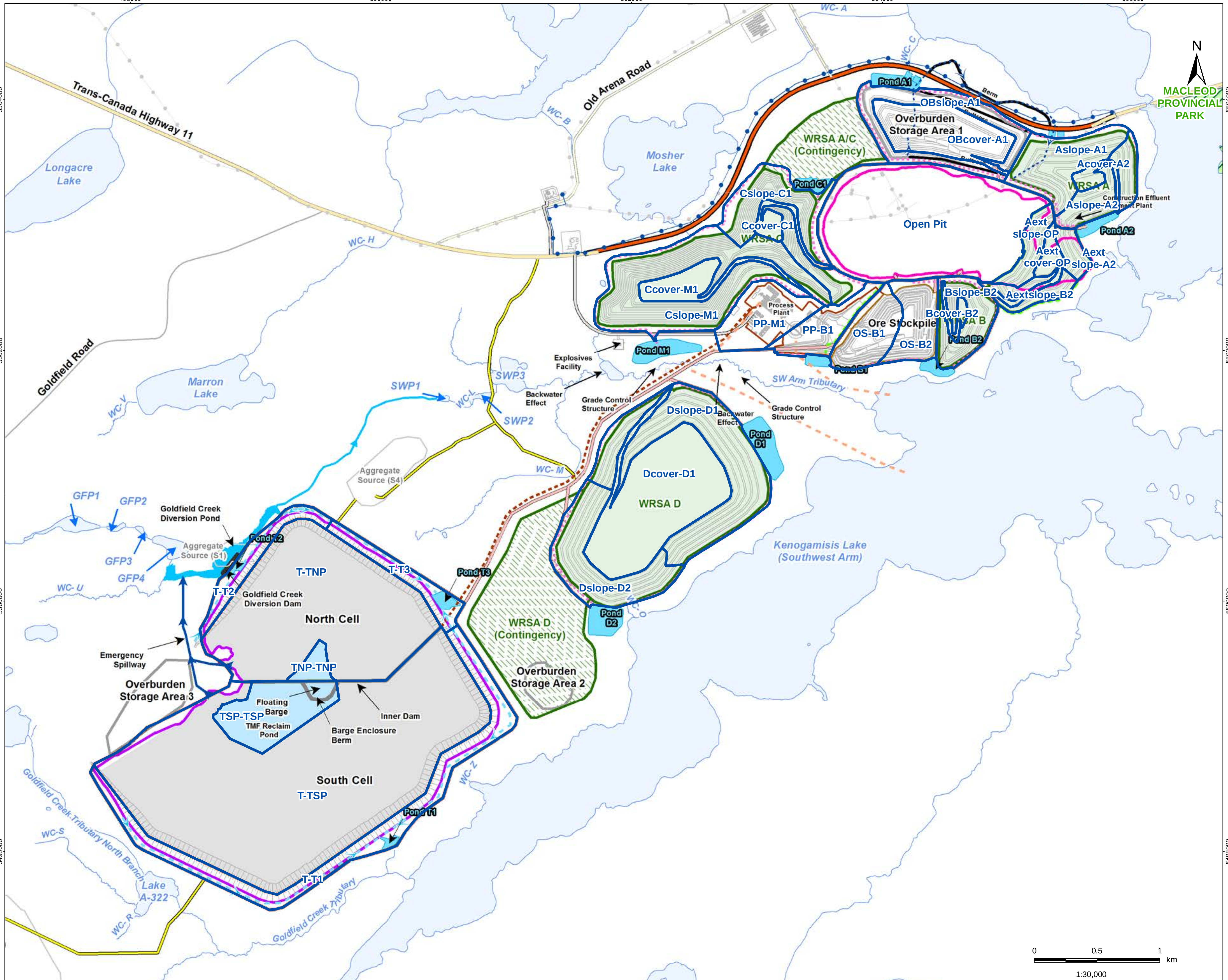
Client/Project

Greenstone Gold Mines GP Inc. (GGM)
Hardrock Project

Figure No.
3-2

Title

Catchment Area – Runoff (Operation)



Stantec

Legend

- Runoff Catchment Area

Key Project Components

- Access Road
- Construction Access Road
- Diversion Channel
- Emergency Spillways
- Haul Road
- Pipeline (Intake and Discharge)
- 44 kV Distribution Line
- Seepage Collection Ditch
- Subsurface Seepage Collection System
- Tailings Pipeline and 13.8 kV Distribution Line
- Contact Water Collection Ditch
- New Highway 11 Alignment
- Aggregate Source
- Collection Ponds
- Open Pit- Full Extent
- Ore Stockpile
- Process Plant Area
- Tailings Management Facility
- Waste Rock Storage Area
- Waste Rock Area (Contingency)

Existing Features

- Highway
- Major Road
- Local Road
- Watercourse
- Provincial Park
- Waterbody

Notes

1. Coordinate System: NAD 1983 UTM Zone 16N
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* Existing Features have been removed in the PDA and do not reflect current conditions.

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Client/Project

Greenstone Gold Mines GP Inc. (GGM)
Hardrock Project

Figure No.
3-3

Title
Catchment Area – Runoff (Closure)

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Revised: 2017-04-07 By: dharvey

The model was run dynamically on a monthly time step for climate normal, 25-year wet and 25-year dry conditions (see Section 4.1) for the construction, operation, and closure phases. The model was run for a 100-year time period which was considered adequate to achieve stable flows and leaching rates from the Project components.

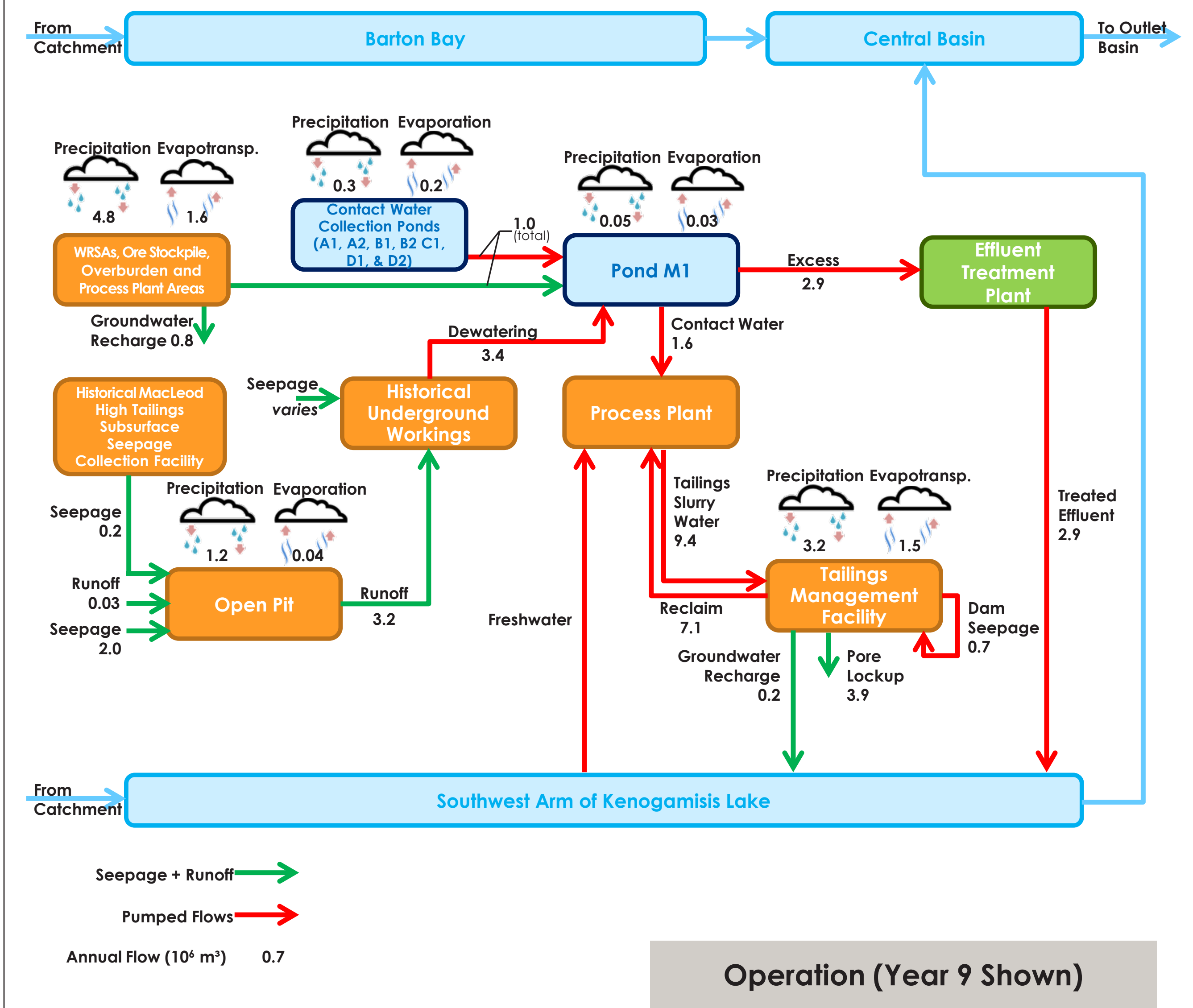
3.2 CONSTRUCTION, OPERATION, AND CLOSURE PHASES

The construction, operation and closure phases were simulated together with the active closure phase assumed to extend for five years after the end of operation. Simplified flow diagrams showing the interactions of the above Project components during operation, active closure and post-closure are presented in Figure 3-4, Figure 3-5 and Figure 3-6.

As stated in Section 2.1.1 the construction phase extends over approximately 29 months beginning in Year -3 and ending partially through Year -1 as the mill commissioning is completed. The operation phase begins with Year 1, which is a partial year as the mill transitions from commissioning to production, and extends to Year 15. As GoldSim™ is not capable of simulating the negative time period associated with the construction period, the model was started with time zero representing the start of Month 12 of Year -3 in the schedule. This timing results in the need to have both Project Year, corresponding to the actual Project schedule in Figure 2-1 and Model Year, corresponding to the time frame used in the model. For the balance of this report both Project Years and Model Years will be used to avoid confusion and are provided in Figure 2-1 for reference.

To simulate closure, the water balance model was extended to run until Model Year 100 with a monthly time-step. The closure period was run under climate normal conditions. Climate change may account for a relatively minor overall increase in precipitation and would have a minimal effect on the open pit filling time.

For the purpose of the water balance and water quality model, the assumption is made that water from all of the collection ponds is pumped to the lower portion of the open pit via Mosher No. 1 Shaft until the pit fills and begins to discharge. In the event that it is feasible to discharge water from the contact water collection system ponds to the natural environment, GGM will evaluate the effect on open pit filing times and may seek approval from MOECC to pump additional water from the Southwest Arm of Kenogamisis Lake to maintain the open pit filling timetable.



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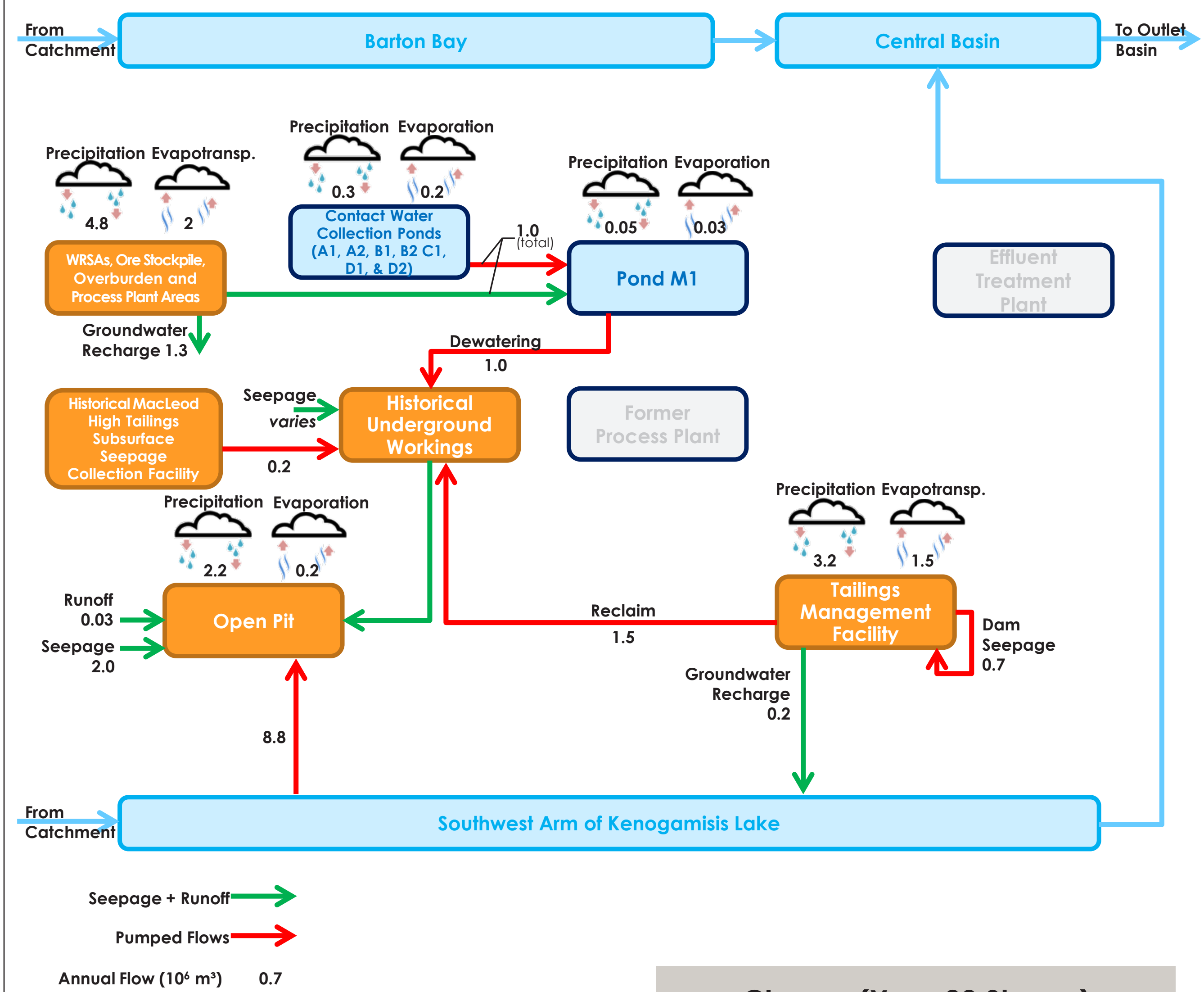
Client/Project

Greenstone Gold Mines GP Inc. (GGM)
Hardrock Project

Figure No.
3-4

Title
Mine Water Management - Operating Condition



Closure (Year 20 Shown)

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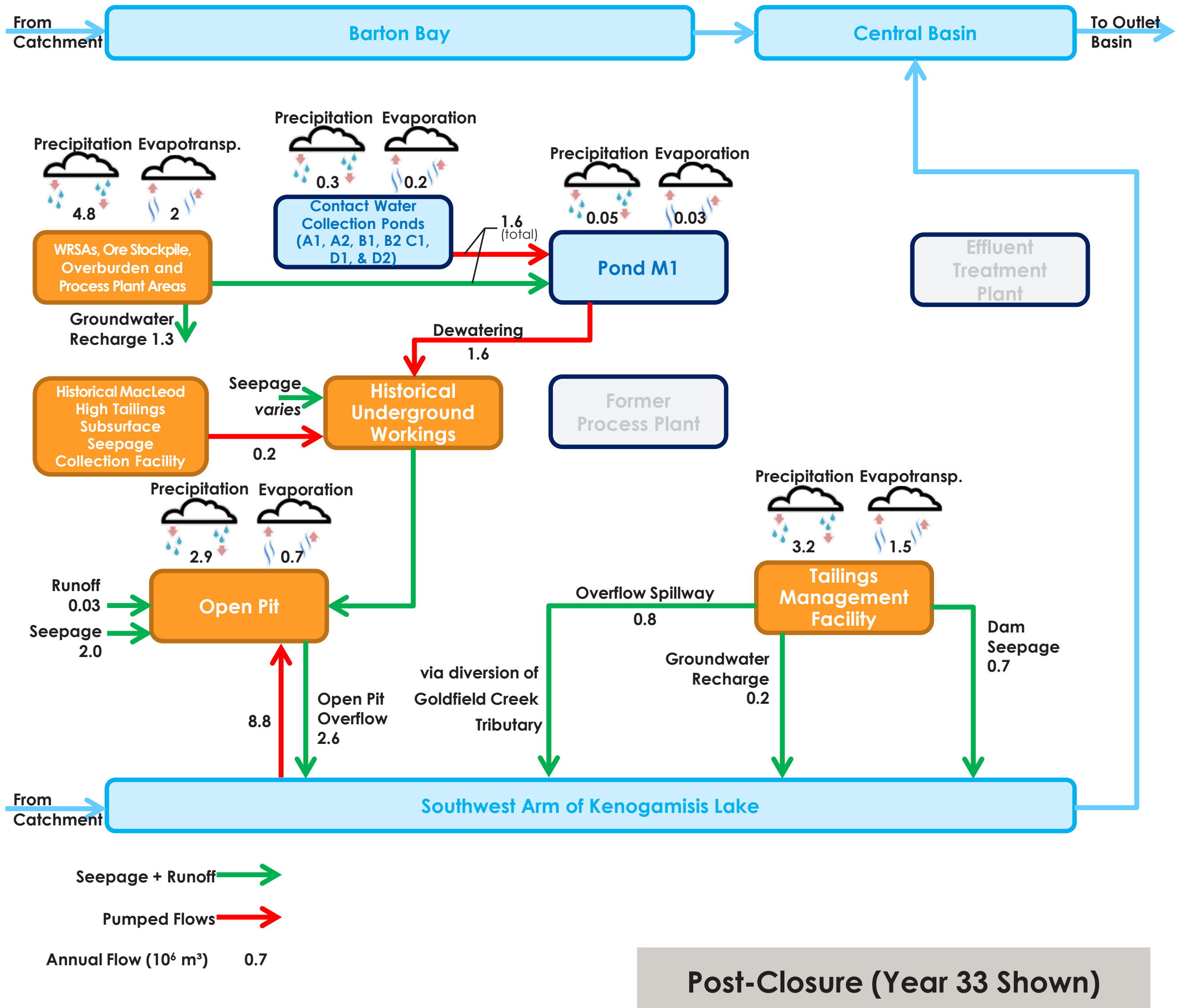
Greenstone Gold Mines GP Inc. (GGM)
Hardrock Project

Figure No.
3-5

Title
Mine Water Management - Closure



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Client/Project

Greenstone Gold Mines GP Inc. (GGM)
Hardrock Project

Figure No.
3-6

Title
Mine Water Management - Post-Closure

4.0 WATER BALANCE MODEL

This section presents the model inputs used in the water balance model and the resulting flows for the main Project components. The results from the water balance model were used as input to the water quality model, which is discussed in detail in Section 5.0.

4.1 MODEL INPUT

4.1.1 Climate

A detailed evaluation of climate and hydrologic data for the Project are presented in the "Environmental Baseline Data Report (combined 2014 and 2015) – Hardrock Project: Hydrology" (Hydrology Baseline Data Report) (Stantec 2016a). For the water balance, precipitation data from Environment Canada's Geraldton Airport (identification number (ID#) 6042716) climate station, which is located within 5 km of the Project, were used to characterize the climatic conditions for normal, 25-year wet, and 25-year dry conditions.

Table 4-1 provides climate normal data from 1981 to 2010 for the Geraldton Airport station. The climate normal data for 1981 to 2010 was used in the water balance model to represent normal climatic conditions. For wet- and dry-year conditions, the climate data from the Geraldton Airport was used to determine the 25-year wet and 25-year dry return period using a Gumbel probability distribution and method of moments analysis.

Table 4-1: Monthly Climate Characteristics at Environment Canada's Geraldton Airport (ID # 6042716), Climate Normals (1981 - 2010)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Temperature (°C)	-18.6	-15.8	-8.9	0.6	8.5	14.3	17.2	16	10.5	3.3	-5.4	-14.2	0.6
Rainfall (millimetres (mm))	0.4	0.6	7.2	22.1	66.1	84.5	108.6	83.6	99.5	62.3	17.5	3.7	556.1
Snowfall (cm)	42.8	29.4	28.4	24	4.6	0	0	0	2	19.6	46.8	45	242.6
Precipitation (mm)	33.5	23.8	31.9	45.7	71.7	84.5	108.6	83.6	101.6	83.1	58.7	38	764.7
Snow Depth (cm)	40.0	49.0	46.0	15.0	1.0	0.0	0.0	0.0	0.0	1.0	8.0	25.0	15.4

Table 4-2 provides a summary of the precipitation data used in the water balance model for the climate normal, 25-year wet, and 25-year dry conditions.

Table 4-2: Climate Normal, 25-Year Wet, and 25-Year Dry Year Precipitation Conditions

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Normal Year Total Precipitation (mm)	33.5	23.8	31.9	45.7	71.7	84.5	108.6	83.6	101.6	83.1	58.7	38	764.7
25-Year Dry Total Precipitation (mm)	12.2	21.2	29.2	18.7	41.8	50.4	101.0	80.7	73.8	81.5	46.6	41.8	599.0
25-Year Wet Total Precipitation (mm)	18.9	18.4	32.5	43.1	119.3	92.3	177.6	81.7	167.0	99.4	49.2	60.6	960.0

Average annual lake evaporation was determined as an average of three Northern Ontario Environment Canada climate stations (Rawson Lake ID # 6036904; Kemptville ID # 6104025; Ottawa CDA ID # 6105976). These stations provide comprehensive year-round monitoring with a period of record that is adequate for characterizing long-term climate conditions in the Project area. Average annual lake evaporation was estimated to be 515 mm with monthly evaporation rates presented in Table 4-3. Actual evapotranspiration (AET) is derived from potential evapotranspiration (PET) and soil-moisture. Soil moisture storage was estimated based on the dominating soil type. The PET in the model was calculated using the Hamon equation (Hamon 1961). The estimated annual AET under the 30-year climate normal condition is 396 mm (Table 4-3).

Table 4-3: Average Monthly Lake Evaporation and AET

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Evaporation (mm)	0	0	0	0	90	120	130	108	67	0	0	0	515
AET (mm)	4.2	5.2	10.1	22.6	48.5	72.3	82.8	70.6	41.1	22.5	10.8	5.5	396

4.1.2 Hydrology

Runoff coefficients were used to transform precipitation into surface runoff considering relief, surface storage, vegetation cover, evaporation, evapotranspiration, and infiltration losses. Runoff represents all surface water flows originating from overland flow, direct precipitation to waterbody surfaces, interflow and groundwater discharge. Table 4-4 presents the runoff coefficients used for various land use conditions.

Table 4-4: Runoff Coefficients used in Water Balance Model

Parameter	Runoff Coefficient
Ponds and Wet Tailings Beach	1.0
Tailings Beach Cover	0.36
Open Pit	0.95
Natural Ground	0.40
Disturbed Ground	0.85

Climate in the Project area is continental with lengthy, cold winters and deep snow. Very little surface runoff occurs during the winter months. Accumulated winter precipitation (snow) is released largely as surface runoff during the spring freshet and is accounted for in the runoff factors in Table 4-5. This process is modelled by applying a monthly precipitation-runoff factor that accounts for how much precipitation becomes surface runoff in a particular month (Table 4-5). The monthly precipitation-runoff factors were selected based on the site environmental water balance presented in the Hydrology Baseline Data Report (Stantec, 2016a). The balance of the precipitation is carried over to the next month.

Table 4-5: Precipitation-Runoff Factors used in Water Balance Model

Month	Precipitation - Runoff Factor	Month	Precipitation - Runoff Factor
January	0.1	July	1.0
February	0.1	August	1.0
March	0.1	September	1.0
April	0.5	October	1.0
May	1.0	November	0.75
June	1.0	December	0.50

The starting month in the water balance model is October because it allows modelling to commence at a time when 100% of precipitation runs off and no precipitation is either advanced from previous months or accumulates to the following months. The water balance results in the report are shown from October to September as it corresponds to the “water year” in Canada. For reporting purposes all data is presented starting in January to correspond to a calendar year.

Catchment areas for runoff and seepage collection from the open pit, mill, ore stockpile, WRSAs, overburden storage area and TMF were calculated for the operating and closure phases and are presented in Figure 3-1 to Figure 3-3. The areas are summarized in Table 4-6 and the timing when each area is active in the model is determined from the schedule in Figure 2-1. It was conservatively assumed that all surface water in the catchment areas is contact water and requires management. The contact water is directed either to the collection ponds via collection ditches or to the open pit.

Table 4-6: Catchment Areas used in Water Balance Model

Catchment Area	Catchment Area – Seepage Collection	Catchment Area – Runoff (Operation)	Catchment Area – Runoff (Closure)
	(ha)	(ha)	(ha)
Open Pit	**137.7**	**137.7**	**137.7**
Open Pit	137.7	137.7	137.7
Process Plant	**38.9**	**48.8**	**48.7**
PP-B1	0.0	19.9	19.9
PP-M1	38.9	28.9	28.8
Ore Stockpile	**60.0**	**45.1**	**45.1**
OS-B1	21.9	19.8	23.2
OS-B2	38.1	25.3	21.9
WRSA A	**96.4**	**97.3**	**97.3**
A-A1	35.6	36.3	33.5
A-A2	24.2	23.5	26.3
Aext-A2	6.8	11.1	7.2
Aext-B2	9.8	10.7	10.9
Aext-OP	20.0	15.7	19.4
WRSA B	**27.3**	**27.3**	**27.3**
B-B2	27.3	27.3	27.3
WRSA C	**144.9**	**145.8**	**146.0**
C-C1	49.5	48.7	51.0
C-M1	95.4	97.1	95.0
WRSA D	**196.9**	**196.9**	**196.9**
D-D1	122.8	129.5	155.7
D-D2	74.1	67.4	41.2
Overburden Storage Area	**70.2**	**70.2**	**70.2**
OB-A1	70.2	70.2	70.2
TMF	**424**	**424**	**424**
TMF (North Cell)	104	104	104
TMF (South Cell)	320	320	320

4.1.3 WRSAs

The deposition plan for the WRSAs is presented in Figure 2-1 and includes both the progressive and active (during active closure phase) rehabilitation of WRSAs. For the purposes of the water balance model it was assumed that progressive rehabilitation occurs over an approximately two-year period after the WRSAs reach storage capacity with no effects on the water balance parameters until the end of progressive rehabilitation. Runoff and seepage from the WRSAs is collected in collection ditches and directed to a series of collection ponds that convey water ultimately to pond M1.

A water balance for the WRSAs was completed to evaluate the evaporation, infiltration, and runoff over the transient and steady-state period during which wetting up of the WRSA will occur and is presented in Table 4-7. The key inputs and conservative assumptions for the analysis were:

- Surface water balance for the three different landform areas (bench, plateau, slope) of the WRSA were considered.
- A 2% loss due to snow sublimation is included in the water balance.
- Waste rock properties, including moisture retention curve (MRC), hydraulic conductivity function (K-function), and initial water content (assumed to be residual) are similar to other WRSAs in northern Ontario.
- The time required for a given depth of material to be at a steady-state saturation or wetted-up condition (using the water balance and the hydraulic properties).
- The approximate aerial extents of each WRSA of various waste thickness (using existing topographic data).
- The proportion of infiltration between lateral seepage (toe seepage) at the base of the WRSA and groundwater recharge was determined using the numerical groundwater flow model presented in the "Technical Data Report: Hardrock Project - Hydrogeology Modelling" (Hydrogeology TDR) (Stantec 2017c). The infiltration that results in groundwater recharge was not assumed to be captured in the contact water collection ditches, providing a conservative estimate of the amount of infiltration that may be lost to the environment.

The wetting of the waste rock was estimated by assuming that a column of waste rock of a given height reaches steady-state with the net infiltration of precipitation into the top of the WRSA equaling the volume of water existing the bottom of the WRSA. The volumetric water content at equilibrium with this infiltration rate (as defined by the hydraulic functions for the material) is the steady-state water content condition for the waste rock. The time it takes for the column of waste rock to reach this water content is then calculated as the time to the wetted-up condition. This analysis was done for a variety of waste rock column heights, as well as a variety of rainfall and net infiltration rates. Additionally, based on the thickness of each WRSA, the time required for approximately 50% of the WRSA (by area) to wet-up was calculated. For the purposes of the water balance model, the time for 50% wet-up by area was used in the model and is provided in Table 4-7. This provides a very conservative estimate of the toe seepage collected and the recharge rates to the groundwater system.

Table 4-7: WRSA Water Balance (% of Total Precipitation)

Scenario		Evaporation / Evapotranspiration[1]	Direct Runoff	Infiltration		Wetting Time	
				Toe Seepage	Recharge	Time for 50% Wet by Area (years)	Steady-State (years)
No Cover	WRSA A	33%	0%	32%	33%	18	45
	WRSA B	33%	0%	32%	33%	23	40
	WRSA C	33%	0%	43%	22%	23	37
	WRSA D	33%	0%	32%	33%	25	30
Progressive Rehabilitation	WRSA A	36%	3%	26%	33%	18	45
	WRSA B	36%	4%	25%	33%	23	40
	WRSA C	36%	5%	35%	22%	23	37
	WRSA D	40%	12%	13%	33%	25	30

Note:
[1]Includes the 2% sublimation loss from snow

Based on the above recharge rates, the travel times and discharge location of water that originates from the WRSAs was estimated using the groundwater flow model (Stantec 2017c).

Runoff and toe seepage is collected in the contact water collection ditches surrounding the WRSAs and directed to the various collection ponds and ultimately conveyed to pond M1. Of the precipitation, 32% is modelled as toe seepage for WRSA A, B, and D and 43% for WRSA C with the balance recharging the underlying groundwater flow system. For modelling purposes, this represents a very conservative estimate of seepage collection as it does not consider the collection of any portion of the groundwater recharge by the perimeter contact water collection ditches. Furthermore, mitigation measures to reduce infiltration to the WRSAs have not been incorporated, including designs to increase the amount of runoff from the WRSAs. As a result, this represents a very conservative prediction of loading to the groundwater environment from the WRSAs.

4.1.4 Open Pit and Historical Underground Workings

Model inputs to the open pit include groundwater inflow, precipitation and runoff that occur within the open pit and evaporation losses from ponded water within the open pit. During operation, precipitation and runoff that accumulates in the open pit will be directed to the underground workings of the historical MacLeod and Hardrock Mines.

This water, together with water currently in storage within the historical underground workings, will require management as part of open pit dewatering. The following provides a summary of the model assumptions and input parameters.

4.1.4.1 Groundwater Inflow

Groundwater inflow rates to the open pit were predicted using the three-dimensional numerical groundwater flow model developed for the Project (Stantec 2017c). The inflow rates consider both groundwater inflow into the underground workings of the historical MacLeod and Hardrock mines as well as groundwater inflow into the open pit. To address input data for the water quality model, groundwater inflow originating from the following sources reporting to the open pit and historical underground workings were estimated and included in the model:

- **Overburden Storage Area** – Groundwater recharge that originates from the overburden storage area, including recharge that passes through the overburden and historical MacLeod tailings that are covered by the overburden storage area
- **Historical Tailings (MacLeod and Hardrock)** – Groundwater recharge that originates from the remaining historical tailings located outside of Project components
- **Ore Stockpile** – Groundwater recharge that originates from the ore stockpile
- **WRSAs** – Groundwater recharge that originates from the WRSAs
- **Shallow and Deep Bedrock** – Groundwater originating from outside the above-noted Project components.

Table 4-8 provides the average inflow rates to the open pit and historical underground workings from each of the Project components.

Table 4-8: Calculated Average Groundwater Inflows (m^3/day) to Open Pit and Historical Underground Workings

Project Year	Model Year	WRSA A	Overburden Storage Area		Ore Stock pile	WRSA B	WRSA C	WRSA D	Historical Tailings		Bedrock		Total Inflow (m^3/day)
			Outside of MacLeod Tailings	Over MacLeod Tailings					Hardrock	MacLeod	Shallow	Deep	
-1*	1.75	0	50	40	6	0	0	0	44	291	1,522	964	2,916
1*	2	34	68	41	30	17	29	0	61	279	1,746	1,161	3,468
2	3	68	87	43	54	35	59	0	77	266	1,970	1,359	4,019
3	4	102	105	45	79	52	88	0	65	254	2,224	1,557	4,570
4	5	136	123	46	103	70	118	0	53	241	2,477	1,754	5,122
5	6	170	142	48	127	87	147	0	41	229	2,730	1,952	5,673
6	7	302	142	52	127	89	147	0	41	229	1,271	3,062	5,462
7	8	302	143	52	127	89	147	0	41	229	1,291	3,062	5,484
8	9	302	143	52	128	89	148	0	41	229	1,311	3,063	5,506
9	10	302	143	52	129	89	148	0	41	229	1,331	3,064	5,528
10	11	302	143	52	130	89	149	0	41	229	1,351	3,065	5,550
11	12	302	143	52	130	89	149	0	41	229	1,370	3,065	5,571
12	13	302	143	52	131	89	150	0	41	229	1,390	3,066	5,593
13	14	302	144	52	132	89	150	0	41	229	1,410	3,067	5,615
14	15	302	144	52	132	89	151	0	41	229	1,430	3,068	5,637
15	16	302	144	52	133	89	151	0	41	229	1,449	3,068	5,659

NOTE:
* Partial years (see Section 3.2)

4.1.4.2 Historical Underground Workings

The underground workings associated with the historical MacLeod and Hardrock Mines are currently filled with water and will need to be dewatered in stages as mining proceeds. To estimate the volume of water within the historical underground workings, GGM provided the void volumes for both the historical MacLeod and Hardrock underground workings by elevation. For portions of the underground that were backfilled, a void ratio of 0.3 was assigned. Table 4-9 provides the volume of water by Project and Model Year currently within the historical underground workings and does not account for variations during operation due to use for storage.

Table 4-9: Historical Underground Mine Workings Water Volume in Storage

Project Year	Model Year	Open Pit Depth Per Phase (m)					Dewatering Depth		Underground Storage Volume			
		Eastern Extension	Borrow Pit Phase	Open Pit Ph1	Open Pit Ph2	Open Pit Ph3	m BGS	m amsl	MacLeod (m³)	Mosher (m³)	Hardrock (m³)	Total (m³)
-1	1.75	0	50	0	0	0	75	275	38,506	0	302,441	340,947
1	2	0	140	40	0	0	165	185	89,888	0	326,977	416,865
2	3	0	140	70	0	0	95	255	0	0	0	0
3	4	0	140	130	0	0	155	195	0	0	0	0
4	5	0	140	180	60	0	205	145	52,040	0	59,717	111,757
5	6	90	140	240	130	40	265	85	55,690	0	60,668	116,358
6	7	140	140	300	190	100	325	25	255,846	0	2,067	257,913
7	8	140	140	300	260	130	285	65	0	0	0	0
8	9	140	140	300	330	190	355	-5	120,776	0	571	121,347
9	10	140	140	300	390	260	415	-65	493,375	0	1,142	494,518
10	11	140	140	300	390	320	345	5	0	0	0	0
11	12	140	140	300	390	380	405	-55	0	0	0	0
12	13	140	140	300	390	430	455	-105	580,626	27,302	13,620	621,547
13	14	140	140	300	390	490	515	-165	520,240	446,995	0	967,236
14	15	140	140	300	390	550	575	-225	168,494	607,571	0	776,065
15	16	140	140	300	390	590	615	-265	16,535	174,814	0	191,348
								Total	**2,392,016**	**1,256,681**	**767,204**	**4,415,902**

NOTES:
1. Ground surface elevation of 350 m amsl provided by GGM.
2. Dewatered elevation includes approximately 25 m depth below pit floor
3. Ph: Phase
4. BGS: below ground surface
5. amsl: above mean sea level
6. Active Mining
7. Not Mined
8. Mined Out

In the water balance model, the historical underground workings were simulated as a storage reservoir by dewatering more water during the winter period than is necessary to support operations and reduce the dewatering requirements during the spring periods when runoff to the open pit is high.

4.1.4.3 Open Pit Dewatering Rates

In the water balance model, open pit dewatering rates were calculated for each mining year with pumping determined from both the Mosher No. 1 Shaft (also referred to as the Consolidated Mosher Longlac Historical Shaft) and Hardrock No. 2 Shaft. To allow pre-production mining to begin, dewatering is initiated in the model six months prior to the start of mining. Actual timing for the start of dewatering will be confirmed and may be over a shorter period of time. A dewatering rate of 2,257 m^3/day (94 m^3/hr) was assumed for the historical Hardrock underground workings and 196 m^3/day (8 m^3/hr) for the historical MacLeod underground workings. This initial water was assumed to be discharged directly to the receiving environment following treatment, as required, in accordance with regulatory approvals.

During operation, water from open pit dewatering will be pumped to pond M1 with a portion of the water used to meet mill demand, as required, with the excess water discharged to the Southwest Arm of Kenogamisis Lake following treatment in accordance with regulatory approvals.

4.1.4.4 Open Pit Filling

Dewatering of the open pit and historical underground workings is terminated in Project Year 15 (Model Year 16), after which water levels within the open pit were allowed to recover naturally as a result of groundwater inflow, direct precipitation, and runoff. The groundwater inflow rates were modelled using the three-dimensional groundwater flow model (Stantec 2017c) and are summarized in Table 4-10.

To accelerate the filling of the open pit, water from the TMF and pond M1 will be directed to the open pit beginning in Project Year 16 (Model Year 17) until the open pit is filled to the design elevation of 331 m above mean sea level (amsl). As the quality of the water from the TMF and pond M1 are not expected to meet the PWQO, this water will be directed to the lower portion of the open pit through Mosher No. 1 Shaft. Once the water level within the open pit reaches an elevation of -140 m amsl (100 m deep), freshwater will be added from Kenogamisis Lake until the pit lake is filled to the design elevation, which occurs at the end of Project Year 31(Model Year 32). A pumping rate from Kenogamisis Lake of 0.278 m^3/s (1,001 m^3/hr) was selected, which represents 10% of the minimum monthly environmental flow at the Kenogamisis Lake dam. The flow rates and timing for pumping water from Kenogamisis Lake will be confirmed as Project planning progresses

Table 4-10: Open Pit Recovery Rates using Groundwater Inflows Only

Stage	Pit Lake Surface Area	Groundwater Inflow Rate into Open Pit	Total Volume Below
(m amsl)	(m^2)	(m^3/day)	(m^3)
-235	3,810	5,955	18,992
-225	10,406	5,945	113,447
-200	23,553	5,934	562,647
-175	38,201	5,923	1,381,120
-150	60,989	5,912	2,735,489
-125	91,303	5,901	4,673,141
-100	119,634	5,891	7,364,772
-75	151,938	5,880	10,938,028
-50	193,244	5,869	15,476,159
-25	241,705	5,858	20,998,348
0	273,346	5,848	27,493,237
25	309,099	5,832	34,987,070
50	365,298	5,826	43,737,782
75	422,692	5,805	53,733,020
100	469,640	5,793	64,972,541
125	513,668	5,778	77,473,425
150	571,332	5,760	91,348,389
175	630,284	5,742	106,475,741
200	692,286	5,716	123,202,788
225	761,566	5,677	141,655,724
250	858,720	5,563	162,387,019
275	965,204	5,276	185,471,379
300	1,067,731	4,850	211,082,564
325	1,279,833	3,112	240,288,047
331	1,447,624	1,355	248,935,682

4.1.5 Process Plant

Inputs for production data for the process plant are presented in Table 4-11 and are based on data provided by GGM.

Table 4-11: Mill Production and Model Input Data

Parameter	Mill Phase 1 (Year 1 to 2)	Mill Phase 2 (Year 3 to 16)	Units
GENERAL DATA			
Daily production rate (for EA)	24,000	30,000	tpd
Mill availability (% time mill available to operate)	92	92	%
MILL			
Moisture content of ore entering the mill	3	3	%
Volume of water leaving the mill in tailings slurry	20,693	25,866	m^3/day
Fresh water required for the mill	40	50	m^3/h
Evaporation and spillage losses at the mill	0	0	m^3/tonne

4.1.6 Tailing Management Facility (TMF)

The areas for the TMF used in the water balance are presented in Table 4-12 and were provided by AMECFW. In the model it is assumed that the north cell is rehabilitated with a vegetated soil cover following Project Year 7 (Model Year 8). In the model, water from the north cell is redirected to the south cell to provide a conservative estimate for water management requirements. Based on actual water quality data it may be possible to discharge water from the north cell to the environment once water quality meets acceptable discharge criteria. Water in the south cell is used in the model to meet mill demand until the end of Project Year 15 (Model Year 16). At closure, water from the TMF is directed to the open pit until the open pit is filled to the design elevation of 331 m amsl. Once the water level within the pit lake reaches this elevation, it is assumed that the TMF reclaim pond will be lower and converted to a sedimentation pond with water direct through the closure spillway to the Goldfield Creek diversion. This change in point of discharge will be informed by ongoing water quality monitoring results during closure.

For the percentage of wet to dry beaches, AMECFW indicated that 20% to 30% of the beaches are expected to be wet during the summer months and 100% during the spring months. For purposes of the water balance, 30% of the beaches were assumed to be wet in the summer months as this is the main period of evaporation. Evaporation rates from the wet and dry beaches were 590 mm/yr and 177 mm/yr, respectively, with evaporation occurring during the summer months of May to September, similar to lake evaporation.

Table 4-12: TMF Areas

Project Year	Beach Area (ha)			Pond Area (ha)	Total Area (ha)
	Dry	Wet	Total		
1	61	26	87	130	218
2	90	39	129	110	239
3	170	73	243	105	348
4	217	93	310	89	399
7	230	99	329	95	424
16	199	85	284	36	320

Tailings properties and TMF inputs are presented in Table 4-13 and were provided by GGM.

Table 4-13: Tailings Properties

Parameter	Phase 1 (Year 1 to 2)	Phase 2 (Year 3 to 16)	Units
TAILINGS			
Tailings/ ore ratio	1	1	n/a
Slurry density (mass of solids/total mass)	53.7	53.7	%
Specific gravity of solid tailings particles	2.8	2.8	n/a
Void ratio of deposited tailings (volume of voids/volume of solids)	1	1	n/a
Dry density of deposited tailings	1.34	1.34	tonne/m^3
Volume of deposited tailings	17,143	21,428	m^3/day
Saturated water content of deposited tailings (% of dry mass tailings)	35.7	35.7	%
Groundwater seepage collected by Seepage Collection System and pumped back to TMF	3,471	3,471	m^3/day
Seepage to environment	470	470	m^3/day
Dead storage volume	500,000	1,500,000	m^3
Active storage volume	500,000	1,500,000	m^3

Seepage collected by the seepage collection system will be pumped back to the TMF during operation and active closure and post-closure until the water quality is acceptable to discharge to the environment. The volume of groundwater collected by the seepage collection system at the end of operation was assumed for the entire operation phase to provide a conservative estimate of seepage collected by the collection system and pumped back to the TMF. In the model, seepage is collected and pumped back to the TMF until the pit lake is full, providing time for improvements in seepage quality. After the pit lake is full, water from the seepage collection system is not accounted for in the water balance model and is assumed to be acceptable for release to the environment, which will be confirmed during post-closure monitoring.

Rehabilitation of the north cell of the TMF is included after Project Year 7 (Model Year 8) and will consist of a vegetated soil cover. At closure, a similar cover will be installed on the south cell. For the rehabilitated areas, a total monthly evapotranspiration rate of 320 mm/yr was assumed over the months of May to September. Lake evaporation (Table 4-3) was applied to the TMF sedimentation pond, which is reduced in area and volume at closure.

4.2 WATER BALANCE MODEL RESULTS

The results of the water balance modelling for climate normal conditions are discussed below for each of Project components. Appendix A includes monthly flows for both climate normal, and the 25-year wet and 25-year dry model runs.

4.2.1 Open Pit and Historical Underground Workings

Figure 4-1 presents the groundwater inflow rate and the net precipitation contribution (precipitation minus evaporation) under climate normal conditions to the open pit. The total dewatering rates and the proportion of water pumped from Mosher No.1 Shaft and Hardrock No. 2 Shaft are also presented. The total dewatering rate includes groundwater inflow and net precipitation, plus the volume of water removed from storage each year. Table A-1 in Appendix A provides monthly water balance data for climate normal, 25-year wet and 25-year dry conditions.

Under climate normal conditions the total dewatering rate from the open pit and historical underground workings ranges from 145,109 m^3/month (202 m^3/hr or 55 L/s) to a maximum of 445,865 m^3/month (619 m^3/hr or 172 L/s) with an average rate of 281,336 m^3/month (391 m^3/hr or 109 L/s). Dewatering rates were set to be higher in winter to lower the water level in the historical underground workings to create storage for the spring periods when runoff to the Project contact water collection system is higher and increased management of surface water runoff is required. High winter dewatering rates also helps to maintain relatively constant discharges to the ETP throughout the year. For the last three years of operation (Project Year 12 to 15, Model Year 13 to 16), there is insufficient storage available in the historical underground workings to store spring runoff, therefore the dewatering rate is high in spring during those years. This period corresponds to the maximum dewatering rate for the Project.

Groundwater inflow rates progressively increase from 82,957 m^3/month (115 m^3/hr or 32 L/s) to a maximum of 175,863 m^3/month (244 m^3/hr or 68 L/s) at the end of Project Year 15 (Model Year 16) and accounts for 37% to 100% of the dewatering requirements with an average over the operating period of 61%. A sensitivity analysis of groundwater inflow rates was completed with the groundwater flow model (Stantec 2017c). The results demonstrated that the model was relatively insensitive to the hydraulic conductivity assigned to the upper and intermediate bedrock with groundwater inflows increased by less than 20% for increases in hydraulic conductivity of one to two orders of magnitude.

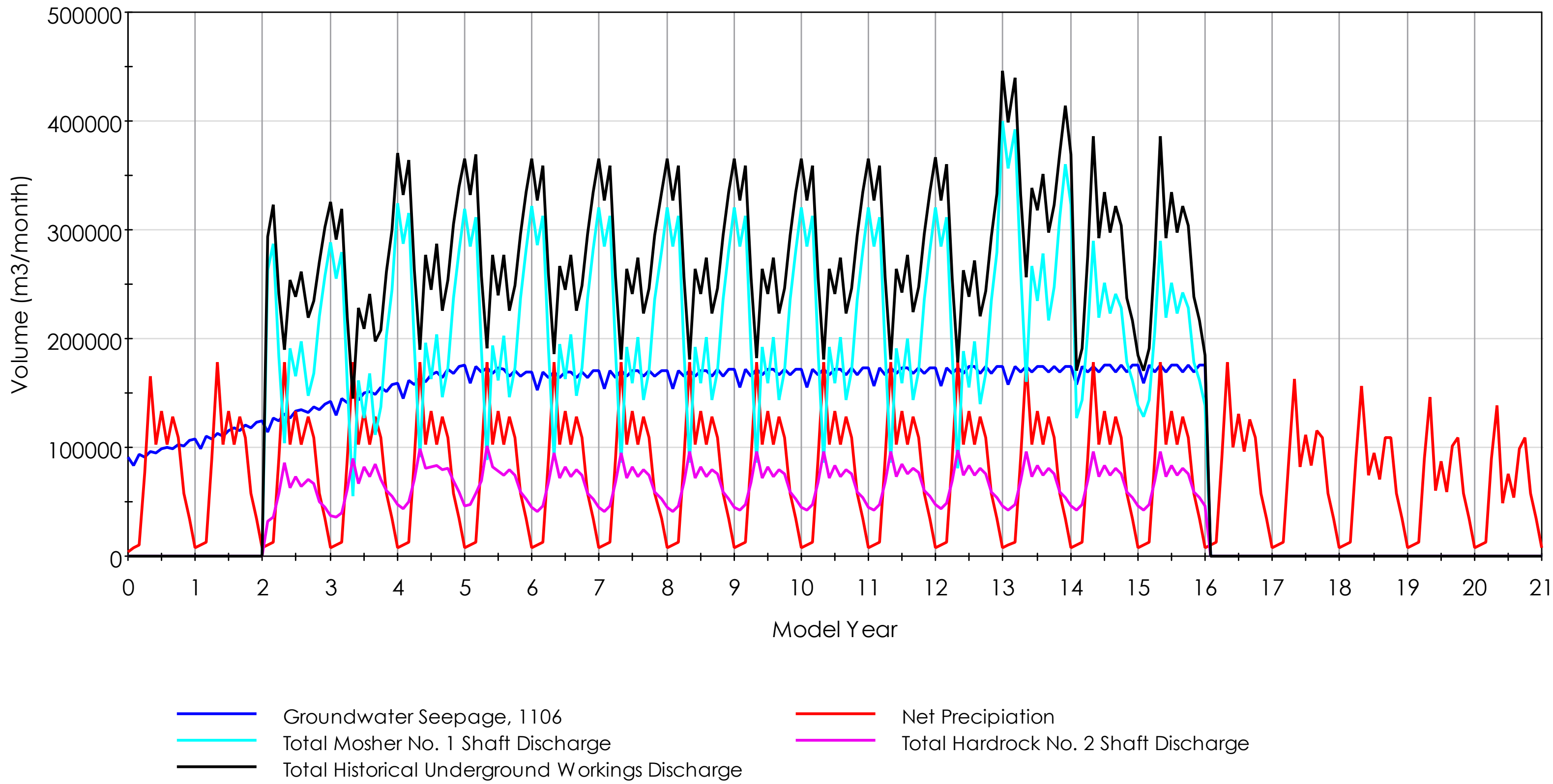


Figure 4-1: Open Pit Seepage and Dewatering Rates (Climate Normal)

Once mining is completed and dewatering is terminated, the open pit and historical underground workings begin to fill from groundwater inflow, direct precipitation, surface water runoff, and water from pond M1 and the TMF (Figure 4-2). The start of fresh water addition from Kenogamisis Lake occurs when the pit lake reaches an elevation of -140 m amsl (100 m deep), corresponding to the middle of Project Year 16 (Model Year 17). Once water levels within the pit lake reach 331 m amsl, water from the pit lake will be directed to the Southwest Arm of Kenogamisis Lake via an outlet channel to be constructed through the ore stockpile area. The model results demonstrate that the open pit and historical underground workings will fill at the end of Project Year 31 (Model Year 32) under climatic normal conditions, which is 16 years after end of operation. The annual discharge rate from the pit lake will range from 65,900 m^3/month (92 m^3/hr or 25 L/s) to 440,900 m^3/month (604 m^3/hr or 168 L/s) under climatic normal conditions and is summarized in Table 4-14.

Table 4-14: Open Pit Overflow Rates Post Closure (m^3/month) – Project Year 32 (Model Year 33)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Open Pit Overflow (m^3)	65,858	68,895	82,581	314,331	440,899	163,353	242,933	182,534	326,099	373,270	216,149	146,995	2,623,897

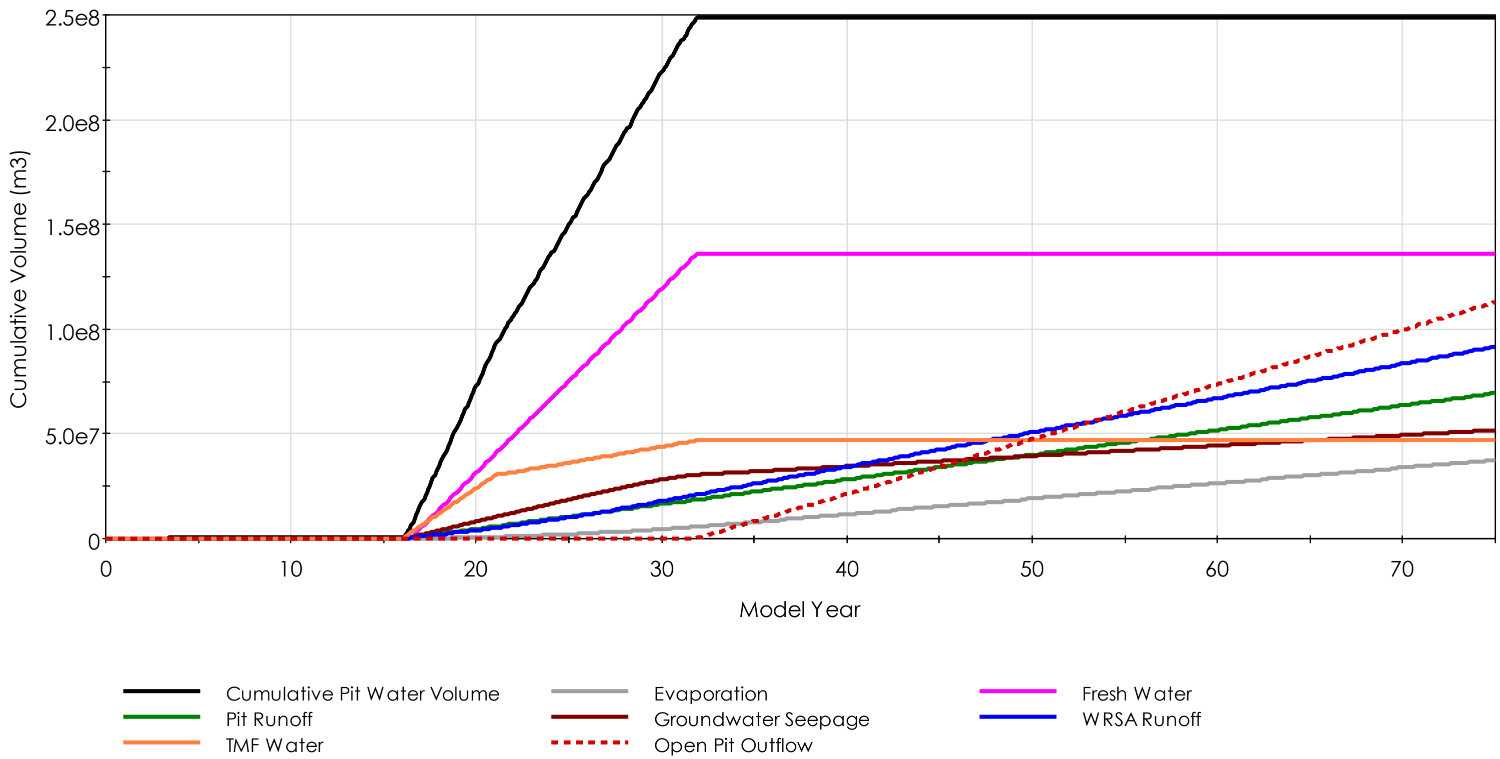


Figure 4-2: Open Pit Filling Rates (Climate Normal: Expedited Filling)

4.2.2 Tailings Management Facility

The water balance model was used to adjust the volume of water within storage in the TMF by balancing mill demand from the TMF with use of other contact water from pond M1 and from the dewatering of the historical underground workings and open pit. Figure 4-3 presents the simulated TMF reclaim pond volumes which demonstrate surpluses above the 'dead' storage volume with all surplus water directed to the process plant to meet mill demand under climate normal conditions. The result also demonstrates that the TMF can be operated with no discharge to the environment during operation under both normal and 25-year wet climate conditions. Tables A-2 in Appendix A provides monthly water balance data for climate normal, 25-year wet and 25-year dry conditions.

The WMMP includes flexibility for extended wet years, where excess TMF water can be stored in the TMF or used for increased mill demand. Under extended dry conditions, if the TMF reclaim pond cannot meet the mill demand, water from pond M1 or additional dewatering of the open pit and historical underground workings can accommodate mill demands.

During closure, water will be directed from the TMF to the open pit from Project Year 16 (Model Year 17) until the open pit is full at the end of Project Year 31 (Model Year 32). At that point excess runoff from the TMF in the model is assumed to be directed through the closure spillway to the Goldfield Creek diversion. The timing for discharge to the environment will be confirmed based on regulatory approvals and actual post-closure monitoring results. Average monthly discharge rates from the TMF for normal, 25-year dry, and 25-year wet climatic conditions are provided in Table 4-15. Average monthly discharge rates under climate normal conditions from the TMF to the diversion channel range from 0 m^3/month to a maximum of 208,800 m^3/month (285 m^3/hr or 79 L/s) during spring freshet conditions with an average annual discharge rate of 68,979 m^3/month (94 m^3/hr or 26 L/s).

Seepage through the TMF dams will be collected in the seepage collection ditches and ponds. During operation and closure, water from the TMF seepage collection ponds (T1, T2, and T3) will be pumped back to the TMF and is already accounted for in the water balance. After closure, once water meets acceptable discharge criteria, water from the seepage collection system will be discharged to the environment. Water from pond T1 will be discharged to the downstream tributary of Goldfield Creek and ultimately to Kenogamisis Lake. Water from pond T2 discharges to the Goldfield Creek Diversion Pond and then to the Goldfield Creek diversion channel and water from pond T3 is expected to discharge to the Southwest Arm of Kenogamisis Lake.

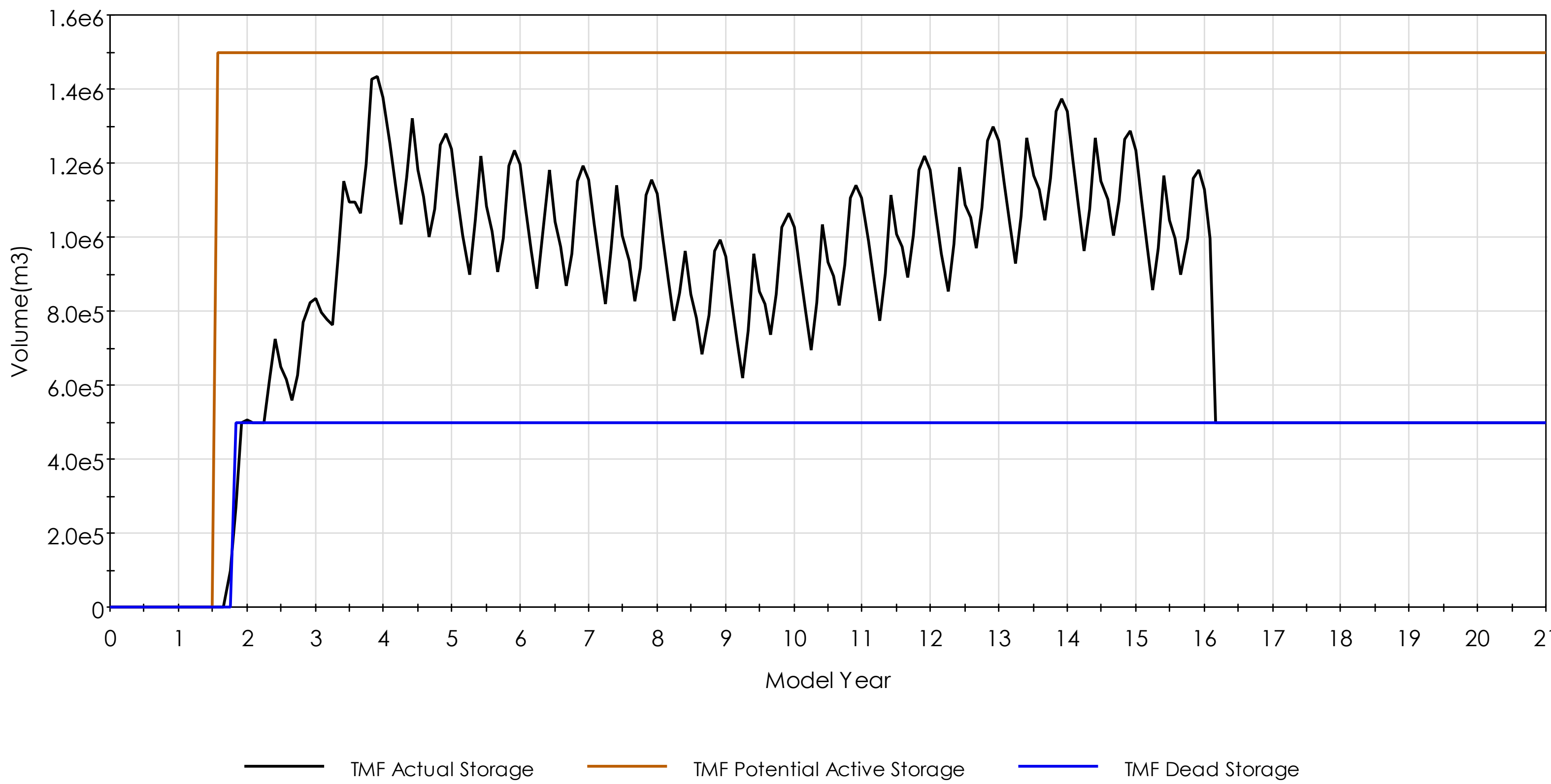


Figure 4-3: TMF Reclaim Pond Volume (Climate Normal)

Table 4-15: TMF Post-Closure Average Monthly Discharge Rates (m^3/month)

Climatic Condition	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Dry	0	0	0	0	0	0	44,655	56,136	83,049	147,478	20,298	0	351,616
Normal	0	0	0	0	208,843	64,126	120,545	64,973	167,762	152,353	47,951	0	826,553
Wet	0	0	0	0	322,173	87,895	330,802	59,183	367,048	202,023	26,240	27,881	1,423,245

4.2.3 Process Plant

The process water supply for the mill is provided from surplus water from the TMF reclaim pond, contact water from pond M1, and dewatering from the open pit and historical underground workings. A small (50 m^3/hr) freshwater demand has been included from Kenogamisis Lake, which is expected to be provided from effluent from the ETP but has been incorporated as another source in the water balance model. Figure 4-4 presents the volume of reclaim water supplied by each of the sources in comparison to the total reclaim demand. Tables A-3 in Appendix A provides monthly water balance data for climate normal, 25-year wet and 25-year dry conditions.

As discussed in Section 4.2.2, the TMF is capable of meeting approximately 80% to 90% of the mill demand under climate normal and 25-year wet conditions with any deficit is provided from pond M1 and dewatering from the open pit and historical underground workings.

4.2.4 WRSAs and Pond M1

Runoff and toe seepage from the WRSAs is collected in a series of collection ponds and ultimately pumped to pond M1. Figure 4-5 presents the water sources that are collected in pond M1. Tables A-4 in Appendix A provides monthly water balance data for climate normal, 25-year wet and 25-year dry conditions.

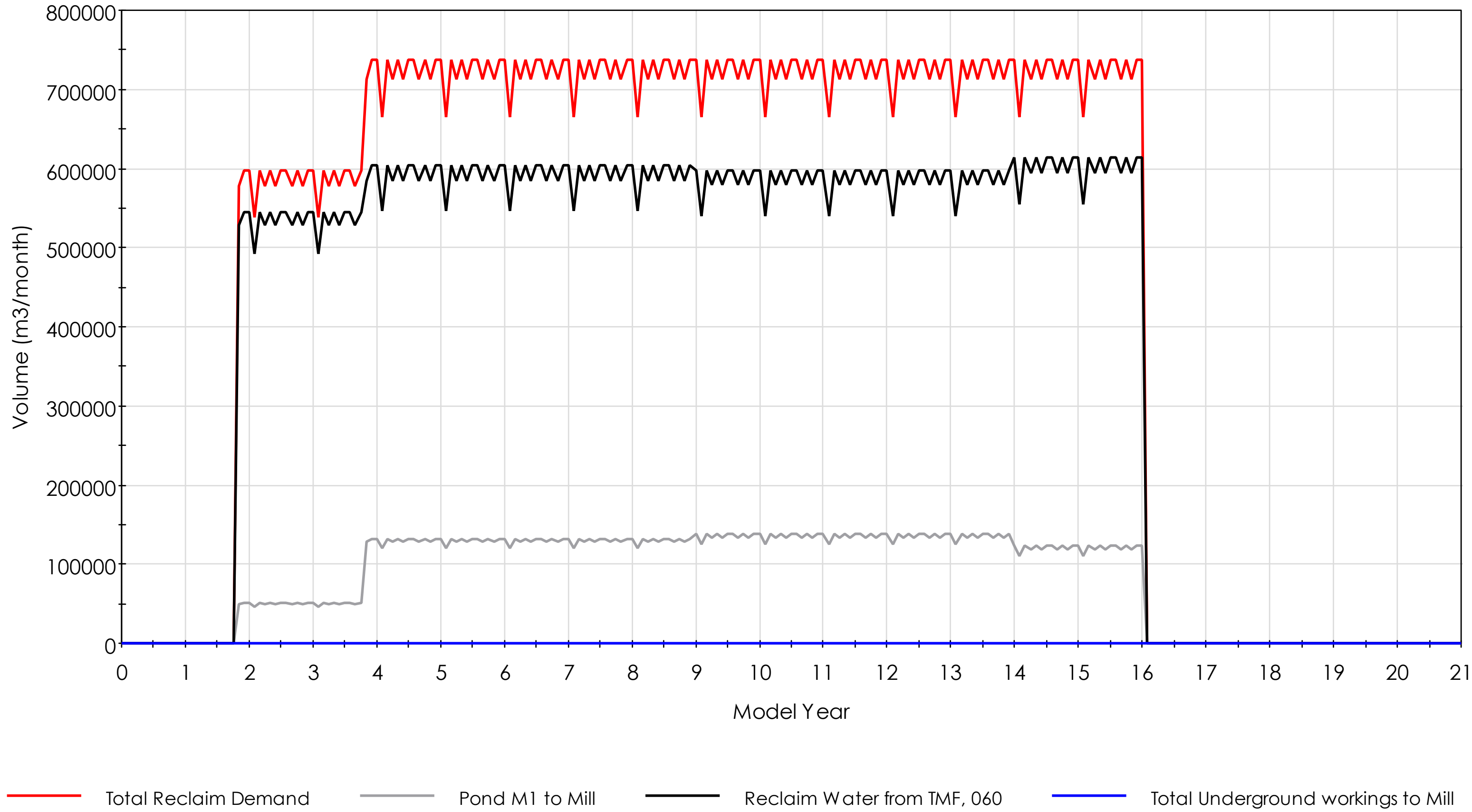


Figure 4-4: Mill Water Supply (Climate Normal)

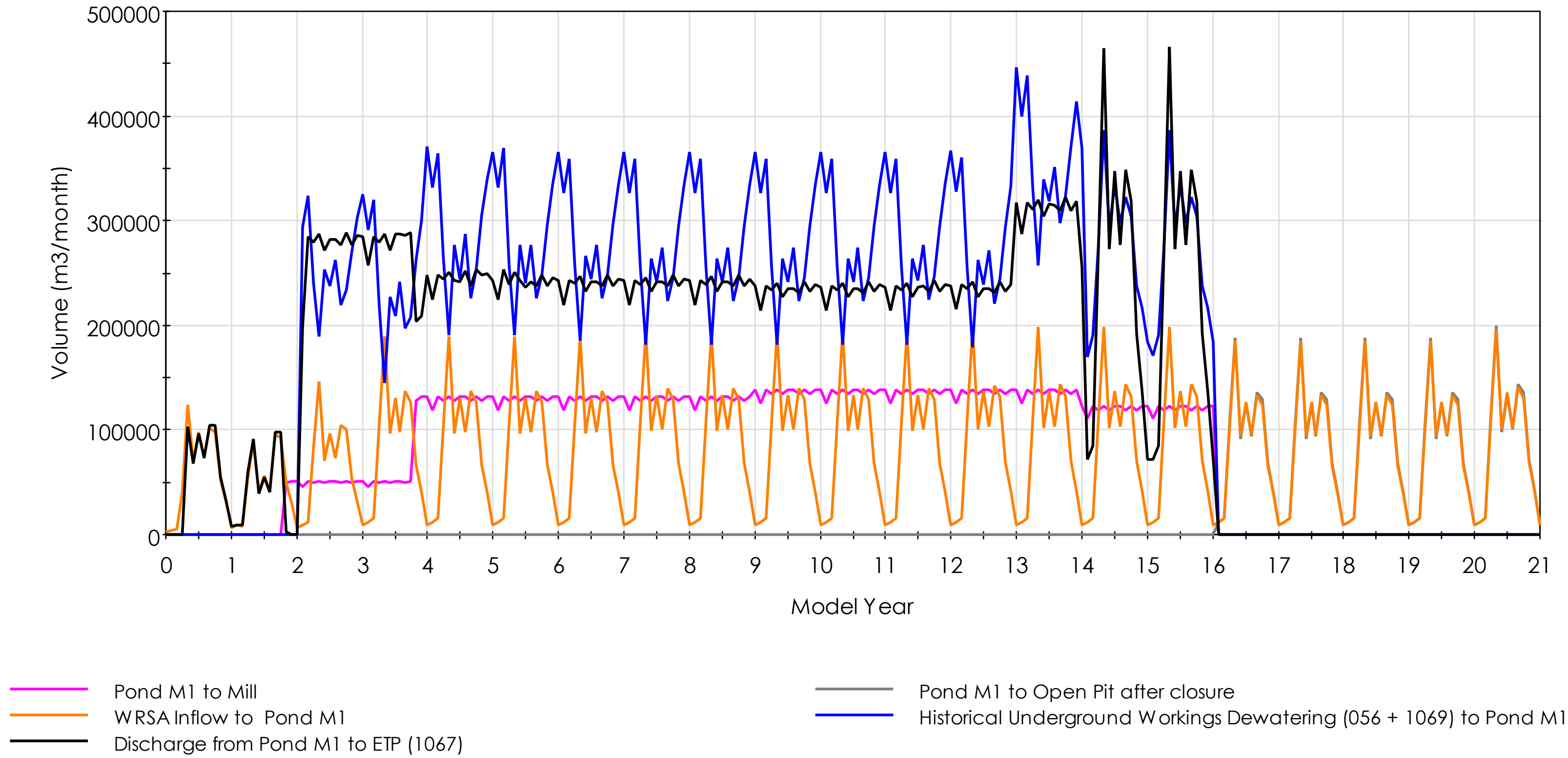


Figure 4-5: WRSA Runoff and Pond M1 Balance (Climate Normal)

Water from pond M1 is discharged to the Southwest Arm of Kenogamisis Lake following the required treatment through the ETP. Treated discharge will meet applicable regulatory requirements which will be confirmed during the permitting period. During the first two years of mining, the average ETP discharge flow is 47,700 m^3/month (65.3 m^3/hr or 18 L/s) resulting from runoff and toe seepage from the WRSAs and mill and process plant area. From Project Year 2 to 12 (Model Year 3 to 13) flows are relatively consistent with an annual average effluent discharge rate of 247,700 m^3/month (338 m^3/hr or 94 L/s)) from excess water from open pit and historical underground dewatering. In the final years of operation (Project Year 12 to 13, Model Year 13 to 14), storage within the historical underground workings is not available to buffer seasonal flows. During this period annual flows range from 72,000 m^3/month (98 m^3/hr or 27 L/s) to 466,000 m^3/month (638 m^3/hr or 177 L/s) with an average annual ETP discharge flow rate of 240,000 m^3/month (328 m^3/hr or 91 L/s) over the two-year period. As design progresses, further refinements to the water balance will be completed to reduce peak pumping volumes during this period through optimization of storage at the Project.

5.0 WATER QUALITY MODEL

This section presents the inputs used in the water quality model. The water quality model uses the water balance results presented in Section 4.0, in conjunction with source term chemistry, to predict water quality from the Project components and treated effluent discharge location to the environment. Inputs to the water quality model were developed from the geochemical baselines studies completed in 2014 and 2015 and presented in the "Environmental Baseline Data Report – Hardrock Project: Geochemical Characterization" (Geochemical Baseline Data Report) (Stantec 2015a) and the "Supplemental 2015 Geochemistry Data Report – Hardrock Project" (Supplemental Geochemical Baseline Data Report) (Stantec 2016b).

5.1 WATER QUALITY MODELLING METHODOLOGY AND INPUTS

The modelling approach for each of the Project components is described in the respective section below. These components are represented by individual cells in GoldSim™. The mass retained of each chemical parameter in the cell between time steps is "dissolved" in the volume of water within the cell (mixed reactor), allowing the calculation of concentrations of selected dissolved chemical parameters.

5.1.1 Parameter Selection

The selection of parameters for inclusion in the model was based on the results of the geochemical characterization presented in the Geochemical Baseline Data Report (Stantec 2015a) and criteria listed in Schedule 4 of the *Metal Mining Effluent Regulations of the Fisheries Act* (MMER) and *Ontario Regulation 560/94* (O. Reg. 560/94), which regulate the discharge quality of water from metal mines. The PWQOs were also used to identify parameters for inclusion in the model. The following dissolved parameters were considered in the modelling:

- major ions: sulphate, nitrate, nitrite, calcium, potassium, fluoride, chloride, magnesium, sodium, phosphorous, silicon
- parameters regulated by the MMER and O. Reg. 560/94: total ammonia, arsenic, cyanide species (CN^{-}_{TOTAL}, CN^{-}_{WAD}, CN^{-}_{FREE}), copper, nickel, lead, zinc
- parameters with PWQO: ammonia, mercury, silver, aluminum, arsenic, beryllium, boron, cadmium, cobalt, chromium, copper, iron, molybdenum, nickel, lead, antimony, selenium, thallium, tungsten, uranium, vanadium, zinc, and zirconium.

It should be noted that pH was not modeled as pH values below six are not expected in ponds or reservoirs within the Project footprint during operation based on geochemical testing data and long-term monitoring from the historical tailings (Stantec 2015a).

Geochemical reactions were not directly simulated in the model with one exception. Groundwater from the historical MacLeod and Hardrock tailings contains over 3.6 milligrams/litre (mg/L) of iron indicating reducing conditions (Appendix B1). As groundwater from the historical tailings is predicted to discharge to the open pit and the subsurface seepage collection system, precipitation of ferrous iron as iron hydroxides will result due to oxidizing conditions. The precipitation of iron hydroxides will adsorb other trace elements, such as arsenic, resulting in reduced concentrations of these elements in surface water. To determine solubility limits for input to the model, concentrations of groundwater from the historical Hardrock and Macleod tailings were equilibrated with oxygen (10 mg/L) using the Geochemist's Workbench® software. The results of initial and equilibrated solutions are shown in Appendix B2-1 and B2-2. The results demonstrate that amorphous iron hydroxide [$Fe(OH)_3$] and kaolinite [$Al_2Si_2O_5(OH)_4$] precipitate from solution limiting the solubility for iron and aluminum. The equilibrated solutions contain lower concentrations of several trace elements due to adsorption on amorphous $Fe(OH)_3$, including arsenic, which generally decreased by approximately 30 to 40% (Appendix B2-1 and B2-2). The equilibrated solutions were used as input concentrations for groundwater originating from the historical tailings that discharges to the open pit (Appendix B1). For all surface waters, the solubility limits for iron (5 micrograms per litre (µg/L)) and aluminum (120 µg/L) were applied in the water quality model. These limits represent the highest average concentrations observed in 2015 data from the field bins containing major waste rock lithologies (Stantec 2016b). These solubility limits are at least an order of magnitude higher than the equilibrated solutions reported in Appendix B2-1 and B2-2 indicating conservative assumptions.

Element precipitation and attenuation during the cyanide detoxification in the process plant and in the TMF reclaim pond is also considered in the water quality model (Section 5.1.5 and 5.1.6).

5.1.2 Waste Rock Storage Areas, Overburden Storage Area and Ore Stockpile

The schedule for deposition of waste rock, overburden, and ore into the different catchments areas is shown in Table 5-1 and Figure 3-1, Figure 3-2 and Figure 3-3. Runoff and seepage from these catchments is collected by the perimeter contact water collection ditches and directed to the collection ponds except for catchment "Aext-OP" where runoff will be directed to the open pit.

The WRSAs have four main sources of chemical loading prior to collection in the contact water collection system:

- leaching of elements as a result of weathering of waste rock and ore and dissolution of nitrogen species from undetonated blasting residues
- leaching of elements from overburden
- atmospheric precipitation.

These sources are discussed in separate subsections below.

5.1.2.1 Leaching Rates from Waste Rock and Ore

Leaching rates of elements from waste rock and ore were calculated as cumulative average mass loading rates from field bin testing data, which better approximate field conditions than humidity cell data (Appendix B3). Weekly loading rates were calculated by multiplying the element concentrations by the volume of leachate collected and divided by the field bin sample mass and by the time between sampling intervals. Initial data and loading rates for individual events were reported in the geochemical baselines studies (Stantec 2015a; 2016b). When concentrations in leachates from field bins were reported below the detection limit, a value of half of the detection limit was used in calculations. Concentrations of many trace elements, including silver, chromium and phosphorous, were consistently below the method detection limits. The method detection limits for silver and total chromium were below the PWQO and the method detection limit for phosphorus was above the PWQO. As a result, by assigning a value of half the detection limit the leaching rates associated with these elements are overestimated in the water quality model and as a result area overestimate in the water quality predictions.

Mass- and surface-leaching rates for each WRSA were calculated as an average weighted proportion of each lithology in the open pit, assuming an equal deposition of waste rock within each WRSA (Appendix B3). A significant decrease in leaching rates for a number of trace elements was observed during the second year of the field kinetic testing program (2015) in comparison to the first year (2014). In particular, arsenic leaching rates in 2015 declined by 3.8 times in comparison to 2014 rates for clastic sediments which represent approximately 72% of the total waste rock volume. In the water quality model, average 2014 leaching rates were applied to the mass of waste rock deposited in the first year. After one year of storage, the 2015 leaching rates were applied to the waste rock with no further reduction in leachate rate over the model timeframe. This is a conservative estimate of leaching rates as a further decrease is observed in 2016 data due. The decreases in leaching rates is related to the decline in oxidation rates of sulphide minerals as the surfaces of minerals become coated with oxidation products, limiting diffusion of oxygen into the mineral.

The resulting average leaching rates from field bin data were used to scaled up to the full size of the WRSAs, overburden storage area, and ore stockpile using the approach described by Kempton (2012) as outlined below:

$$R_n = R_{BF} \times SF_{AREA} \times SF_{TEMP} \times SF_{CONTACT} \qquad \textbf{Equation 5.1}$$

where;

R_n = scaled leaching rate from material n (waste rock or ore) in storage area/ stockpile, mg/kg/week

R_{BF} = 2015 or 2014 average weighted leaching rate from field bins, mg/kg/week (Appendix B3)

SF_{AREA} = scale factor accounting for the reduction in the leaching rate due to lower reactive surface area of waste rock per mass unit compared to material placed in the field bins, which was crushed to 6 mm nominal grain size (0.25 inches, Table 5-2)

SF_{TEMP} = scale factor accounting for the change in mineral oxidation and dissolution rate due to temperature differences (See Table 5-2)

$SF_{CONTACT}$ = contact factor accounting for a reduction in solute leaching due to hydraulic isolation (Table 5-2).

The scaling factors used in Equation 5.1 are presented in Table 5-2. An overview of the assumptions and calculations of these factors is presented in the Appendix B4.

Table 5-1: Overburden, Waste Rock and Ore Deposition Rates in Catchment Areas (kilotonnes per year, kt/yr)

Material		Overburden	Waste Rock											Ore	
Catchment Area		OB-A1	A-A1	A-A2	Aext-OP	Aext-A2	Aext-B2	B-B2	PP-B1	C-C1	C-M1	D-D1	D-D2	OS-B1	OS-B2
Project Year-Month	Model Year														
-2 - M5	0-0.42	3,372	–	–	–	–	–	–	–	–	–	–	–	78	100
-2 - M6	0.50	5,628	–	–	–	–	–	–	–	–	–	–	–	224	287
-2 - M7	0.58	13,128	–	–	–	–	–	24	–	–	–	–	–	509	650
-2 - M8	0.67	13,788	–	–	–	–	–	744	–	–	–	–	–	1,639	2,097
-2 - M9	0.75	8,760	–	–	–	–	–	10,008	–	–	–	–	–	3,299	4,220
-2- M10	0.83	3,012	–	–	–	–	–	21,372	–	–	–	–	–	2,558	3,273
-2 - M11	0.92	3,012	–	–	–	–	–	21,228	–	–	–	–	–	2,558	3,273
-2 - M12	1.00	180	–	–	–	–	–	22,524	–	–	–	–	–	2,738	3,503
-1 - M1	1.08	180	–	–	–	–	–	13,692	–	–	–	–	–	2,738	3,503
-1 - M2	1.17	–	–	–	–	–	–	15,072	–	–	–	–	–	3,480	4,451
-1 - M3	1.25	–	–	–	–	–	–	144	21,994	–	–	–	–	3,480	4,451
-1 - M4	1.33	–	–	–	–	–	–	888	11,546	–	–	–	–	3,785	4,842
-1 - M5	1.42	–	–	–	–	–	–	8,688	11,546	–	–	–	–	3,785	4,842
-1 - M6	1.50	–	–	–	–	–	–	–	20,539	–	–	–	–	3,618	4,628
-1 - M7	1.58	–	–	–	–	–	–	–	20,539	–	–	–	–	3,602	4,607
-1 - M8	1.67	–	–	–	–	–	–	25,200	13,028	–	–	–	–	8,314	10,635
-1 - M9	1.75	–	–	–	–	–	–	15,528	–	–	–	11,748	6,120	7,802	9,980
Start of Operation															
1 - M10	1.83	18,768	–	–	–	–	–	–	–	–	–	13,752	7,164	2,840	3,633
1 - M11	1.92	27,624	–	–	–	–	–	–	–	–	–	260	136	-2,903	-3,713
1 - M12	2.00	6,112	–	–	–	–	–	–	–	–	–	8,366	4,358	-2,841	-3,633
2 - Q1	2.25	5,912	–	–	–	–	–	–	–	–	–	34,947	18,205	-1,516	-1,939
2 - Q2	2.50	664	7,264	4,692	–	–	–	–	–	–	–	29,787	15,517	-596	-762
2 - Q3	2.75	–	10,216	6,600	–	–	–	–	–	–	–	28,930	15,070	-953	-1,219
2 - Q4	3.00	–	3,780	2,442	–	–	–	–	–	–	–	5,297	2,760	-268	-342
3	4	–	10,202	6,591	–	–	–	–	–	668	1,332	22,083	11,504	1,223	1,564
4	5	1,774	8,380	5,413	–	–	–	–	–	4,811	9,593	14,314	7,457	842	1,078
5	6	4,728	–	–	–	–	–	–	–	10,986	21,906	10,520	5,480	176	225
6	7	1	–	–	–	–	–	–	–	6,686	13,332	24,319	12,668	-1,243	-1,590
7	8	–	–	–	8,959	6,334	6,109	–	–	7,860	15,674	–	–	1,060	1,356
8	9	–	–	–	7,903	5,587	5,389	–	–	8,089	16,131	844	440	-801	-1,025
9	10	–	–	–	3,983	2,816	2,716	–	–	472	942	15,416	8,030	-1,031	-1,318
10	11	–	–	–	1,663	1,175	1,134	–	–	–	–	16,823	8,764	309	395
11	12	–	–	–	–	–	–	–	–	–	–	15,345	7,993	527	674
12	13	–	–	–	–	–	–	–	–	–	–	10,910	5,683	722	924
13	14	–	–	–	–	–	–	–	–	–	–	6,931	3,611	-1,226	-1,569
14	15	–	–	–	–	–	–	–	–	–	–	2,670	1,391	-2,929	-3,746
15	16	–	–	–	–	–	–	–	–	–	–	311	162	-1,071	-1,370
Start of Closure															
2034-2118	17.0-100	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Total Deposited (kt)	–	**17,802**	**26,732**	**17,269**	**22,508**	**15,911**	**15,347**	**12,926**	**8,266**	**39,573**	**78,909**	**173,439**	**90,347**	–	–

Note:

1. Minus (-) indicates withdrawal of ore from the catchment.

Table 5-2: Scaling Factors for WRSAs Loading during Operation

Material	Waste Rock				Ore			
Factor	SF_{AREA}	SF_{TEMP}	$SF_{CONTACT}$	SF_{TOTAL}	SF_{AREA}	SF_{TEMP}	$SF_{CONTACT}$	SF_{TOTAL}
January	0.13	0.8	0.03	0.003	0.11	0.8	0.03	0.003
February	0.13	0.8	0.04	0.004	0.11	0.8	0.04	0.004
March	0.13	0.8	0.06	0.006	0.11	0.8	0.06	0.005
April	0.13	0.8	0.38	0.040	0.11	0.8	0.38	0.033
May	0.13	0.8	0.77	0.080	0.11	0.8	0.77	0.068
June	0.13	0.8	0.46	0.048	0.11	0.8	0.46	0.040
July	0.13	0.8	0.6	0.062	0.11	0.8	0.6	0.053
August	0.13	0.8	0.46	0.048	0.11	0.8	0.46	0.040
September	0.13	0.8	0.56	0.058	0.11	0.8	0.56	0.049
October	0.13	0.8	0.46	0.048	0.11	0.8	0.46	0.040
November	0.13	0.8	0.24	0.025	0.11	0.8	0.24	0.021
December	0.13	0.8	0.14	0.015	0.11	0.8	0.14	0.012
Annual average	**0.13**	**0.8**	**0.35**	**0.036**	**0.11**	**0.8**	**0.35**	**0.031**

Equation 5.2 was used to calculate the mass of lost (non-exploded or residual) nitrogen per mass of deposited material (R_N, g/t):

$$R_N = DR \times PF \times P_N \times L_N \times FR_N \times RD \qquad \textbf{Equation 5.2}$$

where,

DR = deposition rate in catchment (t/yr, Table 5-1)

PF = Powder Factor used (260 g/t)

P_N = mass portion of nitrogen in the explosive assumed to be 33.3% of the lost explosive mass (Bailey et al. 2012), dimensionless

L_N = 0.002 nitrogen loss as 0.2% of total nitrogen used (Ferguson and Leask 1988), dimensionless, assuming that loss from explosive emulsion will be similar to ammonium nitrate/fuel oil (ANFO)

FR_N = fraction of nitrogen released from waste rock/ore storage areas (0.5) dimensionless, assuming that another 0.5 will be leached out from rock/ore while in the open pit prior material transfer

RD = runoff distribution factor (Table 5-3), distributes the annual mass of released nitrogen in proportion to the runoff per recommendation of Ferguson and Leask (1988).

Table 5-3: Runoff Distribution Factors

Month	Distribution factor	Month	Distribution factor
January	0.09	July	1.71
February	0.11	August	1.31
March	0.17	September	1.60
April	1.09	October	1.31
May	2.20	November	0.69
June	1.31	December	0.40
		Annual average	1.0

To speciate total nitrogen, the proportion (P_{sp}) of nitrate (87%), ammonia (11%), and nitrite (2%) recommended by Ferguson and Leask (1988) was used. The mass-rates of total nitrogen release were converted into the release of species (R_{Nsp}) according to their molecular mass as follows:

$$R_{Nsp} = R_N \times Psp \times Msp / M_N$$ **Equation 5.3**

where,

R_N = daily mass-rate of lost/released total nitrogen, Equation 5.2

Psp = mass portion of nitrogen species (e.g., 0.11 for ammonia)

Msp = molecular mass of nitrogen species (e.g., 17 for ammonia, moles)

M_N = molecular mass of nitrogen (14 g/mol).

5.1.2.2 Leaching Rates from Overburden

For the overburden storage area, existing groundwater quality data were used to provide the most representative data for characterization of loading rates from runoff and toe seepage originating from the shallow overburden. Median concentrations of water samples from existing groundwater wells in the area of the open pit and WRSAs were used in the model. These concentrations were multiplied by net outflow rate (runoff and toe seepage) from the storage areas to obtain the mass loading rate related to the overburden storage area (see Equation 5.4).

5.1.2.3 Atmospheric Precipitation

Atmospheric precipitation was collected in an empty field bin and water quality analyses were completed on the same frequency as the geochemical characterization (Stantec 2015b; 2016b). The median concentrations for precipitation were multiplied by the catchment runoff rate to obtain the mass loading rate related to atmospheric precipitation (see Equation 5.4).

5.1.2.4 Resulting Rate

The resulting monthly mass loading rate of elements ($R_{Ci\ TOTAL}$, mg/month) generated in the waste rock catchment (i) at time *t* was calculated as follows:

$$R_{Ci\ TOTAL} = K_{REHAB} \times (\sum_n R_n \times \int_t DR_n + R_{Nsp} + (C_P + C_{OB}) \times Q_{NET}) \quad \textbf{Equation 5.4}$$

where,

Q_{NET} =net runoff rate from the catchment calculated from water balance model, m^3/month

K_{REHAB}= coefficient accounting for reduction in net infiltration into WRSA after rehabilitation, unitless (1 during stockpile operation/rehabilitation and 0.923 after rehabilitation)

R_n = estimated scaled leaching rate from material n (waste rock and/or ore) using Equation 5.1, mg/kg/month

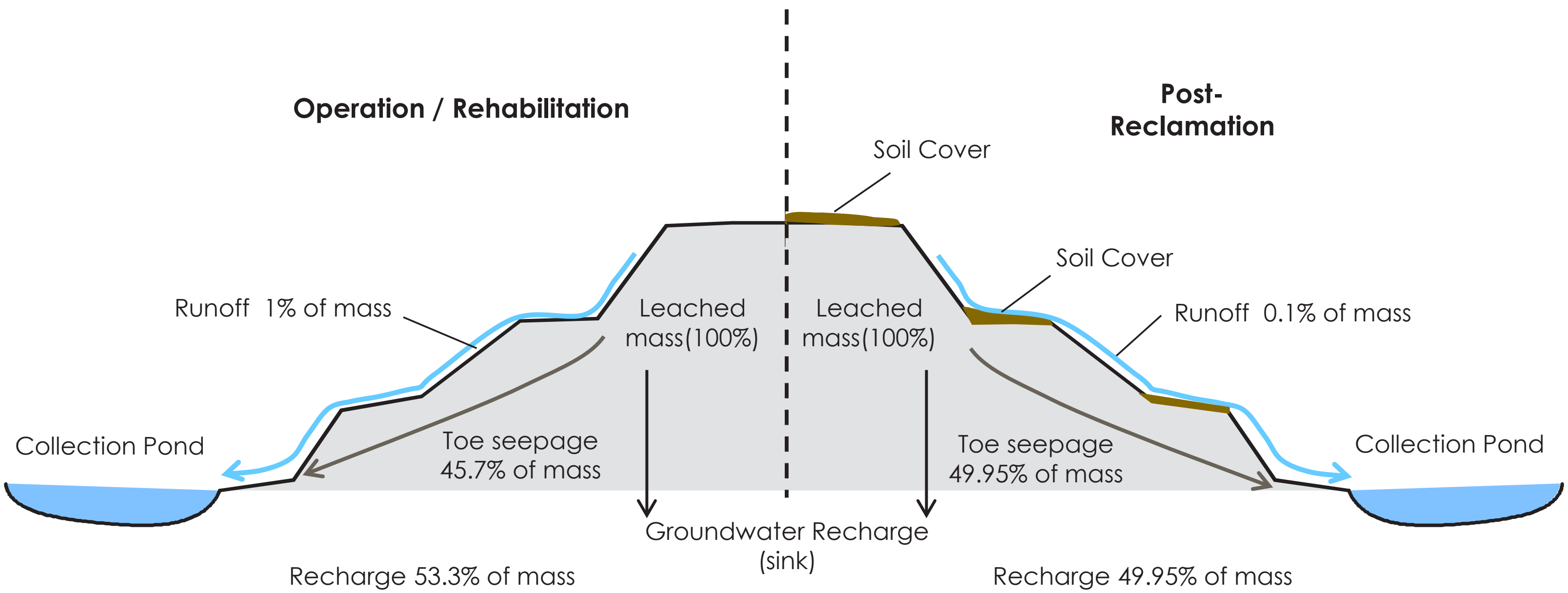
DR_n = deposition rate of material n (waste rock and/or ore) in the catchment i (in kg/month Table 5-1) integrated overtime to obtain total tonnage

R_{Nsp} = mass-rates of nitrogen species from Equation 5.3, in mg/month

C_P = median concentrations in atmospheric precipitation, mg/m^3 (Appendix B1)

C_{OB} = median concentrations in groundwater from overburden storage area, mg/m^3 (Appendix B1).

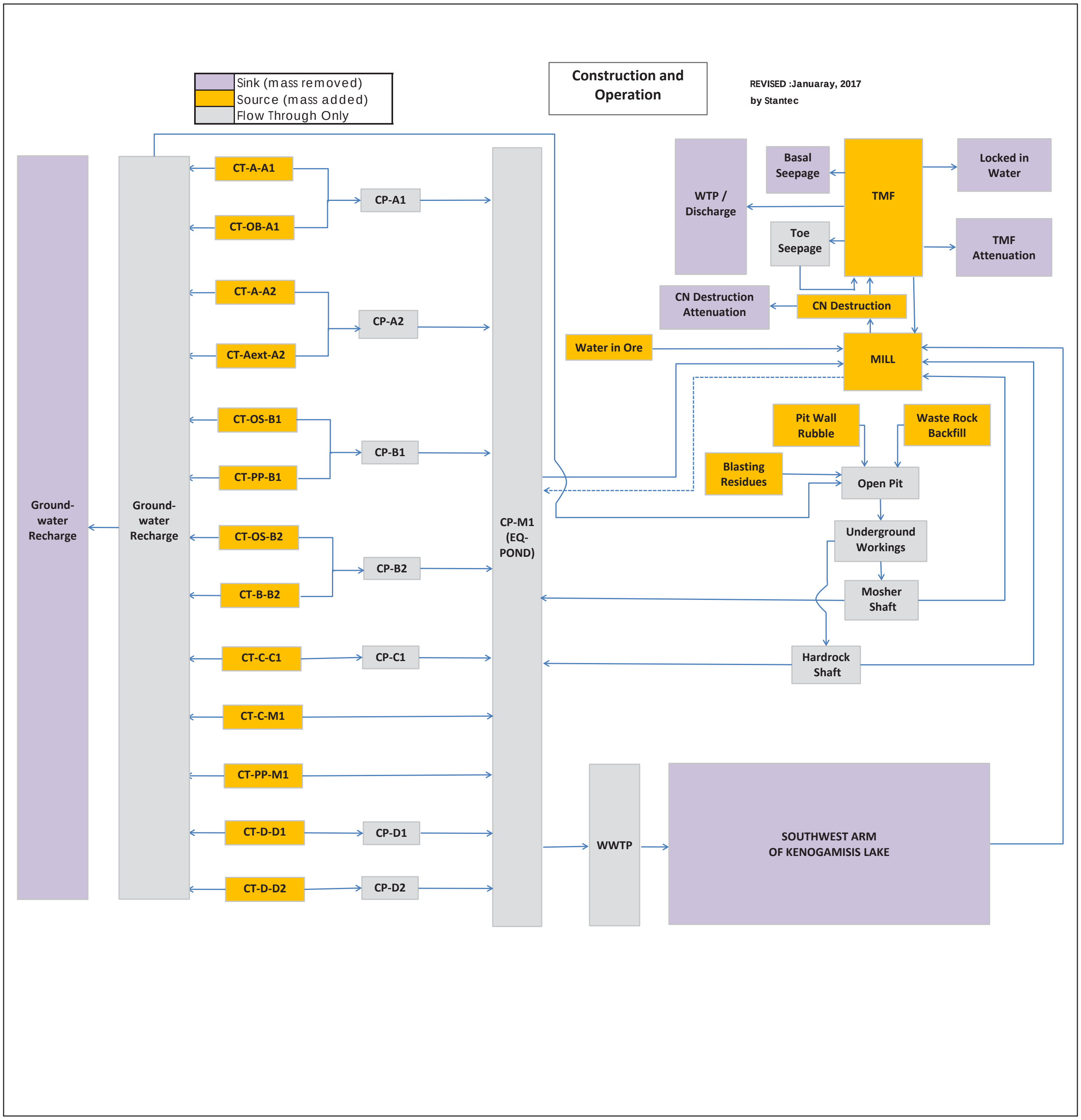
In each WRSA, the calculated total mass loading rate ($R_{Ci\ TOTAL}$) was split between runoff, toe seepage and recharge to groundwater. The mass removed with surface runoff was assumed to be 1% of total mass during operation and 0.1% after rehabilitation/closure. The balance of the total mass was released to porewater stored in each WRSA cell to provide the concentration inside the WRSA at each time step. In the model porewater leaves the WRSA cell as both toe seepage and recharge to groundwater with the mass proportioned to each pathway based on volume (Figure 5-1). The mass associated with runoff and toe seepage is captured by the contact water collection system ditches and ponds with the mass associated with groundwater recharge directed to the open pit or natural environment based on the results of the groundwater flow model (Stantec 2017c). The mass transfer between collection ponds and Project features is presented in Figure 5-2 for operation, in Figure 5-3 for active closure and post-closure, and in Figure 5-4 for post-closure when the pit lake is full.



Client/Project
Greenstone Gold Mines GP Inc. (GGM)
Hardrock Project

Figure No.
5-1

Title
Waste Rock Mass Balance Schematic



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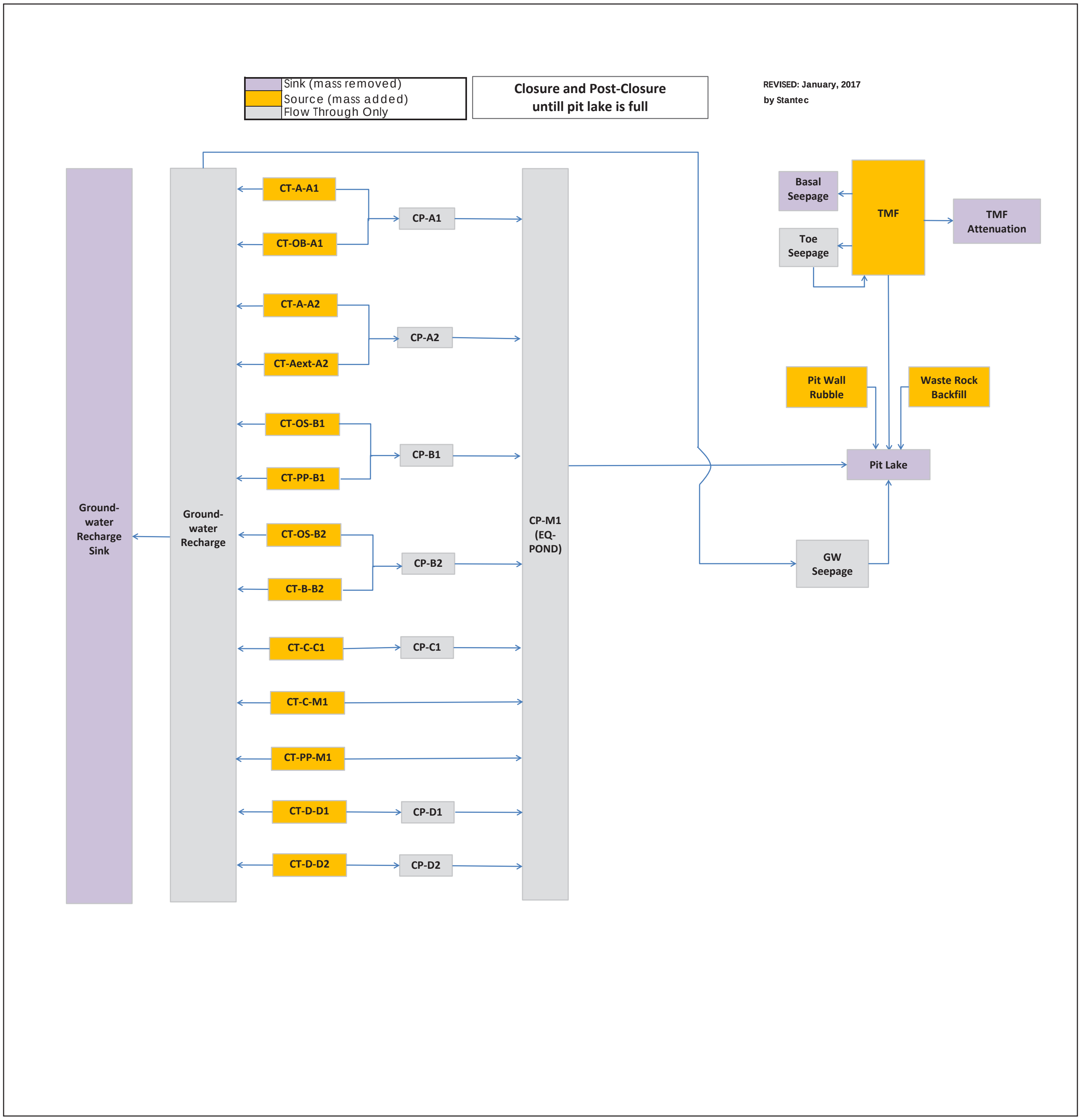
Client/Project

Greenstone Gold Mines GP Inc. (GGM)
Hardrock Project

Figure No.
5-2

Title
Mass Flows in Water Quality Model - Construction and Operation



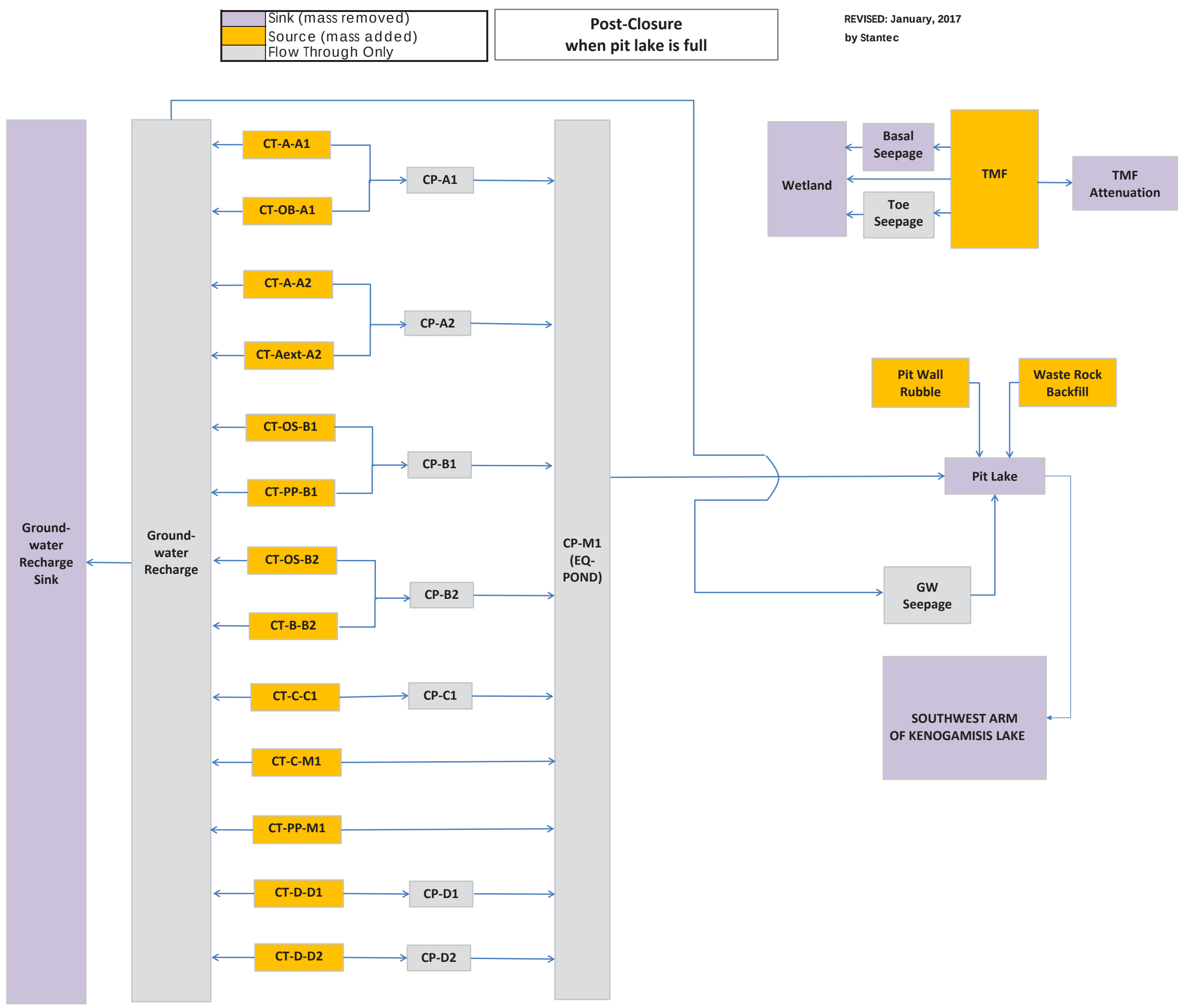
Stantec

Client/Project

Greenstone Gold Mines GP Inc. (GGM)
Hardrock Project

Figure No.
5-3

Title
Mass Flows in Water Quality Model - Closure and Post Closure until pit lake is full



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Client/Project

Greenstone Gold Mines GP Inc. (GGM)
Hardrock Project

Figure No.
5-4

Title
Mass Flows in Water Quality Model - Post Closure when pit lake is full

5.1.3 Open Pit

The open pit contains five major sources of chemical mass loading that have the potential to affect water quality:

- atmospheric precipitation
- groundwater inflow to the open pit
- leaching of elements from waste rock and ore exposed on the open pit walls
- leaching of elements from waste rock deposited in the open pit and rubble that remains on benches
- dissolution of nitrogen species from undetonated blasting residues on blasted rock and ore while awaiting transfer out of the open pit.

5.1.3.1 Atmospheric Precipitation

Similar to the WRSAs, the average concentrations for precipitation were multiplied by the runoff and precipitation rate over the open pit footprint to obtain mass loading rates related to atmospheric precipitation.

5.1.3.2 Groundwater Inflows

Groundwater mass loading rates were calculated for groundwater inflows originating from the overburden, shallow and deep bedrock, historical tailings, WRSAs and ore stockpile. The loading rates were calculated by multiplying the flow rates determined in the groundwater flow model (Stantec 2017c) by the concentrations calculated for the respective sources in Table 5-4. To account for travel times to the open pit, the median groundwater travel times from each source to the open pit were represented in the model with a dispersion coefficient applied in GoldSim™ using the Erlang function (Table 5-4). Figure 5-5 presents the source concentration of arsenic for infiltration beneath each WRSA and the resulting concentration and arrival time at the open pit.

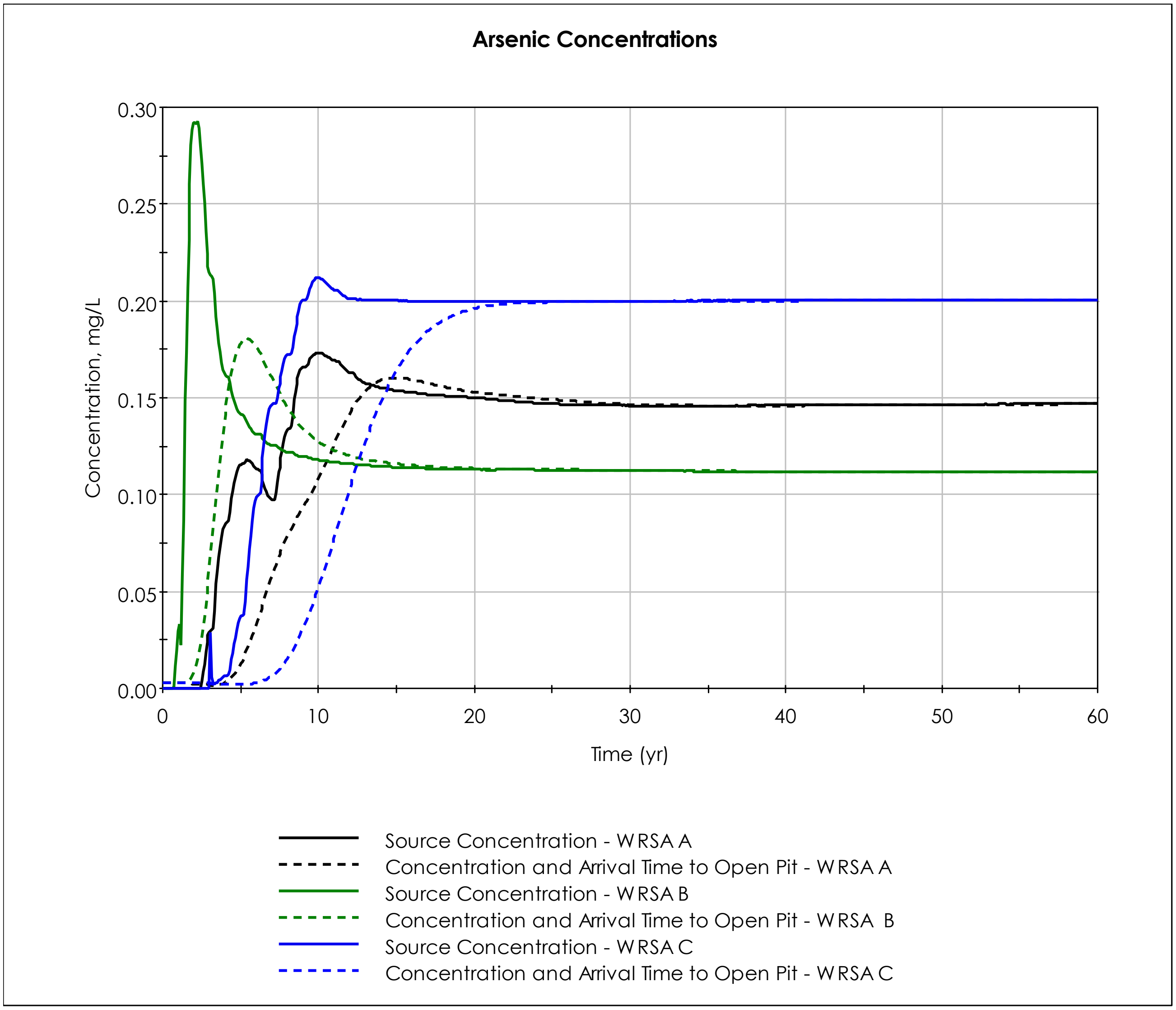

Figure 5-5: Arsenic Source Concentrations and Travel Time from WRSA to Open Pit

Table 5-4: Flow and Concentration to the Open Pit from Groundwater Sources

Pit lake elevation, m amsl	Overburden Storage Area		Ore Stockpile	WRSA A	WRSA B	WRSA C	WRSA D	Insitu Historical Tailings		Bedrock	
	Outside MacLeod Tailings	Over MacLeod Tailings						Hardrock	MacLeod	Shallow	Deep
Pit Dewatering – Project Year -1 to 15 (Model Year 1.75 to end of Year 16) See Table 4-8											
Pit Filling – Project Year 16 to 99 (Model Year 17 to 100) (m^3/day)											
-235	144	52	0	604	178	302	0	41	229	1,249	3,156
-225	144	52	0	604	178	302	0	41	229	1,244	3,151
-200	144	52	0	604	178	302	0	41	229	1,239	3,145
-175	144	52	0	604	178	302	0	41	229	1,234	3,139
-150	144	52	0	604	178	302	0	41	229	1,229	3,133
-125	144	52	0	604	178	302	0	41	229	1,224	3,128
-100	144	52	0	604	178	302	0	41	229	1,219	3,122
-75	144	52	0	604	178	302	0	41	229	1,214	3,116
-50	144	52	0	604	178	302	0	41	229	1,209	3,111
-25	144	52	0	604	178	302	0	41	229	1,203	3,105
0	144	52	0	604	178	302	0	41	229	1,198	3,099
25	144	52	0	604	178	302	0	41	229	1,191	3,091
50	144	52	0	604	178	302	0	41	229	1,188	3,088
75	144	52	0	604	178	302	0	41	229	1,178	3,077
100	144	52	0	604	178	302	0	41	229	1,173	3,071
125	144	52	0	604	178	302	0	41	229	1,166	3,062
150	144	52	0	604	178	302	0	41	229	1,157	3,053

Table 5-4: Flow and Concentration to the Open Pit from Groundwater Sources

Pit lake elevation, m amsl	Overburden Storage Area		Ore Stockpile	WRSA A	WRSA B	WRSA C	WRSA D	Insitu Historical Tailings		Bedrock	
	Outside MacLeod Tailings	Over MacLeod Tailings						Hardrock	MacLeod	Shallow	Deep
175	144	52	0	604	178	302	0	41	229	1,149	3,043
200	144	52	0	604	178	302	0	41	229	1,137	3,030
225	144	52	0	604	178	302	0	41	229	1,119	3,009
250	144	52	0	604	178	302	0	41	229	1,065	2,948
275	144	52	0	604	178	302	0	41	229	930	2,796
300	144	52	0	604	178	302	0	41	229	730	2,571
325	72	26	0	319	92	243	0	21	120	570	1,649
331	0	0	0	33	6	184	0	0	12	669	452
Median Groundwater Travel Time to Open Pit											
yrs	9.6	9.6	2.7	3.7	2.7	6.1	N/A	0.06	19	0	0
Source Concentration Prior to Project Loading											
mg/L	C_{OB}[1]		$C_{DEEP\ BEDROCK}$*							$C_{SHALLOW\ BEDROCK}$[1]	$C_{DEEP\ BEDROCK}$[1]
Source Concentration for Project Loading											
mg/L	C_{OB}[1]	$C_{MacLEOD}$[2]	$C_{ORE\ CALC}$[3]	$C_{A\ CALC}$[3]	$C_{B\ CALC}$[3]	$C_{C\ CALC}$[3]	N/A	$C_{HARDROCK}$[2]	$C_{MacLEOD}$[2]	$C_{SHALLOW\ BEDROCK}$[1]	$C_{DEEP\ BEDROCK}$[1]

NOTES:
N/A – Not Applicable
[1]Median groundwater concentrations from Appendix B1
[2]Equilibrated median groundwater concentrations from Appendix B1
[3]Average concentration in pore water recharging from storage areas calculated by the model

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The subsurface seepage collection system that will be installed around the historical MacLeod high tailings was found to have limited effect during operation as groundwater levels are predicted to decline below the collection system and seepage is captured by the open pit. At closure once the open pit is filled, seepage will be collected within this subsurface collection system and directed to depth within the open pit through Mosher No.1 Shaft.

5.1.3.3 Open Pit Walls

Leaching rates from exposed open pit wall surfaces were calculated by dividing the scaled mass load rate (R_n, mg/kg/week) by the weighted average specific surface area (SA) of ore or waste rock (Appendix B3). The surface area of exposed pit walls, benches and floor as function of elevation were provided by GGM (Table 5-5 and Appendix B5). Based on this information, the annual rate of open pit wall exposure was calculated and used as input in Equation 5.5.

After closure, the open pit will be filled with water and the walls become submerged as the level of the pit lake increases. Submerged walls are not expected to produce substantial mass load due to limited oxidation of sulphide minerals below the water level of the pit lake. Therefore, only exposed open pit walls above the water level of the pit lake generate mass loading in the model. The total surface area of the exposed pit walls as a function of the pit lake level was calculated (Table 5-5).

5.1.3.4 Waste Rock and Bench Rubble

The tonnage of rubble on the open pit benches was calculated and assumes all benches will be covered with rock rubble at an angle of repose of 33 degrees. These tonnages are a function of open pit elevation (Table 5-5 and Appendix B5). In the model it was assumed that 20% of the rubble was comprised by ore and the rest (80%) by waste rock in accordance to the proportion of total masses of waste rock and ore mined over the LOM.

Eastern portions of the open pit will be backfilled with waste rock to allow the development of the extension of WRSA A (Aext-OP) (Figure 3-1 and Table 5-1). The schedule and elevations for the open pit backfill and deposition of waste rock were provided by GGM (Table 5-5 and Appendix B6). The scaled leaching rates were calculated using Equations 5.1 and 5.2. These rates and tonnages of rubble and waste rock were used to calculate total mass-loads in Equation 5.5. Loading from this waste rock is directed to the open pit in the model.

After closure, rubble and waste rock backfill will become submerged as the level of the pit lake increases. Submerged rubble and waste rock backfill was assumed to produce no mass due to limited oxidation of sulphide minerals once submerged under water. The total tonnages of exposed rubble and backfill as a function of the pit lake level are shown in Table 5-5.

5.1.3.5 Blasting Residues

The leaching rate of nitrogen species within the open pit was calculated using the same approach as described in Section 5.1.2. Production tonnages for the open pit were provided by GGM and summarized in Table 5-5.

Table 5-5: Mass of Waste Rock and Bench Rubble in Open Pit

Open pit bottom or Pit Lake water Level (m amsl)	Exposed Bench Rubble (kt)	Open Pit Wall Area (m^2) (exposed above open pit bottom or lake water level)	Waste Rock Backfill (kt)
-250	5,664	2,309,161	18,403
-230	5,664	2,309,161	18,403
-210	5,652	2,298,226	18,403
-190	5,624	2,280,338	18,403
-170	5,582	2,259,314	18,403
-150	5,532	2,232,942	18,403
-130	5,475	2,204,325	18,403
-110	5,407	2,167,482	18,403
-90	5,312	2,115,923	18,403
-70	4,999	2,051,589	18,403
-50	4,866	1,988,347	18,403
-30	4,733	1,919,728	18,403
-10	4,597	1,847,553	18,403
10	4,454	1,779,671	18,403
30	4,306	1,699,787	18,403
50	4,148	1,618,755	18,403
70	3,730	1,531,339	18,403
90	3,560	1,451,000	18,403
110	3,387	1,363,363	18,403
130	3,208	1,276,624	18,403
150	3,027	1,190,700	18,403
170	2,839	1,099,831	18,403
190	2,645	1,007,830	18,403
210	2,137	903,486	18,403
230	1,909	799,118	17,980
250	1,662	675,629	16,829
270	1,383	523,407	14,595
290	1,058	368,760	11,516
310	703	196,729	6,964
320	351	98,365	3,959
340	0	0	0

NOTE:

1. Values between elevations are interpolated by the model.

Table 5-6: Production Rates for Open Pit

Project Year	Model Year	Waste Rock (kt/yr)	Ore (kt/yr)	Project Year	Model year	Waste Rock (kt/yr)	Ore (kt/yr)
-2-M5	0-0.42	2,748	180	1-M12	2.00	38,172	2,568
-2-M6	0.50	5,772	540	2-Q1	2.25	56,408	5,532
-2-M7	0.58	2,256	1,212	2-Q2	2.50	60,504	7,728
-2-M8	0.67	7,320	3,912	2-Q3	2.75	60,784	6,976
-2-M9	0.75	10,548	7,884	2-Q4	3	60,104	8,612
-2-M10	0.83	21,504	6,108	3	4	55,996	12,098
-2-M11	0.92	21,504	6,108	4	5	53,183	12,336
-2-M12	1.00	22,500	6,540	5	6	52,214	10,745
-1-M1	1.08	22,500	6,540	6	7	57,743	7,385
-1-M2	1.17	21,996	8,304	7	8	48,568	12,856
-1-M3	1.25	21,996	8,304	8	9	48,116	8,412
-1-M4	1.33	20,112	9,036	9	10	38,538	7,864
-1-M5	1.42	20,112	9,036	10	11	29,466	11,091
-1-M6	1.50	20,424	9,768	11	12	23,264	11,582
-1-M7	1.58	20,424	9,768	12	13	16,502	12,049
-1-M8	1.67	38,112	22,188	13	14	10,456	7,397
-1-M9	1.75	33,324	25,416	14	15	4,053	3,360
1-M10	1.83	20,760	15,672	15	16	473	787
1-M11	1.92	20,892	2,124	**Total mined (kt)**		530,770	138,610

5.1.3.6 Open Pit Loading Rates

The resulting monthly input mass loading rate of elements ($R_{OPtotal}$ total, mg/month) leaving the open pit at time *t* during operation was calculated as follows:

$$R_{OPtotal} = C_P \times Q_{OP} + C_{GWi} \times Q_{GWi} + R_{ORE}/SA_{ORE} \times A_{ORE}(el) + R_{WR}/SA_{WR} \times A_{WR}(el) + R_{ORE} \times M_{ORE}(el) + R_{WR} \times M_{WR}(el) + R_{Nsp} + R_{Aext\text{-}OP\ TOTAL} - R_{sed} \times A_{Pit\ Lake}(el)$$ **Equation 5.5**

where,

C_P = average concentrations in atmospheric precipitation, mg/m^3 (Appendix B1)

Q_{OP} = runoff rate from open pit catchment, m^3/month (see Section 4.0)

C_{GWi} = average concentrations in groundwater associated with material i, mg/m^3 (Appendix B1). Delayed and dispersed a shown in Table 5-4

Q_{GWi} = groundwater inflow rate into the open pit from material i, m^3/month (Table 5-4)

$R_{ORE\ or\ WR}$ = scaled leaching mass-rate from ore or waste rock per mass unit, respectively, calculated from Equation 5.1, mg/kg/month

$SA_{ORE\ or\ WR}$ = specific surface area of ore or average weighted specific surface area of waste rock, m^2/kg (Appendix B3)

$A_{ORE\ or\ WR}$ = area of open pit wall for ore or waste rock exposed above specific elevation, m^2 (Table 5-5)

$M_{ORE\ or\ WR}$ (el) = tonnage rubble for ore and waste rock exposed above specific elevation, kg (Table 5-5)

R_{sp} = mass-rates of nitrogen species from blasting residues (operation only), in mg/month, using Equation 5.3

$R_{Aext\text{-}OP\ TOTAL}$ = total scaled leaching mass-rate from waste rock in catchment $R_{Aext\text{-}OP}$, mg/month, calculated from Equation 5.4

R_{sed} = sedimentation rate for As and Sb 0.822 mg/m^2/month (Dessouki et al. 2005)

$A_{Pit\ Lake}$(el) = area of open pit surface at specific elevation, m^2 (Table 5-5).

5.1.3.7 Open Pit Closure

At closure the open pit will be filled with water to form a permanently stratified pit lake with the lower portion of the lake chemically and physically disconnected from the upper portion. In the model the following steps were included to develop the stratified pit lake during closure (Figure 5-3):

- Create a dense layer of water at the bottom of the open pit and help to accelerate the filling of the open pit by directing water from the TMF and pond M1 to the lower portions of the open pit through the Mosher No.1 Shaft (Figure 5-3).
- Create an upper layer of fresh water (epilimnion) and permanently stratify the pit lake by adding freshwater from Kenogamisis Lake once the pit lake reaches a depth of 100 m.
- Once the pit lake reaches the design elevation of 331 m amsl, the addition of water from the TMF will cease and water from pond M1 will be directed to the lower portions of the pit lake through Mosher No. 1 Shaft until water quality in pond M1 meets acceptable discharge criteria.

Stratification of the pit lake allows water from the contact water collection ponds to be discharged to the lower level of the pit lake, which has little effect on the epilimnion water quality until such time that the ponds can be decommissioned subject to water quality. As a result, the epilimnion has four loading sources in the model:

- atmospheric precipitation
- leaching of elements from waste rock and ore exposed on open pit walls
- leaching of elements from exposed and rubble waste rock deposited with the open pit
- groundwater inflow from *in-situ* historical tailings and WRSAs.

Removal of arsenic and antimony as a result of adsorption on suspended matter and precipitated minerals (such as iron hydroxide) is included in the epilimnion portion of the model with the mass transferred to the lower portion of the pit lake by sedimentation. A sedimentation rate of 0.82 mg/m^2/month was applied in the model for arsenic and antimony based data from Dessouki et al. (2005). No removal by sedimentation was assumed for other elements.

5.1.4 Historical Underground Workings

In the model, water from the open pit drains into underground workings of the historical MacLeod and Hardrock Mines. The initial volumes of mine workings (Table 4-9) and average concentrations of water within the historical MacLeod and Hardrock underground workings (Appendix B1) were used as the initial conditions in the model. The model calculates concentrations in the historical underground workings as the total mass in the reservoir divided by the total volume of water in the voids/underground workings.

5.1.5 Process Plant

During start-up of the process plant, most of the water is expected to be supplied from the historical underground workings and later from TMF when the tailings reclaim pond reaches the required capacity. Elements/species are released from ore and/or added into the process solution during cyanidation. These solutions are subjected to cyanide detoxification resulting in co-removal of many elements from the solution (Appendix B7). As a result, only a portion of the released elements is transferred to the TMF reclaim pond in water with the tailings. This water is then diluted in the TMF reclaim pond by precipitation and runoff and recycled through the process plant as recycled water. The mass loading rate of elements leaving the process plant (mg/day) were calculated using Equation 5.6:

$$R_{PLANT} = (C_{FRESH} \times Q_{FRESH} + C_{UG} \times Q_{UG} + C_{RECLAIM} \times Q_{RECLAIM} + M_{RATE} \times R_{CN}) \times K_{DETOX} \quad \textbf{Equation 5.6}$$

where,

C_{FRESH} = average concentrations in fresh water supply mg/m^3 (Appendix B1)

Q_{FRESH} = fresh water supply rate, m^3/day (refer to Section 4.0)

C_{UG} = average concentrations in historical underground workings, mg/m^3 (calculated see Appendix B1)

Q_{UG} = pumping rate from historical underground workings, m^3/day (refer to Section 4.0)

$C_{RECLAIM}$ = concentrations in TMF calculated by the model in the previous time step, mg/m^3

$Q_{RECLAIM}$ = rate water reclaimed from TMF reclaim pond, m^3/day (refer to Section 4.0)

M_{RATE} = ore milling/processing rate, kg/day (refer to Section 4.0)

R_{CN} = average element mass addition or removal per mass unit of ore during cyanide leaching, mg/kg (Appendix B7)

K_{DETOX} = coefficient reflecting addition (>1) or removal (<1) of elements from process solution during cyanide detoxification, unitless (Appendix B7).

Testing has been completed to refine the cyanide detoxification process. The average results presented in Appendix B7 were used in the model runs and provide a total cyanide concentration of 8.1 mg/L, with arsenic concentrations decreasing from 1.52 mg/L to 0.076 mg/L in the solution following detoxification. Further refining of the cyanide detoxification process will be completed as design progresses for the process plant.

5.1.6 TMF

The reclaim pond in the TMF has the following mass inputs:

- atmospheric precipitation
- discharge from process plant
- leaching of elements from tailings beaches exposed to the atmosphere
- seepage collection system water pumped back to the TMF reclaim pond during operation and until open pit is filled to final elevation.

The following represent the mass outputs from TMF reclaim pond:

- recycled water to meet mill demand
- locked-in porewater
- removal due to chemical reactions
- recharge to groundwater flow that is not collected by the seepage collection system
- seepage through the dams that is captured by the seepage collection system.

These inputs/outputs are discussed in separate sections below.

For the historical tailings placed into the TMF, the results of groundwater modelling demonstrated that seepage associated with these tailings is captured by the seepage collection system (Stantec 2017c) and as a result is transferred back to the TMF. Additional work will be completed prior to historical tailings transfer in Year 2 to refine the deposition strategy and inform the need for additional adaptive management measures.

5.1.6.1 Atmospheric Precipitation

The mass loading rate input for atmospheric precipitation was calculated as the runoff rate for the active phase of the TMF multiplied by the average concentration in precipitation, similar to other Project components.

5.1.6.2 Discharge from Process Plant

The mass loading rate of discharge from the process plant was calculated using Equation 5.6.

5.1.6.3 Leaching Rates from TMF Exposed Beaches

Element leaching rates from exposed tailings were based on the averages from the forty-week and last five weeks of data from four humidity cells (Appendix B8). Forty-week average rates were used to represent element leaching rates during the operation period. The average leaching rates for the last five weeks were applied for the post-closure period (Project Year 21 to 99, Model Year 22 to 100), when sulphide grains would be covered with secondary minerals reducing oxidation and leaching rates. Concentrations of mercury, silver, chromium, beryllium, cadmium, phosphorous, selenium, and zinc concentrations were below the method detection limits, which were below the PWQO for all parameters except phosphorus. As a result, by assigning a value of half the detection limit the leaching rates and concentrations associated with these elements are overestimated in the water quality model.

The resulting loadings rates were multiplied by the temperature scaling factor of 0.67 (SF in Equation 5.7) reflecting differences in oxidation rates between laboratory (21˚C) and average field temperatures (6.4˚C). This factor was calculated using a rearranged form of the Arrhenius Equation (Appendix B4). The annual scaled mass-loading rate was distributed for each month proportionally to the runoff using the runoff distribution factor (RD) in Table 5-3.

The mass of oxidizing tailings was calculated from the depth of oxidation and area of exposed beaches. The depth of active oxidation of uncovered tailings ($D_{BEACHES}$) was assumed to extend to an average monthly depth of 0.25 m over the entire tailings beach during operation (estimated as monthly volume of tailings solids divided by total area of exposed beach). For operation conditions, the area of exposed beaches TMF (A_{TMF}, m^2) is presented in Table 4-12. The resulted volume was multiplied by tailings density (ρ, 2800 kg/m^3).

Based on these inputs, the scaled average mass loading rate of elements leaching from beaches ($R_{TAILINGS}$, mg/kg/week) was calculated as follows:

$$R_{TAILINGS} = R_{HC} \times SF_{T\ BEACHES} \times RD \times A_{BEACHES} \times D_{BEACHES} \times \rho$$ **Equation 5.7**

For closure, it was assumed that the above parameters will stay the same, but the depth of active oxidation will be reduced to 0.10 m as the tailing beaches will be covered with a soil and vegetated cover. In the model it was assumed that the mass of oxygen consumed in the unsaturated profile of covered tailings will be equivalent to the oxygen consumed by 10 cm of tailings containing 21% oxygen in the pore spaces, which is consistent with laboratory humidity cell data and provides target design parameters for design of the tailings cover system.

5.1.6.4 Reclaimed Water

The mass output from the TMF reclaim pond in recycled water was calculated as the concentration in the pond multiplied by the rate of recycled water pumped from the TMF (refer to Section 4.0).

5.1.6.5 Locked-in Pore water

The mass locked in tailings pore spaces was estimated by multiplying the concentration in the TMF reclaim pond by the rate of water locked in tailings voids.

5.1.6.6 Chemical Reactions in the TMF

The mass removal due to precipitation or degradation of some components in the TMF reclaim pond was included in the model based on the results of aging tests on supernatants generated from the cyanide detoxification testing. Appendix B9 provides the results from the aging tests and the resulting reduction factors that were used in the model. Day 14 of the aging tests corresponds to approximately 20 to 30 days of exposure to sunlight and average residence time of water in the TMF reclaim pond. Therefore, the reductions between day 0 and 14 of the test were used as attenuation fractions for the TMF.

5.2 WATER QUALITY MODELLING RESULTS

Water quality predictions were generated and are presented below for the key Project locations where management of contact water would be required during operation and closure. These include:

1. pond M1
2. open pit
3. historical MacLeod underground workings
4. historical Hardrock underground workings
5. TMF reclaim pond.

Results are generally presented for three periods corresponding to:

- Project Year 15 (Model Year 16) - corresponding to the last year of operation
- Project Year 20 (Model Year 21) - corresponding to the end of the active closure period
- Project Year 32 (Model Year 33) - corresponding to the first full year of discharge from the pit lake to the Southwest Arm of Kenogamisis Lake and when discharge from the TMF reclaim pond is directed to the Goldfield Creek diversion.

For the above periods, the average and maximum concentrations were calculated and presented in Table 5-7. The statistics were compared to the following criteria for screening purposes:

- MMER Schedule 4 and O. Reg. 560/94 to identify parameter that will require treatment
- PWQOs to identify parameters that may require treatment or further evaluation with respect to the receiving environment assimilative capacity.

Concentrations for silver and chromium within the collection ponds that receive runoff from waste rock, and for mercury, silver, chromium, beryllium, cadmium, phosphorous, selenium, and zinc in the TMF reclaim pond are overestimated in the prediction due to the elevated detection limits and effects of scaling up in the model as discussed in Section 5.1. The data for these parameters are presented in Table 5-7, but not discussed in the results section below.

Concentration time trends for parameters that exceed the above criteria are provided in Appendix C.

Table 5-7: Summary of statistics for the predicted concentrations (µg/L) in selected mine components in normal year conditions

Parameter	Cl	F	SO_4^{2-}	CN^-	CN^- WAD	CN^- Free	NH_3 Total	NH_3 Un-ionized	NO_2^-	NO_3^-	Hg	Ag	Al	As	Be	B	Ca	Cd	Co	Cr	Cu	Fe	K	Mg	Mo	Na	Ni	P	Pb	Sb	Se	Si	Tl	W	U	V	Zn	Zr	TDS*
MMER/O.Reg. 560/94	-	-	-	1000	-	-	-	-	-	-	-	-	-	500	-	-	-	-	-	-	300	-	-	-	-	-	500	-	200	-	-	-	-	-	-	-	500		-
PWQO Table 2**	-	-	-	-	5	5	-	20	-	-	0.2	0.1	-	100	1100	-	-	0.2	0.9	1	5	300	-	-	-	-	25	-	25	-	100	-	-	-	-	-	30	-	-
PWQO Table 2 - Interim	-	-	-	-	-	-	-	-	-	-	-	-	75	5	-	200	-	0.1	-	-	5	-	-	-	40	-	-	20	5	20	-	-	-	30	5	6	20	4	-
Sedimentation Pond M1																																							
For year model 16 (Project year 15, last year of operation)																																							
Average	2,456	31	183,743	0.78	0.30	1.1	86	5.0	23	1,119	0.005	0.04	31	**100**	0.35	33	83,716	0.014	**3.5**	0.39	2.1	4.6	6,613	28,588	10.9	5,415	3.8	18	0.34	**73**	1.5	1,672	0.12	3.8	**11**	0.8	2.6	0.51	313,767
Max	3,844	49	219,985	1.21	0.47	1.8	125	7.2	35	1,777	0.006	0.05	39	**115**	0.46	39	94,421	0.016	**4.5**	0.52	2.6	4.9	7,914	32,330	14	6,372	4.6	**23**	0.45	**94**	1.9	2,199	0.15	5.1	**13**	0.9	3.2	0.67	361,978
For model year 21 (Project year 20, last year of closure)																																							
Average	0	0	428,471	0	0	0	40	2.3	22	1,300	0.006	0.02	72	**138**	0.08	44	134,333	0.021	**9.9**	0.1	1.4	3.2	14,883	54,880	31	7,123	8.4	**49**	0.1	**212**	3.5	5,286	0.06	0.8	**28**	1.2	2.3	0.27	646,944
Max	0	0	449,423	0	0	0	42	2.5	23	1,373	0.006	0.02	74	**144**	0.09	46	140,857	0.022	**10.4**	0.1	1.4	3.2	15,549	57,532	33	7,432	8.8	**52**	0.1	**221**	3.6	5,555	0.06	0.9	**29**	1.2	2.4	0.28	678,287
For model year 33 (Post-Closure, Pit Lake starts to discharge)																																							
Average	0	0	488,729	0	0	0	14	0.8	7.6	451	0.006	0.02	**78**	**147**	0.07	50	152,828	0.024	**11.4**	0.1	1.7	3.4	16,406	62,309	36	7,765	9.6	**57**	0.1	**232**	3.9	6,127	0.06	0.7	**31**	1.3	2.6	0.29	735,301
Max	0	0	501,057	0	0	0	14	0.8	7.8	467	0.006	0.02	**79**	**151**	0.08	51	156,678	0.025	**11.7**	0.1	1.7	3.5	16,810	63,875	37	7,954	9.8	**59**	0.1	**238**	4.0	6,283	0.06	0.8	**32**	1.3	2.6	0.29	753,802
Open Pit																																							
For year model 16 (Project year 15, last year of operation)																																							
Average	3,137	40	130,895	1.00	0.4	1.4	84	4.9	16	601	0.005	0.04	20	**92**	0.40	31	74,323	0.013	**2.2**	0.44	2.3	5.0	4,516	23,093	6	4,995	2.7	12	0.38	**39**	1.0	926	0.13	4.3	**6.9**	0.7	2.7	0.56	242,859
Max	4,453	57	159,207	1.40	0.5	2.1	121	7.0	28	1,242	0.006	0.05	25	**113**	0.47	37	89,074	0.015	**2.9**	0.51	2.9	5.0	5,468	26,568	8	6,258	3.3	16	0.45	**52**	1.3	1,283	0.15	5.0	**9.0**	0.8	3.2	0.65	284,542
For model year 33 (Post-Closure, stratified pit lake starts to discharge)																																							
Average	1,002	34	40,778	1.00	0.9	2.2	32	1.9	10	65	0.005	0.05	12	**30**	0.47	27	40,168	0.009	**0.9**	0.48	0.9	5.0	1,828	10,250	2	1,717	1.5	7	0.47	13	0.7	2,476	0.14	4.8	4.0	0.56	2.1	0.51	98,479
Max	1,004	34	41,068	1.01	0.9	2.2	32	1.9	10	65	0.005	0.05	12	**30**	0.47	27	40,226	0.009	**0.9**	0.48	0.9	5.0	1,838	10,282	2	1,723	1.5	7	0.47	13	0.7	2,483	0.14	4.8	4.1	0.56	2.2	0.51	98,872
For model year 100 (Post-Closure, stratified pit lake discharge in long term)																																							
Average	1,037	31.0	92,035	0.75	0.6	1.6	32	1.9	7.0	44	0.006	0.05	20	**41**	0.46	32	53,258	0.012	**2.2**	0.47	1.8	5.0	3,510	16,443	6	2,854	2.5	12	0.45	**37**	1.1	2,264	0.14	4.7	**7.3**	0.68	2.6	0.54	171,696
Max	1,040	31.1	92,717	0.75	0.6	1.6	32	1.9	7.0	44	0.006	0.05	20	**42**	0.46	32	53,432	0.012	**2.2**	0.47	1.8	5.0	3,532	16,522	6	2,866	2.6	13	0.45	**38**	1.1	2,270	0.14	4.7	**7.3**	0.68	2.6	0.54	172,656
TMF pond																																							
For year model 16 (Project year 15, last year of operation)																																							
Average	54,941	210	4,379,667	**1,173**	**50**	**657**	7740	**449**	901	2,890	0.14	0.05	**86**	**43**	0.08	59	594,250	0.046	**62**	0.05	**48**	3.1	135,715	183,609	18	979,888	**26**	**45**	0.8	**136**	17	2,510	0.36	3.5	**8**	0.34	12	0.23	6,344,771
Max	61,017	235	4,971,000	**1,312**	**56**	**735**	8585	**498**	1000	3,274	0.17	0.06	**120**	**55**	0.10	69	703,090	0.064	**67**	0.06	**53**	5.0	151,421	225,406	20	1,082,000	**28**	**66**	0.8	**149**	20	3,050	0.40	4	**9**	0.46	19	0.26	7,179,968
For model year 21 (Project year 20, last year of closure)																																							
Average	0	0	1,343,936	73	0.5	0.5	138	8.0	51	137	0.10	0.02	**120**	**38**	0.08	27	311,094	0.050	**3.5**	0.04	5	5.0	29,727	136,591	2	12,435	1.7	**61**	0.06	7	10	1,733	0.05	1.2	0.3	0.3	20	0.010	1,836,219
Max	0	0	2,259,000	76	0.5	0.5	143	8.3	53	142	0.16	0.03	**120**	**60**	0.14	46	521,925	0.084	**5.9**	0.07	**8**	5.0	49,645	229,315	3	19,688	2.9	**103**	0.11	11	16	2,759	0.09	2	0.5	0.6	**33**	0.023	3,083,151
For model year 33 (Post-Closure, TMF starts to discharge to the environment)																																							
Average	0	0	982,896	104	0.7	0.7	196	11	72	195	0.07	0.02	**120**	**33**	0.08	22	228,626	0.037	**2.6**	0.04	4	5.0	22,090	100,211	2	10,343	1.3	**45**	0.05	5	7	1,426	0.05	1.2	0.4	0.3	15	0.034	1,346,425
Max	0	0	1,127,000	174	1.2	1.2	328	19	121	326	0.08	0.02	**120**	**36**	0.09	24	260,993	0.042	**3.0**	0.04	4	5.0	24,946	114,585	2	11,059	1.5	**51**	0.06	6	8	1,503	0.05	1.3	0.4	0.3	17	0.039	1,540,018
MacLeod Underground																																							
For year model 1 (Project year -1, dewatering and discharge to the environment during construction)																																							
Average	1,605	32.8	28,960	0.93	0.0	2.3	50	2.9	7	164	0.0006	0.01	2.2	**18**	0.14	13	74,199	0.005	0.22	0.1	1.1	5.0	2,413	13,477	0.4	4,003	1.2	6	0.07	0.4	0.1	2	0.02	1.1	1.2	0.27	18.5	0.24	124,985
Max	1,635	33.8	30,700	1.00	0.1	2.5	65	3.8	15	637	0.0015	0.02	2.5	**19**	0.20	16	82,300	0.006	0.26	0.2	1.4	5.0	2,710	14,400	0.5	4,230	1.2	7	0.14	0.6	0.2	6	0.05	1.8	1.4	0.32	**21.8**	0.30	136,106
For year model 16 (Project year 15, last year of operation)																																							
Average	3,126	40	132,950	0.99	0.4	1.4	86	5.0	17	695	0.005	0.04	20	**92**	0.40	32	74,865	0.013	**2.2**	0.45	2.3	5.0	4,591	23,338	7	5,021	2.7	12	0.39	**40**	1.1	956	0.13	4.4	**7.1**	0.7	2.7	0.57	245,922
Max	4,394	56	169,014	1.38	0.5	2.0	132	7.6	34	1,597	0.007	0.06	27	**118**	0.51	40	95,181	0.016	**3.1**	0.57	3.1	5.0	5,809	29,278	9	6,555	3.6	17	0.50	**56**	1.4	1,376	0.16	5.6	**9.6**	0.9	3.5	0.72	308,167
Hardrock Underground																																							
For year model 1 (Project year -1, dewatering and discharge to the environment during construction)																																							
Average	79,232	46	219,838	2.11	0.1	2.1	81	4.7	14	399	0.003	0.015	2	**7**	0.18	38	107,819	0.005	**1.1**	0.19	1.0	5.0	3,657	32,245	0.5	49,555	4.2	2	0.12	0.6	0.1	5	0.04	1.3	1.4	0.30	1.8	0.28	492,961
Max	114,000	50	309,000	2.80	0.1	2.5	110	6.4	34	1,709	0.004	0.03	3	**13**	0.31	46	141,000	0.007	**1.5**	0.33	1.8	5.0	4,870	42,700	0.8	70,500	5.6	2	0.27	0.9	0.3	14	0.09	3.1	1.9	0.40	2.2	0.42	682,335
For year model 12 (Project year 11, last year of Hardrock shaft dewatering during operation)																																							
Average	3,196	40	111,644	0.89	0.4	1.5	202	**22**	84	4,671	0.005	0.04	20	**71**	0.41	30	69,010	0.012	**1.9**	0.45	2.3	5.0	4,093	20,908	6	4,870	2.5	11	0.40	**36**	1.0	791	0.13	4.4	**6.4**	0.7	2.6	0.56	219,713
Max	4,310	53	132,281	1.18	0.5	2.0	250	**27**	112	6,338	0.006	0.05	24	**82**	0.46	34	79,116	0.014	**2.5**	0.51	2.7	5.0	4,770	23,833	7	5,837	3.0	13	0.45	**47**	1.2	1,086	0.15	5.0	**8.0**	0.8	3.0	0.63	252,602

Notes:
MMER – Metal Mining Effluent Regulations (MMER, 2015); Values exceeding guidelines are bolded and highlighted orange
O.Reg 560/94 - Ontario Regulation 560/94 for Effluent Monitoring and Effluent Limits – Metal Mining Sector under the Environmental Protection Act (O.Reg 560/94, MOEE 2007); Values exceeding guidelines are bolded and highlighted orange
PWQO - Provincial Water Quality Objectives (MOEE 1994); Values exceeding approved PWQO Table 2 objectives are bolded and underlined. Values exceeding interim PWQO objectives are bolded
*Total Dissolved Solids (TDS) have been calculated as a sum of all parameters listed in this table with the exception of bicarbonate ions that have not been considered in this model
A concentration of half the method detection limit was used for silver, chromium, and phosphorus for Pond M1 and silver, chromium, phosphorus, mercury, beryllium, cadmium, selenium, and zinc for TMF. As a result, the leaching rates associated with these elements are overestimated in the water quality model.
** PWQO is for hexavalent Cr, which is the lowest concentration of both Cr(VI) and Cr (III) , and was used for screening purposes against total Cr concentrations. Therefore, exceedances highlighted for Cr may not be overstated. Concentration for un-ionized ammonia was calculated for conservalivly high pH (8.1) and temperature (℃) observed in SW Arm of Kenogamisis Lake based on Stantec 2016e.

5.2.1 Pond M1

Pond M1 receives water during operation from all contact water collection ponds and excess water from the open pit and the historical underground workings that is not required for mill water supply. Excess water from pond M1 will be directed to the ETP prior to discharge to the Southwest Arm of Kenogamisis Lake. The predicted water quality from pond M1 is considered as the influent water quality to the ETP and is used to evaluate treatment requirements. The discharge criteria to the Southwest Arm of Kenogamisis Lake were determined in the Assimilative Capacity TDR (Stantec 2017e). After Project Year 15 (Model Year 16), when mining ceases, water collected in pond M1 will be transferred to the deep portions of the open pit through Mosher No. 1 Shaft to help expedite filling of the open pit. No parameters were predicted to be above the MMER/O. Reg. 560/94 in pond M1 during both operation and closure phases of the Project.

Model results demonstrate the following parameters are likely to exceed the PWQO criteria in pond M1 during both the operation and closure phases:

- PWQO: arsenic and cobalt
- Interim PWQO: aluminum, antimony, arsenic, and uranium.

Phosphorus concentrations are overestimated in the model due to the elevated detection limits and as such are not expected to be a concern.

Arsenic, cobalt, and uranium concentrations increase over the operating period reaching their maximum concentrations of 115 µg/L, 4.5 µg/L, and 13 µg/L, respectively at the end of operation (Table 5-7). Once operation ceases and dewatering of the open pit is terminated, concentrations increase in pond M1 by a factor of approximately 2 for cobalt and uranium as these parameters as the primary source for these parameters is from waste rock (Appendix C). The maximum arsenic concentration increases up to 151 µg/L, in pond M1 after closure, due primarily to runoff and toe seepage collection from the WRSAs. Antimony reaches the maximum concentration of 105 µg/L in Project Year 11 (Model Year 12) with a slight decrease to 94 µg/L at the end of operation. Similar to cobalt and uranium, antimony concentrations increase in pond M1 by a factor of approximately 2 after dewatering ceases (Appendix C).

At closure, concentrations of elements in pond M1 approach steady-state conditions and are predicted to be above the PWQO/Interim PWQO for aluminum, antimony, arsenic, cobalt and uranium. These concentrations are conservative and do not account for further reductions in loading rates due to decreases in leaching rates from waste rock beyond the 2015 data used in the model predictions. Armoring or coating of primary source minerals and other processes limiting release and transport of these elements in waste rock leachate is expected to occur over time and is supported by the recent 2016 testing data.

5.2.2 Dewatering from Historical Underground Workings and Open Pit

The quality of water from the dewatering of the historical MacLeod and Hardrock underground workings is provided in Table 5-7 for Project Year -1 (Model Year 1.75), which corresponds to the initial construction period when water is not required for mill demand and is discharged to the environment following treatment as required. The historical Hardrock underground workings are expected to be completely dewatered by the middle of Project Year 11 (Model Year 12), while the historical MacLeod underground workings will continue to be used for dewatering until the end of operation (Project Year 15, Model Year 16).

During construction, concentrations are close to the initial water chemistry observed currently in the historical underground workings as limited chemical mass loading from Project components is predicted given the estimate of groundwater travel times. As dewatering continues, concentrations are directly influenced by loading from groundwater inflow and by leaching from waste rock and ore within the open pit.

No parameters were predicted to be above the MMER/O. Reg. 560/94 in contact water from dewatering the open pit and historical underground workings during operation. Model results demonstrate the following parameters may exceed the PWQO criteria in dewatering water from the open pit and historical underground workings:

- PWQO: arsenic, cobalt, and possibly un-ionized ammonia depending on temperature and pH conditions and actual blasting efficiencies
- Interim PWQO: arsenic, antimony and uranium.

Total chromium concentrations are overestimated in the model due to the elevated detection limits and are not expected to be a concern.

Similar to water quality in pond M1, concentrations for the above parameters progressively increase over the operation phase as groundwater originating from the WRSAs, ore stockpile, overburden storage area, and remaining historical tailings discharges to the open pit and historical underground workings. The only exception is total ammonia which decreases from a maximum concentration of 495 µg/L in Project Year 4 (Model Year 3) to 121 µg/L at the end of operation (Project Year 15, Model Year 16) (Appendix C). This decrease is related to the timing and mass of ammonia released during blasting operations.

5.2.3 Pit Lake

At closure (Project Year 16, Model Year 17), the open pit begins to fill and reaches an elevation of approximately 331 m amsl at the end of Project Year 31 (Model Year 32). Once at this target elevation excess water from the pit lake will overflow to the Southwest Arm of Kenogamisis Lake via a constructed closure spillway. Water quality in the pit lake was predicted for both a fully mixed and stratified lake cases (Appendix C). Model predictions demonstrate the pit lake will permanently stratify in the middle of Model Year 16 and maintain stratification for remainder of the modeled period (Appendix D). The water quality results for the stratified pit lake are summarized in Table 5-7 and discussed below.

When the stratified pit lake starts to discharge (Project Year 32, Model Year 33), the arsenic concentration (30 µg/L) is predicted to be below the PWQO but above the Interim PWQO. From Project Year 32 to 99 (Model Year 33 to 100) arsenic concentrations increase with cobalt, antimony and uranium concentrations also showing an increasing trend with concentrations below the PWQO but above the Interim PWQO in discharge from the pit lake by Model Year 100 (Table 5-7). By Project Year 99 (Model Year 100), the concentration of arsenic, cobalt, antimony, and uranium are predicted to be up to 42 µg/L, 2.2 µg/L, 38 µg/L and 7.3 µg/L, respectively, and are above the PWQO. The effect of discharging water from the pit lake is considered in the surface water effect assessment and concludes that the PWQO will be met within a small mixing zone. Actual predictions of mixing zones and discharge criteria will be developed through monitoring during the closure period.

Water quality from the historical underground workings that are partially backfilled with waste rock can be used to provide an indication of future pit lake water quality and verification of the model results. The predicted maximum arsenic concentration (42 µg/L) in the pit lake discharge in Project Year 99 (Model Year 100) is ~5x over the median values in the historical underground workings (8 µg/L, Appendix B1). Similarly, antimony and uranium concentrations are significantly higher in model predictions (38 µg/L and 7.3 µg/L, respectively) in comparison to the historical underground workings (0.3 µg/L and 1.2 µg/L, respectively). In addition, in the historical MacLeod and Hardrock tailings areas antimony is not typically observed at concentrations above the PWQO suggesting that the conservative modelling approach taken is over predicting concentrations and geochemical reactions may be limiting concentrations of these element, in particular antimony. Therefore, comparison of historical results with the predicted concentrations demonstrate that the model results are likely overestimating the predicted arsenic, antimony and uranium concentrations in the pit lake discharge.

5.2.4 Tailings Management Facility

Discharge from the TMF to the environment is not planned during operation as all of the water is required to meet mill demand. Once deposition in the north cell of the TMF is completed, this cell will be rehabilitated and there is the potential to discharge excess water through the spillway to the Goldfield Creek diversion once water quality meets acceptable discharge criteria. To be conservative, it is assumed that all of the water from the north cell is managed within the TMF until the open pit is filled at closure.

At the end of operation (Project Year 15, Model Year 16), water quality in the TMF reclaim pond is predicted to be above the MMER Schedule 4 criteria of 1 mg/L for total cyanide, but declines below the criteria within 2 months after discharge from the process plant is terminated due to natural degradation within the TMF. Following rehabilitation, water quality improves substantially with no parameters predicted to be above the MMER/O. Reg. 560/94 criteria during the last year of active closure (Table 5-7), corresponding with Project Year 20 (Model Year 21).

During active closure and post closure, runoff and seepage from TMF will be directed to the lower portions of the open pit until the final elevation of the pit lake is reached. At this point, water from the TMF will be directed to the overflow spillway and out to the Goldfield Creek diversion. During the first year of discharge (Project Year 32, Model Year 33), the maximum concentrations in water are predicted to be above the PWQO of 0.9 µg/L for cobalt (3.0 µg/L). The maximum concentration of arsenic (36 µg/L) is predicted to be below the PWQO, but above the Interim PWQO value (5 µg/L). Aluminum (120 µg/L) is above the Interim PWQO of 75 µg/L.

The quality of seepage from the TMF applied in the water quality model was derived from two subaqueous column tests. Concentrations of elements in leachate from these columns stabilized at weeks 20 to 25 indicating that chemical equilibrium was reached between the porewater solutions and tailings in the columns (Stantec 2016b). Average concentrations observed at that time represent post-closure conditions and are shown in Appendix B1. Concentrations of un-ionized ammonia were estimated based on an average pH of 8 and temperature of 21°C measured in the leachate. Un-ionized ammonia and cobalt are the only parameters exceeding the PWQO. Maximum values for un-ionized ammonia and cobalt are 60 µg/L and 3 µg/L, respectively. The average arsenic concentration (66 µg/L) is below the PWQO, but above the Interim PWQO.

6.0 CONCLUSIONS

The results of predictions for climate normal conditions are summarized for the key Project locations where management of contact water would be required during operation and closure: 1) open pit and historical underground workings; 2) pond M1; and 3) TMF. Overall the modelling provides a conservative estimate of water quality due to the following assumptions:

- the time to reach 50% wet by area used in the model for WRSA is expected to overestimate the quantity of water released to the collection ponds and environment
- infiltration rates used for the WRSAs are high and do not consider potential reductions in flow that may be achieved by drainage controls to be developed with ongoing WRSA planning and design
- the use of 25-year wet and 25-year dry climatic conditions continuously for 100 years represents precipitation extremes
- the expected decrease in sulphide oxidation and leaching rates over time is not considered beyond the two years of experimental data
- precipitation and adsorption of elements within waste rock, tailings and overburden were not considered in the model
- no attenuation was assumed along groundwater pathways from historical tailings, WRSAs, and ore stockpile to the open pit
- for elements that were below the method detection limits a value of half of the detection limit was used in the modelling. This resulted in the over prediction of concentrations.

Open Pit and Historical Underground Workings

Dewatering of the historical underground workings will begin prior to the operation phase. This water was assumed to be discharged to the environment following treatment, as required, and used to meet the mill demand during the initial commissioning period until sufficient reclaim water is available within the TMF. During operation, the historical underground workings will be used as a storage reservoir for water and gradually dewatered to maintain water levels approximately 25 m below the active mining level. Total dewatering rates range from 145,109 m^3/month (202 m^3/hr or 55 L/s) to a maximum of 445,865 m^3/month (619 m^3/hr or 172 L/s), with an average of 281,336 m^3/month (391 m^3/hr or 109 L/s). Groundwater inflow to the open pit and historical underground workings accounts for approximately 61% of the average monthly dewatering volume. Water from the historical underground workings will be pumped to pond M1 and used to meet mill demand during operation, with the excess water sent to the ETP prior to discharge to the Southwest Arm of Kenogamisis Lake.

Once mining is completed and dewatering is terminated, the open pit and historical underground workings will fill from groundwater inflow, direct precipitation, surface water runoff, and water transferred from the pond M1 and the TMF. Freshwater will also be added from Kenogamisis Lake until the pit lake is filled. Filling of the open pit is estimated to take 16 years under climate normal conditions after closure (end of Project Year 31, Model Year 32) and will form a permanently stratified pit lake. Discharge from the pit lake will flow to the Southwest Arm of Kenogamisis Lake, with discharge rates ranging from 65,900 m^3/month (92 m^3/hr or 25 L/s) to 440,900 m^3/month (604 m^3/hr or 168 L/s) under climatic normal conditions.

Discharge water quality from the pit lake at closure is represented by the upper layer (epilimnion) because the lower layer becomes chemically disconnected from the epilimnion in the permanently stratified pit lake. Water quality at the end of model simulations demonstrate the maximum concentration of arsenic, cobalt, antimony, and uranium are 42 µg/L, 2.2 µg/L, 38 µg/L and 7.3 µg/L, respectively and above the PWQO/Interim PWQOs. The effect of discharging water from the pit lake is considered in the surface water effect assessment and concludes that the PWQO will be met within a small mixing zone. Actual predictions of mixing zones and discharge criteria will be developed through monitoring during the closure period.

With these conservatively modelled predictions, it is important to consider that the observed water quality from the historical underground workings that are partially backfilled with waste rock provide a reliable indication of future pit lake water quality and verification of the model results. The maximum arsenic concentration (42 µg/L) in the predicted pit lake discharge in Project Year 99 (Model Year 100) is approximately 5x the median values in the historical underground workings (8 µg/L, Appendix B1). Similarly, antimony and uranium concentrations are significantly higher in model predictions (38 µg/L and 7.3 µg/L, respectively) in comparison to the historical underground workings (0.3 µg/L and 1.3 µg/L, respectively). In addition, in the historical MacLeod and Hardrock tailings areas antimony is not typically observed at concentrations above the PWQO. Therefore, comparison of historical results with the predicted concentrations demonstrate that the model results are likely overestimating the predicted arsenic, antimony and uranium concentrations in the pit lake discharge.

Pond M1

Pond M1 receives water during operation from all collection ponds and excess water from the historical underground workings that is not required for mill demand. During operation the water quality from pond M1 is considered as the influent water quality to the ETP and is used to evaluate treatment requirements. Excess water from pond M1 will be treated during operation prior to discharge to the Southwest Arm of Kenogamisis Lake.

No parameters are predicted above the MMER/O. Reg. 560/94 criteria from pond M1 during operation and closure. Arsenic, cobalt and uranium concentrations all increase over the operating period reaching their maximum concentration of 115 µg/L, 4.5 µg/L and 13 µg/L, respectively. Antimony reaches the maximum concentration of 105 µg/L in Project Year 11

(Model Year 12) with a slight decrease to 94 µg/L at the end of operation. Arsenic and cobalt exceed the PWQO and aluminum, antimony, arsenic and uranium exceed the Interim PWQO.

The discharge criteria to the Southwest Arm of Kenogamisis Lake are determined in the Assimilative Capacity TDR (Stantec 2017e) and consider potential effects on the receiving environment. These will be further informed by ongoing Project planning and design.

After closure, water collected in pond M1 will be diverted to the open pit to help expedite filling of the pit. After the pit lake stratifies, water from pond M1 will be sent to the lower portions of the pit lake through Mosher No. 1 Shaft. In the lower portions of the pit lake, anoxic conditions are expected to develop and leading to conditions that will reduce metal concentrations by the formation of metal sulphides under sulphate reducing conditions.

TMF

Surplus water from the TMF will be reclaimed to meet mill demand during operation, with additional water required from contact water from pond M1 and dewatering water from the historical underground workings and open pit. Therefore, the TMF is not planned to discharge to the environment during operation. At the end of operation, water quality in the TMF reclaim pond is predicted to be above the MMER limits for total cyanide, but declines below the criteria within 2 months after discharge from the process plant is terminated due to natural degradation within the TMF.

During active closure and post-closure, runoff and seepage from TMF will be directed to the lower portions of the open pit until the final elevation of the pit lake is reached. At this point, water from the TMF will be directed to the overflow spillway and out to the Goldfield Creek diversion. Average monthly discharge rates from the TMF under climate normal conditions range from 0 m^3/month during the winter months to a maximum of 208,800 m^3/month (285 m^3/hr or 79 L/s) during spring freshet conditions with an average annual discharge rate of 68,979 m^3/month (94 m^3/hr or 26 L/s). During discharge the maximum concentrations of cobalt (3.0 µg/L) in water are predicted to be above the PWQO of 0.9 µg/L. The maximum concentrations of arsenic (36 µg/L) and aluminum (120 µg/L) in the discharge are predicted to be below PWQO but above the Interim PWQO value (5 µg/L), and aluminum (120 µg/L) is above the Interim PWQO of 75 µg/L. Similar to the pit lake, final closure discharge criteria will be developed based on monitoring data collected through operation and closure when the pit lake is being filled.

The quality of seepage from the TMF was derived from subaqueous column testing. Concentrations of elements in the columns showed stabilization at weeks 20 to 25 indicating that chemical equilibrium was reached between the porewater solutions and tailings in the columns (Stantec 2016b). Average concentrations observed at that time represent post-closure conditions. Un-ionized ammonia and cobalt are the only parameters exceeding the PWQO. Maximum values for un-ionized ammonia and cobalt are 60 µg/L and 3 µg/L, respectively. The average arsenic concentration (66 µg/L) is below the PWQO, but above the Interim PWQO. This water quality represents a conservative estimate of seepage quality and does not account for runoff from the TMF dams and surrounding catchment which will reduce concentrations.

7.0 REFERENCES

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APPENDIX A:
ORIGINAL WATER BALANCE TABLES

Table A-1: Open Pit Water Balance

Model Year	Project Year	Dry					Normal					Wet				
		Groundwater Seepage, 1106	Net Precipiation	Total Mosher No. 1 Shaft Discharge	Total Hardrock No. 2 Shaft Discharge	Total Historical Underground Workings Discharge	Groundwater Seepage, 1106	Net Precipiation	Total Mosher No. 1 Shaft Discharge	Total Hardrock No. 2 Shaft Discharge	Total Historical Underground Workings Discharge	Groundwater Seepage, 1106	Net Precipiation	Total Mosher No. 1 Shaft Discharge	Total Hardrock No. 2 Shaft Discharge	Total Historical Underground Workings Discharge
		m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon
0.00	-2.00	90427	1600	0	0	0	90427	4394	0	0	0	90427	2479	0	0	0
0.08	-1.92	82957	4221	0	0	0	82957	7076	0	0	0	82957	4644	0	0	0
0.17	-1.83	93264	7628	0	0	0	93264	10552	0	0	0	93264	8443	0	0	0
0.25	-1.75	91628	46592	0	0	0	91628	77456	0	0	0	91628	66256	0	0	0
0.33	-1.67	96100	95220	0	0	0	96100	165301	0	0	0	96100	216533	0	0	0
0.42	-1.58	94373	57842	0	0	0	94373	102568	0	0	0	94373	112798	0	0	0
0.50	-1.50	98937	123520	0	0	0	98937	133489	0	0	0	98937	223988	0	0	0
0.58	-1.42	100355	98410	0	0	0	100355	102213	0	0	0	100355	99721	0	0	0
0.67	-1.33	98490	92183	0	0	0	98490	128645	0	0	0	98490	214423	0	0	0
0.75	-1.25	103191	106895	0	0	0	103191	108993	0	0	0	103191	130372	0	0	0
0.83	-1.17	101235	45840	0	0	0	101235	57743	0	0	0	101235	48398	0	0	0
0.92	-1.08	106028	35052	0	0	0	106028	34544	0	0	0	106028	47808	0	0	0
1.00	-1.00	107446	5105	0	0	0	107446	7848	0	0	0	107446	7260	0	0	0
1.08	-0.92	98336	7375	0	0	0	98336	10185	0	0	0	98336	8947	0	0	0
1.17	-0.83	110298	10468	0	0	0	110298	13350	0	0	0	110298	12315	0	0	0
1.25	-0.75	108120	59368	0	0	0	108120	90047	0	0	0	108120	83682	0	0	0
1.33	-0.67	113150	107996	0	0	0	113150	177892	0	0	0	113150	233959	0	0	0
1.42	-0.58	110880	57842	0	0	0	110880	102568	0	0	0	110880	112798	0	0	0
1.50	-0.50	116002	123520	0	0	0	116002	133489	0	0	0	116002	223988	0	0	0
1.58	-0.42	117428	98410	0	0	0	117428	102213	0	0	0	117428	99721	0	0	0
1.67	-0.33	115020	92183	0	0	0	115020	128645	0	0	0	115020	214423	0	0	0
1.75	0.75	120280	106895	0	0	0	120280	108993	0	0	0	120280	130372	0	0	0
1.83	0.83	117780	45840	0	0	0	117780	57743	0	0	0	117780	48398	0	0	0
1.92	0.92	123132	35052	0	0	0	123132	34544	0	0	0	123132	47808	0	0	0
2.00	1.00	124558	5105	75163	0	75163	124558	7848	0	0	0	124558	7260	0	0	0
2.08	1.08	113794	7375	340958	30625	371583	113794	10185	262284	31454	293738	113794	8947	312087	31089	343175
2.17	1.17	127415	10468	250779	34943	285722	127415	13350	287653	35793	323446	127415	12315	342407	35488	377895
2.25	1.25	124688	59368	181614	48691	230305	124688	90047	183114	57744	240858	124688	83682	242709	55866	298575
2.33	1.33	130272	107996	148759	64716	213475	130272	177892	103850	85342	189192	130272	233959	89106	101886	190992
2.42	1.42	127453	57842	205455	49304	254760	127453	102568	190728	62502	253231	127453	112798	230306	65521	295828
2.50	1.50	133130	123520	136613	70136	206749	133130	133489	164842	73077	237919	133130	223988	108701	99783	208484
2.58	1.58	134558	98410	162407	63015	225421	134558	102213	198024	64137	262161	134558	99721	254579	63402	317980
2.67	1.67	131600	92183	153574	60310	213884	131600	128645	148028	71070	219098	131600	214423	95356	96382	191738
2.75	1.75	137415	106895	130029	65897	195927	137415	108993	167648	66517	234165	137415	130372	195168	72825	267994
2.83	1.83	134365	45840	195677	47118	242795	134365	57743	220055	50631	270685	134365	48398	283281	47873	331154
2.92	1.92	140272	35052	216848	45412	262260	140272	34544	257643	45262	302905	140272	47808	295051	49176	344227
3.00	2.00	141701	5105	251766	36932	288698	141701	7848	287948	37741	325690	141701	7260	342373	37568	379941
3.08	2.08	129271	7375	223042	34494	257536	129271	10185	255234	35323	290557	129271	8947	305423	34958	340381
3.17	2.17	144543	10468	243228	39225	282452	144543	13350	279201	40075	319276	144543	12315	334279	39770	374048
3.25	2.25	141255	59368	163255	52833	216088	141255	90047	157410	61886	219295	141255	83682	218529	60008	278536
3.33	2.33	147384	107996	117212	68994	186206	147384	177892	55490	89620	145109	147384	233959	27319	106164	133484
3.42	2.42	144005	57842	187297	53442	240740	144005	102568	160974	66640	227614	144005	112798	197899	69659	267558

Table A-1: Open Pit Water Balance

Model Year	Project Year	Dry					Normal					Wet				
		Groundwater Seepage, 1106	Net Precipiation	Total Mosher No. 1 Shaft Discharge	Total Hardrock No. 2 Shaft Discharge	Total Historical Underground Workings Discharge	Groundwater Seepage, 1106	Net Precipiation	Total Mosher No. 1 Shaft Discharge	Total Hardrock No. 2 Shaft Discharge	Total Historical Underground Workings Discharge	Groundwater Seepage, 1106	Net Precipiation	Total Mosher No. 1 Shaft Discharge	Total Hardrock No. 2 Shaft Discharge	Total Historical Underground Workings Discharge
		m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon
3.50	2.50	150226	123520	101371	79479	180850	150226	133489	127015	82420	209435	150226	223988	48646	109126	157772
3.58	2.58	151647	98410	133498	72355	205853	151647	102213	168129	73477	241606	151647	99721	225330	72742	298072
3.67	2.67	148130	92183	126263	74252	200514	148130	128645	111986	85011	196997	148130	214423	38772	110324	149096
3.75	2.75	154489	106895	100164	70167	170330	154489	108993	137280	70786	208066	154489	130372	159680	77095	236775
3.83	2.83	150880	45840	180571	56151	236723	150880	57743	202099	59664	261762	150880	48398	267563	56906	324469
3.92	2.92	157330	35052	204190	54745	258935	157330	34544	245107	54595	299702	157330	47808	279338	58509	337848
4.00	3.00	158751	5105	287669	46262	333932	158751	7848	323847	47072	370918	158751	7260	378273	46898	425171
4.08	3.08	144676	7375	255479	42924	298403	144676	10185	287671	43753	331424	144676	8947	337859	43388	381247
4.17	3.17	161603	10468	279139	48558	327696	161603	13350	315112	49408	364520	161603	12315	370190	49103	419292
4.25	3.25	157770	59368	198007	61867	259874	157770	90047	192161	70920	263081	157770	83682	253280	69042	322322
4.33	3.33	164455	107996	153121	78330	231450	164455	177892	91398	98955	190353	164455	233959	63228	115500	178728
4.42	3.42	160530	57842	222046	67383	289428	160530	102568	195722	80581	276303	160530	112798	232648	83600	316247
4.50	3.50	167307	123520	137277	78761	216038	167307	133489	162921	81703	244624	167307	223988	84552	108409	192961
4.58	3.58	168733	98410	169403	81857	251260	168733	102213	204033	82980	287013	168733	99721	261235	82244	343479
4.67	3.67	164670	92183	161008	68577	229584	164670	128645	146731	79336	226067	164670	214423	73517	104649	178166
4.75	3.75	171585	106895	136065	79589	215655	171585	108993	173182	80209	253391	171585	130372	195582	86517	282100
4.83	3.83	167430	45840	215314	65351	280665	167430	57743	236841	68864	305705	167430	48398	302305	66106	368411
4.92	3.92	174437	35052	240089	59102	299191	174437	34544	281006	58952	339958	174437	47808	315238	62866	378104
5.00	4.00	175863	5105	283391	45471	328863	175863	7848	319569	46281	365849	175863	7260	373995	46107	420102
5.08	4.08	158352	7375	252060	46415	298475	158352	10185	284252	47245	331496	158352	8947	334441	46879	381320
5.17	4.17	174773	10468	275846	57081	332927	174773	13350	311820	57932	369751	174773	12315	366897	57626	424523
5.25	4.25	168608	59368	195297	59670	254967	168608	90047	189451	68723	258174	168608	83682	250570	66845	317415
5.33	4.33	173683	107996	150814	80718	231532	173683	177892	89091	101344	190435	173683	233959	60921	117889	178809
5.42	4.42	167553	57842	220290	69296	289586	167553	102568	193967	82494	276461	167553	112798	230892	85513	316405
5.50	4.50	172593	123520	135956	75027	210983	172593	133489	161599	77969	239568	172593	223988	83231	104674	187905
5.58	4.58	172047	98410	168574	72737	241311	172047	102213	203205	73860	277065	172047	99721	260406	73124	333530
5.67	4.67	165970	92183	160683	69072	229755	165970	128645	146406	79832	226237	165970	214423	73192	105144	178337
5.75	4.75	170957	106895	136222	74284	210506	170957	108993	173339	74903	248242	170957	130372	195739	81212	276951
5.83	4.83	164915	45840	215942	54925	270868	164915	57743	237470	58438	295908	164915	48398	302934	55680	358614
5.92	4.92	169867	35052	241232	53161	294392	169867	34544	282149	53011	335159	169867	47808	316380	56925	373305
6.00	5.00	169322	5105	285027	44012	329039	169322	7848	321204	44822	366025	169322	7260	375630	44648	420278
6.08	5.08	152985	7375	253401	40581	293982	152985	10185	285593	41410	327003	152985	8947	335782	41045	376827
6.17	5.17	169431	10468	277182	45448	322629	169431	13350	313155	46298	359453	169431	12315	368233	45993	414225
6.25	5.25	164018	59368	196445	58693	255138	164018	90047	190599	67746	258345	164018	83682	251718	65868	317586
6.33	5.33	169539	107996	151850	74883	226733	169539	177892	90127	95509	185636	169539	233959	61957	112054	174010
6.42	5.42	164123	57842	221148	58641	279789	164123	102568	194824	71839	266664	164123	112798	231750	74858	306608
6.50	5.50	169648	123520	136692	79090	215782	169648	133489	162336	82031	244367	169648	223988	83967	108737	192704
6.58	5.58	169702	98410	169160	71800	240961	169702	102213	203791	72923	276714	169702	99721	260992	72188	333180
6.67	5.67	164280	92183	161105	68480	229585	164280	128645	146828	79240	226068	164280	214423	73615	104552	178167
6.75	5.75	169810	106895	136509	73996	210505	169810	108993	173626	74615	248241	169810	130372	196026	80924	276950
6.83	5.83	164385	45840	216075	54623	270698	164385	57743	237602	58136	295738	164385	48398	303066	55378	358444
6.92	5.92	169919	35052	241219	52823	294042	169919	34544	282136	52673	334809	169919	47808	316367	56587	372955

Table A-1: Open Pit Water Balance

Model Year	Project Year	Dry					Normal					Wet				
		Groundwater Seepage, 1106	Net Precipiation	Total Mosher No. 1 Shaft Discharge	Total Hardrock No. 2 Shaft Discharge	Total Historical Underground Workings Discharge	Groundwater Seepage, 1106	Net Precipiation	Total Mosher No. 1 Shaft Discharge	Total Hardrock No. 2 Shaft Discharge	Total Historical Underground Workings Discharge	Groundwater Seepage, 1106	Net Precipiation	Total Mosher No. 1 Shaft Discharge	Total Hardrock No. 2 Shaft Discharge	Total Historical Underground Workings Discharge
		m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon
7.00	6.00	169973	5105	284760	44000	328760	169973	7848	320882	44809	365691	169973	7260	375320	44636	419955
7.08	6.08	153578	7375	253096	40571	293667	153578	10185	285228	41400	326628	153578	8947	335443	41035	376478
7.17	6.17	170092	10468	276793	45612	322405	170092	13350	312705	46463	359168	170092	12315	367805	46157	413962
7.25	6.25	164663	59368	195017	58685	253702	164663	90047	188517	67738	256255	164663	83682	249772	65859	315631
7.33	6.33	170211	107996	149246	74701	223947	170211	177892	86033	95326	181359	170211	233959	56667	111871	168538
7.42	6.42	164778	57842	219574	58636	278210	164778	102568	192297	71834	264130	164778	112798	229004	74852	303856
7.50	6.50	170330	123520	133696	79484	213181	170330	133489	159127	82426	241553	170330	223988	78828	109132	187960
7.58	6.58	170389	98410	166731	72070	238801	170389	102213	201281	73192	274473	170389	99721	258535	72457	330992
7.67	6.67	164950	92183	158873	68647	227520	164950	128645	143819	79406	223225	164950	214423	68776	104719	173495
7.75	6.75	170508	106895	134055	74219	208274	170508	108993	171127	74839	245965	170508	130372	193071	81147	274219
7.83	6.83	165065	45840	214927	54840	269767	165065	57743	236201	58352	294553	165065	48398	301864	55594	357458
7.92	6.92	170627	35052	240294	53049	293343	170627	34544	281222	52899	334121	170627	47808	315171	56813	371984
8.00	7.00	170686	5105	284577	44276	328853	170686	7848	320695	45085	365781	170686	7260	375134	44912	420046
8.08	7.08	154219	7375	252936	40730	293666	154219	10185	285068	41559	326627	154219	8947	335283	41194	376477
8.17	7.17	170800	10468	276616	45838	322454	170800	13350	312528	46688	359217	170800	12315	367628	46383	414011
8.25	7.25	165345	59368	194847	58902	253748	165345	90047	188347	67955	256301	165345	83682	249601	66076	315678
8.33	7.33	170913	107996	149071	74925	223996	170913	177892	85857	95551	181408	170913	233959	56491	112096	168587
8.42	7.42	165455	57842	219405	58900	278304	165455	102568	192127	72098	264225	165455	112798	228835	75116	303951
8.50	7.50	171027	123520	133522	79658	213180	171027	133489	158953	82599	241552	171027	223988	78654	109305	187959
8.58	7.58	171084	98410	166558	72340	238897	171084	102213	201107	73462	274569	171084	99721	258361	72727	331088
8.67	7.67	165620	92183	158706	68909	227615	165620	128645	143651	79668	223319	165620	214423	68608	104981	173589
8.75	7.75	171198	106895	133883	74440	208322	171198	108993	170954	75059	246013	171198	130372	192899	81368	274266
8.83	7.83	165730	45840	214761	54960	269722	165730	57743	236035	58473	294507	165730	48398	301698	55715	357413
8.92	7.92	171311	35052	240123	53268	293391	171311	34544	281051	53118	334169	171311	47808	315000	57032	372032
9.00	8.00	171368	5105	284406	44542	328948	171368	7848	320525	45351	365876	171368	7260	374964	45178	420141
9.08	8.08	154838	7375	252781	40973	293754	154838	10185	284913	41802	326715	154838	8947	335128	41437	376565
9.17	8.17	171487	10468	276445	45962	322406	171487	13350	312356	46812	359169	171487	12315	367456	46507	413963
9.25	8.25	166013	59368	194680	59116	253796	166013	90047	188180	68169	256349	166013	83682	249435	66291	315725
9.33	8.33	171606	107996	148898	75243	224141	171606	177892	85684	95868	181553	171606	233959	56318	112413	168732
9.42	8.42	166128	57842	219237	59067	278303	166128	102568	191959	72265	264224	166128	112798	228666	75284	303950
9.50	8.50	171725	123520	133347	79688	213035	171725	133489	158779	82629	241408	171725	223988	78480	109335	187814
9.58	8.58	171784	98410	166383	72321	238704	171784	102213	200932	73443	274376	171784	99721	258186	72708	330894
9.67	8.67	166300	92183	158536	68985	227521	166300	128645	143481	79745	223226	166300	214423	68438	105057	173496
9.75	8.75	171903	106895	133706	74519	208225	171903	108993	170778	75139	245917	171903	130372	192722	81447	274170
9.83	8.83	166415	45840	214590	55131	269721	166415	57743	235863	58643	294506	166415	48398	301527	55885	357412
9.92	8.92	172022	35052	239945	53349	293294	172022	34544	280873	53199	334072	172022	47808	314822	57113	371935
10.00	9.00	172081	5105	284228	44527	328755	172081	7848	320347	45336	365683	172081	7260	374785	45163	419948
10.08	9.08	155472	7375	252622	41045	293667	155472	10185	284754	41874	326628	155472	8947	334970	41508	376478
10.17	9.17	172179	10468	276271	46134	322405	172179	13350	312183	46984	359168	172179	12315	367283	46679	413962
10.25	9.25	166673	59368	194515	59187	253702	166673	90047	188015	68240	256255	166673	83682	249270	66362	315631
10.33	9.33	172277	107996	148730	75217	223947	172277	177892	85516	95843	181359	172277	233959	56150	112388	168538
10.42	9.42	166768	57842	219077	59133	278210	166768	102568	191799	72331	264130	166768	112798	228506	75350	303856

Table A-1: Open Pit Water Balance

Model Year	Project Year	Dry					Normal					Wet				
		Groundwater Seepage, 1106	Net Precipiation	Total Mosher No. 1 Shaft Discharge	Total Hardrock No. 2 Shaft Discharge	Total Historical Underground Workings Discharge	Groundwater Seepage, 1106	Net Precipiation	Total Mosher No. 1 Shaft Discharge	Total Hardrock No. 2 Shaft Discharge	Total Historical Underground Workings Discharge	Groundwater Seepage, 1106	Net Precipiation	Total Mosher No. 1 Shaft Discharge	Total Hardrock No. 2 Shaft Discharge	Total Historical Underground Workings Discharge
		m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon
10.50	9.50	172376	123520	133185	79947	213132	172376	133489	158616	82889	241505	172376	223988	78317	109594	187911
10.58	9.58	172425	98410	166222	72481	238704	172425	102213	200772	73604	274376	172425	99721	258026	72868	330894
10.67	9.67	166910	92183	158383	69138	227521	166910	128645	143329	79897	223226	166910	214423	68286	105210	173496
10.75	9.75	172523	106895	133551	74674	208225	172523	108993	170623	75294	245917	172523	130372	192567	81602	274170
10.83	9.83	167005	45840	214442	55278	269721	167005	57743	235716	58791	294506	167005	48398	301379	56033	357412
10.92	9.92	172621	35052	239796	53499	293294	172621	34544	280723	53349	334072	172621	47808	314672	57263	371935
11.00	10.00	172670	5105	284081	44674	328755	172670	7848	320199	45483	365683	172670	7260	374638	45310	419948
11.08	10.08	156014	7375	252487	41180	293667	156014	10185	284619	42009	326628	156014	8947	334834	41644	376478
11.17	10.17	172789	10468	276119	46286	322405	172789	13350	312031	47137	359168	172789	12315	367131	46831	413962
11.25	10.25	167273	59368	194365	59337	253702	167273	90047	187865	68390	256255	167273	83682	249120	66512	315631
11.33	10.33	172908	107996	148572	75375	223947	172908	177892	85359	96000	181359	172908	233959	55993	112545	168538
11.42	10.42	167388	57842	218922	59288	278210	167388	102568	191644	72486	264130	167388	112798	228351	75505	303856
11.50	10.50	173027	123520	133022	81266	214288	173027	133489	158453	84207	242660	173027	223988	78154	110913	189067
11.58	10.58	173086	98410	166057	74958	241015	173086	102213	200607	76081	276688	173086	99721	257861	75345	333206
11.67	10.67	167560	92183	158221	70419	228640	167560	128645	143166	81179	224345	167560	214423	68123	106491	174614
11.75	10.75	173205	106895	133381	76001	209381	173205	108993	170453	76620	247073	173205	130372	192397	82929	275326
11.83	10.83	167675	45840	214275	56564	270839	167675	57743	235548	60077	295625	167675	48398	301212	57319	358531
11.92	10.92	173324	35052	239620	54830	294450	173324	34544	280548	54680	335228	173324	47808	314496	58594	373091
12.00	11.00	173383	5105	270510	46008	316519	173383	7848	320021	46818	366839	173383	7260	347676	46644	394320
12.08	11.08	156658	7375	240071	42385	282456	156658	10185	284238	43214	327452	156658	8947	310288	42849	353137
12.17	11.17	173502	10468	262323	47620	309943	173502	13350	311564	48471	360035	173502	12315	339902	48165	388068
12.25	11.25	167963	59368	179950	60628	240579	167963	90047	185748	69681	255429	167963	83682	221220	67803	289023
12.33	11.33	173621	107996	132536	76709	209245	173621	177892	81206	97335	178540	173621	233959	23845	113880	137724
12.42	11.42	168078	57842	204362	60579	264941	168078	102568	189079	73777	262856	168078	112798	199645	76796	276441
12.50	11.50	173740	123520	116591	80288	196879	173740	133489	155199	83230	238429	173740	223988	46162	109935	156097
12.58	11.58	173799	98410	150201	72825	223026	173799	102213	198061	73947	272008	173799	99721	228585	73212	301797
12.67	11.67	168250	92183	142998	69473	212471	168250	128645	140116	80232	220348	168250	214423	37301	105545	142846
12.75	11.75	173918	106895	117502	75023	192525	173918	108993	167921	75642	243563	173918	130372	162620	81951	244571
12.83	11.83	168365	45840	200152	55618	255771	168365	57743	234129	59131	293260	168365	48398	274074	56373	330447
12.92	11.92	174037	35052	225293	53853	279146	174037	34544	279624	53703	333326	174037	47808	286502	57617	344119
13.00	12.00	174096	5105	323790	45031	368821	174096	7848	400026	45840	445865	174096	7260	454477	45666	500143
13.08	12.08	157299	7375	288255	41501	329756	157299	10185	356599	42330	398930	157299	8947	406848	41965	448813
13.17	12.17	174210	10468	315658	46641	362299	174210	13350	391668	47492	439160	174210	12315	446796	47186	493982
13.25	12.25	168645	59368	231304	59680	290984	168645	90047	262858	68733	331591	168645	83682	324284	66855	391139
13.33	12.33	174323	107996	185321	75729	261049	174323	177892	160402	96354	256756	174323	233959	129527	112899	242426
13.42	12.42	168755	57842	255681	59630	315310	168755	102568	266079	72828	338907	168755	112798	302511	75847	378358
13.50	12.50	174437	123520	169280	80462	249742	174437	133489	234619	83404	318023	174437	223988	151884	110110	261993
13.58	12.58	174494	98410	203032	72998	276031	174494	102213	277655	74121	351776	174494	99721	334977	73386	408362
13.67	12.67	168920	92183	194155	69640	263796	168920	128645	216999	80400	297399	168920	214423	139648	105712	245360
13.75	12.75	174608	106895	170329	75195	245524	174608	108993	247520	75815	323335	174608	130372	268889	82123	351013
13.83	12.83	169030	45840	251582	55784	307367	169030	57743	311415	59297	370712	169030	48398	377330	56539	433869
13.92	12.92	174721	35052	278503	54024	332527	174721	34544	359621	53874	413494	174721	47808	393212	57788	451000

Table A-1: Open Pit Water Balance

Model Year	Project Year	Dry					Normal					Wet				
		Groundwater Seepage, 1106	Net Precipiation	Total Mosher No. 1 Shaft Discharge	Total Hardrock No. 2 Shaft Discharge	Total Historical Underground Workings Discharge	Groundwater Seepage, 1106	Net Precipiation	Total Mosher No. 1 Shaft Discharge	Total Hardrock No. 2 Shaft Discharge	Total Historical Underground Workings Discharge	Groundwater Seepage, 1106	Net Precipiation	Total Mosher No. 1 Shaft Discharge	Total Hardrock No. 2 Shaft Discharge	Total Historical Underground Workings Discharge
		m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon
14.00	13.00	174778	5105	363054	45201	408255	174778	7848	323405	46010	369415	174778	7260	247985	45837	293821
14.08	13.08	157911	7375	124962	41654	166616	157911	10185	127450	42483	169933	157911	8947	126354	42118	168471
14.17	13.17	174881	10468	140428	46809	187237	174881	13350	142980	47660	190640	174881	12315	142063	47354	189418
14.25	13.25	169290	59368	179524	59841	239366	169290	90047	206684	68895	275578	169290	83682	201049	67016	268065
14.33	13.33	174985	107996	227683	75894	303577	174985	177892	289559	96520	386079	174985	233959	339194	113065	452258
14.42	13.42	169390	57842	179366	59789	239155	169390	102568	218960	72987	291947	169390	112798	228017	76006	304023
14.50	13.50	175088	123520	241876	80625	322501	175088	133489	250700	83567	334267	175088	223988	330817	110272	441089
14.58	13.58	175140	98410	219480	73160	292640	175140	102213	222847	74282	297129	175140	99721	220641	73547	294188
14.67	13.67	169540	92183	209386	69795	279181	169540	128645	241665	80555	322219	169540	214423	317601	105867	423469
14.75	13.75	175243	106895	226063	75354	301417	175243	108993	227921	75974	303895	175243	130372	246847	82282	329129
14.83	13.83	169640	45840	167811	55937	223748	169640	57743	178348	59449	237797	169640	48398	170075	56692	226767
14.92	13.92	175346	35052	162541	54180	216721	175346	34544	162091	54030	216121	175346	47808	173832	57944	231777
15.00	14.00	175398	5105	136068	45356	181424	175398	7848	138496	46165	184662	175398	7260	137975	45992	183967
15.08	14.08	158424	7375	125347	41782	167130	158424	10185	127835	42612	170446	158424	8947	126739	42246	168985
15.17	14.17	175398	10468	140815	46938	187754	175398	13350	143367	47789	191156	175398	12315	142451	47484	189934
15.25	14.25	169740	59368	179862	59954	239816	169740	90047	207021	69007	276028	169740	83682	201387	67129	268515
15.33	14.33	175398	107996	227993	75998	303990	175398	177892	289869	96623	386492	175398	233959	339504	113168	452671
15.42	14.42	169740	57842	179629	59876	239505	169740	102568	219223	73074	292297	169740	112798	228279	76093	304373
15.50	14.50	175398	123520	242108	80703	322811	175398	133489	250933	83644	334577	175398	223988	331050	110350	441399
15.58	14.58	175398	98410	219674	73225	292898	175398	102213	223041	74347	297388	175398	99721	220835	73612	294446
15.67	14.67	169740	92183	209536	69845	279381	169740	128645	241815	80605	322419	169740	214423	317751	105917	423669
15.75	14.75	175398	106895	226179	75393	301572	175398	108993	228037	76012	304050	175398	130372	246963	82321	329284
15.83	14.83	169740	45840	167886	55962	223848	169740	57743	178423	59474	237897	169740	48398	170150	56717	226867
15.92	14.92	175398	35052	162579	54193	216772	175398	34544	162129	54043	216173	175398	47808	173871	57957	231828

Table A-2: TMF Water Balance

Model Year	Project Year	Dry	Normal	Wet
		Actual Storage	Actual Storage	Actual Storage
		m^3/mon	m^3/mon	m^3/mon
0.00	-2.00	0	0	0
0.08	-1.92	0	0	0
0.17	-1.83	0	0	0
0.25	-1.75	0	0	0
0.33	-1.67	0	0	0
0.42	-1.58	0	0	0
0.50	-1.50	0	0	0
0.58	-1.42	0	0	0
0.67	-1.33	0	0	0
0.75	-1.25	0	0	0
0.83	-1.17	0	0	0
0.92	-1.08	0	0	0
1.00	-1.00	0	0	0
1.08	-0.92	0	0	0
1.17	-0.83	0	0	0
1.25	-0.75	0	0	0
1.33	-0.67	0	0	0
1.42	-0.58	0	0	0
1.50	-0.50	0	0	0
1.58	-0.42	0	0	0
1.67	-0.33	0	0	0
1.75	0.75	37726	98291	240773
1.83	0.83	209555	273494	450342
1.92	0.92	500000	500000	500000
2.00	1.00	570118	505383	500000
2.08	1.08	592098	500000	500000
2.17	1.17	620261	500000	500000
2.25	1.25	652482	500000	500000
2.33	1.33	774367	613835	544413
2.42	1.42	825323	724049	695604
2.50	1.50	733436	649691	582044
2.58	1.58	743687	613590	647601
2.67	1.67	747120	559807	531595
2.75	1.75	810957	626126	696289
2.83	1.83	1013000	768060	818069
2.92	1.92	1110000	823067	798227
3.00	2.00	1186000	833799	774502
3.08	2.08	1139000	797484	679318
3.17	2.17	1103000	776274	596760
3.25	2.25	1074000	760386	520383
3.33	2.33	1175000	949007	634296
3.42	2.42	1193000	1153000	923843

Table A-2: TMF Water Balance

Model Year	Project Year	Dry	Normal	Wet
		Actual Storage	Actual Storage	Actual Storage
		m^3/mon	m^3/mon	m^3/mon
3.50	2.50	1011000	1095000	835511
3.58	2.58	978719	1094000	1009000
3.67	2.67	931619	1063000	913850
3.75	2.75	963790	1198000	1218000
3.83	2.83	1182000	1428000	1445000
3.92	2.92	1210000	1435000	1352000
4.00	3.00	1206000	1378000	1253000
4.08	3.08	1125000	1253000	1050000
4.17	3.17	1055000	1141000	857410
4.25	3.25	992532	1034000	672057
4.33	3.33	1079000	1163000	704880
4.42	3.42	1082000	1319000	950545
4.50	3.50	859685	1181000	767286
4.58	3.58	810009	1109000	885359
4.67	3.67	740496	999066	691868
4.75	3.75	756932	1075000	952097
4.83	3.83	977679	1250000	1114000
4.92	3.92	1023000	1280000	1040000
5.00	4.00	1033000	1236000	958703
5.08	4.08	953947	1114000	804133
5.17	4.17	885729	1003000	659173
5.25	4.25	824708	899596	521747
5.33	4.33	922758	1045000	616167
5.42	4.42	931568	1221000	936610
5.50	4.50	700791	1083000	801195
5.58	4.58	653652	1015000	985983
5.67	4.67	585473	906828	839722
5.75	4.75	608693	996102	1176000
5.83	4.83	849146	1191000	1407000
5.92	4.92	903492	1232000	1388000
6.00	5.00	919333	1195000	1361000
6.08	5.08	850679	1074000	1175000
6.17	5.17	791592	963746	996163
6.25	5.25	739702	859994	825256
6.33	5.33	846884	1005000	886194
6.42	5.42	864825	1181000	1173000
6.50	5.50	643179	1043000	1004000
6.58	5.58	605172	975258	1156000
6.67	5.67	546124	867227	975825
6.75	5.75	578475	956500	1278000
6.83	5.83	828059	1152000	1476000
6.92	5.92	891536	1193000	1423000

Table A-2: TMF Water Balance

Model Year	Project Year	Dry	Normal	Wet
		Actual Storage	Actual Storage	Actual Storage
		m^3/mon	m^3/mon	m^3/mon
7.00	6.00	916509	1155000	1363000
7.08	6.08	847855	1034000	1177000
7.17	6.17	788768	924144	998341
7.25	6.25	736878	820392	827433
7.33	6.33	844060	965812	888372
7.42	6.42	862001	1141000	1175000
7.50	6.50	640355	1003000	1006000
7.58	6.58	602348	935656	1158000
7.67	6.67	543299	827625	978002
7.75	6.75	575651	916898	1280000
7.83	6.83	825235	1112000	1479000
7.92	6.92	888712	1153000	1426000
8.00	7.00	913685	1116000	1366000
8.08	7.08	847848	997597	1182000
8.17	7.17	786008	882221	999249
8.25	7.25	729601	771741	822406
8.33	7.33	793247	849314	820542
8.42	7.42	802585	962701	1002000
8.50	7.50	636031	844323	844952
8.58	7.58	608941	779879	930131
8.67	7.67	562783	681821	770100
8.75	7.75	579987	787382	1090000
8.83	7.83	775607	960950	1267000
8.92	7.92	828242	991307	1203000
9.00	8.00	848008	948603	1138000
9.08	8.08	778947	831227	945955
9.17	8.17	717107	721939	760384
9.25	8.25	660699	617546	580497
9.33	8.33	744751	746293	615555
9.42	8.42	789959	956054	928212
9.50	8.50	623405	853128	785409
9.58	8.58	611391	817608	960839
9.67	8.67	572038	735403	797764
9.75	8.75	620237	847052	1115000
9.83	8.83	848094	1027000	1288000
9.92	8.92	900729	1063000	1221000
10.00	9.00	920495	1027000	1153000
10.08	9.08	851434	909158	961444
10.17	9.17	789594	799871	775872
10.25	9.25	733186	695478	595986
10.33	9.33	817238	824225	631044
10.42	9.42	862446	1034000	943700

Table A-2: TMF Water Balance

Model Year	Project Year	Dry Actual Storage m³/mon	Normal Actual Storage m³/mon	Wet Actual Storage m³/mon
10.50	9.50	695892	931060	800898
10.58	9.58	683878	895539	976328
10.67	9.67	644525	813335	813252
10.75	9.75	692724	924983	1130000
10.83	9.83	920581	1105000	1304000
10.92	9.92	973216	1141000	1237000
11.00	10.00	992982	1104000	1169000
11.08	10.08	923921	987090	976933
11.17	10.17	862081	877803	791361
11.25	10.25	805673	773409	611475
11.33	10.33	889725	902157	646533
11.42	10.42	934933	1112000	959189
11.50	10.50	768379	1009000	816387
11.58	10.58	756365	973471	991816
11.67	10.67	717012	891266	828741
11.75	10.75	765211	1003000	1145000
11.83	10.83	993068	1183000	1319000
11.92	10.92	1046000	1219000	1252000
12.00	11.00	1065000	1182000	1184000
12.08	11.08	996408	1065000	992422
12.17	11.17	934568	955735	806850
12.25	11.25	878160	851341	626963
12.33	11.33	962212	980089	662022
12.42	11.42	1007000	1190000	974678
12.50	11.50	840866	1087000	831876
12.58	11.58	828852	1051000	1007000
12.67	11.67	789498	969198	844230
12.75	11.75	837698	1081000	1161000
12.83	11.83	1066000	1261000	1335000
12.92	11.92	1118000	1297000	1268000
13.00	12.00	1138000	1260000	1200000
13.08	12.08	1069000	1143000	1008000
13.17	12.17	1007000	1034000	822339
13.25	12.25	950647	929273	642452
13.33	12.33	1035000	1058000	677510
13.42	12.42	1080000	1268000	990167
13.50	12.50	913353	1165000	847365
13.58	12.58	901339	1129000	1023000
13.67	12.67	861985	1047000	859719
13.75	12.75	910185	1159000	1176000
13.83	12.83	1138000	1338000	1350000
13.92	12.92	1191000	1375000	1283000

Table A-2: TMF Water Balance

Model Year	Project Year	Dry	Normal	Wet
		Actual Storage	Actual Storage	Actual Storage
		m^3/mon	m^3/mon	m^3/mon
14.00	13.00	1210000	1338000	1215000
14.08	13.08	1126000	1206000	1023000
14.17	13.17	1049000	1081000	837828
14.25	13.25	977478	961549	657941
14.33	13.33	1046000	1075000	692999
14.42	13.42	1076000	1270000	1006000
14.50	13.50	894527	1151000	862854
14.58	13.58	867295	1101000	1038000
14.67	13.67	812722	1003000	875208
14.75	13.75	845703	1100000	1192000
14.83	13.83	1058000	1264000	1366000
14.92	13.92	1096000	1285000	1299000
15.00	14.00	1100000	1234000	1231000
15.08	14.08	1016000	1101000	1039000
15.17	14.17	938966	976467	853316
15.25	14.25	867340	856855	673430
15.33	14.33	936172	970384	708488
15.42	14.42	966162	1165000	1021000
15.50	14.50	784389	1047000	878342
15.58	14.58	757156	996042	1054000
15.67	14.67	702584	898619	890697
15.75	14.75	735565	995049	1207000
15.83	14.83	948203	1159000	1381000
15.92	14.92	985619	1181000	1314000

Table A-3: Mill Water Balance

Model Year	Project Year	Dry				Normal				Wet			
		Total Reclaim Demand	SP M1 to Mill	Reclaim Water from TMF, 060	Total Underground workings to Mill	Total Reclaim Demand	SP M1 to Mill	Reclaim Water from TMF, 060	Total Underground workings to Mill	Total Reclaim Demand	SP M1 to Mill	Reclaim Water from TMF, 060	Total Underground workings to Mill
		m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon
0.00	-2.00	0	0	0	0	0	0	0	0	0	0	0	0
0.08	-1.92	0	0	0	0	0	0	0	0	0	0	0	0
0.17	-1.83	0	0	0	0	0	0	0	0	0	0	0	0
0.25	-1.75	0	0	0	0	0	0	0	0	0	0	0	0
0.33	-1.67	0	0	0	0	0	0	0	0	0	0	0	0
0.42	-1.58	0	0	0	0	0	0	0	0	0	0	0	0
0.50	-1.50	0	0	0	0	0	0	0	0	0	0	0	0
0.58	-1.42	0	0	0	0	0	0	0	0	0	0	0	0
0.67	-1.33	0	0	0	0	0	0	0	0	0	0	0	0
0.75	-1.25	0	0	0	0	0	0	0	0	0	0	0	0
0.83	-1.17	0	0	0	0	0	0	0	0	0	0	0	0
0.92	-1.08	0	0	0	0	0	0	0	0	0	0	0	0
1.00	-1.00	0	0	0	0	0	0	0	0	0	0	0	0
1.08	-0.92	0	0	0	0	0	0	0	0	0	0	0	0
1.17	-0.83	0	0	0	0	0	0	0	0	0	0	0	0
1.25	-0.75	0	0	0	0	0	0	0	0	0	0	0	0
1.33	-0.67	0	0	0	0	0	0	0	0	0	0	0	0
1.42	-0.58	0	0	0	0	0	0	0	0	0	0	0	0
1.50	-0.50	0	0	0	0	0	0	0	0	0	0	0	0
1.58	-0.42	0	0	0	0	0	0	0	0	0	0	0	0
1.67	-0.33	0	0	0	0	0	0	0	0	0	0	0	0
1.75	0.75	0	0	0	0	0	0	0	0	0	0	0	0
1.83	0.83	577590	112590	465000	0	577590	49590	528000	0	577590	0	585000	0
1.92	0.92	596843	41180	480500	0	596843	51243	545600	0	596843	0	604500	0
2.00	1.00	596843	4599	480500	75163	596843	51243	545600	0	596843	0	604500	0
2.08	1.08	539084	105084	434000	111744	539084	46284	492800	0	539084	0	546000	0
2.17	1.17	596843	116343	480500	0	596843	51243	545600	0	596843	0	604500	0
2.25	1.25	577590	112590	465000	0	577590	49590	528000	0	577590	0	585000	0
2.33	1.33	596843	116343	480500	0	596843	51243	545600	0	596843	0	604500	0
2.42	1.42	577590	112590	465000	0	577590	49590	528000	0	577590	0	585000	0
2.50	1.50	596843	116343	480500	0	596843	51243	545600	0	596843	0	604500	0
2.58	1.58	596843	116343	480500	0	596843	51243	545600	0	596843	0	604500	0
2.67	1.67	577590	112590	465000	0	577590	49590	528000	0	577590	0	585000	0
2.75	1.75	596843	116343	480500	0	596843	51243	545600	0	596843	0	604500	0
2.83	1.83	577590	112590	465000	0	577590	49590	528000	0	577590	0	585000	0
2.92	1.92	596843	116343	480500	0	596843	51243	545600	0	596843	0	604500	0
3.00	2.00	596843	45043	551800	0	596843	51243	545600	0	596843	0	604500	0
3.08	2.08	539084	40684	498400	0	539084	46284	492800	0	539084	0	546000	0
3.17	2.17	596843	45043	551800	0	596843	51243	545600	0	596843	0	604500	0
3.25	2.25	577590	43590	534000	0	577590	49590	528000	0	577590	0	585000	0
3.33	2.33	596843	45043	551800	0	596843	51243	545600	0	596843	0	604500	0
3.42	2.42	577590	43590	534000	0	577590	49590	528000	0	577590	0	585000	0
3.50	2.50	596843	45043	551800	0	596843	51243	545600	0	596843	0	604500	0
3.58	2.58	596843	45043	551800	0	596843	51243	545600	0	596843	0	604500	0

Table A-3: Mill Water Balance

Model Year	Project Year	Dry				Normal				Wet			
		Total Reclaim Demand	SP M1 to Mill	Reclaim Water from TMF, 060	Total Underground workings to Mill	Total Reclaim Demand	SP M1 to Mill	Reclaim Water from TMF, 060	Total Underground workings to Mill	Total Reclaim Demand	SP M1 to Mill	Reclaim Water from TMF, 060	Total Underground workings to Mill
		m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon
3.67	2.67	577590	43590	534000	0	577590	49590	528000	0	577590	0	585000	0
3.75	2.75	596843	45043	551800	0	596843	51243	545600	0	596843	0	604500	0
3.83	2.83	712980	178980	534000	0	712980	127980	585000	0	712980	52980	660000	0
3.92	2.92	736746	184946	551800	0	736746	132246	604500	0	736746	54746	682000	0
4.00	3.00	736746	184946	551800	0	736746	132246	604500	0	736746	54746	682000	0
4.08	3.08	665448	167048	498400	0	665448	119448	546000	0	665448	49448	616000	0
4.17	3.17	736746	184946	551800	0	736746	132246	604500	0	736746	54746	682000	0
4.25	3.25	712980	178980	534000	0	712980	127980	585000	0	712980	52980	660000	0
4.33	3.33	736746	184946	551800	0	736746	132246	604500	0	736746	54746	682000	0
4.42	3.42	712980	178980	534000	0	712980	127980	585000	0	712980	52980	660000	0
4.50	3.50	736746	184946	551800	0	736746	132246	604500	0	736746	54746	682000	0
4.58	3.58	736746	184946	551800	0	736746	132246	604500	0	736746	54746	682000	0
4.67	3.67	712980	178980	534000	0	712980	127980	585000	0	712980	52980	660000	0
4.75	3.75	736746	184946	551800	0	736746	132246	604500	0	736746	54746	682000	0
4.83	3.83	712980	178980	534000	0	712980	127980	585000	0	712980	52980	660000	0
4.92	3.92	736746	184946	551800	0	736746	132246	604500	0	736746	54746	682000	0
5.00	4.00	736746	184946	551800	0	736746	132246	604500	0	736746	101246	635500	0
5.08	4.08	665448	167048	498400	0	665448	119448	546000	0	665448	91448	574000	0
5.17	4.17	736746	184946	551800	0	736746	132246	604500	0	736746	101246	635500	0
5.25	4.25	712980	178980	534000	0	712980	127980	585000	0	712980	97980	615000	0
5.33	4.33	736746	184946	551800	0	736746	132246	604500	0	736746	101246	635500	0
5.42	4.42	712980	178980	534000	0	712980	127980	585000	0	712980	97980	615000	0
5.50	4.50	736746	184946	551800	0	736746	132246	604500	0	736746	101246	635500	0
5.58	4.58	736746	184946	551800	0	736746	132246	604500	0	736746	101246	635500	0
5.67	4.67	712980	178980	534000	0	712980	127980	585000	0	712980	97980	615000	0
5.75	4.75	736746	184946	551800	0	736746	132246	604500	0	736746	101246	635500	0
5.83	4.83	712980	178980	534000	0	712980	127980	585000	0	712980	97980	615000	0
5.92	4.92	736746	184946	551800	0	736746	132246	604500	0	736746	101246	635500	0
6.00	5.00	736746	194246	542500	0	736746	132246	604500	0	736746	67146	669600	0
6.08	5.08	665448	175448	490000	0	665448	119448	546000	0	665448	60648	604800	0
6.17	5.17	736746	194246	542500	0	736746	132246	604500	0	736746	67146	669600	0
6.25	5.25	712980	187980	525000	0	712980	127980	585000	0	712980	64980	648000	0
6.33	5.33	736746	194246	542500	0	736746	132246	604500	0	736746	67146	669600	0
6.42	5.42	712980	187980	525000	0	712980	127980	585000	0	712980	64980	648000	0
6.50	5.50	736746	194246	542500	0	736746	132246	604500	0	736746	67146	669600	0
6.58	5.58	736746	194246	542500	0	736746	132246	604500	0	736746	67146	669600	0
6.67	5.67	712980	187980	525000	0	712980	127980	585000	0	712980	64980	648000	0
6.75	5.75	736746	194246	542500	0	736746	132246	604500	0	736746	67146	669600	0
6.83	5.83	712980	187980	525000	0	712980	127980	585000	0	712980	64980	648000	0
6.92	5.92	736746	194246	542500	0	736746	132246	604500	0	736746	67146	669600	0
7.00	6.00	736746	194246	542500	0	736746	132246	604500	0	736746	67146	669600	0
7.08	6.08	665448	175448	490000	0	665448	119448	546000	0	665448	60648	604800	0
7.17	6.17	736746	194246	542500	0	736746	132246	604500	0	736746	67146	669600	0
7.25	6.25	712980	187980	525000	0	712980	127980	585000	0	712980	64980	648000	0

Table A-3: Mill Water Balance

Model Year	Project Year	Dry				Normal				Wet			
		Total Reclaim Demand	SP M1 to Mill	Reclaim Water from TMF, 060	Total Underground workings to Mill	Total Reclaim Demand	SP M1 to Mill	Reclaim Water from TMF, 060	Total Underground workings to Mill	Total Reclaim Demand	SP M1 to Mill	Reclaim Water from TMF, 060	Total Underground workings to Mill
		m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon
7.33	6.33	736746	194246	542500	0	736746	132246	604500	0	736746	67146	669600	0
7.42	6.42	712980	187980	525000	0	712980	127980	585000	0	712980	64980	648000	0
7.50	6.50	736746	194246	542500	0	736746	132246	604500	0	736746	67146	669600	0
7.58	6.58	736746	194246	542500	0	736746	132246	604500	0	736746	67146	669600	0
7.67	6.67	712980	187980	525000	0	712980	127980	585000	0	712980	64980	648000	0
7.75	6.75	736746	194246	542500	0	736746	132246	604500	0	736746	67146	669600	0
7.83	6.83	712980	187980	525000	0	712980	127980	585000	0	712980	64980	648000	0
7.92	6.92	736746	194246	542500	0	736746	132246	604500	0	736746	67146	669600	0
8.00	7.00	736746	194246	542500	0	736746	132246	604500	0	736746	67146	669600	0
8.08	7.08	665448	175448	490000	0	665448	119448	546000	0	665448	60648	604800	0
8.17	7.17	736746	194246	542500	0	736746	132246	604500	0	736746	67146	669600	0
8.25	7.25	712980	187980	525000	0	712980	127980	585000	0	712980	64980	648000	0
8.33	7.33	736746	194246	542500	0	736746	132246	604500	0	736746	67146	669600	0
8.42	7.42	712980	187980	525000	0	712980	127980	585000	0	712980	64980	648000	0
8.50	7.50	736746	194246	542500	0	736746	132246	604500	0	736746	67146	669600	0
8.58	7.58	736746	194246	542500	0	736746	132246	604500	0	736746	67146	669600	0
8.67	7.67	712980	187980	525000	0	712980	127980	585000	0	712980	64980	648000	0
8.75	7.75	736746	194246	542500	0	736746	132246	604500	0	736746	67146	669600	0
8.83	7.83	712980	187980	525000	0	712980	127980	585000	0	712980	64980	648000	0
8.92	7.92	736746	194246	542500	0	736746	132246	604500	0	736746	67146	669600	0
9.00	8.00	736746	194246	542500	0	736746	138446	598300	0	736746	64046	672700	0
9.08	8.08	665448	175448	490000	0	665448	125048	540400	0	665448	57848	607600	0
9.17	8.17	736746	194246	542500	0	736746	138446	598300	0	736746	64046	672700	0
9.25	8.25	712980	187980	525000	0	712980	133980	579000	0	712980	61980	651000	0
9.33	8.33	736746	194246	542500	0	736746	138446	598300	0	736746	64046	672700	0
9.42	8.42	712980	187980	525000	0	712980	133980	579000	0	712980	61980	651000	0
9.50	8.50	736746	194246	542500	0	736746	138446	598300	0	736746	64046	672700	0
9.58	8.58	736746	194246	542500	0	736746	138446	598300	0	736746	64046	672700	0
9.67	8.67	712980	187980	525000	0	712980	133980	579000	0	712980	61980	651000	0
9.75	8.75	736746	194246	542500	0	736746	138446	598300	0	736746	64046	672700	0
9.83	8.83	712980	187980	525000	0	712980	133980	579000	0	712980	61980	651000	0
9.92	8.92	736746	194246	542500	0	736746	138446	598300	0	736746	64046	672700	0
10.00	9.00	736746	194246	542500	0	736746	138446	598300	0	736746	64046	672700	0
10.08	9.08	665448	175448	490000	0	665448	125048	540400	0	665448	57848	607600	0
10.17	9.17	736746	194246	542500	0	736746	138446	598300	0	736746	64046	672700	0
10.25	9.25	712980	187980	525000	0	712980	133980	579000	0	712980	61980	651000	0
10.33	9.33	736746	194246	542500	0	736746	138446	598300	0	736746	64046	672700	0
10.42	9.42	712980	187980	525000	0	712980	133980	579000	0	712980	61980	651000	0
10.50	9.50	736746	194246	542500	0	736746	138446	598300	0	736746	64046	672700	0
10.58	9.58	736746	194246	542500	0	736746	138446	598300	0	736746	64046	672700	0
10.67	9.67	712980	187980	525000	0	712980	133980	579000	0	712980	61980	651000	0
10.75	9.75	736746	194246	542500	0	736746	138446	598300	0	736746	64046	672700	0
10.83	9.83	712980	187980	525000	0	712980	133980	579000	0	712980	61980	651000	0
10.92	9.92	736746	194246	542500	0	736746	138446	598300	0	736746	64046	672700	0

Table A-3: Mill Water Balance

Model Year	Project Year	Dry				Normal				Wet			
		Total Reclaim Demand	SP M1 to Mill	Reclaim Water from TMF, 060	Total Underground workings to Mill	Total Reclaim Demand	SP M1 to Mill	Reclaim Water from TMF, 060	Total Underground workings to Mill	Total Reclaim Demand	SP M1 to Mill	Reclaim Water from TMF, 060	Total Underground workings to Mill
		m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon
11.00	10.00	736746	194246	542500	0	736746	138446	598300	0	736746	64046	672700	0
11.08	10.08	665448	175448	490000	0	665448	125048	540400	0	665448	57848	607600	0
11.17	10.17	736746	194246	542500	0	736746	138446	598300	0	736746	64046	672700	0
11.25	10.25	712980	187980	525000	0	712980	133980	579000	0	712980	61980	651000	0
11.33	10.33	736746	194246	542500	0	736746	138446	598300	0	736746	64046	672700	0
11.42	10.42	712980	187980	525000	0	712980	133980	579000	0	712980	61980	651000	0
11.50	10.50	736746	194246	542500	0	736746	138446	598300	0	736746	64046	672700	0
11.58	10.58	736746	194246	542500	0	736746	138446	598300	0	736746	64046	672700	0
11.67	10.67	712980	187980	525000	0	712980	133980	579000	0	712980	61980	651000	0
11.75	10.75	736746	194246	542500	0	736746	138446	598300	0	736746	64046	672700	0
11.83	10.83	712980	187980	525000	0	712980	133980	579000	0	712980	61980	651000	0
11.92	10.92	736746	194246	542500	0	736746	138446	598300	0	736746	64046	672700	0
12.00	11.00	736746	194246	542500	0	736746	138446	598300	0	736746	64046	672700	0
12.08	11.08	665448	175448	490000	0	665448	125048	540400	0	665448	57848	607600	0
12.17	11.17	736746	194246	542500	0	736746	138446	598300	0	736746	64046	672700	0
12.25	11.25	712980	187980	525000	0	712980	133980	579000	0	712980	61980	651000	0
12.33	11.33	736746	194246	542500	0	736746	138446	598300	0	736746	64046	672700	0
12.42	11.42	712980	187980	525000	0	712980	133980	579000	0	712980	61980	651000	0
12.50	11.50	736746	194246	542500	0	736746	138446	598300	0	736746	64046	672700	0
12.58	11.58	736746	194246	542500	0	736746	138446	598300	0	736746	64046	672700	0
12.67	11.67	712980	187980	525000	0	712980	133980	579000	0	712980	61980	651000	0
12.75	11.75	736746	194246	542500	0	736746	138446	598300	0	736746	64046	672700	0
12.83	11.83	712980	187980	525000	0	712980	133980	579000	0	712980	61980	651000	0
12.92	11.92	736746	194246	542500	0	736746	138446	598300	0	736746	64046	672700	0
13.00	12.00	736746	194246	542500	0	736746	138446	598300	0	736746	64046	672700	0
13.08	12.08	665448	175448	490000	0	665448	125048	540400	0	665448	57848	607600	0
13.17	12.17	736746	194246	542500	0	736746	138446	598300	0	736746	64046	672700	0
13.25	12.25	712980	187980	525000	0	712980	133980	579000	0	712980	61980	651000	0
13.33	12.33	736746	194246	542500	0	736746	138446	598300	0	736746	64046	672700	0
13.42	12.42	712980	187980	525000	0	712980	133980	579000	0	712980	61980	651000	0
13.50	12.50	736746	194246	542500	0	736746	138446	598300	0	736746	64046	672700	0
13.58	12.58	736746	194246	542500	0	736746	138446	598300	0	736746	64046	672700	0
13.67	12.67	712980	187980	525000	0	712980	133980	579000	0	712980	61980	651000	0
13.75	12.75	736746	194246	542500	0	736746	138446	598300	0	736746	64046	672700	0
13.83	12.83	712980	187980	525000	0	712980	133980	579000	0	712980	61980	651000	0
13.92	12.92	736746	194246	542500	0	736746	138446	598300	0	736746	64046	672700	0
14.00	13.00	736746	178746	558000	0	736746	122946	613800	0	736746	64046	672700	0
14.08	13.08	665448	161448	504000	0	665448	111048	554400	0	665448	57848	607600	0
14.17	13.17	736746	178746	558000	0	736746	122946	613800	0	736746	64046	672700	0
14.25	13.25	712980	172980	540000	0	712980	118980	594000	0	712980	61980	651000	0
14.33	13.33	736746	178746	558000	0	736746	122946	613800	0	736746	64046	672700	0
14.42	13.42	712980	172980	540000	0	712980	118980	594000	0	712980	61980	651000	0
14.50	13.50	736746	178746	558000	0	736746	122946	613800	0	736746	64046	672700	0
14.58	13.58	736746	178746	558000	0	736746	122946	613800	0	736746	64046	672700	0

Table A-3: Mill Water Balance

Model Year	Project Year	Dry				Normal				Wet			
		Total Reclaim Demand	SP M1 to Mill	Reclaim Water from TMF, 060	Total Underground workings to Mill	Total Reclaim Demand	SP M1 to Mill	Reclaim Water from TMF, 060	Total Underground workings to Mill	Total Reclaim Demand	SP M1 to Mill	Reclaim Water from TMF, 060	Total Underground workings to Mill
		m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon
14.67	13.67	712980	172980	540000	0	712980	118980	594000	0	712980	61980	651000	0
14.75	13.75	736746	178746	558000	0	736746	122946	613800	0	736746	64046	672700	0
14.83	13.83	712980	172980	540000	0	712980	118980	594000	0	712980	61980	651000	0
14.92	13.92	736746	178746	558000	0	736746	122946	613800	0	736746	64046	672700	0
15.00	14.00	736746	178746	558000	0	736746	122946	613800	0	736746	64046	672700	0
15.08	14.08	665448	161448	504000	0	665448	111048	554400	0	665448	57848	607600	0
15.17	14.17	736746	178746	558000	0	736746	122946	613800	0	736746	64046	672700	0
15.25	14.25	712980	172980	540000	0	712980	118980	594000	0	712980	61980	651000	0
15.33	14.33	736746	178746	558000	0	736746	122946	613800	0	736746	64046	672700	0
15.42	14.42	712980	172980	540000	0	712980	118980	594000	0	712980	61980	651000	0
15.50	14.50	736746	178746	558000	0	736746	122946	613800	0	736746	64046	672700	0
15.58	14.58	736746	178746	558000	0	736746	122946	613800	0	736746	64046	672700	0
15.67	14.67	712980	172980	540000	0	712980	118980	594000	0	712980	61980	651000	0
15.75	14.75	736746	178746	558000	0	736746	122946	613800	0	736746	64046	672700	0
15.83	14.83	712980	172980	540000	0	712980	118980	594000	0	712980	61980	651000	0
15.92	14.92	736746	178746	558000	0	736746	122946	613800	0	736746	64046	672700	0.00

Table A-4: WRSA Water Balance

Model Year	Project Year	Dry					Normal					Wet				
		SP M1 To Mill	M1 To Open Pit after closure	WRSA Inflow to SP-M1	Historical Underground Workings Dewatering 056 + 1069	Discharge from M1 to ETP, 1067	SP M1 To Mill	M1 To Open Pit after closure	WRSA Inflow to SP-M1	Historical Underground Workings Dewatering 056 + 1069	Discharge from M1 to ETP, 1067	SP M1 To Mill	M1 To Open Pit after closure	WRSA Inflow to SP-M1	Historical Underground Workings Dewatering 056 + 1069	Discharge from M1 to ETP, 1067
		m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon
0.00	-2.00	0	0	836	0	0	0	0	2296	0	0	0	0	1295	0	0
0.08	-1.92	0	0	2206	0	0	0	0	3698	0	0	0	0	2427	0	0
0.17	-1.83	0	0	3987	0	0	0	0	5515	0	0	0	0	4412	0	0
0.25	-1.75	0	0	24348	0	0	0	0	40477	0	0	0	0	34624	0	0
0.33	-1.67	0	0	66179	0	17625	0	0	124634	0	102982	0	0	169146	0	139598
0.42	-1.58	0	0	38297	0	33689	0	0	70614	0	68264	0	0	78006	0	76173
0.50	-1.50	0	0	89877	0	87958	0	0	97412	0	95996	0	0	174951	0	178102
0.58	-1.42	0	0	71487	0	69680	0	0	74362	0	72747	0	0	72479	0	70738
0.67	-1.33	0	0	69185	0	69636	0	0	102079	0	104370	0	0	179463	0	186083
0.75	-1.25	0	0	96433	0	101829	0	0	98326	0	103828	0	0	117613	0	124193
0.83	-1.17	0	0	41354	0	43668	0	0	52092	0	55006	0	0	43661	0	46104
0.92	-1.08	0	0	31622	0	33391	0	0	31163	0	32907	0	0	43129	0	45542
1.00	-1.00	0	0	4606	0	4863	0	0	7080	0	7476	0	0	6549	0	6916
1.08	-0.92	0	0	6654	0	7026	0	0	9188	0	9702	0	0	8071	0	8523
1.17	-0.83	0	0	6388	0	6916	0	0	8147	0	8821	0	0	7515	0	8136
1.25	-0.75	0	0	36227	0	39224	0	0	54948	0	59493	0	0	51064	0	55288
1.33	-0.67	0	0	45882	0	45688	0	0	87971	0	91304	0	0	122184	0	128347
1.42	-0.58	0	0	21203	0	16596	0	0	41955	0	39605	0	0	46702	0	44868
1.50	-0.50	0	0	51207	0	49287	0	0	55832	0	54415	0	0	106952	0	110103
1.58	-0.42	0	0	40589	0	38782	0	0	42354	0	40739	0	0	41198	0	39457
1.67	-0.33	0	0	64180	0	64631	0	0	95189	0	97479	0	0	168137	0	174757
1.75	0.75	0	0	90906	0	96301	0	0	92691	0	98192	0	0	110872	0	117452
1.83	0.83	112590	0	38984	0	0	49590	0	49106	0	2430	0	0	41159	0	43601
1.92	0.92	41180	0	29809	0	0	51243	0	29377	0	0	0	0	40657	0	43070
2.00	1.00	4599	0	4342	0	0	51243	0	6674	0	0	0	0	6174	0	6540
2.08	1.08	105084	0	6272	259840	86188	46284	0	8662	293738	198557	0	0	7609	343175	351236
2.17	1.17	116343	0	8902	285722	178809	51243	0	11354	323446	284231	0	0	10473	377895	388990
2.25	1.25	112590	0	54815	230305	175527	49590	0	83142	240858	278955	0	0	77265	298575	380064
2.33	1.33	116343	0	81149	213475	178087	51243	0	145608	189192	286891	0	0	197376	190992	394531
2.42	1.42	112590	0	30361	254760	167923	49590	0	70769	253231	272060	0	0	80013	295828	374006
2.50	1.50	116343	0	87875	206749	176361	51243	0	96881	237919	282140	0	0	179885	208484	391519
2.58	1.58	116343	0	69203	225421	176474	51243	0	72639	262161	281942	0	0	70388	317980	386627
2.67	1.67	112590	0	71236	213884	172980	49590	0	104902	219098	276701	0	0	184102	191738	382460
2.75	1.75	116343	0	98697	195927	183676	51243	0	100635	234165	289058	0	0	120375	267994	394948
2.83	1.83	112590	0	42325	242795	174844	49590	0	53315	270685	277325	0	0	44686	331154	378283
2.92	1.92	116343	0	32364	262260	180050	51243	0	31895	302905	285301	0	0	44141	344227	390781
3.00	2.00	45043	0	5927	288698	249839	51243	0	9111	325690	283953	0	0	8427	379941	388734
3.08	2.08	40684	0	8576	257536	225800	46284	0	11843	290557	256630	0	0	10403	340381	351236

Table A-4: WRSA Water Balance

Model Year	Project Year	Dry					Normal					Wet				
		SP M1 To Mill	M1 To Open Pit after closure	WRSA Inflow to SP-M1	Historical Underground Workings Dewatering 056 + 1069	Discharge from M1 to ETP, 1067	SP M1 To Mill	M1 To Open Pit after closure	WRSA Inflow to SP-M1	Historical Underground Workings Dewatering 056 + 1069	Discharge from M1 to ETP, 1067	SP M1 To Mill	M1 To Open Pit after closure	WRSA Inflow to SP-M1	Historical Underground Workings Dewatering 056 + 1069	Discharge from M1 to ETP, 1067
		m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon
3.17	2.17	45043	0	12172	282452	250109	51243	0	15524	319276	284231	0	0	14320	374048	388990
3.25	2.25	43590	0	69032	216088	244527	49590	0	104705	219295	278955	0	0	97304	278536	380064
3.33	2.33	45043	0	108418	186206	249387	51243	0	189691	145109	286891	0	0	254884	133484	394531
3.42	2.42	43590	0	44381	240740	236923	49590	0	96386	227614	272060	0	0	108282	267558	374006
3.50	2.50	45043	0	118843	180850	252730	51243	0	130434	209435	287209	0	0	235665	157772	396588
3.58	2.58	45043	0	93839	205853	252842	51243	0	98262	241606	287010	0	0	95364	298072	391695
3.67	2.67	43590	0	94415	200514	251789	49590	0	136812	196997	286510	0	0	236553	149096	392269
3.75	2.75	45043	0	124295	170330	254977	51243	0	126735	208066	289059	0	0	151594	236775	394949
3.83	2.83	178980	0	53302	236723	113358	127980	0	67142	261762	203839	52980	0	56276	324469	330207
3.92	2.92	184946	0	40758	258935	116516	132246	0	40167	299702	209367	54746	0	55590	337848	341104
4.00	3.00	184946	0	5936	333932	155180	132246	0	9126	370918	248194	54746	0	8441	425171	379232
4.08	3.08	167048	0	8576	298403	140303	119448	0	11843	331424	224333	49448	0	10403	381247	342654
4.17	3.17	184946	0	12172	327696	155450	132246	0	15524	364520	248472	54746	0	14320	419292	379488
4.25	3.25	178980	0	69032	259874	152922	127980	0	104705	263081	244350	52980	0	97304	322322	370869
4.33	3.33	184946	0	108418	231450	154728	132246	0	189691	190353	251131	54746	0	254884	178728	385029
4.42	3.42	178980	0	44381	289428	150221	127980	0	96386	276303	242359	52980	0	108282	316247	369715
4.50	3.50	184946	0	118843	216038	148016	132246	0	130434	244624	241395	54746	0	235665	192961	377031
4.58	3.58	184946	0	93839	251260	158346	132246	0	98262	287013	251414	54746	0	95364	343479	382356
4.67	3.67	178980	0	94415	229584	145469	127980	0	136812	226067	237190	52980	0	236553	178166	368359
4.75	3.75	184946	0	124295	215655	160399	132246	0	126735	253391	253381	54746	0	151594	282100	385528
4.83	3.83	178980	0	53302	280665	157300	127980	0	67142	305705	247781	52980	0	56276	368411	374149
4.92	3.92	184946	0	40758	299191	156773	132246	0	40167	339958	249623	54746	0	55590	378104	381360
5.00	4.00	184946	0	5936	328863	150111	132246	0	9126	365849	243125	101246	0	8441	420102	327663
5.08	4.08	167048	0	8576	298475	140375	119448	0	11843	331496	224405	91448	0	10403	381320	300727
5.17	4.17	184946	0	12172	332927	160681	132246	0	15524	369751	253703	101246	0	14320	424523	338218
5.25	4.25	178980	0	69032	254967	148016	127980	0	104705	258174	239444	97980	0	97304	317415	320963
5.33	4.33	184946	0	108418	231532	154809	132246	0	189691	190435	251213	101246	0	254884	178809	338611
5.42	4.42	178980	0	44381	289586	150379	127980	0	96386	276461	242517	97980	0	108282	316405	324873
5.50	4.50	184946	0	118843	210983	142960	132246	0	130434	239568	236339	101246	0	235665	187905	325475
5.58	4.58	184946	0	93839	241311	148397	132246	0	98262	277065	241465	101246	0	95364	333530	325907
5.67	4.67	178980	0	94415	229755	145640	127980	0	136812	226237	237360	97980	0	236553	178337	323530
5.75	4.75	184946	0	124295	210506	155250	132246	0	126735	248242	248232	101246	0	151594	276951	333879
5.83	4.83	178980	0	53302	270868	147503	127980	0	67142	295908	237984	97980	0	56276	358614	319352
5.92	4.92	184946	0	40758	294392	151974	132246	0	40167	335159	244824	101246	0	55590	373305	330061
6.00	5.00	194246	0	5936	329039	140987	132246	0	9126	366025	243301	67146	0	8441	420278	361940
6.08	5.08	175448	0	8576	293982	127483	119448	0	11843	327003	219912	60648	0	10403	376827	327034
6.17	5.17	194246	0	12172	322629	141083	132246	0	15524	359453	243405	67146	0	14320	414225	362021
6.25	5.25	187980	0	69032	255138	139186	127980	0	104705	258345	239615	64980	0	97304	317586	354133

Table A-4: WRSA Water Balance

Model Year	Project Year	Dry					Normal					Wet				
		SP M1 To Mill	M1 To Open Pit after closure	WRSA Inflow to SP-M1	Historical Underground Workings Dewatering 056 + 1069	Discharge from M1 to ETP, 1067	SP M1 To Mill	M1 To Open Pit after closure	WRSA Inflow to SP-M1	Historical Underground Workings Dewatering 056 + 1069	Discharge from M1 to ETP, 1067	SP M1 To Mill	M1 To Open Pit after closure	WRSA Inflow to SP-M1	Historical Underground Workings Dewatering 056 + 1069	Discharge from M1 to ETP, 1067
		m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon
6.33	5.33	194246	0	108418	226733	140710	132246	0	189691	185636	246414	67146	0	254884	174010	367912
6.42	5.42	187980	0	44381	279789	131582	127980	0	96386	266664	232719	64980	0	108282	306608	348076
6.50	5.50	194246	0	118843	215782	138459	132246	0	130434	244367	241138	67146	0	235665	192704	364374
6.58	5.58	194246	0	93839	240961	138747	132246	0	98262	276714	241115	67146	0	95364	333180	359657
6.67	5.67	187980	0	94415	229585	136470	127980	0	136812	226068	237191	64980	0	236553	178167	356360
6.75	5.75	194246	0	124295	210505	145949	132246	0	126735	248241	248231	67146	0	151594	276950	367978
6.83	5.83	187980	0	53302	270698	138334	127980	0	67142	295738	237815	64980	0	56276	358444	352183
6.92	5.92	194246	0	40758	294042	142323	132246	0	40167	334809	244474	67146	0	55590	372955	363811
7.00	6.00	194246	0	6040	328760	140812	132246	0	9285	365691	243126	67146	0	8589	419955	361764
7.08	6.08	175448	0	8733	293667	127324	119448	0	12060	326628	219754	60648	0	10594	376478	326876
7.17	6.17	194246	0	12395	322405	141082	132246	0	15808	359168	243404	67146	0	14582	413962	362020
7.25	6.25	187980	0	70298	253702	139017	127980	0	106625	256255	239445	64980	0	99089	315631	353964
7.33	6.33	194246	0	110853	223947	140360	132246	0	193617	181359	246064	67146	0	260006	168538	367561
7.42	6.42	187980	0	45790	278210	131413	127980	0	98750	264130	232550	64980	0	110864	303856	347906
7.50	6.50	194246	0	121668	213181	138683	132246	0	133472	241553	241362	67146	0	240633	187960	364598
7.58	6.58	194246	0	96097	238801	138845	132246	0	100600	274473	241213	67146	0	97650	330992	359755
7.67	6.67	187980	0	96479	227520	136469	127980	0	139654	223225	237190	64980	0	241225	173495	356359
7.75	6.75	194246	0	126575	208274	145998	132246	0	129060	245965	248280	67146	0	154374	274219	368027
7.83	6.83	187980	0	54280	269767	138380	127980	0	68374	294553	237861	64980	0	57308	357458	352229
7.92	6.92	194246	0	41506	293343	142372	132246	0	40904	334121	244522	67146	0	56609	371984	363860
8.00	7.00	194246	0	6045	328853	140910	132246	0	9293	365781	243224	67146	0	8596	420046	361862
8.08	7.08	175448	0	8733	293666	127323	119448	0	12060	326627	219753	60648	0	10594	376477	326875
8.17	7.17	194246	0	12395	322454	141131	132246	0	15808	359217	243453	67146	0	14582	414011	362069
8.25	7.25	187980	0	70298	253748	139063	127980	0	106625	256301	239491	64980	0	99089	315678	354010
8.33	7.33	194246	0	110853	223996	140409	132246	0	193617	181408	246112	67146	0	260006	168587	367610
8.42	7.42	187980	0	45790	278304	131507	127980	0	98750	264225	232645	64980	0	110864	303951	348001
8.50	7.50	194246	0	121668	213180	138682	132246	0	133472	241552	241361	67146	0	240633	187959	364597
8.58	7.58	194246	0	96097	238897	138940	132246	0	100600	274569	241308	67146	0	97650	331088	359850
8.67	7.67	187980	0	96479	227615	136564	127980	0	139654	223319	237284	64980	0	241225	173589	356454
8.75	7.75	194246	0	126575	208322	146046	132246	0	129060	246013	248328	67146	0	154374	274266	368075
8.83	7.83	187980	0	54280	269722	138335	127980	0	68374	294507	237815	64980	0	57308	357413	352184
8.92	7.92	194246	0	41506	293391	142420	132246	0	40904	334169	244570	67146	0	56609	372032	363908
9.00	8.00	194246	0	6045	328948	141005	138446	0	9293	365876	237120	64046	0	8596	420141	365058
9.08	8.08	175448	0	8733	293754	127412	125048	0	12060	326715	214242	57848	0	10594	376565	329763
9.17	8.17	194246	0	12395	322406	141083	138446	0	15808	359169	237205	64046	0	14582	413963	365121
9.25	8.25	187980	0	70298	253796	139110	133980	0	106625	256349	233539	61980	0	99089	315725	357057
9.33	8.33	194246	0	110853	224141	140553	138446	0	193617	181553	240057	64046	0	260006	168732	370855
9.42	8.42	187980	0	45790	278303	131506	133980	0	98750	264224	226644	61980	0	110864	303950	351000

Table A-4: WRSA Water Balance

Model Year	Project Year	Dry					Normal					Wet				
		SP M1 To Mill	M1 To Open Pit after closure	WRSA Inflow to SP-M1	Historical Underground Workings Dewatering 056 + 1069	Discharge from M1 to ETP, 1067	SP M1 To Mill	M1 To Open Pit after closure	WRSA Inflow to SP-M1	Historical Underground Workings Dewatering 056 + 1069	Discharge from M1 to ETP, 1067	SP M1 To Mill	M1 To Open Pit after closure	WRSA Inflow to SP-M1	Historical Underground Workings Dewatering 056 + 1069	Discharge from M1 to ETP, 1067
		m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon
9.50	8.50	194246	0	121668	213035	138537	138446	0	133472	241408	235017	64046	0	240633	187814	367552
9.58	8.58	194246	0	96097	238704	138747	138446	0	100600	274376	234915	64046	0	97650	330894	362757
9.67	8.67	187980	0	96479	227521	136470	133980	0	139654	223226	231191	61980	0	241225	173496	359360
9.75	8.75	194246	0	126575	208225	145949	138446	0	129060	245917	242031	64046	0	154374	274170	371078
9.83	8.83	187980	0	54280	269721	138334	133980	0	68374	294506	231815	61980	0	57308	357412	355183
9.92	8.92	194246	0	41506	293294	142323	138446	0	40904	334072	238274	64046	0	56609	371935	366911
10.00	9.00	194246	0	6045	328755	140812	138446	0	9293	365683	236926	64046	0	8596	419948	364864
10.08	9.08	175448	0	8733	293667	127324	125048	0	12060	326628	214154	57848	0	10594	376478	329676
10.17	9.17	194246	0	12395	322405	141082	138446	0	15808	359168	237204	64046	0	14582	413962	365120
10.25	9.25	187980	0	70298	253702	139017	133980	0	106625	256255	233445	61980	0	99089	315631	356964
10.33	9.33	194246	0	110853	223947	140360	138446	0	193617	181359	239864	64046	0	260006	168538	370661
10.42	9.42	187980	0	45790	278210	131413	133980	0	98750	264130	226550	61980	0	110864	303856	350906
10.50	9.50	194246	0	121668	213132	138634	138446	0	133472	241505	235113	64046	0	240633	187911	367649
10.58	9.58	194246	0	96097	238704	138747	138446	0	100600	274376	234915	64046	0	97650	330894	362757
10.67	9.67	187980	0	96479	227521	136470	133980	0	139654	223226	231191	61980	0	241225	173496	359360
10.75	9.75	194246	0	126575	208225	145949	138446	0	129060	245917	242031	64046	0	154374	274170	371078
10.83	9.83	187980	0	54280	269721	138334	133980	0	68374	294506	231815	61980	0	57308	357412	355183
10.92	9.92	194246	0	41506	293294	142323	138446	0	40904	334072	238274	64046	0	56609	371935	366911
11.00	10.00	194246	0	6045	328755	140812	138446	0	9293	365683	236926	64046	0	8596	419948	364864
11.08	10.08	175448	0	8733	293667	127324	125048	0	12060	326628	214154	57848	0	10594	376478	329676
11.17	10.17	194246	0	12395	322405	141082	138446	0	15808	359168	237204	64046	0	14582	413962	365120
11.25	10.25	187980	0	70298	253702	139017	133980	0	106625	256255	233445	61980	0	99089	315631	356964
11.33	10.33	194246	0	110853	223947	140360	138446	0	193617	181359	239864	64046	0	260006	168538	370661
11.42	10.42	187980	0	45790	278210	131413	133980	0	98750	264130	226550	61980	0	110864	303856	350906
11.50	10.50	194246	0	121668	214288	139790	138446	0	133472	242660	236269	64046	0	240633	189067	368805
11.58	10.58	194246	0	96097	241015	141059	138446	0	100600	276688	237227	64046	0	97650	333206	365069
11.67	10.67	187980	0	96479	228640	137589	133980	0	139654	224345	232309	61980	0	241225	174614	360479
11.75	10.75	194246	0	126575	209381	147105	138446	0	129060	247073	243187	64046	0	154374	275326	372234
11.83	10.83	187980	0	54280	270839	139452	133980	0	68374	295625	232933	61980	0	57308	358531	356302
11.92	10.92	194246	0	41506	294450	143479	138446	0	40904	335228	239430	64046	0	56609	373091	368067
12.00	11.00	194246	0	6045	316519	128576	138446	0	9293	366839	238082	64046	0	8596	394320	339236
12.08	11.08	175448	0	8893	282456	116272	125048	0	12280	327452	215198	57848	0	10787	353137	306528
12.17	11.17	194246	0	12621	309943	128846	138446	0	16097	360035	238360	64046	0	14848	388068	339492
12.25	11.25	187980	0	71580	240579	127175	133980	0	108570	255429	234564	61980	0	100896	289023	332162
12.33	11.33	194246	0	113319	209245	128124	138446	0	197592	178540	241020	64046	0	265192	137724	345033
12.42	11.42	187980	0	47218	264941	119571	133980	0	101143	262856	227669	61980	0	113478	276441	326105
12.50	11.50	194246	0	124529	196879	125242	138446	0	136547	238429	235113	64046	0	245663	156097	340865
12.58	11.58	194246	0	98382	223026	125355	138446	0	102968	272008	234915	64046	0	99963	301797	335973

Table A-4: WRSA Water Balance

Model Year	Project Year	Dry					Normal					Wet				
		SP M1 To Mill	M1 To Open Pit after closure	WRSA Inflow to SP-M1	Historical Underground Workings Dewatering 056 + 1069	Discharge from M1 to ETP, 1067	SP M1 To Mill	M1 To Open Pit after closure	WRSA Inflow to SP-M1	Historical Underground Workings Dewatering 056 + 1069	Discharge from M1 to ETP, 1067	SP M1 To Mill	M1 To Open Pit after closure	WRSA Inflow to SP-M1	Historical Underground Workings Dewatering 056 + 1069	Discharge from M1 to ETP, 1067
		m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon
12.67	11.67	187980	0	98569	212471	123510	133980	0	142532	220348	231191	61980	0	245954	142846	333440
12.75	11.75	194246	0	128883	192525	132557	138446	0	131413	243563	242031	64046	0	157190	244571	344294
12.83	11.83	187980	0	55269	255771	125374	133980	0	69620	293260	231815	61980	0	58353	330447	329263
12.92	11.92	194246	0	42262	279146	128931	138446	0	41650	333326	238274	64046	0	57641	344119	340127
13.00	12.00	194246	0	6156	368821	180988	138446	0	9463	445865	317278	64046	0	8753	500143	445216
13.08	12.08	175448	0	8932	329756	163612	125048	0	12334	398930	286730	57848	0	10835	448813	402252
13.17	12.17	194246	0	12677	362299	181258	138446	0	16168	439160	317556	64046	0	14914	493982	445472
13.25	12.25	187980	0	71896	290984	177897	133980	0	109049	331591	311205	61980	0	101341	391139	434724
13.33	12.33	194246	0	113927	261049	180536	138446	0	198572	256756	320216	64046	0	266470	242426	451013
13.42	12.42	187980	0	47570	315310	170293	133980	0	101733	338907	304310	61980	0	114122	378358	428666
13.50	12.50	194246	0	125234	249742	178810	138446	0	137305	318023	315465	64046	0	246903	261993	448001
13.58	12.58	194246	0	98945	276031	178923	138446	0	103552	351776	315267	64046	0	100534	408362	443109
13.67	12.67	187980	0	99084	263796	175350	133980	0	143241	297399	308951	61980	0	247120	245360	437120
13.75	12.75	194246	0	129452	245524	186125	138446	0	131993	323335	322383	64046	0	157884	351013	451430
13.83	12.83	187980	0	55513	307367	177214	133980	0	69928	370712	309575	61980	0	58611	433869	432943
13.92	12.92	194246	0	42449	332527	182499	138446	0	41834	413494	318626	64046	0	57896	451000	447263
14.00	13.00	178746	0	6183	408255	235949	122946	0	9504	369415	256370	64046	0	8792	293821	238933
14.08	13.08	161448	0	8932	166616	14472	111048	0	12334	169933	71733	57848	0	10835	168471	121910
14.17	13.17	178746	0	12677	187237	21696	122946	0	16168	190640	84535	64046	0	14914	189418	140907
14.25	13.25	172980	0	71896	239366	141278	118980	0	109049	275578	270192	61980	0	101341	268065	311650
14.33	13.33	178746	0	113927	303577	238563	122946	0	198572	386079	465038	64046	0	266470	452258	660845
14.42	13.42	172980	0	47570	239155	109137	118980	0	101733	291947	272350	61980	0	114122	304023	354331
14.50	13.50	178746	0	125234	322501	267069	122946	0	137305	334267	347210	64046	0	246903	441089	627097
14.58	13.58	178746	0	98945	292640	211032	122946	0	103552	297129	276120	64046	0	100534	294188	328935
14.67	13.67	172980	0	99084	279181	205735	118980	0	143241	322219	348771	61980	0	247120	423469	615229
14.75	13.75	178746	0	129452	301417	257519	122946	0	131993	303895	318443	64046	0	157884	329129	429547
14.83	13.83	172980	0	55513	223748	108595	118980	0	69928	237797	191660	61980	0	58611	226767	225840
14.92	13.92	178746	0	42449	216721	82193	122946	0	41834	216121	136752	64046	0	57896	231777	228039
15.00	14.00	178746	0	6183	181424	9119	122946	0	9504	184662	71616	64046	0	8792	183967	129079
15.08	14.08	161448	0	8932	167130	14986	111048	0	12334	170446	72246	57848	0	10835	168985	122423
15.17	14.17	178746	0	12677	187754	22213	122946	0	16168	191156	85052	64046	0	14914	189934	141423
15.25	14.25	172980	0	71896	239816	141728	118980	0	109049	276028	270642	61980	0	101341	268515	312100
15.33	14.33	178746	0	113927	303990	238976	122946	0	198572	386492	465451	64046	0	266470	452671	661259
15.42	14.42	172980	0	47570	239505	109487	118980	0	101733	292297	272700	61980	0	114122	304373	354681
15.50	14.50	178746	0	125234	322811	267379	122946	0	137305	334577	347520	64046	0	246903	441399	627407
15.58	14.58	178746	0	98945	292898	211290	122946	0	103552	297388	276378	64046	0	100534	294446	329193
15.67	14.67	172980	0	99084	279381	205935	118980	0	143241	322419	348971	61980	0	247120	423669	615429
15.75	14.75	178746	0	129452	301572	257674	122946	0	131993	304050	318598	64046	0	157884	329284	429702

Table A-4: WRSA Water Balance

Model Year	Project Year	Dry					Normal					Wet				
		SP M1 To Mill	M1 To Open Pit after closure	WRSA Inflow to SP-M1	Historical Underground Workings Dewatering 056 + 1069	Discharge from M1 to ETP, 1067	SP M1 To Mill	M1 To Open Pit after closure	WRSA Inflow to SP-M1	Historical Underground Workings Dewatering 056 + 1069	Discharge from M1 to ETP, 1067	SP M1 To Mill	M1 To Open Pit after closure	WRSA Inflow to SP-M1	Historical Underground Workings Dewatering 056 + 1069	Discharge from M1 to ETP, 1067
		m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon	m^3/mon
15.83	14.83	172980	0	55513	223848	108695	118980	0	69928	237897	191760	61980	0	58611	226867	225940
15.92	14.92	178746	0	42449	216772	82245	122946	0	41834	216173	136804	64046	0	57896	231828	228091

APPENDIX B: INPUTS TO WATER QUALITY MODEL

APPENDIX B1: SURFACE WATER AND GROUNDWATER CONCENTRATION INPUTS FOR THE MODEL, µG/L

Appendix B1: Surface water and groundwater concentration inputs for the model, µg/L.

Parameters Selected for WQ Modelling	MMER and O.Reg. 560/94	PWQO	PWQO - Interim	Site 1, Kenagomisis	Shallow Bedrock	Overburden	MacLeod Tailings		Hardrock Tailings		Deep Bedrock	Hardrock Shaft 1	Mosher Shaft and MacLeod Workings	Atmospheric Precipitation	Subaqueous Columns: CND 13-3P2	Subaqueous Columns: CND 13 Comb	Subaqueous Columns: Average of Medians for CND 13-3P2 and CND 13 Comb
				Median	Median	Median	Median	Median Equilibrated	Median	Median Equilibrated	Median	Median	Median	Median	Median Last 5 weeks		
Cl	-	-	-	49	743	756	6930	6930	3000	3220	7480	114000	1580	–	–	–	–
Fl	-	-	-	24	113	193	115	115	134	134	47	50	32	–	–	–	–
SO42-	-	-	-	1290	6720	4570	1670000	1723521	2230000	1741941	34000	309000	30700	301	61000	62000	61500
CN^-	**1000**	-	-	1.0	1.000	1.000	19.8	19.8	22.5	22.5	1.0	2.8	1.0	–	930	490	710
CN^- WAD	-	-	-	1.0	–	–	–	–	–	–	1.0	–	–	–	5.0	5.0	5.0
CN^- Free	-	**5**	-	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	–	5.0	5.0	5.0
NH_3 Total	-	-	-	33	118	125	1360	1360	1210	1210	45	81	46	–	1100	1100	1336
NO_2^-	-	-	-	5.0	7.0	7.0	58	58	50	50	10	10	5	–	150	150	493
NO_3^-	-	-	-	15.0	16.3	15.1	112	1360	75	1211	–	50	28	–	300	300	1329
Hg	-	**0.2**	-	0.005	0.004	0.0035	0.004	0.004	0	0	0.005	0.003	0	0.004	0.005	0.005	0.005
Ag	-	**0.1**	-	0.005	0.020	0.028	0.10	**0.10**	**0.28**	**0.28**	0.050	0.005	0.005	0.042	0.001	0.001	0.001
Al	-	-	**75**	6.3	6	4.1	17	0.013	24	0.012	2.5	1	2	2	10.0	5.0	7.5
As	**500**	**100**	**5**	2.5	1.6	1.2	**6060**	**3307**	**3140**	**2008**	3.4	2.8	**18.6**	1.69	**57.8**	**74.5**	**66.2**
Be	-	**1100**	-	0.2	0.20	0.3	1.00	0.0023	2.8	0.016	0.5	0.1	0.1	0.42	0.0035	0.0035	0.0035
B	-	-	**200**	5	19	22	120	120	180	180	25	46	12	21	12	12	12
Ca	-	-	-	26500	70900	63700	506000	500278	432000	397953	69400	141000	82300	726	29200	29300	29250
Cd	-	**0.2**	**0.1**	0.005	0.009	0.01	0.043	0.042	0.064	0.063	0.009	0.003	0.005	0.007	0.002	0.002	0.002
Co	-	**0.9**	-	0.05	0.55	0.47	**5.8**	**5.7**	**6.5**	**6.4**	0.3	**1.5**	0.2	0.21	0.67	**0.93**	0.80
Cr	-	**1**	-	0.50	0.28	0.33	1.00	0.99	**2.8**	**2.8**	0.5	0.1	0.1	0.42	0.06	0.04	0.05
Cu	**300**	**5**	**5**	0.50	0.5	0.51	1.8	0.051	2.9	0.21	2.4	0.5	0.9	3.0	3.1	1.67	2.4
Fe	-	**300**	-	41	205	61	**24600**	0.10	**11200**	0.10	10	**561**	**1270**	8	290	190	240
K	-	-	-	676	2030	1900	35400	35400	9700	9700	1350	4870	2710	208	5730	6420	6075
Mg	-	-	-	5350	18100	15600	188000	187887	279000	278942	13500	42700	14400	91	10600	10600	10600
Mo	-	-	**40**	0.1	2.0	1.9	2.1	2.1	2.8	2.8	0.5	0.4	0.3	0.4	4.0	4.7	4.4
Na	-	-	-	765	6930	7670	12600	12601	10600	10601	5380	70500	4230	146	18300	17600	17950
Ni	**500**	**25**	-	0.5	1.4	1.0	5.1	4.7	7.8	7.6	1.0	5.6	1.2	0.8	0.4	0.5	0.5
P	-	-	**30**	1.5	9	9	**70**	**70**	**40**	**40**	1.5	1.5	6.9	–	14	4.5	9.3
Pb	**200**	**25**	**5**	0.05	0.12	0.23	0.6	0.016	2.4	0.11	0.5	0.025	0.025	0.42	0.030	0.030	0.030
Sb	-	-	**20**	0.05	0.27	0.22	1.10	1.10	2.0	2.0	1.1	0.4	0.3	0.25	9.40	1.20	5.30
Se	-	**100**	-	0.09	0.26	0.28	0.60	0.60	2.4	2.4	0.5	0.03	0.06	0.42	0.10	0.02	0.06
Si	-	-	-	2080	–	–	–	–	–	–	–	–	–	–	2510	2080	2295
Tl	-	-	-	0.03	0.03	0.07	0.14	0.14	0.68	0.68	0.15	0.01	0.01	0.13	0.0025	0.0025	0.0025
W	-	-	**30**	0.1	3.1	2.1	3.8	3.8	21	21	5.0	0.1	0.6	4.2	1.4	1.9	1.7
U	-	-	**5**	0.2	1.3	1.4	2.3	2.3	**10.2**	**10.2**	2.5	1.1	1.1	2.1	0.2	0.1	0.2
V	-	-	**6**	0.25	0.35	0.77	4.2	4.2	4.3	4.3	0.50	0.25	0.25	0.42	–	–	–
Zn	**500**	**30**	**20**	1.5	3.3	2.6	9.5	9.4	13	13	1.5	1.6	**21.8**	2.0	3.0	8.0	5.5
Zr	-	-	**4**	0.2	0.6	0.6	2.9	2.9	3.8	3.8	0.5	0.2	0.2	0.4	–	–	–

Notes: MMER - Metal Mining Effluent Regulation guidelines (MMER 2012); O.Reg. 560/94 - Ontario Regulation 560/94 under the Environmental Protection Act (O.Reg 560/94 1994); PWQO - Approved Ontario Provincial Water Quality Objectives (MOEE 1994); PWQO-Interim - Interim Ontario Provincial Water Quality Objective prepared in case of insufficient toxicological information available for a particular parameter to prepare a PWQO objective; Values exceeding MMER guidelines are bolded and highlighted orange; Values exceeding PWQO objectives are bolded and double underlined; Values exceeding Interim PWQO are bolded; For '-' values, zero µg/L concentrations were used in the model.

APPENDIX B2: INPUT AND OUTPUT FILES FROM GEOCHEMIST'S WORKBENCH FOR HARDROCK (B2-1) AND MACLEOD (B2-2) TAILINGS

```
Step #      0              Xi = 0.0000
Temperature =  10.0 C      Pressure =  0.918 bars
pH =  7.260
Eh =   0.8254 volts        pe =  14.6926
Ionic strength        =    0.058645
Activity of water     =    0.999226
Solvent mass          =    1.000000 kg
Solution mass         =    1.003193 kg
Solution density      =    1.025    g/cm3
Chlorinity            =    0.000089 molal
Dissolved solids      =        3182 mg/kg sol'n
Hardness              =     2174.10 mg/kg sol'n as CaCO3
  carbonate           =      439.24 mg/kg sol'n as CaCO3
  non-carbonate       =     1734.86 mg/kg sol'n as CaCO3
Rock mass             =    0.001000 kg
Carbonate alkalinity=        439.24 mg/kg sol'n as CaCO3
Water type            =    Mg-SO4
HFO sorbing surface:
  Surface charge      =       0.000 uC/cm2
  Surface potential   =       0.000 mV
  Surface area        =       0.000 cm2
```

Minerals in system	moles	log moles	grams	volume (cm3)
SiO2 (am,ppt)	0.01664	-1.779	1.000	
(total)			1.000	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
SO4--	0.01165	1116.	0.4429	-2.2872
HCO3-	0.008278	503.5	0.8158	-2.1705
Mg++	0.008006	194.0	0.4429	-2.4503
Ca++	0.007138	285.2	0.4429	-2.5001
CaSO4 (aq)	0.003169	430.1	1.0136	-2.4931
MgSO4 (aq)	0.002903	348.3	1.0136	-2.5313
H4SiO4	0.001297	124.2	1.0136	-2.8813
H2CO3* (aq)	0.001065	65.83	1.0136	-2.9669
Na+	0.0004377	10.03	0.8158	-3.4472
MgHCO3+	0.0003156	26.85	0.8158	-3.5893
O2(aq)	0.0003060	9.761	1.0136	-3.5084
CaHCO3+	0.0002423	24.42	0.8158	-3.7040
K+	0.0002364	9.214	0.8158	-3.7148
Fe(OH)2+	0.0001955	17.51	0.8158	-3.7974
Cl-	8.715e-005	3.080	0.8158	-4.1482
NH4+	8.003e-005	1.439	0.8158	-4.1852
HAsO4--	3.148e-005	4.391	0.4429	-4.8556
H3BO3	1.611e-005	0.9928	1.0136	-4.7871
NaSO4-	1.215e-005	1.442	0.8158	-5.0037
MgCO3 (aq)	1.059e-005	0.8901	1.0136	-4.9692
H2AsO4-	9.791e-006	1.376	0.8158	-5.0976
CO3--	9.018e-006	0.5395	0.4429	-5.3986
KSO4-	6.509e-006	0.8769	0.8158	-5.2749
NH4SO4-	4.427e-006	0.5035	0.8158	-5.4424
H4SiO4SO4--	4.234e-006	0.8110	0.4429	-5.7270
CaCO3 (aq)	3.125e-006	0.3118	1.0136	-5.4993
NaHCO3 (aq)	1.515e-006	0.1268	1.0136	-5.8138
H3SiO4-	1.507e-006	0.1429	0.8158	-5.9103
MgCl+	1.129e-006	0.06728	0.8158	-6.0356
Fe(OH)3 (aq)	7.201e-007	0.07671	1.0136	-6.1367
Al(OH)4-	6.602e-007	0.06252	0.8158	-6.2688
CaCl+	6.354e-007	0.04784	0.8158	-6.2854
Mg2CO3++	4.411e-007	0.04777	0.4429	-6.7091
Be(OH)2 (aq)	3.030e-007	0.01299	1.0136	-6.5127
NH3 (aq)	2.184e-007	0.003707	1.0136	-6.6549
H2BO3-	1.574e-007	0.009542	0.8158	-6.8915
FeOH++	1.392e-007	0.01011	0.4429	-7.2101

```
  Zn++                1.140e-007      0.007427     0.4429        -7.2969
  H2VO4-              7.863e-008      0.009167     0.8158        -7.1928
  Ni++                7.322e-008      0.004285     0.4429        -7.4890
  Al(OH)3 (aq)        6.869e-008      0.005341     1.0136        -7.1572
  OH-                 6.809e-008      0.001154     0.8158        -7.2553
  H+                  6.736e-008    6.768e-005     0.8158        -7.2600
  Co++                6.637e-008      0.003899     0.4429        -7.5317
  Fe(OH)4-            5.936e-008      0.007330     0.8158        -7.3149
  NaCO3-              5.030e-008      0.004161     0.8158        -7.3869
  ZnSO4 (aq)          4.926e-008      0.007927     1.0136        -7.3016
  Ca2UO2(CO3)3 (aq    4.121e-008       0.02178     1.0136        -7.3791
  CuCO3 (aq)          3.742e-008      0.004609     1.0136        -7.4210
  Al(OH)2+            3.697e-008      0.002248     0.8158        -7.5206
  Al2(OH)2CO3++       3.687e-008      0.005439     0.4429        -7.7870
  MgOH+               3.296e-008      0.001357     0.8158        -7.5705
  NiSO4 (aq)          2.911e-008      0.004491     1.0136        -7.5301
  CrO4--              2.744e-008      0.003173     0.4429        -7.9153
  CaH2BO3+            2.651e-008      0.002667     0.8158        -7.6650
  CoSO4 (aq)          2.616e-008      0.004042     1.0136        -7.5764
  SeO4--              2.588e-008      0.003688     0.4429        -7.9408
  NiHCO3+             2.295e-008      0.002739     0.8158        -7.7276
  HSO4-               2.250e-008      0.002177     0.8158        -7.7363
  CaCrO4 (aq)         2.232e-008      0.003473     1.0136        -7.6454
  MgH2BO3+            1.951e-008      0.001656     0.8158        -7.7981
  Sb(OH)6-            1.610e-008      0.003591     0.8158        -7.8817
  NaCl (aq)           1.489e-008     0.0008676     1.0136        -7.8211
  MgMoO4(aq)          1.451e-008      0.002665     1.0136        -7.8324
  CoHCO3+             1.313e-008      0.001569     0.8158        -7.9703
  ZnCO3 (aq)          1.145e-008      0.001431     1.0136        -7.9355
   (only species > 1e-8 molal listed)

 Mineral saturation states
                    log Q/K                              log Q/K
----------------------------------------------------------------
  CoFe2O4           28.1674s/sat   Al2O3                 0.2887s/sat
  Hematite          19.3462s/sat   SiO2 (am,ppt)         0.0000 sat
  Cupric Ferrite    16.9134s/sat   SiO2 (am,gel)        -0.0407
  Magnetite         14.8258s/sat   Fe3(OH)8             -0.0592
  Maghemite         12.7394s/sat   Vaterite             -0.0965
  Magnesioferrite   11.7462s/sat   Gypsum               -0.1687
  Co3O4              9.5664s/sat   Magnesite            -0.2032
  Fe(OH)2.7Cl.3      9.1799s/sat   Anhydrite            -0.4941
  K-Jarosite         8.6736s/sat   Al(OH)3 (am)         -0.6602
  Goethite           8.5093s/sat   CaCO3xH2O            -0.8272
  Lepidocrocite      8.1916s/sat   Cerrusite            -1.2850
  Kaolinite          7.7707s/sat   Sepiolite            -1.3231
  Ferrihydrite (ag   6.8722s/sat   PbMoO4               -1.5543
  Cr(VI)-Jarosite    5.9395s/sat   FeAsO4:2H2O          -1.5820
  Ferrihydrite       5.4303s/sat   H-Jarosite           -1.6092
  Halloysite         5.3205s/sat   Smithsonite          -1.8307
  Al4(OH)10SO4       5.1740s/sat   CoCO3                -1.8488
  Cuprous Ferrite    4.7331s/sat   Be(OH)2 (beta)       -1.8727
  Imogolite          4.6630s/sat   ZnCO3                -1.8955
  Diaspore           3.3409s/sat   Co(OH)3              -2.0091
  Na-Jarosite        2.9462s/sat   NiCO3                -2.0736
  Alunite            2.8930s/sat   Be(OH)2 (alpha)      -2.2727
  Gibbsite (C)       2.4555s/sat   AlOHSO4              -2.4064
  Al(OH)3 (Soil)     1.9055s/sat   Hercynite            -2.4269
  Boehmite           1.5000s/sat   ZnCO3:1H2O           -2.4358
  Quartz             1.3269s/sat   Huntite              -2.4777
  Dolomite (ordere   0.9759s/sat   Epsomite             -2.5060
  Chalcedony         0.8523s/sat   Tenorite(c)          -2.5151
  Cristobalite       0.6551s/sat   Cerargyrite          -2.5708
  Calcite            0.5118s/sat   Be(OH)2 (am)         -2.5727
  Dolomite (disord   0.3618s/sat   CuCO3                -2.6910
  Aragonite          0.3567s/sat   CaMoO4               -2.9269
   (only minerals with log Q/K > -3 listed)

 Gases                      fugacity       log fug.
-----------------------------------------------
  O2 (g)                        0.2596       -0.586
```

CO2 (g)	0.02008	-1.697
NH3 (g)	1.848e-009	-8.733
Hg (g)	2.045e-028	-27.689
Hg2 (g)	9.118e-057	-56.040
H2Se (g)	5.933e-111	-110.227
H2S (g)	6.333e-151	-150.198
CH4 (g)	7.826e-153	-152.106
Hg(CH3)2 (g)	0.0000	-300.000

Original basis	total moles	In fluid moles	In fluid mg/kg	Sorbed moles	Sorbed mg/kg	Kd L/kg
>(s)FeOH	0.000					
>(w)FeOH	0.000					
Ag+	2.54e-009	2.54e-009	0.000273			
Al+++	8.46e-007	8.46e-007	0.0227			
AsO4---	4.13e-005	4.13e-005	5.72			
Be++	3.04e-007	3.04e-007	0.00273			
CO3--	0.00993	0.00993	594.			
Ca++	0.0106	0.0106	422.			
Cd++	5.55e-010	5.55e-010	6.22e-005			
Cl-	8.89e-005	8.89e-005	3.14			
Co+++	1.08e-007	1.08e-007	0.00634			
CrO4--	5.23e-008	5.23e-008	0.00605			
Cu++	4.47e-008	4.47e-008	0.00283			
Fe+++	0.000196	0.000196	10.9			
H+	0.0106	0.0106	10.7			
H2O	55.5	55.5	9.97e+005			
H3BO3	1.63e-005	1.63e-005	1.01			
H4SiO4	0.0179	0.00130	125.			
HVO4--	8.27e-008	8.27e-008	0.00956			
Hg(OH)2	2.42e-014	2.42e-014	5.66e-009			
K+	0.000243	0.000243	9.47			
Mg++	0.0112	0.0112	272.			
MoO4--	2.88e-008	2.88e-008	0.00459			
NH4+	8.47e-005	8.47e-005	1.52			
Na+	0.000451	0.000451	10.3			
Ni++	1.30e-007	1.30e-007	0.00761			
O2(aq)	0.000306	0.000306	9.76			
Pb++	1.13e-008	1.13e-008	0.00234			
SO4--	0.0178	0.0178	1.70e+003			
Sb(OH)6-	1.61e-008	1.61e-008	0.00359			
SeO4--	2.95e-008	2.95e-008	0.00420			
Tl(OH)3	3.26e-009	3.26e-009	0.000830			
UO2++	4.20e-008	4.20e-008	0.0113			
Zn++	1.90e-007	1.90e-007	0.0124			

Elemental composition	total moles	In fluid moles	In fluid mg/kg	Sorbed moles	Sorbed mg/kg
Ag	2.542e-009	2.542e-009	0.0002733		
Al	8.456e-007	8.456e-007	0.02274		
As	4.127e-005	4.127e-005	3.083		
B	1.631e-005	1.631e-005	0.1758		
Be	3.042e-007	3.042e-007	0.002733		
C	0.009926	0.009926	118.8		
Ca	0.01055	0.01055	421.7		
Cd	5.549e-010	5.549e-010	6.218e-005		
Cl	8.893e-005	8.893e-005	3.143		
Co	1.080e-007	1.080e-007	0.006344		
Cr	5.234e-008	5.234e-008	0.002713		
Cu	4.469e-008	4.469e-008	0.002831		
Fe	0.0001964	0.0001964	10.93		
H	111.0	111.0	1.116e+005		
Hg	2.421e-014	2.421e-014	4.840e-009		
K	0.0002429	0.0002429	9.468		
Mg	0.01124	0.01124	272.3		
Mo	2.877e-008	2.877e-008	0.002752		
N	8.468e-005	8.468e-005	1.182		
Na	0.0004515	0.0004515	10.35		
Ni	1.301e-007	1.301e-007	0.007613		

O	55.65	55.62	8.870e+005
Pb	1.134e-008	1.134e-008	0.002343
S	0.01775	0.01775	567.5
Sb	1.610e-008	1.610e-008	0.001953
Se	2.945e-008	2.945e-008	0.002318
Si	0.01795	0.001303	36.47
Tl	3.259e-009	3.259e-009	0.0006639
U	4.196e-008	4.196e-008	0.009956
V	8.268e-008	8.268e-008	0.004198
Zn	1.902e-007	1.902e-007	0.01240

```
Step #      0             Xi = 0.0000
Temperature =  10.0 C     Pressure =  0.918 bars
pH =  6.879
Eh =   0.8468 volts       pe =  15.0738
Ionic strength      =     0.056581
Activity of water   =     0.999273
Solvent mass        =     1.000037 kg
Solution mass       =     1.003019 kg
Solution density    =     1.024    g/cm3
Chlorinity          =     0.000089 molal
Dissolved solids    =         2973 mg/kg sol'n
Hardness            =      2091.08 mg/kg sol'n as CaCO3
  carbonate         =       346.28 mg/kg sol'n as CaCO3
  non-carbonate     =      1744.80 mg/kg sol'n as CaCO3
Rock mass           =     0.001171 kg
Carbonate alkalinity=       346.28 mg/kg sol'n as CaCO3
Water type          =     Mg-SO4
HFO sorbing surface:
  Surface charge    =        -1.38 uC/cm2
  Surface potential =        -45.9 mV
  Surface area      =    1.26e+005 cm2
```

Minerals in system	moles	log moles	grams	volume (cm3)
Calcite	0.0008314	-3.080	0.08322	
Chalcedony	0.01776	-1.751	1.067	
Ferrihydrite	0.0001964	-3.707	0.02099	
Kaolinite	4.226e-007	-6.374	0.0001091	
(total)			1.171	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
SO4--	0.01175	1126.	0.4473	-2.2792
Mg++	0.007992	193.7	0.4473	-2.4467
HCO3-	0.006599	401.5	0.8178	-2.2679
Ca++	0.006548	261.7	0.4473	-2.5333
CaSO4 (aq)	0.002993	406.2	1.0131	-2.5183
MgSO4 (aq)	0.002983	358.0	1.0131	-2.5197
H2CO3* (aq)	0.002048	126.7	1.0131	-2.6829
Na+	0.0004378	10.04	0.8178	-3.4460
O2(aq)	0.0003060	9.763	1.0131	-3.5086
MgHCO3+	0.0002537	21.58	0.8178	-3.6830
K+	0.0002363	9.211	0.8178	-3.7139
H4SiO4	0.0001823	17.47	1.0131	-3.7335
CaHCO3+	0.0001790	18.04	0.8178	-3.8345
Cl-	8.718e-005	3.082	0.8178	-4.1469
NH4+	8.007e-005	1.440	0.8178	-4.1838
H3BO3	1.623e-005	1.000	1.0131	-4.7841
HAsO4--	1.496e-005	2.088	0.4473	-5.1743
NaSO4-	1.238e-005	1.470	0.8178	-4.9945
H2AsO4-	1.128e-005	1.585	0.8178	-5.0350
KSO4-	6.626e-006	0.8930	0.8178	-5.2661
NH4SO4-	4.512e-006	0.5132	0.8178	-5.4330
MgCO3 (aq)	3.549e-006	0.2983	1.0131	-5.4443
CO3--	2.966e-006	0.1775	0.4473	-5.8772
NaHCO3 (aq)	1.214e-006	0.1017	1.0131	-5.9100
MgCl+	1.139e-006	0.06788	0.8178	-6.0308
CaCO3 (aq)	9.622e-007	0.09602	1.0131	-6.0111

H4SiO4SO4--	6.000e-007	0.1150	0.4473	-6.5712
CaCl+	5.889e-007	0.04435	0.8178	-6.3173
H+	1.617e-007	0.0001625	0.8178	-6.8787
Mg2CO3++	1.475e-007	0.01597	0.4473	-7.1806
Zn++	1.187e-007	0.007739	0.4473	-7.2748
NH3 (aq)	9.109e-008	0.001547	1.0131	-7.0349
H3SiO4-	8.780e-008	0.008326	0.8178	-7.1438
H2VO4-	8.095e-008	0.009439	0.8178	-7.1791
Ni++	7.478e-008	0.004377	0.4473	-7.4756
Co++	6.777e-008	0.003982	0.4473	-7.5183
H2BO3-	6.570e-008	0.003984	0.8178	-7.2698
HSO4-	5.499e-008	0.005322	0.8178	-7.3470
ZnSO4 (aq)	5.283e-008	0.008503	1.0131	-7.2715
Ca2UO2(CO3)3 (aq	4.101e-008	0.02168	1.0131	-7.3814
NiSO4 (aq)	3.060e-008	0.004722	1.0131	-7.5086
OH-	2.823e-008	0.0004787	0.8178	-7.6366
CoSO4 (aq)	2.750e-008	0.004250	1.0131	-7.5550
CrO4--	2.633e-008	0.003045	0.4473	-7.9289
SeO4--	2.608e-008	0.003717	0.4473	-7.9331
CaCrO4 (aq)	2.005e-008	0.003120	1.0131	-7.6922
NiHCO3+	1.887e-008	0.002253	0.8178	-7.8115
NaCO3-	1.671e-008	0.001383	0.8178	-7.8643
Sb(OH)6-	1.609e-008	0.003591	0.8178	-7.8807
NaCl (aq)	1.498e-008	0.0008731	1.0131	-7.8187
MgMoO4(aq)	1.476e-008	0.002711	1.0131	-7.8254
MgOH+	1.378e-008	0.0005676	0.8178	-7.9481
CoHCO3+	1.079e-008	0.001291	0.8178	-8.0542
CaH2BO3+	1.025e-008	0.001032	0.8178	-8.0764

(only species > 1e-8 molal listed)

Surface species	molality	moles	Boltzman fct.	log molality
>(w)FeOH2+	1.230e-005	1.230e-005	0.16742	-4.9102
>(w)FeHAsO4-	8.801e-006	8.802e-006	5.9729	-5.0555
>(w)FeAsO4--	5.094e-006	5.094e-006	35.676	-5.2929
>(w)FeCO3H	4.345e-006	4.346e-006	1.0000	-5.3620
>(w)FeOMg+	3.240e-006	3.240e-006	0.16742	-5.4895
>(w)FeOSi(OH)3	2.813e-006	2.813e-006	1.0000	-5.5508
>(w)FeH2AsO4	9.594e-007	9.595e-007	1.0000	-6.0180
>(s)FeOHCa++	9.590e-007	9.591e-007	0.028030	-6.0182
>(w)FeOH	7.986e-007	7.987e-007	1.0000	-6.0976
>(w)FeOBe+	2.934e-007	2.934e-007	0.16742	-6.5325
>(w)FeOHAsO4---	1.697e-007	1.697e-007	213.09	-6.7704
>(w)FeOCa+	1.493e-007	1.493e-007	0.16742	-6.8260
>(w)FeCO3-	1.414e-007	1.414e-007	5.9729	-6.8494
>(w)FeOSiO(OH)2-	1.126e-007	1.127e-007	5.9729	-6.9483
>(w)FeOCu+	4.049e-008	4.049e-008	0.16742	-7.3926
>(s)FeOBe+	9.075e-009	9.076e-009	0.16742	-8.0421
>(s)FeOPb+	7.935e-009	7.935e-009	0.16742	-8.1005
>(w)FeSO4-	5.605e-009	5.606e-009	5.9729	-8.2514
>(w)FeONi+	3.817e-009	3.817e-009	0.16742	-8.4183
>(w)FeOPb+	2.879e-009	2.879e-009	0.16742	-8.5408
>(s)FeOH2+	1.514e-009	1.514e-009	0.16742	-8.8198
>(w)FeO-	1.188e-009	1.188e-009	5.9729	-8.9251
>(s)FeHAsO4-	1.084e-009	1.084e-009	5.9729	-8.9651
>(w)FeOCo+	1.069e-009	1.069e-009	0.16742	-8.9711
>(s)FeOCu+	9.721e-010	9.722e-010	0.16742	-9.0123
>(w)FeOHSO4--	7.258e-010	7.258e-010	35.676	-9.1392
>(s)FeAsO4--	6.273e-010	6.273e-010	35.676	-9.2026
>(s)FeCO3H	5.350e-010	5.351e-010	1.0000	-9.2716
>(w)FeOSiO2OH--	4.834e-010	4.834e-010	35.676	-9.3157
>(w)ZnOH2+	4.570e-010	4.570e-010	0.16742	-9.3401
>(s)FeONi+	3.484e-010	3.484e-010	0.16742	-9.4579
>(s)FeOSi(OH)3	3.464e-010	3.464e-010	1.0000	-9.4604
>(s)FeH2AsO4	1.181e-010	1.181e-010	1.0000	-9.9276
>(s)FeOH	9.834e-011	9.834e-011	1.0000	-10.0073
>(w)FeOMo(OH)5	5.621e-011	5.621e-011	1.0000	-10.2502
>(w)FeH2BO3	5.477e-011	5.477e-011	1.0000	-10.2615
>(s)ZnOH2+	5.374e-011	5.374e-011	0.16742	-10.2697
>(s)FeOCo+	4.670e-011	4.670e-011	0.16742	-10.3307
>(s)FeOHAsO4---	2.089e-011	2.089e-011	213.09	-10.6800

>(s)FeCO3-	1.742e-011	1.742e-011	5.9729	-10.7591
>(w)FeCrO4-	1.475e-011	1.475e-011	5.9729	-10.8312
>(s)FeOSiO(OH)2-	1.387e-011	1.387e-011	5.9729	-10.8579
>(w)FeOCd+	6.842e-012	6.842e-012	0.16742	-11.1648
>(w)FeOHVO4---	4.047e-012	4.047e-012	213.09	-11.3929
>(w)FeOHCrO4--	2.094e-012	2.094e-012	35.676	-11.6790
>(s)FeOCd+	1.975e-012	1.975e-012	0.16742	-11.7044
>(s)FeSO4-	6.902e-013	6.902e-013	5.9729	-12.1610
>(w)FeSbO(OH)4	3.496e-013	3.496e-013	1.0000	-12.4564
>(s)FeO-	1.463e-013	1.463e-013	5.9729	-12.8348
>(w)FeOHMoO4--	1.365e-013	1.365e-013	35.676	-12.8648
>(s)FeOHSO4--	8.937e-014	8.937e-014	35.676	-13.0488
>(s)FeOSiO2OH--	5.951e-014	5.952e-014	35.676	-13.2254
>(w)FeOAg	5.053e-014	5.053e-014	1.0000	-13.2965
>(w)FeOHSbO(OH4	3.514e-014	3.514e-014	5.9729	-13.4542
>(s)FeOAg	2.365e-014	2.365e-014	1.0000	-13.6261
>(w)FeSeO4-	1.108e-014	1.108e-014	5.9729	-13.9553
>(s)FeOMo(OH)5	6.921e-015	6.921e-015	1.0000	-14.1598
>(s)FeH2BO3	6.744e-015	6.744e-015	1.0000	-14.1711
>(s)FeCrO4-	1.816e-015	1.816e-015	5.9729	-14.7408
>(w)FeOHSeO4--	1.648e-015	1.648e-015	35.676	-14.7831
>(w)HgOH2+	8.211e-016	8.211e-016	0.16742	-15.0856
>(s)FeOHVO4---	4.983e-016	4.983e-016	213.09	-15.3025
>(s)FeOHCrO4--	2.579e-016	2.579e-016	35.676	-15.5886
>(s)FeSbO(OH)4	4.305e-017	4.305e-017	1.0000	-16.3661
>(s)FeOHMoO4--	1.681e-017	1.681e-017	35.676	-16.7745
>(s)FeOHSbO(OH4	4.327e-018	4.327e-018	5.9729	-17.3638
>(s)HgOH2+	2.064e-018	2.064e-018	0.16742	-17.6853
>(s)FeSeO4-	1.365e-018	1.365e-018	5.9729	-17.8650
>(s)FeOHSeO4--	2.029e-019	2.029e-019	35.676	-18.6927
>(w)FeO(FeII)+	2.682e-020	2.682e-020	0.16742	-19.5715
>(w)FeOTl	1.469e-020	1.469e-020	1.0000	-19.8331
>(s)FeOTl	4.542e-021	4.542e-021	1.0000	-20.3427
>(s)FeO(FeII)+	3.539e-022	3.539e-022	0.16742	-21.4511
>(w)FeO(FeII)OH	9.142e-023	9.142e-023	1.0000	-22.0390
>(w)FeSeO3-	7.507e-024	7.507e-024	5.9729	-23.1246
>(s)FeOCrOH+	2.038e-024	2.038e-024	0.16742	-23.6908
>(w)FeOHSeO3--	2.869e-025	2.869e-025	35.676	-24.5423
>(s)FeSeO3-	9.243e-028	9.243e-028	5.9729	-27.0342
>(s)FeOHSeO3--	3.532e-029	3.532e-029	35.676	-28.4520
>(w)FeH2AsO3	4.396e-035	4.396e-035	1.0000	-34.3570
>(w)FeHAsO3-	1.929e-036	1.929e-036	5.9729	-35.7147
>(s)FeH2AsO3	5.413e-039	5.413e-039	1.0000	-38.2666
>(s)FeHAsO3-	2.375e-040	2.375e-040	5.9729	-39.6244

(Boltzman factor = exp(zF PSI/RT), where PSI is surface potential)

Mineral saturation states

	log Q/K		log Q/K
CoFe2O4	16.5576s/sat	Dolomite (disord	-0.6250
Hematite	8.4855s/sat	Magnesite	-0.6783
Co3O4	7.3190s/sat	SiO2 (am,ppt)	-0.8523
Cupric Ferrite	4.5327s/sat	SiO2 (am,gel)	-0.8929
Fe(OH)2.7Cl.3	3.8643s/sat	Al(OH)3 (Soil)	-1.1275
Goethite	3.0789s/sat	CaCO3xH2O	-1.3390
Lepidocrocite	2.7612s/sat	Magnetite	-1.4652
Maghemite	1.8788s/sat	Boehmite	-1.5331
Ferrihydrite (ag	1.4419s/sat	Cuprous Ferrite	-2.2172
Quartz	0.4747s/sat	Imogolite	-2.2554
Diaspore	0.3079s/sat	Smithsonite	-2.2872
Magnesioferrite	0.1266s/sat	CoCO3	-2.3139
Kaolinite	0.0000 sat	ZnCO3	-2.3520
Chalcedony	0.0000 sat	Halloysite	-2.4502
Ferrihydrite	0.0000 sat	Epsomite	-2.4943
Calcite	0.0000 sat	NiCO3	-2.5388
Dolomite (ordere	-0.0110	Cerargyrite	-2.5693
Aragonite	-0.1551	PbMoO4	-2.6323
Gypsum	-0.1937	Co(OH)3	-2.7582
Cristobalite	-0.1971	Cerrusite	-2.8452
Anhydrite	-0.5192	ZnCO3:1H2O	-2.8923
Gibbsite (C)	-0.5775	CaMoO4	-2.9566

Vaterite -0.6083
(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
O2 (g)	0.2594	-0.586
CO2 (g)	0.03860	-1.413
NH3 (g)	7.702e-010	-9.113
Hg (g)	1.472e-028	-27.832
Hg2 (g)	4.724e-057	-56.326
H2Se (g)	3.499e-110	-109.456
H2S (g)	3.738e-150	-149.427
CH4 (g)	1.506e-152	-151.822
Hg(CH3)2 (g)	0.0000	-300.000

		In fluid		Sorbed		Kd
Original basis	total moles	moles	mg/kg	moles	mg/kg	L/kg
>(s)FeOH	9.82e-007					
>(w)FeOH	3.93e-005					
Ag+	2.54e-009	2.54e-009	0.000273	7.42e-014	7.98e-009	
Al+++	8.46e-007	4.34e-010	1.17e-005			
AsO4---	4.13e-005	2.62e-005	3.64	1.50e-005	2.08	
Be++	3.04e-007	1.71e-009	1.54e-005	3.03e-007	0.00272	
CO3--	0.00993	0.00909	544.	4.49e-006	0.268	
Ca++	0.0106	0.00972	388.	1.11e-006	0.0443	
Cd++	5.55e-010	5.46e-010	6.12e-005	8.82e-012	9.88e-007	
Cl-	8.89e-005	8.89e-005	3.14			
Co+++	1.08e-007	1.07e-007	0.00628	1.12e-009	6.56e-005	
CrO4--	5.23e-008	5.23e-008	0.00605	1.68e-011	1.95e-006	
Cu++	4.47e-008	3.22e-009	0.000204	4.15e-008	0.00263	
Fe+++	0.000196	1.75e-009	9.73e-005	-5.11e-010	-2.84e-005	
H+	0.0106	0.0112	11.2	4.29e-005	0.0431	
H2O	55.5	55.5	9.97e+005	-2.24e-005	-0.403	
H3BO3	1.63e-005	1.63e-005	1.01	5.48e-011	3.38e-006	
H4SiO4	0.0179	0.000183	17.5	2.93e-006	0.280	
HVO4--	8.27e-008	8.27e-008	0.00956	4.05e-012	4.68e-007	
Hg(OH)2	2.42e-014	2.34e-014	5.47e-009	8.23e-016	1.93e-010	
K+	0.000243	0.000243	9.47			
Mg++	0.0112	0.0112	272.	3.24e-006	0.0785	
MoO4--	2.88e-008	2.87e-008	0.00458	5.64e-011	8.99e-006	
NH4+	8.47e-005	8.47e-005	1.52			
Na+	0.000451	0.000451	10.3			
Ni++	1.30e-007	1.26e-007	0.00737	4.17e-009	0.000244	
O2(aq)	0.000306	0.000306	9.76	-2.79e-010	-8.90e-006	
Pb++	1.13e-008	5.29e-010	0.000109	1.08e-008	0.00223	
SO4--	0.0178	0.0178	1.70e+003	6.33e-009	0.000606	
Sb(OH)6-	1.61e-008	1.61e-008	0.00359	3.85e-013	8.59e-008	
SeO4--	2.95e-008	2.95e-008	0.00420	1.27e-014	1.81e-009	
Tl(OH)3	3.26e-009	3.26e-009	0.000830	1.92e-020	4.90e-015	
UO2++	4.20e-008	4.20e-008	0.0113			
Zn++	1.90e-007	1.90e-007	0.0124	5.11e-010	3.33e-005	

Sorbed	fraction	log fraction
Ag+	2.919e-005	-4.535
AsO4---	0.3641	-0.439
Be++	0.9944	-0.002
CO3--	0.0004935	-3.307
Ca++	0.0001140	-3.943
Cd++	0.01589	-1.799
Co+++	0.01033	-1.986
CrO4--	0.0003219	-3.492
Cu++	0.9279	-0.032
H3BO3	3.358e-006	-5.474
H4SiO4	0.01574	-1.803
HVO4--	4.896e-005	-4.310
Hg(OH)2	0.03400	-1.468

Mg++	0.0002883	-3.540
MoO4--	0.001958	-2.708
Ni++	0.03202	-1.495
Pb++	0.9534	-0.021
SO4--	3.566e-007	-6.448
Sb(OH)6-	2.391e-005	-4.621
SeO4--	4.323e-007	-6.364
Tl(OH)3	5.901e-012	-11.229
Zn++	0.002685	-2.571

Elemental composition		In fluid		Sorbed	
	total moles	moles	mg/kg	moles	mg/kg
Ag	2.542e-009	2.542e-009	0.0002733	7.419e-014	7.978e-009
Al	8.456e-007	4.341e-010	1.168e-005		
As	4.127e-005	2.625e-005	1.961	1.503e-005	1.122
B	1.631e-005	1.631e-005	0.1758	5.478e-011	5.904e-007
Be	3.042e-007	1.709e-009	1.535e-005	3.025e-007	0.002718
C	0.009926	0.009090	108.8	4.488e-006	0.05374
Ca	0.01055	0.009722	388.5	1.108e-006	0.04429
Cd	5.549e-010	5.461e-010	6.120e-005	8.817e-012	9.881e-007
Cl	8.893e-005	8.893e-005	3.143		
Co	1.080e-007	1.069e-007	0.006280	1.116e-009	6.555e-005
Cr	5.234e-008	5.232e-008	0.002712	1.685e-011	8.734e-007
Cu	4.469e-008	3.221e-009	0.0002041	4.146e-008	0.002627
Fe	0.0001964	1.747e-009	9.728e-005	-5.108e-010	-2.844e-005
H	111.0	111.0	1.116e+005	9.667e-006	0.009714
Hg	2.421e-014	2.338e-014	4.677e-009	8.232e-016	1.646e-010
K	0.0002429	0.0002429	9.470		
Mg	0.01124	0.01123	272.3	3.240e-006	0.07854
Mo	2.877e-008	2.872e-008	0.002747	5.635e-011	5.390e-006
N	8.468e-005	8.468e-005	1.183		
Na	0.0004515	0.0004515	10.35		
Ni	1.301e-007	1.259e-007	0.007371	4.165e-009	0.0002438
O	55.65	55.61	8.871e+005	6.286e-005	1.003
Pb	1.134e-008	5.286e-010	0.0001092	1.081e-008	0.002234
S	0.01775	0.01775	567.6	6.332e-009	0.0002024
Sb	1.610e-008	1.610e-008	0.001954	3.848e-013	4.671e-008
Se	2.945e-008	2.945e-008	0.002319	1.273e-014	1.002e-009
Si	0.01795	0.0001830	5.125	2.927e-006	0.08195
Tl	3.259e-009	3.259e-009	0.0006640	1.923e-020	3.918e-015
U	4.196e-008	4.196e-008	0.009957		
V	8.268e-008	8.267e-008	0.004199	4.048e-012	2.056e-007
Zn	1.902e-007	1.897e-007	0.01236	5.108e-010	3.329e-005

```
Step #      0              Xi = 0.0000
Temperature =  10.0 C      Pressure =  0.918 bars
pH =  7.060
Eh =   0.8367 volts        pe =  14.8937
Ionic strength        =    0.055145
Activity of water     =    0.999274
Solvent mass          =    1.000000 kg
Solution mass         =    1.003074 kg
Solution density      =    1.024    g/cm3
Chlorinity            =    0.000191 molal
Dissolved solids      =        3064 mg/kg sol'n
Hardness              =     1988.91 mg/kg sol'n as CaCO3
  carbonate           =      314.79 mg/kg sol'n as CaCO3
  non-carbonate       =     1674.12 mg/kg sol'n as CaCO3
Rock mass             =    0.001000 kg
Carbonate alkalinity=        314.79 mg/kg sol'n as CaCO3
Water type            =    Ca-SO4
HFO sorbing surface:
  Surface charge      =       0.000 uC/cm2
  Surface potential =         0.000 mV
  Surface area        =       0.000 cm2
```

Minerals in system	moles	log moles	grams	volume (cm3)
SiO2 (am,ppt)	0.01664	-1.779	1.000	
(total)			1.000	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
SO4--	0.01166	1117.	0.4506	-2.2795
Ca++	0.008321	332.5	0.4506	-2.4261
HCO3-	0.005993	364.5	0.8193	-2.3089
Mg++	0.005385	130.5	0.4506	-2.6150
CaSO4 (aq)	0.003829	519.7	1.0128	-2.4114
MgSO4 (aq)	0.002024	242.8	1.0128	-2.6884
H4SiO4	0.001298	124.4	1.0128	-2.8812
H2CO3* (aq)	0.001228	75.93	1.0128	-2.9053
K+	0.0008622	33.61	0.8193	-3.1510
Na+	0.0005205	11.93	0.8193	-3.3701
Fe(OH)2+	0.0004298	38.50	0.8193	-3.4533
O2(aq)	0.0003094	9.872	1.0128	-3.5039
CaHCO3+	0.0002080	20.97	0.8193	-3.7685
Cl-	0.0001880	6.645	0.8193	-3.8124
MgHCO3+	0.0001564	13.30	0.8193	-3.8925
NH4+	8.977e-005	1.614	0.8193	-4.1334
HAsO4--	5.312e-005	7.411	0.4506	-4.6210
H2AsO4-	2.653e-005	3.727	0.8193	-4.6629
KSO4-	2.416e-005	3.256	0.8193	-4.7034
NaSO4-	1.471e-005	1.746	0.8193	-4.9189
H3BO3	1.079e-005	0.6650	1.0128	-4.9615
Mn++	9.601e-006	0.5258	0.4506	-5.3639
NH4SO4-	5.054e-006	0.5749	0.8193	-5.3829
F-	4.985e-006	0.09441	0.8193	-5.3889
H4SiO4SO4--	4.237e-006	0.8117	0.4506	-5.7192
CO3--	4.067e-006	0.2433	0.4506	-5.7370
MgCO3 (aq)	3.327e-006	0.2797	1.0128	-5.4724
MnSO4 (aq)	3.314e-006	0.4988	1.0128	-5.4742
CaCO3 (aq)	1.701e-006	0.1698	1.0128	-5.7637
MgCl+	1.667e-006	0.09933	0.8193	-5.8646
CaCl+	1.625e-006	0.1224	0.8193	-5.8756
NaHCO3 (aq)	1.316e-006	0.1102	1.0128	-5.8752
Fe(OH)3 (aq)	1.004e-006	0.1070	1.0128	-5.9927
H3SiO4-	9.468e-007	0.08977	0.8193	-6.1103
MgF+	7.277e-007	0.03142	0.8193	-6.2246
FeOH++	4.788e-007	0.03478	0.4506	-6.6661
MnHCO3+	4.498e-007	0.05200	0.8193	-6.4335
MnCO3 (aq)	3.922e-007	0.04495	1.0128	-6.4009

Al(OH)4-	3.425e-007	0.03244	0.8193	-6.5519
CaF+	1.913e-007	0.01126	0.8193	-6.8049
NH3 (aq)	1.554e-007	0.002638	1.0128	-6.8032
Be(OH)2 (aq)	1.079e-007	0.004627	1.0128	-6.9616
H+	1.063e-007	0.0001068	0.8193	-7.0600
Mg2CO3++	9.315e-008	0.01009	0.4506	-7.3771
Zn++	8.840e-008	0.005761	0.4506	-7.3998
H2VO4-	7.822e-008	0.009120	0.8193	-7.1932
Al2(OH)2CO3++	7.151e-008	0.01055	0.4506	-7.4919
H2BO3-	6.617e-008	0.004012	0.8193	-7.2659
Co++	6.133e-008	0.003603	0.4506	-7.5586
KCl (aq)	5.865e-008	0.004359	1.0128	-7.2262
Al(OH)3 (aq)	5.676e-008	0.004414	1.0128	-7.2404
Fe(OH)4-	5.196e-008	0.006417	0.8193	-7.3709
Ni++	5.082e-008	0.002974	0.4506	-7.6403
Al(OH)2+	4.817e-008	0.002929	0.8193	-7.4038
OH-	4.278e-008	0.0007254	0.8193	-7.4553
ZnSO4 (aq)	3.960e-008	0.006373	1.0128	-7.3968
HCN (aq)	3.944e-008	0.001063	1.0128	-7.3985
NaCl (aq)	3.857e-008	0.002247	1.0128	-7.4083
HSO4-	3.614e-008	0.003497	0.8193	-7.5286
NaCO3-	2.744e-008	0.002270	0.8193	-7.6482
CoSO4 (aq)	2.506e-008	0.003872	1.0128	-7.5955
NiSO4 (aq)	2.094e-008	0.003230	1.0128	-7.6736
CuCO3 (aq)	2.044e-008	0.002518	1.0128	-7.6840
MgOH+	1.417e-008	0.0005837	0.8193	-7.9352
CaH2BO3+	1.322e-008	0.001330	0.8193	-7.9654
NiHCO3+	1.173e-008	0.001400	0.8193	-8.0173

(only species > 1e-8 molal listed)

Mineral saturation states

	log Q/K		log Q/K
CoFe2O4	28.0286s/sat	Calcite	0.2474s/sat
Hematite	19.6343s/sat	Dolomite (ordere	0.2083s/sat
Cupric Ferrite	16.8768s/sat	Al2O3	0.1222s/sat
Magnetite	15.2568s/sat	Aragonite	0.0922s/sat
Maghemite	13.0275s/sat	SiO2 (am,ppt)	0.0000 sat
Magnesioferrite	11.4696s/sat	SiO2 (am,gel)	-0.0407
K-Jarosite	10.2850s/sat	Gypsum	-0.0869
Fe(OH)2.7Cl.3	9.4846s/sat	Rhodochrosite	-0.1184
Nsutite	8.8083s/sat	Vaterite	-0.3609
Pyrolusite	8.7582s/sat	H-Jarosite	-0.3617
Goethite	8.6533s/sat	Dolomite (disord	-0.4058
Lepidocrocite	8.3356s/sat	Anhydrite	-0.4124
Co3O4	8.2883s/sat	MnCO3 (am)	-0.6009
Birnessite	8.2213s/sat	Magnesite	-0.7064
Bixbyite	8.2064s/sat	Al(OH)3 (am)	-0.7433
Kaolinite	7.6043s/sat	FeAsO4:2H2O	-0.8033
Ferrihydrite (ag	7.0163s/sat	CaCO3xH2O	-1.0916
Cr(VI)-Jarosite	6.5531s/sat	PbMoO4	-2.0158
Ferrihydrite	5.5744s/sat	Cerrusite	-2.0206
Manganite	5.3692s/sat	Fluorite	-2.0577
Al4(OH)10SO4	5.2489s/sat	AlOHSO4	-2.0819
Hausmannite	5.2367s/sat	CoCO3	-2.2140
Halloysite	5.1541s/sat	Smithsonite	-2.2721
Cuprous Ferrite	4.5514s/sat	Be(OH)2 (beta)	-2.3216
Imogolite	4.4966s/sat	ZnCO3	-2.3368
Na-Jarosite	4.0708s/sat	Co(OH)3	-2.4347
Alunite	3.8227s/sat	Hercynite	-2.4504
Diaspore	3.2577s/sat	Sepiolite	-2.4525
Gibbsite (C)	2.3724s/sat	NiCO3	-2.5633
Al(OH)3 (Soil)	1.8224s/sat	Epsomite	-2.6629
Boehmite	1.4168s/sat	Be(OH)2 (alpha)	-2.7216
Quartz	1.3269s/sat	Tenorite(c)	-2.8397
Chalcedony	0.8523s/sat	ZnCO3:1H2O	-2.8771
Cristobalite	0.6551s/sat	CaMoO4	-2.9173
Fe3(OH)8	0.3718s/sat	CuCO3	-2.9540

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
O2 (g)	0.2623	-0.581
CO2 (g)	0.02313	-1.636
NH3 (g)	1.313e-009	-8.882
Hg (g)	1.998e-032	-31.699
HgF2 (g)	1.763e-057	-56.754
Hg2 (g)	8.702e-065	-64.060
HgF (g)	4.857e-066	-65.314
H2Se (g)	3.671e-111	-110.435
H2S (g)	1.586e-150	-149.800
CH4 (g)	8.834e-153	-152.054
Hg(CH3)2 (g)	0.0000	-300.000

Original basis	total moles	In fluid moles	In fluid mg/kg	Sorbed moles	Sorbed mg/kg	Kd L/kg
>(s)FeOH	0.000					
>(w)FeOH	0.000					
Ag+	9.08e-010	9.08e-010	9.76e-005			
Al+++	6.17e-007	6.17e-007	0.0166			
AsO4---	7.97e-005	7.97e-005	11.0			
Be++	1.09e-007	1.09e-007	0.000976			
CN-	4.14e-008	4.14e-008	0.00107			
CO3--	0.00760	0.00760	454.			
Ca++	0.0124	0.0124	494.			
Cd++	3.75e-010	3.75e-010	4.20e-005			
Cl-	0.000191	0.000191	6.76			
Co+++	9.64e-008	9.64e-008	0.00566			
CrO4--	1.86e-008	1.86e-008	0.00215			
Cu++	2.77e-008	2.77e-008	0.00176			
F-	5.93e-006	5.93e-006	0.112			
Fe+++	0.000431	0.000431	24.0			
H+	0.00804	0.00804	8.08			
H2O	55.5	55.5	9.97e+005			
H3BO3	1.09e-005	1.09e-005	0.670			
H4SiO4	0.0179	0.00130	125.			
HVO4--	8.07e-008	8.07e-008	0.00933			
Hg(OH)2	1.96e-011	1.96e-011	4.59e-006			
K+	0.000886	0.000886	34.6			
Mg++	0.00757	0.00757	184.			
Mn+++	1.38e-005	1.38e-005	0.754			
MoO4--	2.14e-008	2.14e-008	0.00342			
NH4+	9.50e-005	9.50e-005	1.71			
Na+	0.000537	0.000537	12.3			
Ni++	8.51e-008	8.51e-008	0.00498			
O2(aq)	0.000306	0.000306	9.76			
Pb++	2.84e-009	2.84e-009	0.000586			
SO4--	0.0176	0.0176	1.68e+003			
Sb(OH)6-	8.84e-009	8.84e-009	0.00197			
SeO4--	7.47e-009	7.47e-009	0.00106			
Tl(OH)3	7.18e-010	7.18e-010	0.000183			
UO2++	9.39e-009	9.39e-009	0.00253			
Zn++	1.42e-007	1.42e-007	0.00927			

Elemental composition	total moles	In fluid moles	In fluid mg/kg	Sorbed moles	Sorbed mg/kg
Ag	9.077e-010	9.077e-010	9.761e-005		
Al	6.169e-007	6.169e-007	0.01659		
As	7.965e-005	7.965e-005	5.949		
B	1.087e-005	1.087e-005	0.1172		
Be	1.086e-007	1.086e-007	0.0009761		
C	0.007597	0.007597	90.96		
Ca	0.01236	0.01236	493.9		
Cd	3.746e-010	3.746e-010	4.197e-005		
Cl	0.0001914	0.0001914	6.765		
Co	9.636e-008	9.636e-008	0.005661		
Cr	1.857e-008	1.857e-008	0.0009626		
Cu	2.773e-008	2.773e-008	0.001757		
F	5.927e-006	5.927e-006	0.1123		
Fe	0.0004313	0.0004313	24.01		

H	111.0	111.0	1.116e+005
Hg	1.962e-011	1.962e-011	3.923e-006
K	0.0008864	0.0008864	34.55
Mg	0.007571	0.007571	183.5
Mn	1.376e-005	1.376e-005	0.7536
Mo	2.143e-008	2.143e-008	0.002049
N	9.503e-005	9.503e-005	1.327
Na	0.0005366	0.0005366	12.30
Ni	8.505e-008	8.505e-008	0.004978
O	55.64	55.61	8.870e+005
Pb	2.835e-009	2.835e-009	0.0005857
S	0.01757	0.01757	561.5
Sb	8.841e-009	8.841e-009	0.001073
Se	7.465e-009	7.465e-009	0.0005877
Si	0.01795	0.001303	36.49
Tl	7.185e-010	7.185e-010	0.0001464
U	9.391e-009	9.391e-009	0.002229
V	8.073e-008	8.073e-008	0.004100
Zn	1.423e-007	1.423e-007	0.009273

```
Step #      0             Xi = 0.0000
Temperature =  10.0 C     Pressure =  0.918 bars
pH =   6.863
Eh =   0.8478 volts       pe =  15.0910
Ionic strength      =     0.054318
Activity of water   =     0.999306
Solvent mass        =     1.000033 kg
Solution mass       =     1.002942 kg
Solution density    =     1.024    g/cm3
Chlorinity          =     0.000191 molal
Dissolved solids    =         2900 mg/kg sol'n
Hardness            =      1974.65 mg/kg sol'n as CaCO3
  carbonate         =       281.14 mg/kg sol'n as CaCO3
  non-carbonate     =      1693.51 mg/kg sol'n as CaCO3
Rock mass           =     0.001127 kg
Carbonate alkalinity=       281.14 mg/kg sol'n as CaCO3
Water type          =     Ca-SO4
HFO sorbing surface:
  Surface charge    =        -1.54 uC/cm2
  Surface potential =        -51.5 mV
  Surface area      =    2.77e+005 cm2
```

Minerals in system	moles	log moles	grams	volume (cm3)
Calcite	0.0001379	-3.860	0.01381	
Chalcedony	0.01776	-1.751	1.067	
Ferrihydrite	0.0004313	-3.365	0.04609	
Kaolinite	3.082e-007	-6.511	7.957e-005	
(total)			1.127	0.0000*

Aqueous species	molality	mg/kg sol'n	act. coef.	log act.
SO4--	0.01166	1117.	0.4524	-2.2776
Ca++	0.008218	328.4	0.4524	-2.4297
Mg++	0.005381	130.4	0.4524	-2.6136
HCO3-	0.005379	327.3	0.8201	-2.3554
CaSO4 (aq)	0.003814	517.8	1.0126	-2.4131
MgSO4 (aq)	0.002040	244.8	1.0126	-2.6850
H2CO3* (aq)	0.001739	107.5	1.0126	-2.7544
K+	0.0008621	33.61	0.8201	-3.1506
Na+	0.0005206	11.93	0.8201	-3.3696
O2(aq)	0.0003094	9.873	1.0126	-3.5040
Cl-	0.0001880	6.646	0.8201	-3.8120
CaHCO3+	0.0001852	18.67	0.8201	-3.8185
H4SiO4	0.0001824	17.48	1.0126	-3.7334
MgHCO3+	0.0001408	11.98	0.8201	-3.9374
NH4+	8.981e-005	1.615	0.8201	-4.1328
KSO4-	2.426e-005	3.270	0.8201	-4.7011
HAsO4--	2.415e-005	3.370	0.4524	-4.9615
H2AsO4-	1.906e-005	2.678	0.8201	-4.8061

NaSO4-	1.478e-005	1.754	0.8201	-4.9165
H3BO3	1.082e-005	0.6670	1.0126	-4.9604
Mn++	9.643e-006	0.5282	0.4524	-5.3602
NH4SO4-	5.078e-006	0.5777	0.8201	-5.3804
F-	5.000e-006	0.09471	0.8201	-5.3871
MnSO4 (aq)	3.357e-006	0.5055	1.0126	-5.4686
CO3--	2.310e-006	0.1382	0.4524	-5.9808
MgCO3 (aq)	1.905e-006	0.1602	1.0126	-5.7147
MgCl+	1.673e-006	0.09969	0.8201	-5.8626
CaCl+	1.612e-006	0.1214	0.8201	-5.8788
NaHCO3 (aq)	1.184e-006	0.09920	1.0126	-5.9211
CaCO3 (aq)	9.627e-007	0.09608	1.0126	-6.0111
MgF+	7.324e-007	0.03163	0.8201	-6.2214
H4SiO4SO4--	5.954e-007	0.1141	0.4524	-6.5696
MnHCO3+	4.073e-007	0.04709	0.8201	-6.4762
MnCO3 (aq)	2.257e-007	0.02587	1.0126	-6.6410
CaF+	1.903e-007	0.01121	0.8201	-6.8067
H+	1.673e-007	0.0001681	0.8201	-6.8627
NH3 (aq)	9.878e-008	0.001677	1.0126	-6.9999
Zn++	8.913e-008	0.005809	0.4524	-7.3944
H3SiO4-	8.438e-008	0.008002	0.8201	-7.1599
H2VO4-	7.912e-008	0.009226	0.8201	-7.1878
Co++	6.059e-008	0.003561	0.4524	-7.5620
KCl (aq)	5.877e-008	0.004369	1.0126	-7.2254
HSO4-	5.711e-008	0.005527	0.8201	-7.3294
Mg2CO3++	5.328e-008	0.005771	0.4524	-7.6179
Ni++	4.819e-008	0.002821	0.4524	-7.6614
H2BO3-	4.207e-008	0.002552	0.8201	-7.4621
ZnSO4 (aq)	4.027e-008	0.006483	1.0126	-7.3895
HCN (aq)	3.939e-008	0.001061	1.0126	-7.3992
NaCl (aq)	3.866e-008	0.002253	1.0126	-7.4073
OH-	2.713e-008	0.0004601	0.8201	-7.6526
CoSO4 (aq)	2.497e-008	0.003859	1.0126	-7.5971
NiSO4 (aq)	2.003e-008	0.003091	1.0126	-7.6929
NaCO3-	1.565e-008	0.001295	0.8201	-7.8915
NiHCO3+	1.003e-008	0.001197	0.8201	-8.0849

(only species > 1e-8 molal listed)

Surface species	molality	moles	Boltzman fct.	log molality
>(w)FeOH2+	2.997e-005	2.997e-005	0.13495	-4.5233
>(w)FeHAsO4-	2.275e-005	2.275e-005	7.4099	-4.6430
>(w)FeAsO4--	1.023e-005	1.023e-005	54.907	-4.9902
>(w)FeCO3H	6.978e-006	6.978e-006	1.0000	-5.1563
>(w)FeOSi(OH)3	5.326e-006	5.326e-006	1.0000	-5.2736
>(w)FeOMg+	4.994e-006	4.994e-006	0.13495	-5.3016
>(w)FeH2AsO4	3.193e-006	3.193e-006	1.0000	-5.4959
>(s)FeOHCa++	2.135e-006	2.135e-006	0.018213	-5.6705
>(w)FeOH	1.512e-006	1.512e-006	1.0000	-5.8205
>(w)FeOCa+	4.289e-007	4.289e-007	0.13495	-6.3677
>(w)FeOHAsO4---	2.647e-007	2.647e-007	406.86	-6.5773
>(w)FeCO3-	1.764e-007	1.764e-007	7.4099	-6.7534
>(w)FeOSiO(OH)2-	1.657e-007	1.657e-007	7.4099	-6.7808
>(w)FeOMn+	1.127e-007	1.127e-007	0.13495	-6.9482
>(w)FeOBe+	1.064e-007	1.064e-007	0.13495	-6.9730
>(w)FeOCu+	2.656e-008	2.656e-008	0.13495	-7.5758
>(s)FeOMn+	1.051e-008	1.051e-008	0.13495	-7.9782
>(w)FeSO4-	8.908e-009	8.908e-009	7.4099	-8.0502
>(w)FeONi+	5.631e-009	5.631e-009	0.13495	-8.2494
>(s)FeOH2+	2.222e-009	2.222e-009	0.13495	-8.6533
>(w)FeOCo+	2.188e-009	2.188e-009	0.13495	-8.6600
>(s)FeOBe+	1.981e-009	1.981e-009	0.13495	-8.7031
>(w)FeO-	1.747e-009	1.747e-009	7.4099	-8.7576
>(s)FeOPb+	1.723e-009	1.723e-009	0.13495	-8.7637
>(s)FeHAsO4-	1.686e-009	1.687e-009	7.4099	-8.7730
>(w)FeOPb+	1.038e-009	1.038e-009	0.13495	-8.9837
>(w)FeOHSO4--	8.960e-010	8.960e-010	54.907	-9.0477
>(w)ZnOH2+	7.854e-010	7.854e-010	0.13495	-9.1049
>(s)FeAsO4--	7.583e-010	7.583e-010	54.907	-9.1202
>(w)FeOSiO2OH--	5.522e-010	5.522e-010	54.907	-9.2579
>(s)FeCO3H	5.173e-010	5.173e-010	1.0000	-9.2863
>(s)FeOSi(OH)3	3.948e-010	3.948e-010	1.0000	-9.4036

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 >(s)FeOCu+          3.839e-010    3.839e-010       0.13495      -9.4158
 >(s)FeONi+          3.094e-010    3.094e-010       0.13495      -9.5095
 >(s)FeH2AsO4        2.367e-010    2.367e-010        1.0000      -9.6259
 >(w)FeCN            1.466e-010    1.466e-010        1.0000      -9.8340
 >(s)FeOH            1.121e-010    1.121e-010        1.0000      -9.9505
 >(w)FeOMo(OH)5      9.773e-011    9.774e-011        1.0000     -10.0100
 >(w)FeH2BO3         6.910e-011    6.910e-011        1.0000     -10.1605
 >(s)FeOCo+          5.754e-011    5.754e-011       0.13495     -10.2400
 >(s)ZnOH2+          5.560e-011    5.560e-011       0.13495     -10.2549
 >(s)FeOHAsO4---     1.962e-011    1.962e-011        406.86     -10.7073
 >(s)FeCO3-          1.308e-011    1.308e-011        7.4099     -10.8834
 >(s)FeOSiO(OH)2-    1.228e-011    1.228e-011        7.4099     -10.9108
 >(w)FeOCd+          1.041e-011    1.041e-011       0.13495     -10.9827
 >(w)FeCrO4-         7.517e-012    7.518e-012        7.4099     -11.1239
 >(w)FeOHCN-         7.220e-012    7.221e-012        7.4099     -11.1414
 >(w)FeOHVO4---      3.652e-012    3.653e-012        406.86     -11.4374
 >(s)FeOCd+          1.808e-012    1.808e-012       0.13495     -11.7427
 >(w)FeOHCrO4--      8.291e-013    8.291e-013        54.907     -12.0814
 >(s)FeSO4-          6.603e-013    6.603e-013        7.4099     -12.1803
 >(w)FeSbO(OH)4      3.783e-013    3.783e-013        1.0000     -12.4222
 >(w)FeOHMoO4--      1.432e-013    1.432e-013        54.907     -12.8440
 >(s)FeO-            1.295e-013    1.295e-013        7.4099     -12.8876
 >(s)FeOHSO4--       6.642e-014    6.642e-014        54.907     -13.1777
 >(s)FeOSiO2OH--     4.093e-014    4.093e-014        54.907     -13.3879
 >(w)FeOHSbO(OH4     2.953e-014    2.954e-014        7.4099     -13.5297
 >(s)FeCN            1.086e-014    1.086e-014        1.0000     -13.9640
 >(s)FeOMo(OH)5      7.245e-015    7.245e-015        1.0000     -14.1400
 >(s)FeH2BO3         5.122e-015    5.122e-015        1.0000     -14.2906
 >(w)FeSeO4-         4.356e-015    4.356e-015        7.4099     -14.3609
 >(w)FeOAg           1.391e-015    1.391e-015        1.0000     -14.8568
 >(s)FeCrO4-         5.573e-016    5.573e-016        7.4099     -15.2539
 >(s)FeOHCN-         5.352e-016    5.353e-016        7.4099     -15.2714
 >(w)FeOHSeO4--      5.031e-016    5.031e-016        54.907     -15.2984
 >(s)FeOAg           3.919e-016    3.919e-016        1.0000     -15.4068
 >(s)FeOHVO4---      2.707e-016    2.708e-016        406.86     -15.5674
 >(s)FeOHCrO4--      6.146e-017    6.146e-017        54.907     -16.2114
 >(s)FeSbO(OH)4      2.804e-017    2.804e-017        1.0000     -16.5522
 >(s)FeOHMoO4--      1.062e-017    1.062e-017        54.907     -16.9740
 >(s)FeOHSbO(OH4     2.189e-018    2.189e-018        7.4099     -17.6597
 >(s)FeSeO4-         3.229e-019    3.229e-019        7.4099     -18.4909
 >(w)HgOH2+          2.739e-019    2.739e-019       0.13495     -18.5625
 >(w)FeO(FeII)+      6.519e-020    6.519e-020       0.13495     -19.1858
 >(s)FeOHSeO4--      3.729e-020    3.729e-020        54.907     -19.4284
 >(w)FeOTl           6.093e-021    6.094e-021        1.0000     -20.2151
 >(s)FeOTl           1.135e-021    1.135e-021        1.0000     -20.9451
 >(s)FeO(FeII)+      5.178e-022    5.178e-022       0.13495     -21.2858
 >(s)HgOH2+          4.145e-022    4.145e-022       0.13495     -21.3825
 >(w)FeO(FeII)OH     1.726e-022    1.726e-022        1.0000     -21.7630
 >(w)FeSeO3-         2.935e-024    2.935e-024        7.4099     -23.5325
 >(s)FeOCrOH+        1.028e-024    1.028e-024       0.13495     -23.9880
 >(w)FeOHSeO3--      8.711e-026    8.712e-026        54.907     -25.0599
 >(s)FeSeO3-         2.175e-028    2.175e-028        7.4099     -27.6625
 >(s)FeOHSeO3--      6.458e-030    6.458e-030        54.907     -29.1899
 >(w)FeH2AsO3        1.455e-034    1.455e-034        1.0000     -33.8371
 >(w)FeHAsO3-        4.959e-036    4.959e-036        7.4099     -35.3046
 >(s)FeH2AsO3        1.079e-038    1.079e-038        1.0000     -37.9671
 >(s)FeHAsO3-        3.676e-040    3.676e-040        7.4099     -39.4346
  (Boltzman factor = exp(zF PSI/RT),  where PSI is surface potential)

 Mineral saturation states
                   log Q/K                            log Q/K
----------------------------------------------------------------
  CoFe2O4          16.4817s/sat   Dolomite (ordere  -0.2814
  Hematite          8.4855s/sat   Rhodochrosite     -0.3584
  Nsutite           8.4173s/sat   Anhydrite         -0.4141
  Pyrolusite        8.3672s/sat   Gibbsite (C)      -0.5775
  Birnessite        7.8303s/sat   Vaterite          -0.6083
  Bixbyite          7.4245s/sat   MnCO3 (am)        -0.8410
  Co3O4             7.0939s/sat   SiO2 (am,ppt)     -0.8523
  Manganite         4.9782s/sat   SiO2 (am,gel)     -0.8929
  Hausmannite       4.0638s/sat   Dolomite (disord  -0.8955
  Fe(OH)2.7Cl.3     3.9696s/sat   Magnesite         -0.9487
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Cupric Ferrite	3.9626s/sat	Al(OH)3 (Soil)	-1.1275
Goethite	3.0789s/sat	CaCO3xH2O	-1.3389
Lepidocrocite	2.7612s/sat	Magnetite	-1.4664
Maghemite	1.8787s/sat	Boehmite	-1.5331
Ferrihydrite (ag	1.4419s/sat	Fluorite	-2.0577
Quartz	0.4747s/sat	Imogolite	-2.2554
Diaspore	0.3078s/sat	Halloysite	-2.4502
Kaolinite	0.0000 sat	CoCO3	-2.4612
Ferrihydrite	0.0000 sat	Smithsonite	-2.5105
Chalcedony	0.0000 sat	ZnCO3	-2.5752
Calcite	0.0000 sat	Epsomite	-2.6595
Magnesioferrite	-0.0724	Cuprous Ferrite	-2.7884
Gypsum	-0.0886	NiCO3	-2.8282
Aragonite	-0.1551	Co(OH)3	-2.8329
Cristobalite	-0.1971	CaMoO4	-2.9221

(only minerals with log Q/K > -3 listed)

Gases	fugacity	log fug.
O2 (g)	0.2622	-0.581
CO2 (g)	0.03274	-1.485
NH3 (g)	8.349e-010	-9.078
Hg (g)	2.004e-032	-31.698
HgF2 (g)	4.422e-057	-56.354
Hg2 (g)	8.755e-065	-64.058
HgF (g)	7.704e-066	-65.113
H2Se (g)	9.156e-111	-110.038
H2S (g)	3.955e-150	-149.403
CH4 (g)	1.251e-152	-151.903
Hg(CH3)2 (g)	0.0000	-300.000

		In fluid		Sorbed		Kd
Original basis	total moles	moles	mg/kg	moles	mg/kg	L/kg
>(s)FeOH	2.16e-006					
>(w)FeOH	8.63e-005					
Ag+	9.08e-010	9.08e-010	9.76e-005	1.78e-015	1.92e-010	
Al+++	6.17e-007	4.87e-010	1.31e-005			
AsO4---	7.97e-005	4.32e-005	5.99	3.64e-005	5.05	
Be++	1.09e-007	2.55e-010	2.29e-006	1.08e-007	0.000974	
CN-	4.14e-008	4.12e-008	0.00107	1.54e-010	3.99e-006	
CO3--	0.00760	0.00745	446.	7.16e-006	0.428	
Ca++	0.0124	0.0122	488.	2.56e-006	0.102	
Cd++	3.75e-010	3.62e-010	4.06e-005	1.22e-011	1.37e-006	
Cl-	0.000191	0.000191	6.77			
Co+++	9.64e-008	9.41e-008	0.00553	2.25e-009	0.000132	
CrO4--	1.86e-008	1.86e-008	0.00215	8.35e-012	9.65e-007	
Cu++	2.77e-008	7.92e-010	5.02e-005	2.69e-008	0.00171	
F-	5.93e-006	5.93e-006	0.112			
Fe+++	0.000431	1.81e-009	0.000101	-8.41e-010	-4.68e-005	
H+	0.00804	0.00923	9.28	0.000103	0.104	
H2O	55.5	55.5	9.97e+005	-4.90e-005	-0.881	
H3BO3	1.09e-005	1.09e-005	0.670	6.91e-011	4.26e-006	
H4SiO4	0.0179	0.000183	17.5	5.49e-006	0.526	
HVO4--	8.07e-008	8.07e-008	0.00933	3.65e-012	4.22e-007	
Hg(OH)2	1.96e-011	1.96e-011	4.59e-006	2.74e-019	6.42e-014	
K+	0.000886	0.000886	34.6			
Mg++	0.00757	0.00757	183.	4.99e-006	0.121	
Mn+++	1.38e-005	1.36e-005	0.747	1.23e-007	0.00675	
MoO4--	2.14e-008	2.13e-008	0.00340	9.79e-011	1.56e-005	
NH4+	9.50e-005	9.50e-005	1.71			
Na+	0.000537	0.000537	12.3			
Ni++	8.51e-008	7.91e-008	0.00463	5.94e-009	0.000348	
O2(aq)	0.000306	0.000306	9.76	-3.14e-008	-0.00100	
Pb++	2.84e-009	7.38e-011	1.52e-005	2.76e-009	0.000571	
SO4--	0.0176	0.0176	1.68e+003	9.80e-009	0.000939	
Sb(OH)6-	8.84e-009	8.84e-009	0.00197	4.08e-013	9.10e-008	
SeO4--	7.47e-009	7.47e-009	0.00106	4.86e-015	6.93e-010	
Tl(OH)3	7.18e-010	7.18e-010	0.000183	7.23e-021	1.84e-015	
UO2++	9.39e-009	9.39e-009	0.00253			
Zn++	1.42e-007	1.41e-007	0.00922	8.41e-010	5.48e-005	

Sorbed	fraction	log fraction
Ag+	1.964e-006	-5.707
AsO4---	0.4575	-0.340
Be++	0.9977	-0.001
CN-	0.003715	-2.430
CO3--	0.0009594	-3.018
Ca++	0.0002098	-3.678
Cd++	0.03261	-1.487
Co+++	0.02330	-1.633
CrO4--	0.0004495	-3.347
Cu++	0.9715	-0.013
H3BO3	6.355e-006	-5.197
H4SiO4	0.02912	-1.536
HVO4--	4.525e-005	-4.344
Hg(OH)2	1.398e-008	-7.854
Mg++	0.0006596	-3.181
Mn+++	0.008953	-2.048
MoO4--	0.004568	-2.340
Ni++	0.06984	-1.156
Pb++	0.9740	-0.011
SO4--	5.582e-007	-6.253
Sb(OH)6-	4.613e-005	-4.336
SeO4--	6.509e-007	-6.186
Tl(OH)3	1.006e-011	-10.997
Zn++	0.005910	-2.228

Elemental composition		In fluid		Sorbed	
	total moles	moles	mg/kg	moles	mg/kg
Ag	9.077e-010	9.077e-010	9.762e-005	1.782e-015	1.917e-010
Al	6.169e-007	4.867e-010	1.309e-005		
As	7.965e-005	4.321e-005	3.228	3.644e-005	2.722
B	1.087e-005	1.087e-005	0.1172	6.910e-011	7.448e-007
Be	1.086e-007	2.549e-010	2.290e-006	1.084e-007	0.0009740
C	0.007597	0.007451	89.24	7.156e-006	0.08569
Ca	0.01236	0.01222	488.4	2.564e-006	0.1025
Cd	3.746e-010	3.624e-010	4.061e-005	1.222e-011	1.369e-006
Cl	0.0001914	0.0001914	6.765		
Co	9.636e-008	9.412e-008	0.005530	2.245e-009	0.0001319
Cr	1.857e-008	1.856e-008	0.0009623	8.347e-012	4.328e-007
Cu	2.773e-008	7.917e-010	5.016e-005	2.694e-008	0.001707
F	5.927e-006	5.927e-006	0.1123		
Fe	0.0004313	1.808e-009	0.0001007	-8.410e-010	-4.683e-005
H	111.0	111.0	1.116e+005	2.735e-005	0.02748
Hg	1.962e-011	1.962e-011	3.923e-006	2.743e-019	5.486e-014
K	0.0008864	0.0008864	34.56		
Mg	0.007571	0.007566	183.4	4.994e-006	0.1211
Mn	1.376e-005	1.364e-005	0.7469	1.232e-007	0.006748
Mo	2.143e-008	2.133e-008	0.002040	9.789e-011	9.364e-006
N	9.503e-005	9.503e-005	1.327	1.538e-010	2.148e-006
Na	0.0005366	0.0005366	12.30		
Ni	8.505e-008	7.911e-008	0.004631	5.940e-009	0.0003477
O	55.64	55.60	8.870e+005	0.0001401	2.236
Pb	2.835e-009	7.377e-011	1.524e-005	2.762e-009	0.0005705
S	0.01757	0.01757	561.6	9.805e-009	0.0003135
Sb	8.841e-009	8.840e-009	0.001073	4.078e-013	4.951e-008
Se	7.465e-009	7.465e-009	0.0005877	4.859e-015	3.826e-010
Si	0.01795	0.0001831	5.128	5.493e-006	0.1538
Tl	7.185e-010	7.185e-010	0.0001464	7.228e-021	1.473e-015
U	9.391e-009	9.391e-009	0.002229		
V	8.073e-008	8.073e-008	0.004100	3.653e-012	1.855e-007
Zn	1.423e-007	1.415e-007	0.009220	8.410e-010	5.482e-005

APPENDIX B3: SURFACE AREAS AND UNSCALED CUMULATIVE MASS AND SURFACE LOADING RATES FROM FIELD BINS (FBS)

Appendix B3: Surface Areas and Unscaled Cumulative Mass and Surface Loading Rates from Field Bins (FBS)

Field Bin ID	Specific Gravity (g/cm^3)	SA (m^2/kg)	% material represented	Cl	Fl	SO_4^{2-} (mg/kg/ week)	CN^-	CN^- WAD	CN^- Free	NH^3	NO_2^-	NO_3^-	Hg	Ag	Al	As	Be	B	Ca	Cd	Co	Cr	Cu	Fe	K	Mg	Mo	Na	Ni	P	Pb	Sb	Se	Tl	W	U	V	Zn	Zr
2014 Mass loadings (μg/kg/week, except for SO_4^{2-} mg/kg/week)																																							
FB_OB, Overburden	–	–	100%	**–**	**–**	**5.5**	**–**	**–**	**–**	**–**	**–**	**–**	**0.000052**	**0.00052**	**0.086**	**0.29**	**0.0052**	**0.23**	**2040**	**0.00009**	**0.015**	**0.0052**	**0.046**	**0.59**	**49**	**467**	**0.031**	**102**	**0.015**	–	**0.0043**	**0.011**	**0.011**	**0.0016**	**0.055**	**0.022**	**0.0052**	**0.034**	**0.0052**
FB_Ore, Ore	–	–	100%	**–**	**–**	**4.0**	**–**	**–**	**–**	**–**	**–**	**–**	**0.00011**	**0.0011**	**1.5**	**0.42**	**0.011**	**0.50**	**1118**	**0.00018**	**0.031**	**0.011**	**0.015**	**0.21**	**282**	**530**	**0.083**	**145**	**0.16**	–	**0.011**	**0.87**	**0.022**	**0.0032**	**0.11**	**0.052**	**0.011**	**0.048**	**0.011**
FB_WR-S	–	–	72.00%	–	–	1.4	–	–	–	–	–	–	0.000086	0.00086	2.4	2.9	0.0086	0.41	520	0.00015	0.030	0.011	0.011	0.72	165	249	0.17	82	0.051	–	0.0086	3.0	0.043	0.0024	0.086	0.19	0.019	0.036	0.0086
FB_WR-I	–	–	15.90%	–	–	0.6	–	–	–	–	–	–	0.000056	0.00056	1.0	1.4	0.0056	0.31	278	0.00010	0.0046	0.0056	0.013	0.11	103	154	0.021	119	0.022	–	0.0056	0.63	0.0053	0.0017	0.056	0.027	0.023	0.019	0.0056
FB_WR-C	–	–	11.00%	–	–	2.3	–	–	–	–	–	–	0.000086	0.00086	1.8	0.20	0.0086	0.41	797	0.00015	0.0045	0.0086	0.010	0.30	124	219	0.12	70	0.018	–	0.0086	0.94	0.010	0.0026	0.086	0.045	0.0086	0.026	0.0086
FB_WR-M	–	–	0.90%	–	–	0.6	–	–	–	–	–	–	0.00018	0.0018	8.0	0.68	0.018	0.89	566	0.00033	0.0089	0.016	0.21	1.3	230	223	0.071	168	0.090	–	0.018	1.3	0.018	0.0054	0.18	0.079	0.033	0.070	0.026
FB_WR-E	–	–	0.40%	–	–	0.6	–	–	–	–	–	–	0.00013	0.0013	4.9	1.8	0.013	1.3	420	0.00021	0.0072	0.023	0.019	2.8	136	139	0.017	146	0.030	–	0.013	0.35	0.012	0.0038	0.13	0.060	0.092	0.045	0.014
FB_WR-PAG	–	–	0.06%	–	–	10.3	–	–	–	–	–	–	0.00010	0.0039	0.74	0.73	0.0090	0.82	2592	0.00023	0.023	0.0090	0.022	0.18	324	1213	0.16	252	0.10	–	0.0090	0.35	0.046	0.0027	0.090	0.042	0.0090	0.080	0.010
FB_WR-V	–	–	0.04%	–	–	0.8	–	–	–	–	–	–	0.00024	0.0024	4.0	2.0	0.024	1.2	819	0.00069	0.029	0.024	0.073	0.61	86	222	0.42	142	0.049	–	0.024	0.68	0.022	0.0072	0.24	0.11	0.076	0.13	0.024
Waste rock average*	0	0	100%	**0**	**0**	**1.4**	**0**	**0**	**0**	**0**	**0**	**0**	**0.000082**	**0.00082**	**2.2**	**2.3**	**0.0082**	**0.41**	**515**	**0.00014**	**0.023**	**0.010**	**0.013**	**0.59**	**151**	**231**	**0.14**	**88**	**0.043**	–	**0.0082**	**2.4**	**0.033**	**0.0023**	**0.082**	**0.15**	**0.019**	**0.032**	**0.0083**
2014 Surface loadings (μg/m^2/week, except for SO_4^{2-} mg/m^2/week)																																							
FB_OB, Overburden	2.77	89.2	100%	**–**	**–**	**0.06**	**–**	**–**	**–**	**–**	**–**	**–**	**0.00000059**	**0.0000059**	**0.0010**	**0.0032**	**0.000059**	**0.0025**	**23**	**0.0000010**	**0.00017**	**0.000059**	**0.00052**	**0.0066**	**0.55**	**5**	**0.00035**	**1.1**	**0.00016**	–	**0.000048**	**0.00012**	**0.00013**	**0.000018**	**0.00061**	**0.00025**	**0.000059**	**0.00038**	**0.000059**
FB_Ore, Ore	3.01	**17.5**	100%	**–**	**–**	**0.23**	**–**	**–**	**–**	**–**	**–**	**–**	**0.0000061**	**0.000061**	**0.089**	**0.024**	**0.00061**	**0.029**	**64**	**0.000010**	**0.0018**	**0.00061**	**0.00087**	**0.012**	**16**	**30**	**0.0048**	**8.3**	**0.0093**	–	**0.00061**	**0.050**	**0.0012**	**0.00018**	**0.0061**	**0.0029**	**0.00061**	**0.0027**	**0.00061**
FB_WR-S	2.80	13.6	72.00%	–	–	0.11	–	–	–	–	–	–	0.0000063	0.000063	0.17	0.21	0.00063	0.031	38	0.000011	0.0022	0.00078	0.00084	0.053	12	18	0.013	6.1	0.0037	–	0.00063	0.22	0.0032	0.00018	0.0063	0.014	0.0014	0.0026	0.00063
FB_WR-I	2.82	19.6	15.90%	–	–	0.03	–	–	–	–	–	–	0.0000029	0.000029	0.051	0.069	0.00029	0.016	14	0.0000049	0.00023	0.00029	0.00065	0.0057	5.3	8	0.0011	6.1	0.0011	–	0.00029	0.032	0.00027	0.000086	0.0029	0.0014	0.0012	0.0010	0.00029
FB_WR-C	3.23	17.8	11.00%	–	–	0.13	–	–	–	–	–	–	0.0000048	0.000048	0.10	0.011	0.00048	0.023	45	0.0000082	0.00025	0.00048	0.00054	0.017	6.9	12	0.0069	3.9	0.0010	–	0.00048	0.053	0.00054	0.00015	0.0048	0.0025	0.00048	0.0015	0.00048
FB_WR-M	2.83	25.4	0.90%	–	–	0.02	–	–	–	–	–	–	0.0000070	0.000070	0.31	0.027	0.00070	0.035	22	0.000013	0.00035	0.00062	0.0082	0.053	9.0	9	0.0028	6.6	0.0036	–	0.00070	0.051	0.00070	0.00021	0.0070	0.0031	0.0013	0.0027	0.0010
FB_WR-E	2.81	23.4	0.40%	–	–	0.02	–	–	–	–	–	–	0.0000054	0.000054	0.21	0.079	0.00054	0.057	18	0.0000092	0.00031	0.00098	0.00083	0.12	5.8	6	0.00073	6.2	0.0013	–	0.00054	0.015	0.00052	0.00016	0.0054	0.0025	0.0039	0.0019	0.00058
FB_WR-PAG	2.94	13.3	0.06%	–	–	0.78	–	–	–	–	–	–	0.0000077	0.00030	0.056	0.055	0.00068	0.062	195	0.000017	0.0017	0.00068	0.0016	0.014	24	91	0.012	19	0.0076	–	0.00068	0.026	0.0035	0.00020	0.0068	0.0031	0.00068	0.0060	0.00072
FB_WR-V	2.81	18.7	0.04%	–	–	0.04	–	–	–	–	–	–	0.000013	0.00013	0.22	0.11	0.0013	0.064	44	0.000037	0.0015	0.0013	0.0039	0.033	4.6	12	0.023	7.6	0.0026	–	0.0013	0.036	0.0012	0.00039	0.013	0.0058	0.0041	0.0072	0.0013
Waste rock average*	**2.86**	**15.2**	100%	**0**	**0**	**0.10**	**0**	**0**	**0**	**0**	**0**	**0**	**0.0000056**	**0.000056**	**0.15**	**0.16**	**0.00056**	**0.028**	**35**	**0.0000098**	**0.0017**	**0.00067**	**0.00085**	**0.042**	**10**	**16**	**0.010**	**5.9**	**0.0030**	–	**0.00056**	**0.17**	**0.0024**	**0.00016**	**0.0056**	**0.011**	**0.0013**	**0.0022**	**0.00057**
2015 Mass loadings (μg/kg/week, except for SO_4^{2-} mg/kg/week)																																							
FB_OB, Overburden	–	–	100%	**–**	**–**	**0.99**	**–**	**–**	**–**	**–**	**–**	**–**	**0.000013**	**0.00011**	**0.019**	**0.12**	**0.00016**	**0.063**	**452**	**0.000099**	**0.0049**	**0.00039**	**0.025**	**0.13**	**15**	**110**	**0.016**	**20**	**0.0078**	**0.0813**	**0.000081**	**0.0050**	**0.0011**	**0.000048**	**0.022**	**0.0032**	**0.00081**	**0.0061**	**0.00049**
FB_Ore, Ore	–	–	100%	**–**	**–**	**2.23**	**–**	**–**	**–**	**–**	**–**	**–**	**0.000031**	**0.000062**	**0.57**	**0.16**	**0.00062**	**0.14**	**705**	**0.000044**	**0.025**	**0.00062**	**0.0051**	**0.062**	**97**	**341**	**0.045**	**27**	**0.029**	**0.311**	**0.00031**	**0.32**	**0.014**	**0.000062**	**0.0052**	**0.018**	**0.0031**	**0.0097**	**0.0019**
FB_WR-S	–	–	72.00%	–	–	2.60	–	–	–	–	–	–	0.000027	0.000054	0.38	0.74	0.00054	0.17	785	0.00017	0.065	0.00054	0.0057	0.054	82	323	0.17	36	0.049	0.270	0.00027	1.2	0.021	0.00022	0.0042	0.17	0.0035	0.010	0.0016
FB_WR-I	–	–	15.90%	–	–	0.17	–	–	–	–	–	–	0.000012	0.000024	0.43	0.55	0.00024	0.06	109	0.000012	0.0021	0.00024	0.0034	0.024	23	51	0.0078	18	0.0039	0.1216	0.00012	0.23	0.0018	0.000024	0.0033	0.0061	0.0098	0.0051	0.00073
FB_WR-C	–	–	11.00%	–	–	1.34	–	–	–	–	–	–	0.000021	0.000042	0.30	0.061	0.00042	0.14	477	0.000084	0.0030	0.00042	0.0072	0.042	46	168	0.21	24	0.0021	0.2077	0.00021	0.52	0.010	0.000042	0.011	0.033	0.0021	0.0050	0.0012
FB_WR-M	–	–	0.90%	–	–	0.70	–	–	–	–	–	–	0.000063	0.00013	2.7	0.26	0.0013	0.13	595	0.00014	0.0017	0.0013	0.028	0.13	66	208	0.14	43	0.0063	0.6250	0.00063	1.0	0.0060	0.00013	0.0055	0.029	0.013	0.031	0.0038
FB_WR-E	–	–	0.40%	–	–	0.91	–	–	–	–	–	–	0.000025	0.000050	0.63	1.4	0.00050	0.31	385	0.000040	0.0053	0.00063	0.0082	0.050	62	98	0.026	32	0.0063	0.2481	0.00025	0.14	0.0053	0.00010	0.0025	0.0059	0.032	0.014	0.0015
FB_WR-PAG	–	–	0.06%	–	–	2.35	–	–	–	–	–	–	0.000010	0.000019	0.10	0.078	0.00019	0.11	549	0.000050	0.0056	0.00019	0.0037	0.019	47	300	0.037	23	0.0050	0.0961	0.00014	0.049	0.0097	0.000090	0.0019	0.0044	0.00096	0.010	0.00058
FB_WR-V	–	–	0.04%	–	–	0.70	–	–	–	–	–	–	0.000055	0.00011	1.5	0.93	0.0011	0.11	560	0.00012	0.0066	0.0011	0.038	0.11	39	127	0.20	30	0.018	0.545	0.00055	0.41	0.010	0.00011	0.018	0.034	0.020	0.024	0.0033
Waste rock average*	0	0	100%	**0**	**0**	**2.1**	**0**	**0**	**0**	**0**	**0**	**0**	**0.000024**	**0.000049**	**0.40**	**0.64**	**0.00049**	**0.15**	**643**	**0.00013**	**0.048**	**0.00049**	**0.0058**	**0.049**	**68**	**262**	**0.15**	**32**	**0.036**	**0.243**	**0.00024**	**0.96**	**0.016**	**0.00017**	**0.0049**	**0.13**	**0.0046**	**0.009**	**0.0015**
2015 Surface loadings (μg/m^2/week, except for SO_4^{2-} mg/m^2/week)																																							
FB_OB, Overburden	2.77	89.2	100%	**–**	**–**	**0.011**	**–**	**–**	**–**	**–**	**–**	**–**	**0.00000014**	**0.0000013**	**0.00021**	**0.0013**	**0.0000018**	**0.00071**	**5.1**	**0.0000011**	**0.00005**	**0.0000043**	**0.00028**	**0.0015**	**0.17**	**1.2**	**0.00018**	**0.22**	**0.000088**	**0.000912**	**0.00000091**	**0.000056**	**0.000012**	**0.00000053**	**0.00025**	**0.000036**	**0.0000091**	**0.000069**	**0.0000055**
FB_Ore, Ore	3.01	**17.5**	100%	**–**	**–**	**0.13**	**–**	**–**	**–**	**–**	**–**	**–**	**0.0000018**	**0.0000036**	**0.032**	**0.0093**	**0.000036**	**0.0078**	**40**	**0.0000025**	**0.0015**	**0.000036**	**0.00029**	**0.0036**	**5.6**	**19**	**0.0025**	**1.6**	**0.0017**	**0.0178**	**0.000018**	**0.018**	**0.00078**	**0.0000036**	**0.00030**	**0.0010**	**0.00018**	**0.00056**	**0.00011**
FB_WR-S	2.80	13.6	72.00%	–	–	0.19	–	–	–	–	–	–	0.0000020	0.0000040	0.028	0.055	0.000040	0.013	58	0.000012	0.0048	0.000040	0.00042	0.0040	6.0	24	0.012	2.6	0.0036	0.0199	0.000020	0.088	0.0015	0.000016	0.00031	0.013	0.00026	0.00075	0.00012
FB_WR-I	2.82	19.6	15.90%	–	–	0.009	–	–	–	–	–	–	0.00000062	0.0000012	0.022	0.028	0.000012	0.0031	5.6	0.0000006	0.00011	0.000012	0.00018	0.0012	1.2	2.6	0.00040	0.92	0.00020	0.00621	0.0000062	0.012	0.000092	0.0000012	0.00017	0.00031	0.00050	0.00026	0.000037
FB_WR-C	3.23	17.8	11.00%	–	–	0.075	–	–	–	–	–	–	0.0000012	0.0000023	0.017	0.0034	0.000023	0.0081	27	0.0000047	0.00017	0.000023	0.00041	0.0023	2.6	9.5	0.012	1.3	0.00012	0.01167	0.000012	0.029	0.00059	0.0000023	0.00064	0.0019	0.00012	0.00028	0.000070
FB_WR-M	2.83	25.4	0.90%	–	–	0.027	–	–	–	–	–	–	0.0000025	0.0000049	0.11	0.010	0.000049	0.0049	23	0.0000054	0.000066	0.000049	0.0011	0.0049	2.6	8.2	0.0055	1.7	0.00025	0.02457	0.000025	0.039	0.00024	0.0000049	0.00022	0.0011	0.00050	0.0012	0.00015
FB_WR-E	2.81	23.4	0.40%	–	–	0.039	–	–	–	–	–	–	0.0000011	0.0000021	0.027	0.060	0.000021	0.013	16	0.0000017	0.00023	0.000027	0.00035	0.0021	2.7	4.2	0.0011	1.3	0.00027	0.01061	0.000011	0.0059	0.00023	0.0000043	0.00011	0.00025	0.0014	0.00058	0.000064
FB_WR-PAG	2.94	13.3	0.06%	–	–	0.18	–	–	–	–	–	–	0.00000072	0.0000014	0.008	0.0059	0.000014	0.0086	41	0.0000038	0.00042	0.000014	0.00028	0.0014	3.6	23	0.0028	1.8	0.00038	0.00722	0.000010	0.0037	0.00073	0.0000068	0.00014	0.00033	0.000072	0.00074	0.000043
FB_WR-V	2.81	18.7	0.04%	–	–	0.037	–	–	–	–	–	–	0.0000029	0.0000058	0.081	0.050	0.000058	0.0058	30	0.0000063	0.00035	0.000058	0.0021	0.0058	2.1	6.8	0.011	1.6	0.00098	0.02915	0.000029	0.022	0.00053	0.0000058	0.00094	0.0018	0.0010	0.0013	0.00017
Waste rock average*	**2.86**	**15.2**	100%	**0**	**0**	**0.15**	**0**	**0**	**0**	**0**	**0**	**0**	**0.0000017**	**0.0000034**	**0.027**	**0.045**	**0.000034**	**0.011**	**46**	**0.0000095**	**0.0035**	**0.000034**	**0.00039**	**0.0034**	**4.8**	**19**	**0.010**	**2.2**	**0.0027**	**0.0169**	**0.000017**	**0.069**	**0.0012**	**0.000012**	**0.00032**	**0.0095**	**0.00029**	**0.00063**	**0.00010**

Note: – Not analyzed; * Waste rock average weighted by % material represented; Bolded values were used as input in Equation 5-1.

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APPENDIX B4: DERIVATION OF SCALE UP FACTORS

Appendix B4: Derivation of scale up factors

R_{BF} Determination

The R_{BF} term is determined from field kinetic testing that was completed between May 2014 and November 2014. A total of 10 field bins were set up to characterize leaching rates from various waste-rock lithologies, ore, and overburden soils. Details of the testing are discussed in the geochemical characterization report which is currently in process. Summary of the cumulative average loading rates from the field bins are provided in Table **Attachment B3**. Bolded values in that table are used as input for unscaled loading rates to the model.

SF_{AREA} Determination

In field bins, material is cursed down minus 6 mm and has significantly higher reactive area per mass unit than blasted material deposited in stockpiles. Therefore, loadings from field bins should be adjusted to be reflective of the conditions within the waste-rock piles. Factor SF area was used to make such adjustments. Such adjustment can be made, if the specific surface area of the material stockpiles is divided by the specific surface area of the same material in the field bins. Specific surface area materials in field bins were estimated from particle size distribution analysis and are reported in (**Attachment B3**). Particle size for of the blasted waste rock and ore was estimated by Gmining for fractions above 1 mm, which is not sufficient for calculation of specific surface area, but enough to find similar waste rock tested for smaller fractions (**Gmining 2014, Table B4-1**). Distribution for larger fractions, which is predicted by the Hardrock fragmentation model, is similar to waste rock from the Daivik mine (Smith et al. 2013). Therefore, sieve data from the Daivik mine can be used as surrogate for Hardrock waste-rock and ore stockpiles. A specific surface area of 2.0 m^2/kg was calculated for Dvaik waste rock and is used as a specific surface area for the proposed waste rock and ore in stockpiles of Hardrock project. Dividing the surface area from the Daivik study (2.0 m^2/kg) by an average weighted specific surface area of waste rock in the field bins (15.2 m^2/kg) by the, a SF_{AREA} of 0.13 was calculated.

SF_T Determination

The loading rates from the field bins reflected only summer temperatures and did not account for the internal temperatures of the large waste-rock dumps, which will be closer to average ground temperatures. The scale factor for temperature was calculated using a rearranged form of the Arrhenius equation:

$$SF_T = r_{\text{full dump}}/r_{\text{field bin}} = \exp[-E_a/R\times(1/T_{\text{field bin}} - 1/T_{\text{full dump}})] \quad \text{(C1)}$$

$r_{\text{full dump}}/r_{\text{field bin}}$ – ratio of reaction rates in field bin and in full dump, respectively;

E_a: activation energy for arsenopyrite, major carrier of arsenic, is 18.5 kJ/mole (McKibben et. al 2008)

R: universal gas constant (0.008314 kJ/mole/°K);

$T_{\text{full dump}}$ and $T_{\text{field bin}}$ – temperatures in the dump and in the field bin, respectively (°K).

The average temperature of leachate from the field bins was 14.5 °C (252°K). Average ground temperatures were assumed to be equal to the average annual temperature of shallow groundwater, which was measured at 6.4 C° (243.9°K) at 1.5 m below the ground surface (Stantec 2014). Significant heating of the stockpiles is not expected from exothermic reactions of sulfide oxidation due to the relatively low content of sulfide minerals in ore or waste-rock

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stockpiles compared with the cases where this effect was observed (MEND 1994). Based on the selected inputs, the SF_T factor is calculated as 0.8, indicating little dependence of arsenopyrite oxidation on temperature (McKibben et al, 2008).

Table B4-1: Comparison Waste-rock Fragmentation at Hardrock and Daivik

Size (mm)	Hardrock - JK Fragmentation Model				Daivik Sieved	
	Cumulative % Passing				Mass Fraction	Surface Area
	HRQD	MRQD	LRQD	Sample	g/kg	m^2/kg
0.08	no data	no data	no data	1.8	18	1.269
0.10	no data	no data	no data	2.4	6	0.134
0.20	no data	no data	no data	4.0	16	0.226
0.50	no data	no data	no data	7.2	32	0.202
1	6	6	6	9.6	24	0.068
5	12	13	13	17.2	76	0.068
10	17	17	17	22	48	0.014
20	22	23	23	28	60	0.008
50	32	33	34	40	120	0.008
100	42	43	44	52	120	0.003
250	71	76	80	72	200	0.003
400	91	94	96	80	80	0.001
500	97	98	99	83	30	0.0001
750	100	100	100	90	70	0.0002
1000	100	100	100	100	100	0.0002
Total						**2.00**

$SF_{CONTACT}$ Determination

The water contact factor is related to the internal structure of the stockpiles, having large variability in unsaturated hydraulic conductivity. The contact factor accounts for a reduction in solute leaching because some portions of the piles are expected to become hydraulically isolated through the development of preferential flow paths and will not be flushed by pore water as often as the bins, some of which were also artificially irrigated (Stantec 2015). The review of contact water factors indicated they generally range between 0.1 and 0.65 (Kempton 2012). A mid-range value of 0.35 was selected as the average annual water contact factor for all waste rock and ore. This value was distributed for each month proportionally to runoff from the storage areas, as shown in **Table B4-2.**

The other scale-up factors such as the factor accounting for the decrease in sulfide oxidation due to lower pore-gas oxygen concentrations inside the waste-rock pile were assumed to be insignificant. A decrease in oxygen content is observed in waste rock containing over 15% of sulfide sulfur on average (Kempton 2012). Average concentrations of sulfide sulfur do not exceed 1% in any major waste rock lithologies supporting our assumption (Stantec 2015).

Table B4-2 Contact Factors used in to Scale-up Rates from Field Bins

Month	SFcontact	Month	SFcontact
January	0.03	July	0.56
February	0.06	August	0.43
March	0.07	September	0.54
April	0.43	October	0.46
May	0.8	November	0.24
June	0.43	December	0.15
Annual Average			**0.35**

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APPENDIX B5: RUBBLE TONNAGE ON CATCH BENCHES FINAL PIT 2D SURFACE AREA PER 20 M INTERVAL MEMORANDUM (GMINING SERVICES 2016)

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Memorandum

To: **Bouchaib Semlali**

CC: **Louis-Pierre Gignac & Stantec**

From: **Agata Loboda**

Date: **July 21rst 2016**

Subject : **Hardrock Project – Rubble tonnage on catch benches**

For environmental purpose, potential rubble quantity on catch benches was calculated.

Tables below show on which elevation the catch bench is found, at 20m intervals, and the quantity of rubble expected. Majority of catch benches are 10m wide, at the exception of geotechnical berms of 16m wide found every 140m. The waste rock angle of repose used is of 37°.

The total potential quantity of rubble on catch benches at end of mine life is of 5.4 Mt in the main pit and 0.2Mt in Satellite pit.

Table 1 : Rubble Tonnage and volume per elevation in Satellite Pit

SATELLITE PIT						
Elevation Bench	Crest Length	Catch Bench Width	Height Rubble	2D area rubble	Volume Rubble on Catch Bench	Tonnage Rubble
m	*m*	*m*	*m*	*m²*	*m³*	*tonne*
300	1324	10	5.73	28.67	37 967	**81 483**
280	933	10	5.73	28.67	26 742	**57 392**
260	653	10	5.73	28.67	18 725	**40 186**
240	547	10	5.73	28.67	15 687	**33 667**
220	405	10	5.73	28.67	11 609	**24 915**
						237 643

Note: The satellite pit is planned to be backfilled from year 2025.

Table 2 : Rubble Tonnage and volume per elevation in Main Pit

MAIN PIT						
Elevation Bench	Crest Length	Catch Bench Width	Height Rubble	2D area rubble	Volume Rubble on Catch Bench	Tonnage Rubble
m	m	m	m	m^2	m^3	tonne
310	4460	16	9.17	73.39	327 374	**702 595**
290	4455	10	5.73	28.67	127 723	**274 114**
270	4339	10	5.73	28.67	124 394	**266 968**
250	3888	10	5.73	28.67	111 475	**239 243**
230	3464	10	5.73	28.67	99 319	**213 153**
210	3308	10	5.73	28.67	94 843	**203 547**
190	3221	16	9.17	73.39	236 395	**507 341**
170	3152	10	5.73	28.67	90 374	**193 956**
150	3055	10	5.73	28.67	87 577	**187 954**
130	2944	10	5.73	28.67	84 397	**181 129**
110	2914	10	5.73	28.67	83 535	**179 278**
90	2814	10	5.73	28.67	80 688	**173 169**
70	2763	10	5.73	28.67	79 202	**169 979**
50	2652	16	9.17	73.39	194 665	**417 781**
30	2569	10	5.73	28.67	73 640	**158 044**
10	2415	10	5.73	28.67	69 224	**148 565**
-10	2313	10	5.73	28.67	66 316	**142 325**
-30	2210	10	5.73	28.67	63 358	**135 975**
-50	2164	10	5.73	28.67	62 040	**133 146**
-70	2157	10	5.73	28.67	61 827	**132 690**
-90	1992	16	9.17	73.39	146 213	**313 796**
-110	1538	10	5.73	28.67	44 091	**94 627**
-130	1099	10	5.73	28.67	31 506	**67 616**
-150	928	10	5.73	28.67	26 617	**57 125**
-170	824	10	5.73	28.67	23 622	**50 696**
-190	676	10	5.73	28.67	19 369	**41 569**
-210	459	10	5.73	28.67	13 148	**28 219**
-230	261	8.6	4.91	21.06	5 502	**11 809**
						5 426 408

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Memorandum

To:	**Stantec - Nikolay Sidenko**
CC:	**Bouchaib Semlali & Louis-Pierre Gignac**
From:	**Agata Loboda**
Date:	**September 14 2016**
Subject:	**Final Pit 2D Surface Area per 20m interval**

The memorandum presents the surface area, in square meters (m^2), of the rock face exposed after mining at each 20m bench for the Final Pit design (Phase 3 and Satellite Pit). Table 1 presents the 2D surface area of Phase 3 and Table 2 presents the 2D surface area of Satellite pit.

The total open surface area is of 2 970 135 m^2 including fresh rock and overburden. Overburden excavation sums up to an exposed surface of 660 973 m^2. Fresh rock in Phase 3 sums up to an excavated 2D area of 2 188 515 m^2 and of 120 646m^2 for the Satellite Pit.

Figure 1 – 3D View of Final Pit Design

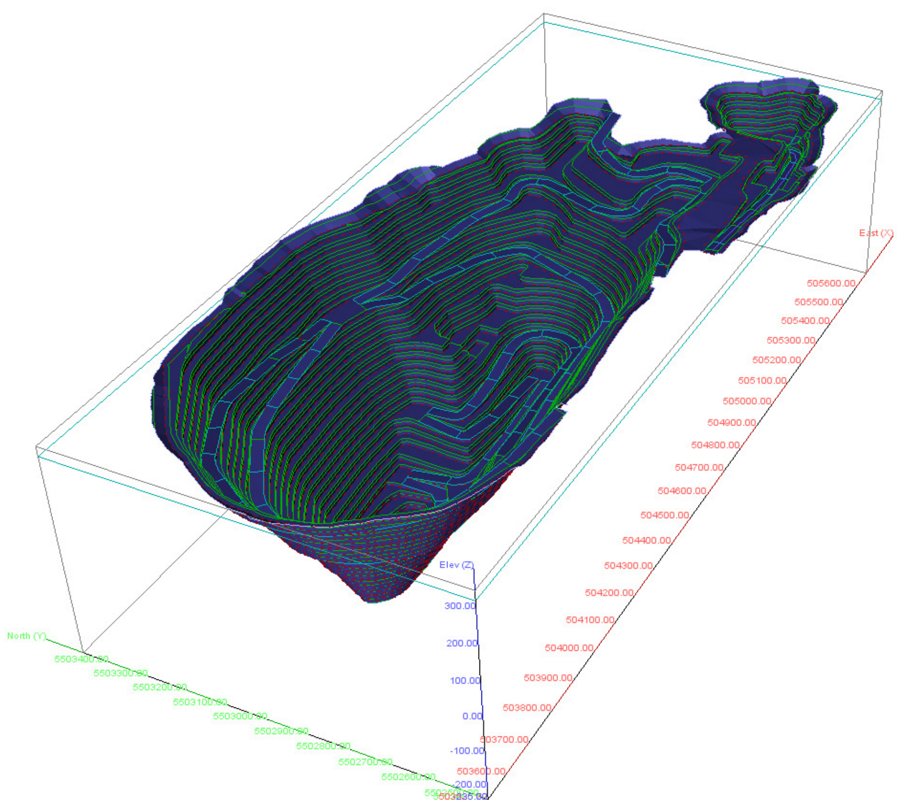

Table 1 – Final Pit 2D Surface Area Open

Bench	Bench Face Area	Catch Bench Area	2D Surface Area
	m^2	m^2	m^2
Ovb	-	-	**660 973**
310	89 209	63 422	**152 631**
290	89 099	56 025	**145 124**
270	86 777	47 379	**134 156**
250	77 765	57 745	**135 510**
230	69 285	41 766	**111 051**
210	66 162	38 206	**104 367**
190	64 417	39 928	**104 345**
170	63 044	28 956	**92 001**
150	61 093	29 776	**90 869**
130	58 875	27 048	**85 924**
110	58 273	28 465	**86 739**
90	56 288	31 349	**87 637**
70	55 251	25 089	**80 340**
50	53 046	34 370	**87 416**
30	51 371	29 661	**81 032**
10	48 290	31 593	**79 883**
-10	46 262	21 620	**67 882**
-30	44 198	27 977	**72 175**
-50	43 279	25 341	**68 620**
-70	43 130	20 111	**63 242**
-90	39 843	24 491	**64 334**
-110	30 758	20 802	**51 560**
-130	21 978	14 865	**36 843**
-150	18 568	10 049	**28 617**
-170	16 479	9 894	**26 372**
-190	13 512	7 512	**21 024**
-210	9 172	8 715	**17 888**
-230	2 613	8 322	**10 935**
-250	-	-	**-**
TOTAL	**1 378 039**	**810 476**	**2 849 488**

Table 2 - Satellite Pit 2D Surface Area Open

Bench	Bench Face Area	Catch Bench Area	2D Surface Area
	m^2	m^2	m^2
Ovb	-	-	**-**
300	26 486	17 612	**44 098**
280	18 655	8 252	**26 907**
260	13 062	7 429	**20 491**
240	10 943	5 768	**16 712**
220	4 049	8 390	**12 439**
200	-	-	**-**
TOTAL	**73 195**	**47 451**	**120 646**

APPENDIX B6: DETAILED IN-PIT DUMPING MEMORANDUM (GMINING SERVICES INC. 2016)

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Memorandum

To: Bouchaib Semlali

CC: Louis-Pierre Gignac & Stantec Team

From: Agata Loboda

Date: July 21rst 2016

Subject : Hardrock Project – Detailed In-pit dumping

Details on in-pit dumping, tonnage per elevation, was requested.

In the following table, planes represent the quantity of waste rock from the defined plane elevation and 10m upwards. For example, the Satellite pit is backfilled with 1'587 kt at plane 300; which means the 1'587 kt are spread between elevation 300 and 310.

Following is a figure showing a section view of the open pit. In yellow is the area of in-pit dumping in main pit and in blue is the whole satellite pit backfilled. The WRA A Extension is shown in purple and will be pilled after both Main in-pit dumping and Satellite pit backfill are done.

Table 1 : Backfill Quantity per area

PLANE	Satellite Pit Backfill		Main In-Pit Dumping		Total In-Pit Dumping
	Volume (000'm³)	*Tonnage (kt)*	*Volume (000'm³)*	*Tonnage (kt)*	*Tonnage (kt)*
350	-	-	-	-	-
340	-	-	-	-	-
330	-	-	-	-	-
320	1 216	2 611	628	1 348	3 959
310	804	1 725	597	1 280	3 005
300	739	1 587	408	876	2 462
290	536	1 150	438	940	2 090
280	506	1 086	262	562	1 648
270	394	846	273	585	1 431
260	362	778	191	410	1 187
250	263	565	225	483	1 047
240	246	527	56	121	648
230	168	361	66	142	503
220	150	322	-	-	322
210	47	101	-	-	101
200	-	-	-	-	-
TOTAL	5 432	11 658	3 143	6 745	18 403

Figure 1 : Backfill Areas – Section View

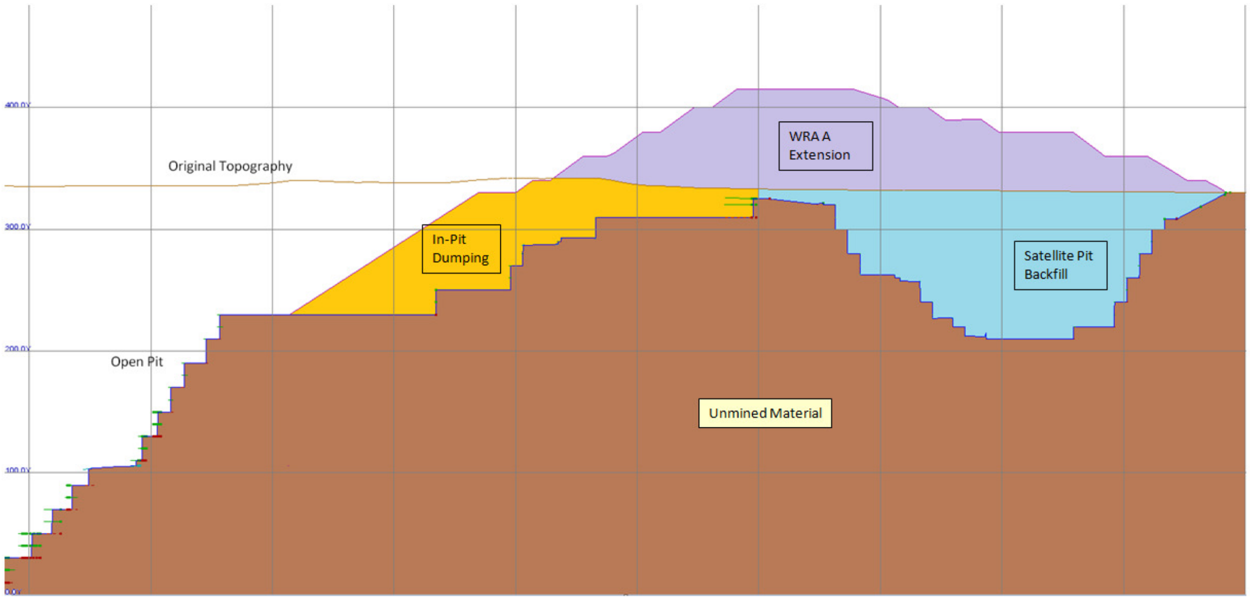
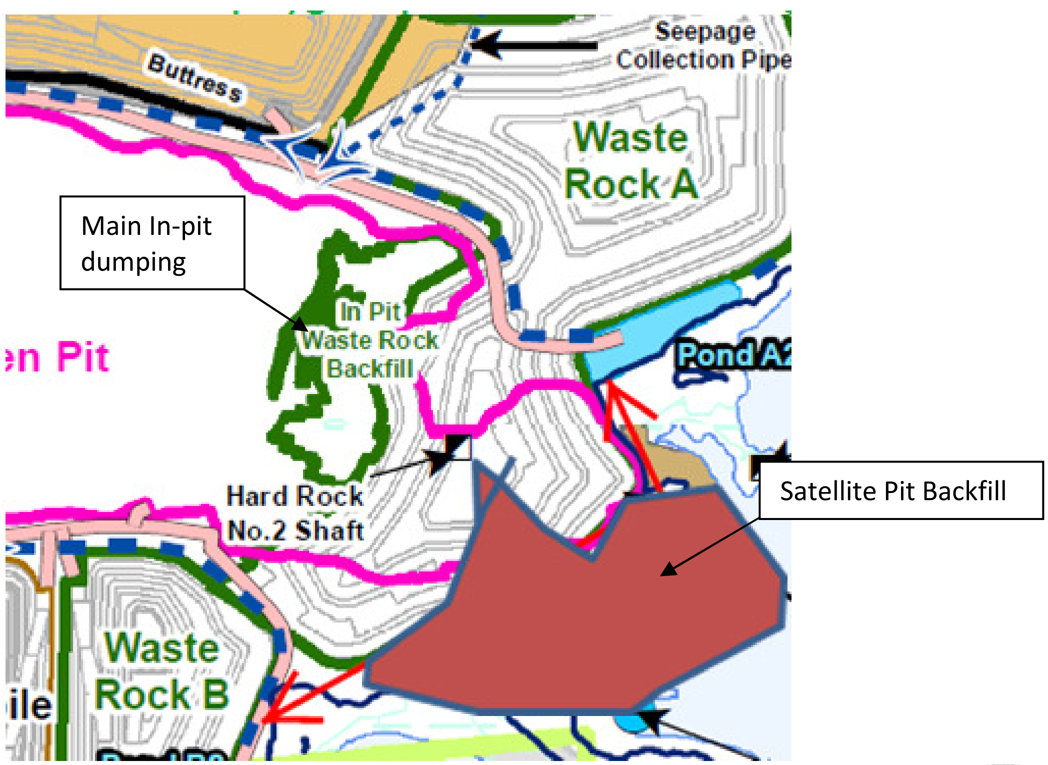


Figure 2 : ID-153_Figure: Original Provided by Stantec



Note:

The ***Green*** *outlined area is presented as the Main In-pit dumping in Table 1. The Red outline is presented in Table 1 as the Satellite Pit Backfill.*

APPENDIX B7: CONCENTRATIONS OF NITROGEN, CYANIDE SPECIES, AND TRACE ELEMENTS (mg/L) IN THE SOLUTIONS BEFORE (BARREN SOLUTIONS) AND AFTER CYANIDE DESTRUCTION

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Appendix B7. Concentrations of nitrogen, cyanide species, and trace elements (mg/L) in the solutions before (barren solutions) and after cyanide destruction

Test No.	Solution	$CN_{(T)}$	$CN_{(F)}$	CN_{WAD}	CNS	CNO	NH_3	NO_2	NO_3	Ag	Al	As	Be	B	Ca	Cd	Co	Cr	Cu	Fe	K	Mg	Mo	Na	Ni	P	Pb	Sb	Se	Si	Tl	U	V	Zn
CN-71	Final Barren	316	200	195	32	50	0.9	-	-	0.002	1.75	0.76	*0.00001*	0.04	10	0.000566	0.18	0.004	5.99	2.18	39.9	0.20	0.04	339	0.109	0.141	0.001	0.29	0.004	3.75	*0.0001*	0.00004	0.00944	0.95
CND8-2	Final Destruction	0.27	*1*	0.02	38	210	2.6	*0.49*	*1.3*	0.000005	0.04	0.0018	*0.00001*	0.02	257	0.000077	0.0013	0.0013	0.01	0.12	54.6	11.50	0.00	618	0.0089	0.018	0.001	0.0024	0.002	1.85	*0.0001*	0.00007	0.00014	*0.001*
CN-55	Final Barren	241	160	215	62	48	1.1	-	-	0.03980	2.21	4.62	*0.00001*	0.03	16.70	0.000166	0.22	0.003	6.95	3.63	43.4	0.25	0.05	304	0.181	*0.0045*	0.004	0.21	0.004	3.65	*0.0001*	0.00013	0.0229	0.90
CND5-1	Final Destruction	1.49	*1*	0.03	49	180	8.7	*0.49*	*1.3*	0.00007	0.06	0.186	*0.00001*	0.03	286	0.000024	0.10	0.00025	0.03	0.55	64.0	7.24	0.04	827	0.102	0.019	0.000	0.07	0.001	2.07	0.0003	0.00315	0.00026	*0.001*
CN-56	Final Barren	267	190	209	22	44	1.2	-	-	0.00715	1.80	2.90	*0.00001*	0.02	7.30	0.000062	0.18	0.0028	5.35	3.08	33.8	0.32	0.04	288	0.0845	*0.0045*	0.008	0.20	0.002	3.73	*0.0001*	0.00013	0.0149	0.93
CND6-2	Final Destruction	0.94	*1*	0.03	20	160	6.6	*0.49*	*1.3*	0.00003	0.05	0.134	*0.00001*	0.02	294	0.000026	0.08	0.00025	0.02	0.36	57.5	11.7	0.03	735	0.037	0.024	0.000	0.08	0.001	2.35	*0.0001*	0.00247	0.00023	*0.001*
CN-57	Final Barren	219	175	194	13	44	1.2	-	-	0.08150	11.10	0.51	0.0002	0.03	16.7	0.0119	0.19	0.0325	10.3	15.0	35.0	10.3	0.05	314	0.282	0.287	0.028	0.90	0.008	16.8	*0.0001*	0.00163	0.0337	5.1
CND2-1	Final Destruction	3.67	0.03	0.03	15	200	7.8	*0.49*	*1.3*	0.00013	0.07	0.02	*0.00001*	0.02	309	0.000047	0.11	0.00025	0.02	1.41	50.6	12.5	0.04	762	0.0076	0.013	0.022	0.36	0.002	1.80	*0.0001*	0.00658	0.00024	*0.001*
CN-58	Final Barren	245	104	214	180	32	0.5	-	-	0.00277	0.93	0.36	*0.00001*	0.03	6.60	0.00175	0.12	0.0034	5.56	12.6	36.5	0.82	0.05	458	0.111	0.124	0.003	0.25	0.001	1.01	*0.0001*	0.00031	0.00168	0.78
CND7-3	Final Destruction	24	*1*	0.14	130	70	1.7	*0.49*	*1.3*	0.00007	0.05	0.07	*0.00001*	0.02	68.0	1.5E-06	0.06	0.00025	0.13	8.00	35.5	14.9	0.03	423	0.0397	*0.0045*	0.00013	0.07	0.016	1.44	*0.0001*	0.00183	*0.000015*	*0.001*
CN-59	Final Barren	270	177	187	16	34	1.7	-	-	0.00274	2.22	1.37	*0.00001*	0.03	14.8	0.00005	0.22	0.0014	4.74	1.83	41.0	0.26	0.05	305	0.207	0.135	0.002	0.88	0.004	3.78	*0.0001*	0.00010	0.0172	0.83
CND10-3	Final Destruction	0.97	*1*	0.03	20	200	4.1	*0.49*	*1.3*	0.00003	0.06	0.04	*0.00001*	0.02	164.0	0.000029	0.11	0.00025	0.04	0.32	53.7	13	0.04	514	0.0367	0.011	0.000	0.23	0.003	1.46	*0.0001*	0.00344	0.00011	*0.001*
CN-60	Final Barren	186	156	161	39	38	1.6	-	-	0.00263	1.19	0.14	*0.00001*	0.02	2.80	0.00058	0.06	0.0019	4.18	7.51	34.5	0.35	0.04	315	0.0393	0.014	0.003	0.15	0.002	1.52	*0.0001*	0.00039	0.0016	1.37
CND3-R	Final Destruction	14.0	*1*	< 0.1	32	120	2.1	*0.49*	*1.3*	0.00007	0.08	0.01	*0.00001*	0.02	108	0.000015	0.03	0.0005	0.09	3.17	41.4	14.8	0.04	506	0.0151	0.033	0.000	0.06	0.002	1.38	*0.0001*	0.00284	0.00012	*0.001*
CN-61	Final Barren	216	220	214	7.6	35	1.5	-	-	0.09130	1.76	1.61	*0.00001*	0.02	6.22	0.000351	0.07	0.0039	4.29	2.69	40.9	0.23	0.04	333	0.0215	0.034	0.007	0.04	0.002	5.84	*0.0001*	0.00016	0.0164	2.37
CND4-3	Final Destruction	0.12	*1*	0.03	8.9	140	4.0	*0.49*	*1.3*	0.00002	0.09	0.07	*0.00001*	0.02	200	0.000012	0.03	0.00025	0.08	0.07	52.8	8.41	0.04	680	0.0184	0.046	0.001	0.02	0.001	2.22	*0.0001*	0.00298	0.00023	*0.001*
CN-62	Final Barren	341	125	145	160	23	9.4	-	-	0.00845	0.94	0.17	*0.00001*	0.06	8.83	0.000383	0.06	0.0017	4.36	18.0	35.7	0.58	0.05	377	0.0902	0.107	0.002	0.05	0.002	1.08	*0.0001*	0.00061	0.00155	0.78
CND9-2	Final Destruction	33.7	*1*	0.17	160	85	1.8	*0.49*	*1.3*	0.00022	0.06	0.0242	*0.00001*	0.02	117	0.000048	0.04	0.00025	0.37	11.60	50.6	14.5	0.0383	558	0.0442	0.021	0.0001	0.0225	0.001	1.18	*0.0001*	0.00209	0.0001	0.002
CN-63	Final Barren	301	210	271	74	31	1.0	-	-	0.684	2.06	2.85	*0.00001*	0.03	9.73	0.000477	0.145	0.0027	6.00	3.3	35.4	0.377	0.0584	365	0.112	0.249	0.00272	0.153	0.01	3.29	*0.0001*	0.000045	0.011	0.907
CND11-4	Final Destruction	1.90	*1*	0.05	63	150	4.4			2.7E-05	0.12	0.241	*0.0000035*	0.03	257	0.000002	0.0849	0.00008	0.0319	1.01	51.8	10.1	0.0344	785	0.0113	0.018	0.00009	0.0819	0.003	2.07	0.000072	0.00224	0.00046	*0.001*
Average Weighted Final Barren		240	167	198	56	38	1.7	-	-	0.068	3.35	1.52	0.00004	0.03	10	0.0026	0.14	0.0081	6.1	7.9	38	2.2	0.047	336	0.14	0.11	0.0084	0.36	0.0039	5.5	0.00010	0.00049	0.015	1.9
Average Weighted Final Destruction		8.10	0.82	0.06	48	150	4.9	0.47	1.26	0.000075	0.070	0.076	0.00001	0.02	203	0.000024	0.072	0.00028	0.077	2.6	50	12	0.036	645	0.035	0.021	0.0041	0.13	0.0034	1.8	0.00013	0.0034	0.00019	0.0011
Ratio Average Destruction to Average Barren		**0.034**	**0.0049**	**0.00032**	**0.85**	3.9	2.8	**0**	**0**	**0.0011**	**0.021**	**0.050**	**0.26**	**0.78**	19	**0.0091**	**0.50**	**0.03**	**0.013**	**0.33**	1.3	5.4	**0.77**	1.9	**0.26**	**0.20**	**0.49**	**0.35**	**0.89**	**0.32**	1.3	7.0	**0.012**	**0.00056**
Addition Factor to Account for Concentration Increase During Destruction		0	0	0	0	**2.9**	**1.8**	0	0	0	0	0	0	0	**18.4**	0	0	0	0	0	**0.3**	**4.4**	0	**0.9**	0	0	0	0	0	0	**0.3**	**6.0**	0	0

Note: Half detection limits (DLs) were used for calculations in case if concentrations were less than their DLs; Half DLs are highlighted in italics; All metals analyzed are dissolved metals; Equal mass of ore and solution was used in metallurgical and cyanide destruction tests, which allows to directly convert measured concentrations from mg/L to mass release/attenuation per mass unit of ore, mg/kg (See RCN or KDESTR in Equation 5.7); Shaded values used as input to RCN in Equation 5.7; Values in bold are used as input to KDESTR in Equation 5.7.

APPENDIX B8: UNSCALED CUMULATIVE MASS-LOADING RATES FROM TAILINGS HUMIDITY CELLS (µG/KG/WEEK)

Table B8. Unscaled cumulative mass- loading rates from tailings humidity cells (µg/kg/week)

Cell ID	Cl	Fl	SO_4^{2-}	CN^-	CN^- WAD	CN^- Free	NH_3	NO_2^-	NO_3^-	Hg	Ag	Al	As	Be	B	Ca	Cd	Co	Cr	Cu	Fe	K	Mg	Mo	Na	Ni	P	Pb	Sb	Se	Si	Tl	W	U	V	Zn	Zr
Unscaled cumulative mass- loading rates from tailings humidity cells																																					
HC_CND8 Comp	–	–	63577	–	–	–	–	–	–	0.0050	0.0086	14	3.2	0.0034	2.3	16700	0.0024	0.28	0.030	0.46	2.7	1794	6098	0.43	4407	0.68	6.5	0.012	0.91	0.50	130	0.0024	0.020	0.035	0.017	1.0	–
HC_CND7 Comp	–	–	110058	–	–	–	–	–	–	0.0059	0.0032	5.7	0.8	0.0034	1.9	25445	0.0033	0.45	0.019	0.40	1.6	1406	13147	0.16	988	0.68	5.7	0.020	0.47	0.49	60	0.0025	0.17	0.018	0.013	0.98	–
HC_CND9 Comp	–	–	89583	–	–	–	–	–	–	0.0049	0.0028	7.0	0.6	0.0034	1.8	24239	0.0024	0.30	0.030	0.42	2.9	2262	9749	0.11	1251	0.35	5.4	0.011	0.24	0.49	59	0.0025	0.13	0.025	0.011	0.98	–
HC_CND11 Comp	–	–	41236	–	–	–	–	–	–	0.0056	0.0028	13	11	0.0034	1.4	12007	0.0015	0.29	0.025	0.38	2.5	1376	4030	0.35	1085	0.36	5.1	0.019	0.83	0.48	100	0.0024	0.12	0.020	0.024	0.97	–
Average	**0**	**0**	**76114**	**0**	**0**	**0**	**0**	**0**	**0**	**0.0054**	**0.0043**	**9.8**	**3.8**	**0.0034**	**1.9**	**19598**	**0.0024**	**0.33**	**0.026**	**0.42**	**2.4**	**1710**	**8256**	**0.26**	**1933**	**0.52**	**5.7**	**0.016**	**0.62**	**0.49**	**87**	**0.0024**	**0.11**	**0.024**	**0.016**	**0.99**	**0**
Last five week to average cumulative loading ratios from tailings humidity cells																																					
Last five weeks CND8/Avg CND8	–	–	0.7	–	–	–	–	–	–	0.9	0.1	0.8	1.0	0.9	0.7	0.8	2.0	0.5	0.5	0.4	0.5	0.7	0.7	0.4	0.1	0.2	0.6	0.4	0.5	0.9	0.8	0.9	1.0	0.5	0.9	0.9	–
Last five weeks CND7/Avg CND7	–	–	0.9	–	–	–	–	–	–	0.8	0.3	0.8	1.0	0.9	0.9	0.9	0.9	0.5	0.7	0.9	1.5	0.9	0.9	0.5	0.4	0.1	0.9	1.2	0.5	0.9	0.8	0.9	0.2	0.6	1.2	0.9	–
Last five weeks CND9/Avg CND9	–	–	1.1	–	–	–	–	–	–	0.9	0.3	0.6	0.8	0.9	0.7	1.2	1.3	0.7	0.4	0.8	1.3	0.8	0.9	0.6	0.3	0.1	1.4	1.2	0.4	0.9	1.3	0.9	0.2	0.5	0.8	0.9	–
Last five weeks CND11/Avg CND11	–	–	0.8	–	–	–	–	–	–	0.9	0.3	0.8	1.0	1.0	0.6	0.7	1.0	0.8	0.6	0.9	1.2	1.0	0.9	1.1	0.4	0.3	0.9	0.6	0.6	1.0	0.9	1.0	0.2	0.7	1.2	1.0	–
Average	**0**	**0**	**0.9**	**0**	**0**	**0**	**0**	**0**	**0**	**0.9**	**0.3**	**0.8**	**0.9**	**0.9**	**0.7**	**0.9**	**1.3**	**0.6**	**0.6**	**0.7**	**1.1**	**0.8**	**0.9**	**0.6**	**0.3**	**0.2**	**0.9**	**0.8**	**0.5**	**0.9**	**1.0**	**0.9**	**0.4**	**0.6**	**1.1**	**0.9**	**0**

Note: Average values (bold) were used as input in the model.

APPENDIX B9: CONCENTRATIONS ON DAY 0 AND 14 (MG/L) AND THE RATIOS OF SOLUTION AGEING TEST CONCENTRATIONS ON DAY 14 VS DAY 0

Appendix B9: Concentrations on day 0 and 14 (mg/L) and the ratios of solution ageing concentrations on day 14 vs day 0

Tailings Cell	CND2			CND 5			CND 8			CND 9			Average ratio	TMF reduction factor
	Day 0	Day 14	ratio	Day 0	Day 14	ratio	Day 0	Day 14	ratio	Day 0	Day 14	ratio		
Cl	4.2	4.2	1.0	12	12	1.0	32	26	0.81	12	12	1.0	0.95	0.05
F	0.26	0.21	0.81	0.3	0.25	0.83	0.15	0.13	0.87	0.11	0.1	0.91	0.85	0.15
SO_4^{2-}	500	490	0.98	1900	1800	0.95	1600	1500	0.94	1200	1200	1.0	0.97	0.03
$CN_{(T)}$	0.13	0.01	0.08	0.36	0.16	0.44	1.44	0.005	0.00	15.8	2.79	0.18	0.18	0.82
CN_{WAD}	0.005	0.005	1.0	0.01	0.005	0.50	0.005	0.005	1.0	0.03	0.06	2.0	1.13	**0.00**
$CN_{(F)}$	0.005	0.005	1.0	0.01	0.005	0.50	0.005	0.005	1.0	0.03	0.058	1.9	1.11	**0.00**
NH_3+NH_4	14.4	14.5	1.0	26.4	20.2	0.77	42.8	30.5	0.71	5.4	6.6	1.2	0.93	0.07
NO_2^-	0.15	0.15	1.0	0.15	0.15	1.0	0.15	0.15	1.0	0.15	0.15	1.0	1.00	**0.00**
NO_3^-	0.3	0.3	1.0	0.3	0.3	1.0	0.3	0.3	1.0	0.3	0.3	1.0	1.00	**0.00**
Hg, Dissolved	0.000005	0.000005	1.0	0.000005	0.000005	1.0	0.000005	0.000005	1.0	0.000005	0.000005	1.0	1.00	**0.00**
Ag, Dissolved	0.00006	0.000108	1.8	0.00015	0.000014	0.09	0.00062	0.000148	0.24	0.00024	0.000243	1.0	0.79	0.21
Al, Dissolved	0.01	0.005	0.50	0.005	0.02	4.0	0.005	0.02	4.0	0.005	0.005	1.0	2.38	**0.00**
As, Dissolved	0.017	0.0109	0.64	0.057	0.0176	0.31	0.023	0.014	0.61	0.012	0.0013	0.11	0.42	0.58
Be, Dissolved	0.0000035	0.0000035	1.0	0.0000035	0.0000035	1.0	0.0000035	0.0000035	1.0	0.0000035	0.0000035	1.0	1.00	**0.00**
B, Dissolved	0.021	0.02	0.95	0.021	0.0179	0.85	0.024	0.0213	0.89	0.021	0.0189	0.90	0.90	0.10
Ca, Dissolved	66.5	49.8	0.75	252	225	0.89	152	121	0.80	130	116	0.89	0.83	0.17
Cd, Dissolved	0.0000015	0.0000015	1.0	0.0000015	0.0000015	1.0	0.0000015	0.0000015	1.0	0.0000015	0.000019	13	3.92	**0.00**
Co, Dissolved	0.00868	0.00609	0.70	0.0746	0.0597	0.80	0.0449	0.0372	0.83	0.0177	0.0146	0.82	0.79	0.21
Cr, Dissolved	0.0007	0.000015	0.02	0.0012	0.00022	0.18	0.0009	0.00011	0.12	0.0009	0.00017	0.19	0.13	0.87
Cu, Dissolved	0.0032	0.00221	0.69	0.0089	0.00765	0.86	0.0092	0.0066	0.72	0.0077	0.00466	0.61	0.72	0.28
Fe, Dissolved	0.063	0.011	0.17	0.5	0.006	0.012	0.128	0.008	0.06	5.65	1.03	0.18	0.11	0.89
K, Dissolved	18.4	19.1	1.0	60.2	63.2	1.0	55.1	58.8	1.1	43.4	46.7	1.1	1.06	**0.00**
Mg, Dissolved	17.3	15.9	0.92	22.7	20.9	0.92	39.2	35.9	0.92	41.5	37.4	0.90	0.91	0.09
Mn, Dissolved	0.0562	0.00503	0.09	0.0844	0.0759	0.90	0.14	0.0194	0.14	0.0896	0.0652	0.73	0.46	0.54
Na, Dissolved	184	178	0.97	567	482	0.85	544	477	0.88	526	467	0.89	0.90	0.10
Ni, Dissolved	0.009	0.0044	0.49	0.01	0.0083	0.83	0.018	0.0146	0.81	0.004	0.004	1.0	0.78	0.22
P, Dissolved	0.012	0.0045	0.38	0.0045	0.0045	1.0	0.011	0.0045	0.41	0.012	0.0045	0.38	0.54	0.46
Pb, Dissolved	0.0005	0.00028	0.56	0.0004	0.00003	0.08	0.0011	0.0001	0.09	0.0011	0.00012	0.11	0.21	0.79
Sb, Dissolved	0.014	0.0139	0.99	0.008	0.0143	1.8	0.024	0.0257	1.1	0.004	0.0044	1.1	1.24	**0.00**
Se, Dissolved	0.0005	0.0005	1.0	0.0005	0.002	4.0	0.005	0.001	0.20	0.0005	0.0005	1.0	1.55	**0.00**
Si, Dissolved	1.86	1.8	0.97	1.29	1.13	0.88	1.52	1.39	0.91	1.23	0.85	0.69	0.86	0.14
Tl, Dissolved	0.0000025	0.000011	4.4	0.0000025	0.000018	7.2	0.0000025	0.000022	8.8	0.0000025	0.0000025	1.0	5.35	**0.00**
W, Dissolved	0.00001	0.00038	38	0.0004	0.00047	1.2	0.0002	0.00036	1.8	0.0003	0.00022	0.73	10.43	**0.00**
U, Dissolved	0.00308	0.00283	0.92	0.00416	0.00357	0.86	0.00318	0.00283	0.89	0.00182	0.00163	0.90	0.89	0.11
V, Dissolved	0.000005	0.00003	6.0	0.000005	0.00004	8.0	0.000005	0.00008	16	0.000005	0.00001	2.0	8.00	**0.00**
Zn, Dissolved	0.001	0.001	1.0	0.01	0.004	0.40	0.01	0.003	0.30	0.001	0.003	3.0	1.18	**0.00**
Zr, Dissolved	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**0.00**

Note: Shaded values are calculated using concentrations equal or around DL (up to 5xDL); TMF reduction factor indicates fraction of element mass removed from TMF pond in a month due to ageing; TMF reduction factor = 1-average ratio, if average ratio <1, or otherwise it was 0.

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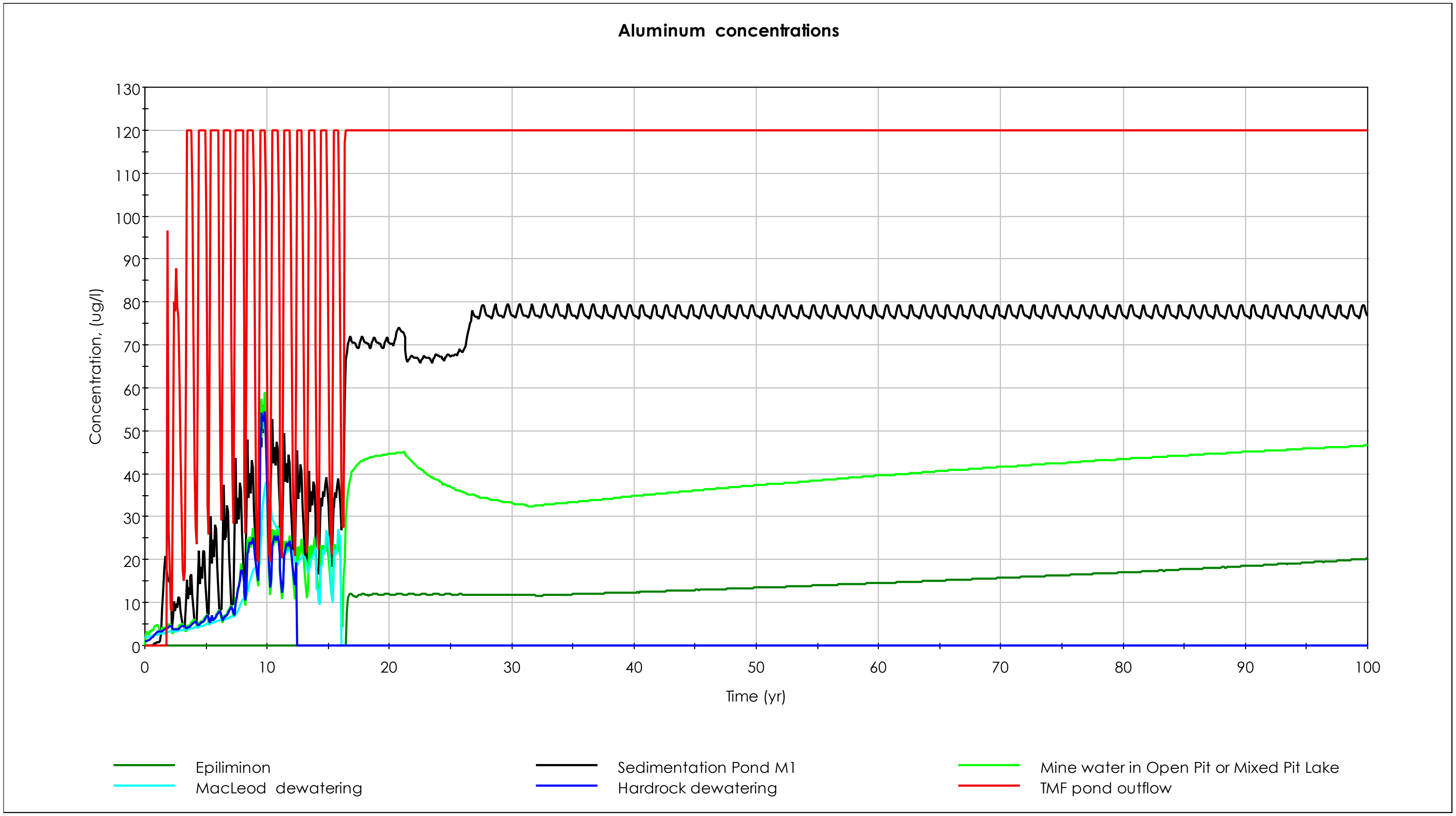
APPENDIX C: CONCENTRATION TIME TRENDS FOR SELECTED ELEMENTS

Appendix C: Concentration Time Trends for Selected Elements



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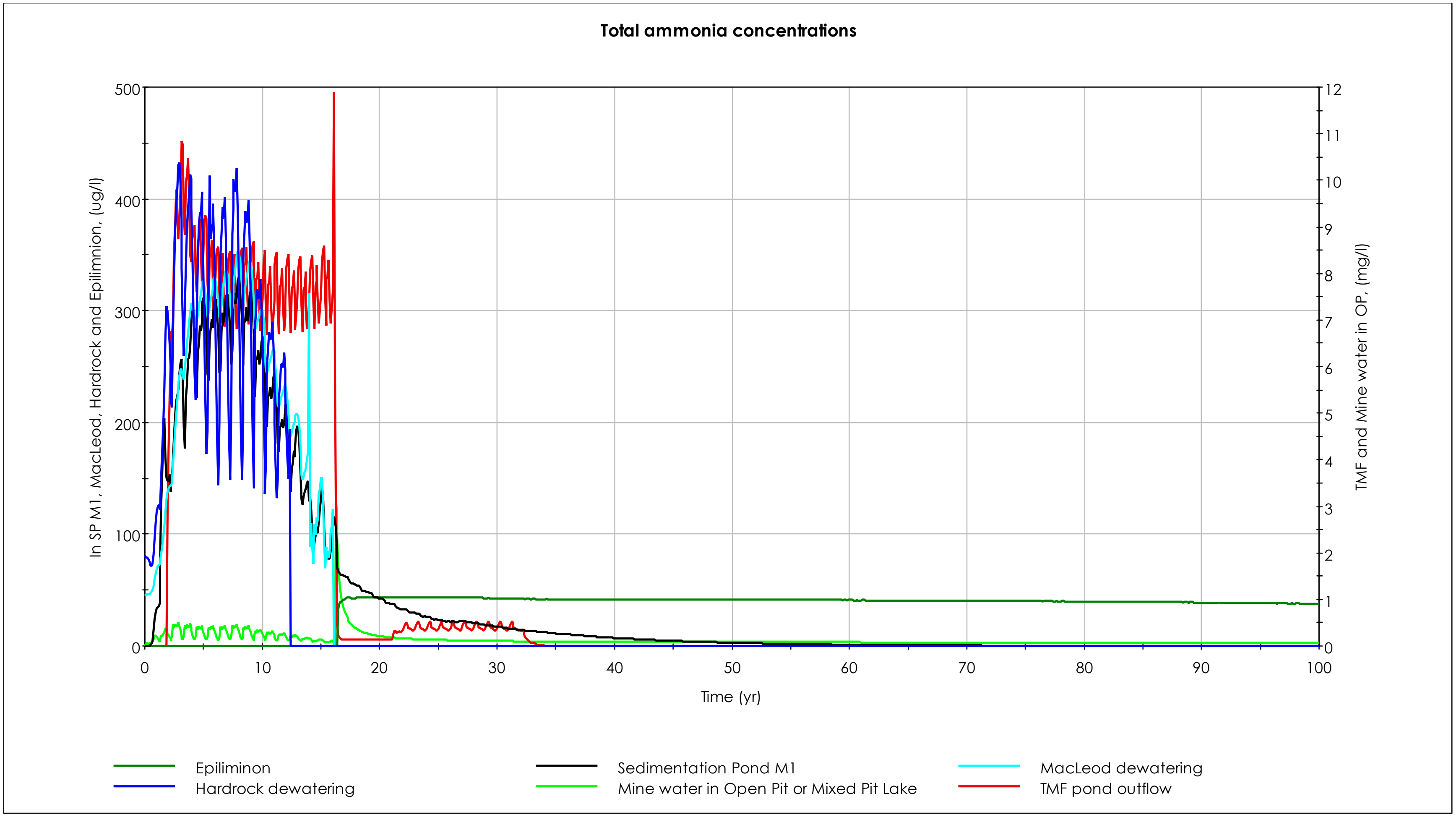
Total ammonia concentrations
In SP M1, MacLeod, Hardrock and Epilimnion, (ug/l)
TMF and Mine water in OP, (mg/l)
Time (yr)
0
100
200
300
400
500
0
1
2
3
4
5
6
7
8
9
10
11
12
0
10
20
30
40
50
60
70
80
90
100
Epiliminon
Hardrock dewatering
Sedimentation Pond M1
Mine water in Open Pit or Mixed Pit Lake
MacLeod dewatering
TMF pond outflow

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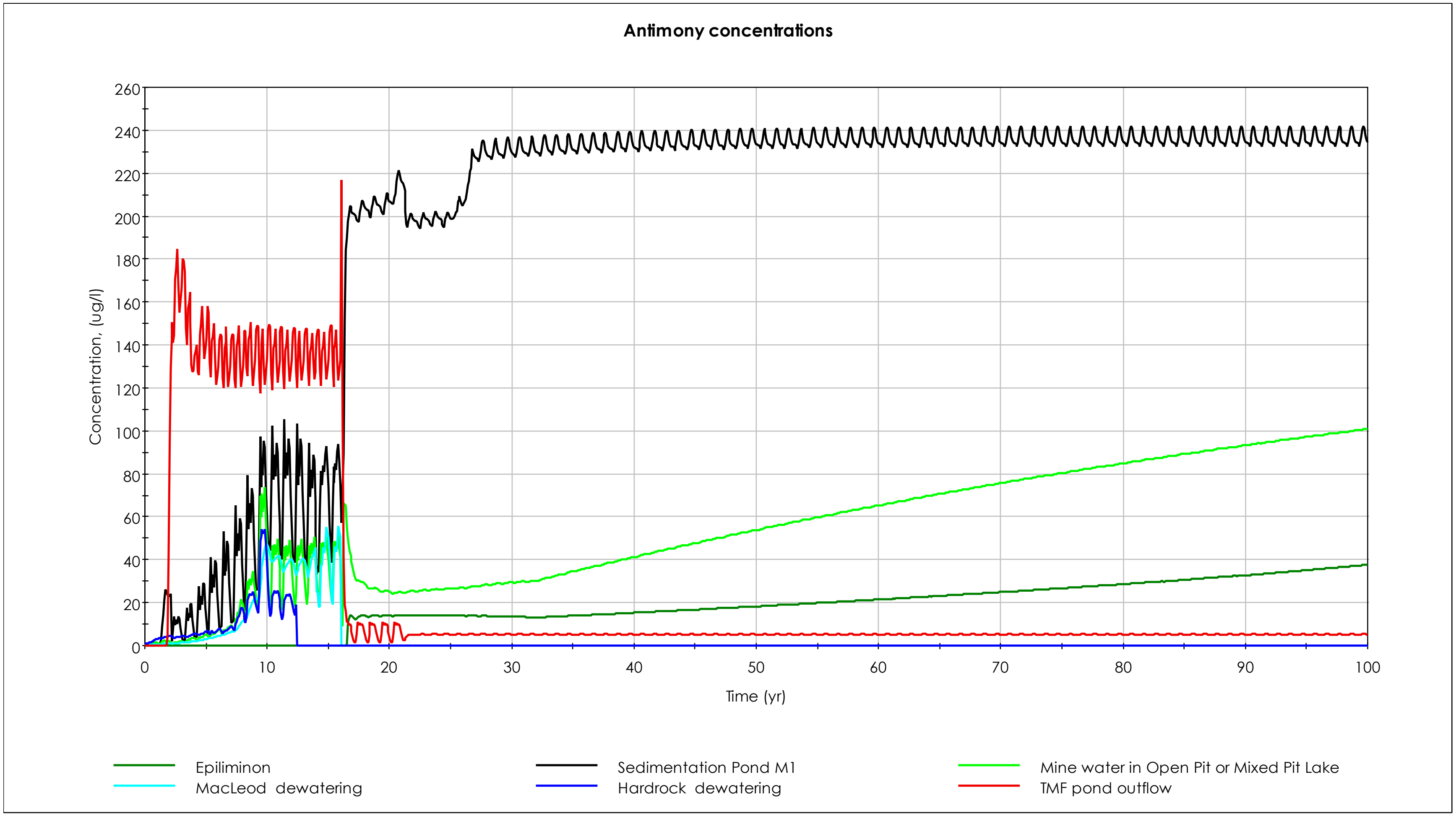
Antimony concentrations
Concentration, (ug/l)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
0
10
20
30
40
50
60
70
80
90
100
Time (yr)
Epiliminon
MacLeod dewatering
Sedimentation Pond M1
Hardrock dewatering
Mine water in Open Pit or Mixed Pit Lake
TMF pond outflow

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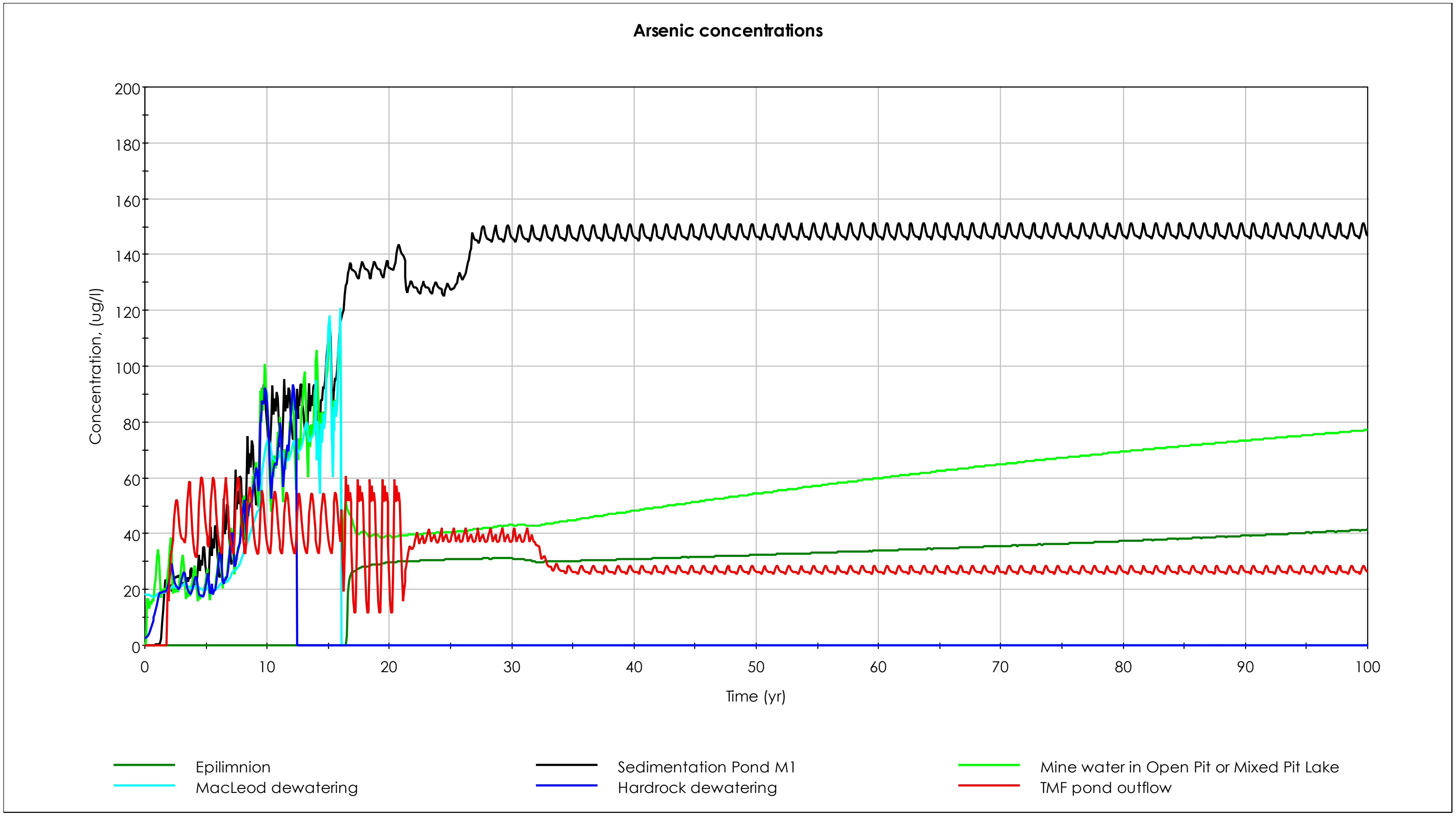
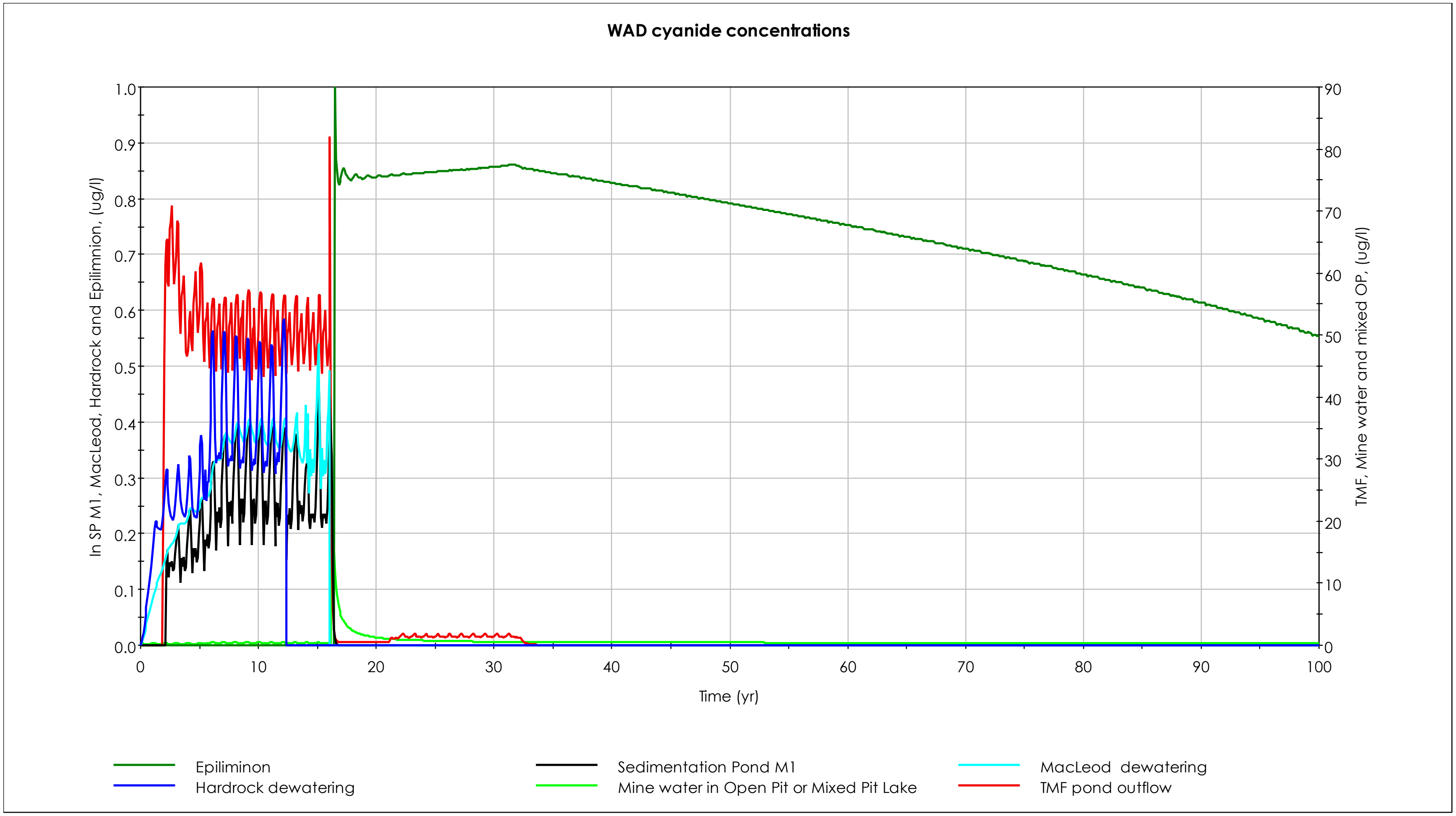
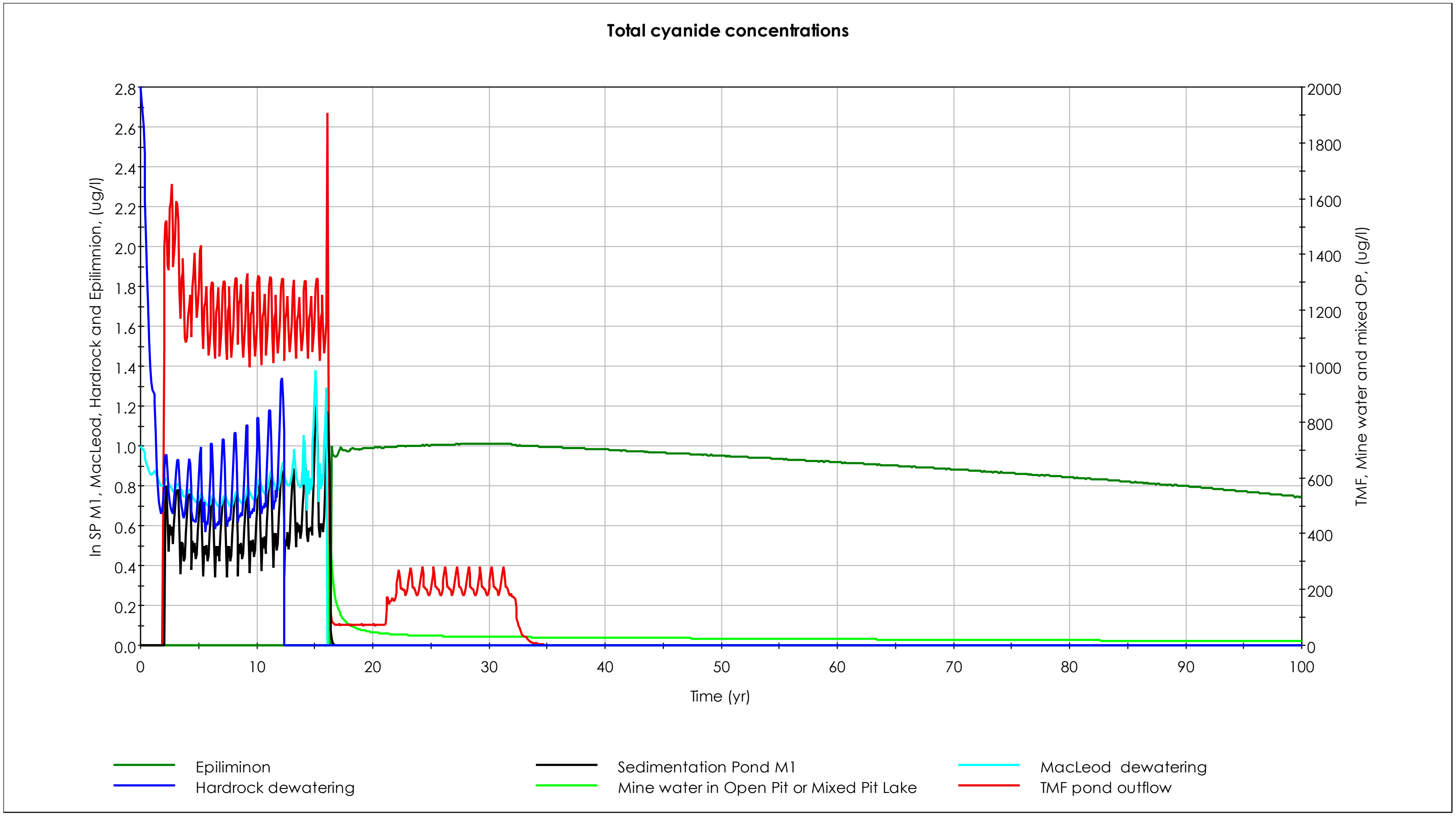


Arsenic concentrations
Concentration, (ug/l)
200
180
160
140
120
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
90
100
Time (yr)
Epilimnion
MacLeod dewatering
Sedimentation Pond M1
Hardrock dewatering
Mine water in Open Pit or Mixed Pit Lake
TMF pond outflow

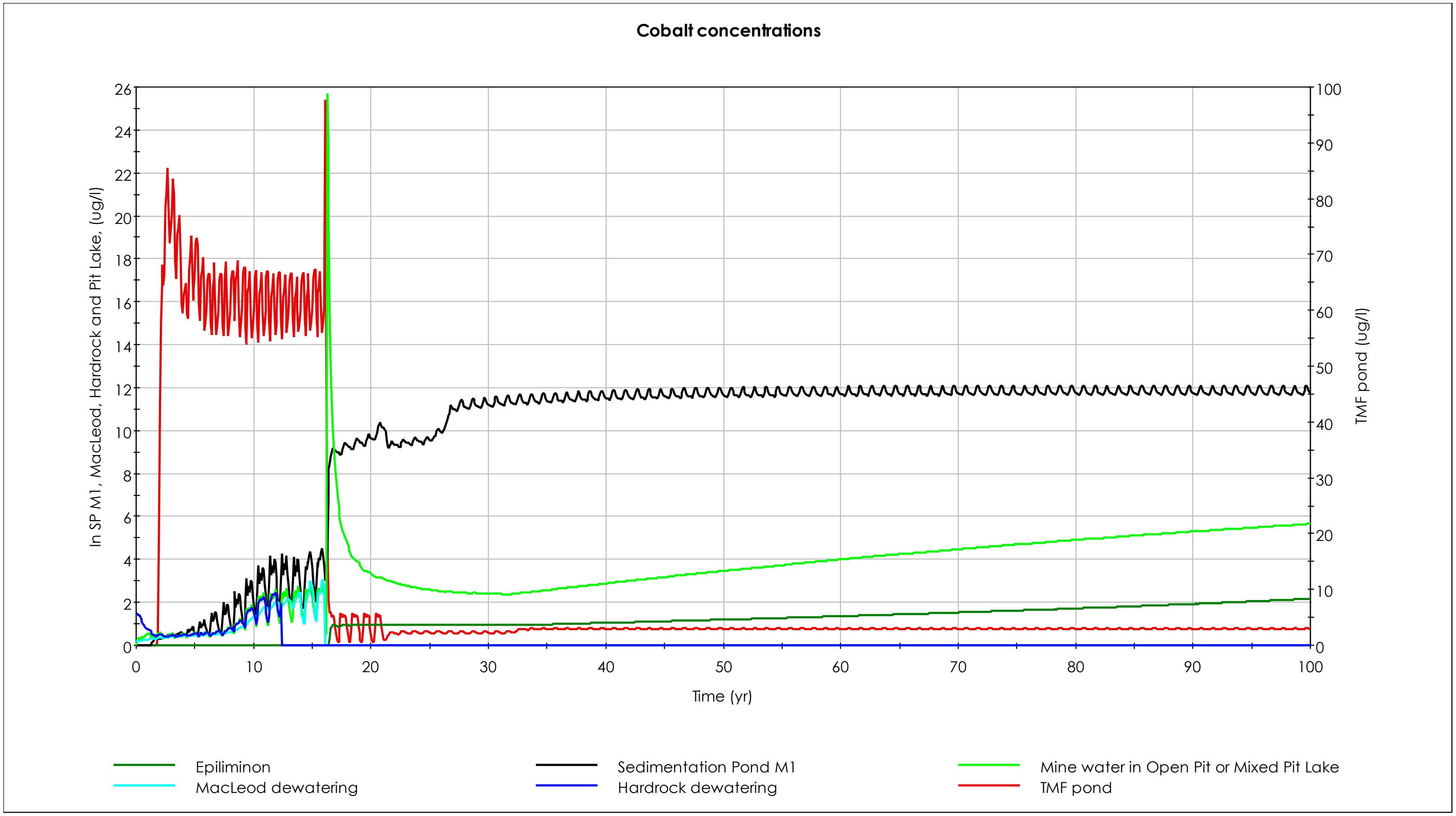


WAD cyanide concentrations
In SP M1, MacLeod, Hardrock and Epilimnion, (ug/l)
TMF, Mine water and mixed OP, (ug/l)
Time (yr)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
0
10
20
30
40
50
60
70
80
90
100
Epiliminon
Hardrock dewatering
Sedimentation Pond M1
Mine water in Open Pit or Mixed Pit Lake
MacLeod dewatering
TMF pond outflow

Stantec



Total cyanide concentrations
In SP M1, MacLeod, Hardrock and Epilimnion, (ug/l)
TMF, Mine water and mixed OP, (ug/l)
Time (yr)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
0
200
400
600
800
1000
1200
1400
1600
1800
2000
0
10
20
30
40
50
60
70
80
90
100
Epiliminon
Hardrock dewatering
Sedimentation Pond M1
Mine water in Open Pit or Mixed Pit Lake
MacLeod dewatering
TMF pond outflow



Cobalt concentrations
In SP M1, MacLeod, Hardrock and Pit Lake, (ug/l)
TMF pond (ug/l)
Time (yr)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
0
10
20
30
40
50
60
70
80
90
100
Epiliminon
MacLeod dewatering
Sedimentation Pond M1
Hardrock dewatering
Mine water in Open Pit or Mixed Pit Lake
TMF pond

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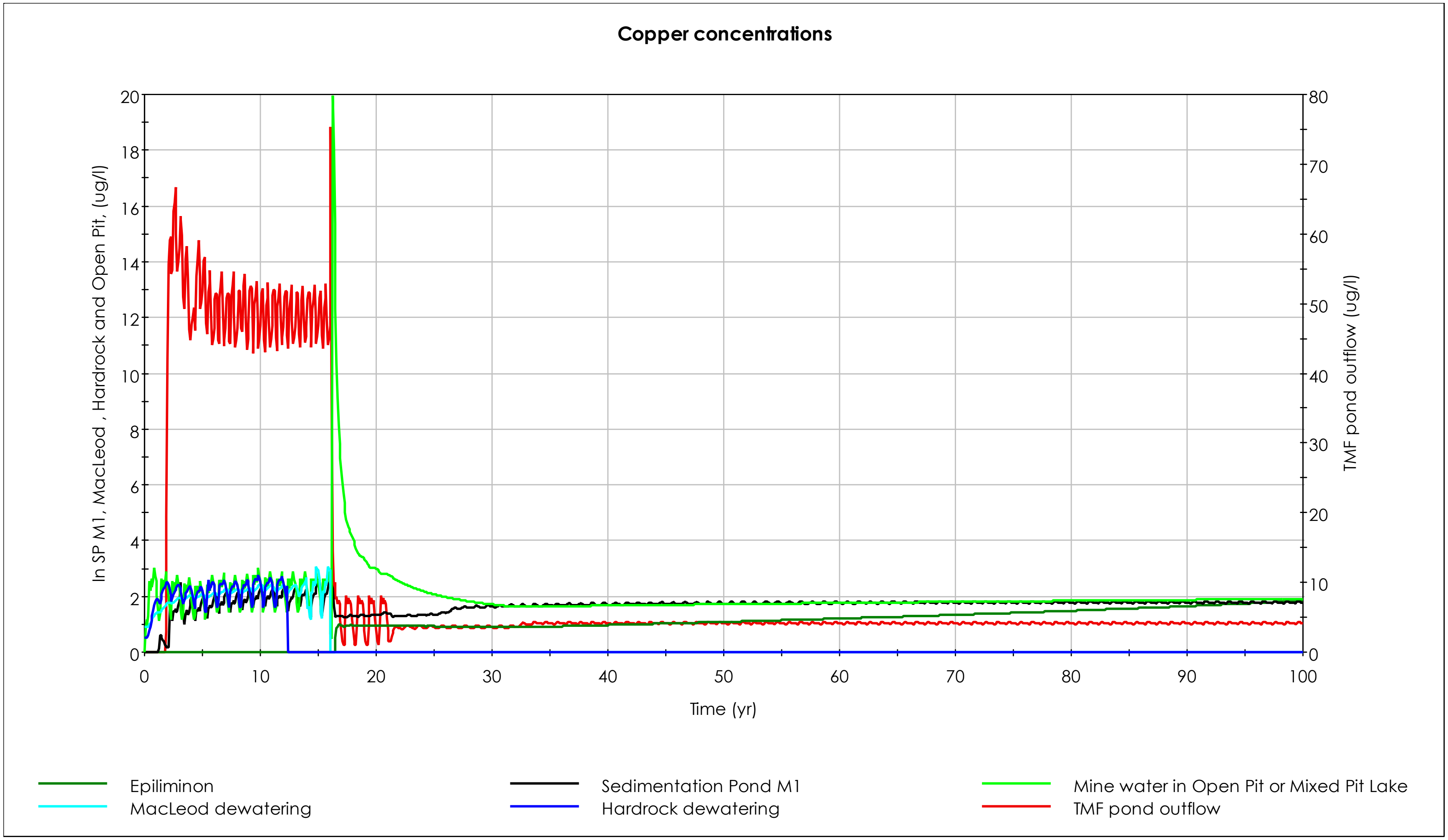
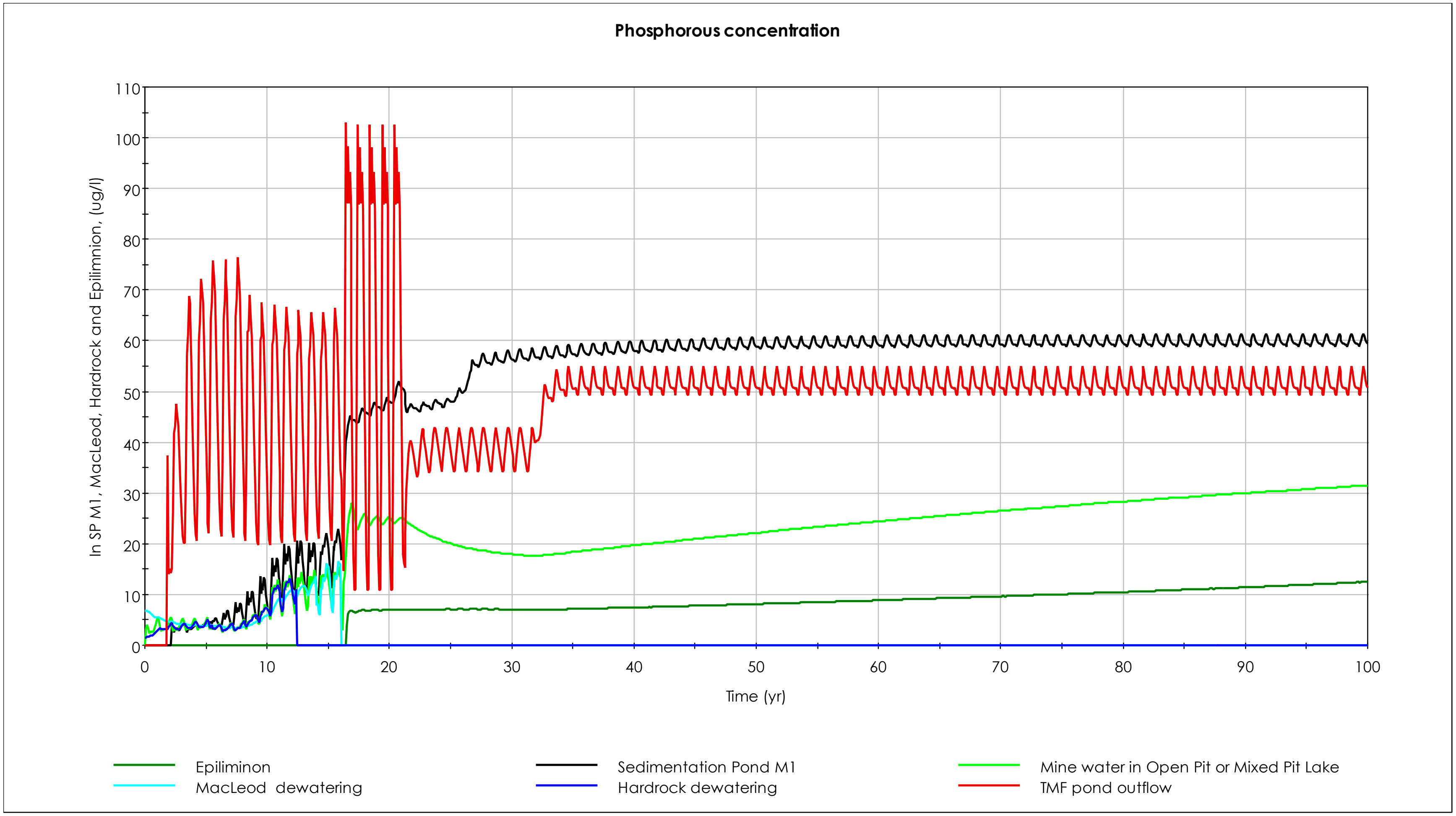

Copper concentrations
In SP M1, MacLeod , Hardrock and Open Pit, (ug/l)
TMF pond outflow (ug/l)
Time (yr)
0
2
4
6
8
10
12
14
16
18
20
0
10
20
30
40
50
60
70
80
0
10
20
30
40
50
60
70
80
90
100
Epiliminon
MacLeod dewatering
Sedimentation Pond M1
Hardrock dewatering
Mine water in Open Pit or Mixed Pit Lake
TMF pond outflow


Phosphorous concentration
In SP M1, MacLeod, Hardrock and Epilimnion, (ug/l)
0
10
20
30
40
50
60
70
80
90
100
110
Time (yr)
Epiliminon
MacLeod dewatering
Sedimentation Pond M1
Hardrock dewatering
Mine water in Open Pit or Mixed Pit Lake
TMF pond outflow

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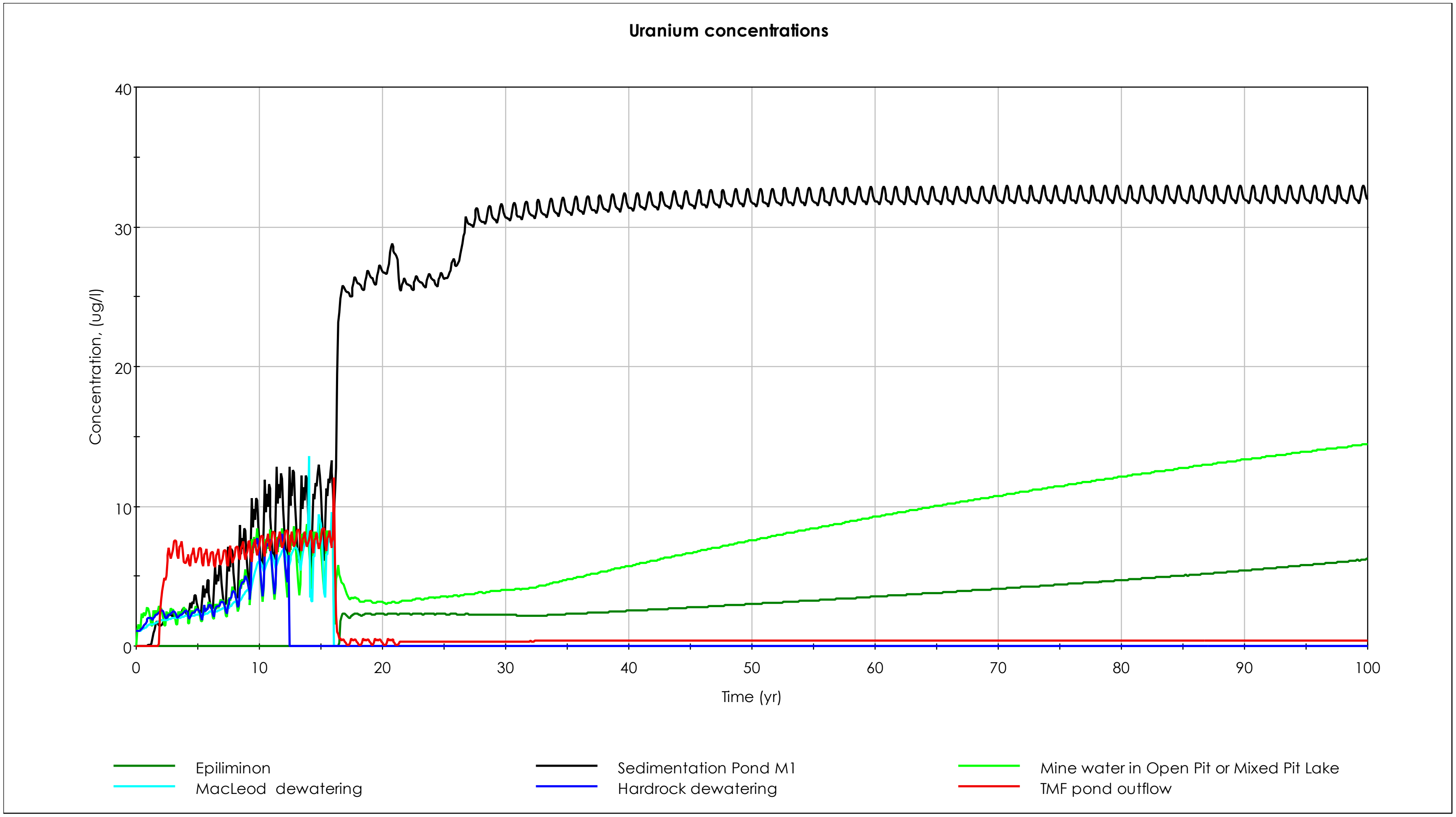

Uranium concentrations
Concentration, (ug/l)
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
Time (yr)
Epiliminon
MacLeod dewatering
Sedimentation Pond M1
Hardrock dewatering
Mine water in Open Pit or Mixed Pit Lake
TMF pond outflow

APPENDIX D: MODELLING PERMANENT STRATIFICATION OF PIT LAKE

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Modelling Permanent Stratification of the Pit Lake

Permanent stratification of the Hardrock pit lake is a critical concept for mine closure because it allows management of site water (store and passively treat), which does not comply with discharge standards. The following steps are proposed to manage the pit lake during and after closure:

- to create a dense layer of water at the bottom of the pit, water from the TMF and pond M1 will be discharged to the lower portions of the open pit using historic shafts after operation ceases.
- to create an upper layer of fresh water (epilimnion) and permanently stratify a pit lake, fresh water will be added from Kenogamisis Lake to the surface of the pit lake when the dense bottom layer is 100 m deep (arbitrary selection of depth).
- To maintain stratification and accelerate pit filling, continue pumping water from the TMF and pond M1 to the lower portions and freshwater from Kenogamisis to the surface of the pit lake until the pit reaches the spill elevation (Figure D.1).

When the pit is full, pumping water from the TMF and freshwater stops, while water from pond M1 continues to be pumped to lower portions of the pit lake.

Modeling results indicate that mixed pit lake will be 100 m deep approximately 5 months after the closure. At that time, addition of freshwater starts and continues until pit lake is full and starts to discharge approximately 16 years after closure (year 32 of the model).

The stratification stability of pit lake was predicted from calculation of the Wedderburn Number (Stevens and Lawrence, 1997; Gammons et al., 2008). A Wedderburn Number (W) >1 indicates a lake with stable permanent stratification, while lakes with W<1 indicate a greater likelihood of turnover. Wedderburn Number and stratification remains stable if epilimnion is thicker or/and density between layers is large (Equation D.1). A minimum thickness of epilimnion required for permanent stability can be estimated from Equation D.2, assuming W=1 and rearranging Equation D.1. The estimates are based on conservative inputs for wind speed (high end of range) and density (low end of expected range). Density was calculated from salinity and temperature using Equation D.3 (McCutcheon et al. 1993).

$$W = \frac{h_E^2 g(\rho_M - \rho_E)}{(C_D U_{10}^2 \rho_A L)}$$ Equation D.1

$$h_{E,min} = U_{10}\sqrt{\frac{C_D \rho_A L}{g(\rho_M - \rho_E)}}$$ Equation D.2

where:

$h_{E\ min}$ = minimum thickness of epilimnion required for stability of meromictic lake

U_{10} = Wind velocity 10 m above the lake surface, conservatively assumed at 20 m/s (~72 km/h);

C_D = drag coefficient, 10^{-3}, dimensionless;

ρ_A = air density, 1.2 kg/m^3;

g = gravity acceleration, m^2/sec

ρ_{M} and ρ_E densities of the dense bottom layer (monimolimnion) and epilimnion, respectively, calculated from Equation D.3 and shown in Figure D.2, kg/m^3.

$\rho(T,S) = \rho(T) + A\times S + B\times S^{3/2} + C\times S^2$ Equation D.3

where:
$\rho(T)$ = water density as function of temperature calculated as
$\rho(T) = 1000\times(1-(T+288.94)/(508929.2\times(T+68.13))\times(T-3.986)^2)$

T = temperature in Celsius, conservatively assumed to be higher in monimolimnion (6°C – average groundwater temperatures approximating shaft temperatures) than in epilimnion (4°C temperature of highest water density).

S = salinity assumed to be equal to concentrations of Total Dissolved Solids of monimolimnion and epilimnion, which was calculated by model as sum of all species in these layers + 200 mg/L of alkalinity (alkalinity or bicarbonate are included in the set of model species).

A, B, C are fitting coefficients;
$A = 0.824493 – 0.0040899\times T + 7.6438\times10^{-5}\times T^2 - 8.2467\times10^{-7}\times T^3 + 5.3675\times10^{-7}\times T^4$
$B = -5.724\times10^{-3} + 1.0227\times10^{-4}\times T - 1.6546 \times10^{-6}\times T^2$
$C = 4.8314\times10^{-4}$

The calculated minimum thickness of epilimnion required for permanent stratification increases from 3.5 m in year 17 to 16 m in year 100, because decrease in density difference between the layers (Figure D.2). The thickness of the epilimnion is ~20m in the existing Detour Pit Lake, which is naturally stratified under similar climatic conditions (Mueller *et al.* 2012).

The modeled thicknesses of the epilimnion were calculated by GoldSim based on pitshell topology (elevation vs. volume) water balances done for epilimnion and monimolimnion, separately (Figure D.1 and Section 5.1 of the report). After two month of freshwater addition, the modeled thickness of epilimnion becomes greater (~22 m) than both the minimum required thickness (3.5 m) and epilimnion thickness of Detour Pit Lake (~20m) indicating that the Hardrock pit lake will permanently stratify in the first year of the closure. The thickness of epilimnion reaches the maximum thickness of 209 m when pit starts to discharge. After the pit lake starts to discharge, the epilimnion becomes thinner because lake freshwater supply to epilimnion stops, but monimolimnion still receives water from pond M1 (receiving runoff and toe seepage form waste rock). This results in displacement and discharge of water from the epilimnion. The epilimnion reached minimum thickness (41 m) in the last year of the model, which remains greater than minimum required thickness (16 m). Beyond 100 years, the water quality model assumptions are considered too conservative for reliable predictions. For example, the model does not account for either reduction in leaching rates or geochemical reactions that lead to improvement in the quality of runoff/seepage from waste rock during post-closure (during last 71 years of model). If this water quality improves and pond M1 meets discharge standards, there is no need to send pond M1 water to the monimolimnion. In this case, the thickness of the epilimnion stabilizes further supporting long-term stratification of pit lake.

It can be concluded that, permanent stratification of pit lake will stable for a minimum of 83 years based on current model inputs that are biased to conservatively high concentrations for project facilities. For this period, pit lake can be used for storage and potential passive treatment of water, which does not comply with discharge standards.

References:

McCutcheon, S.C., Martin, J.L, Barnwell, T.O. Jr. 1993. Water Quality in Maidment, D.R. (Editor). Handbook of Hydrology, McGraw-Hill, New York, NY (p. 113).

Mueller, P., A. Martin, J. Robertson, D. Flather, C. Fraser and M. Bednarz. 2012. Characterization of an Existing Pit Lake as in situ Model for Closure Planning for the Detour Gold Mine. Proceedings of the 9th International Conference on Acid Rock Drainage (ICARD 2012). Ottawa, Canada. 20-26 May 2012.

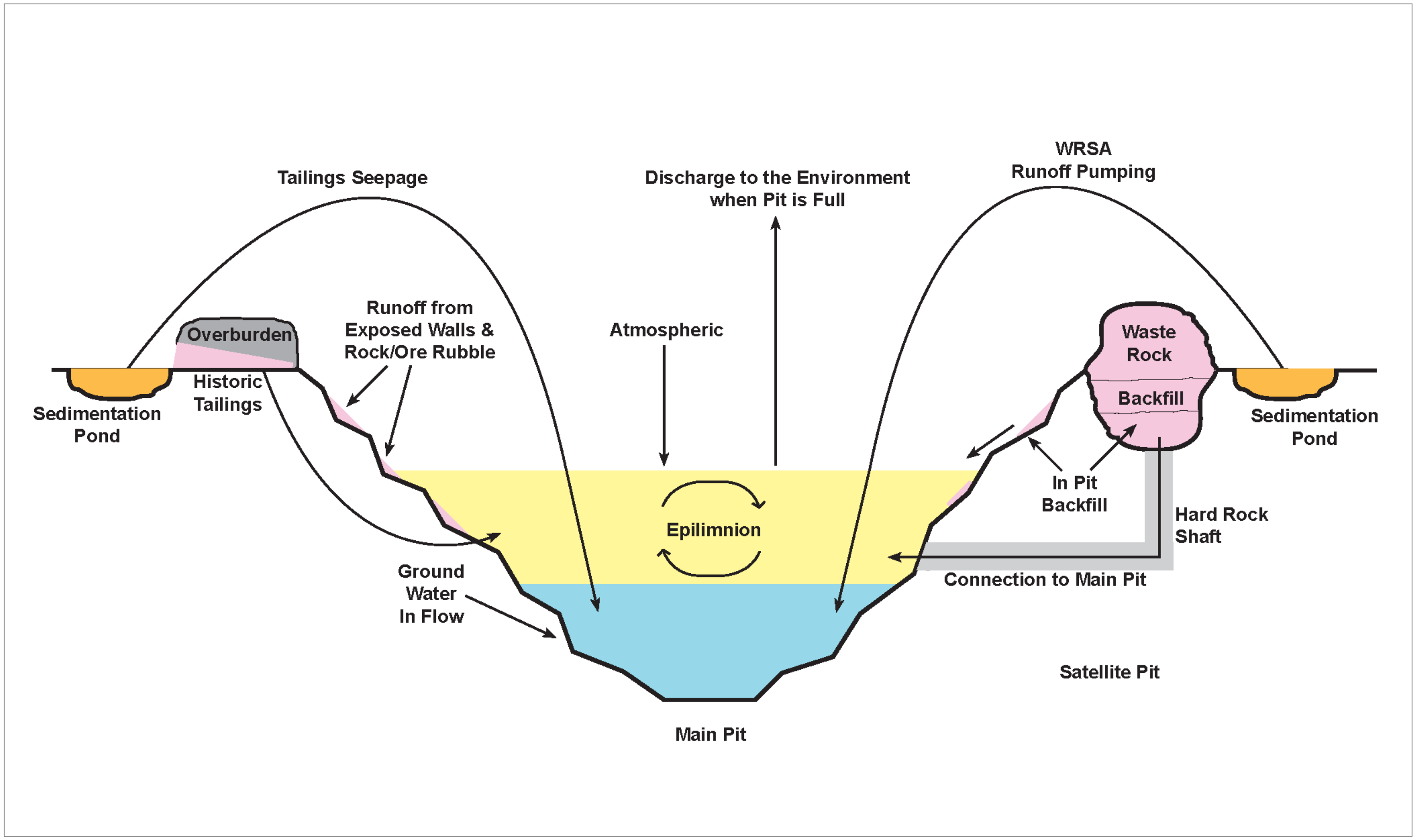

Figure D.1. Mass inputs/outputs for pit lake layers.

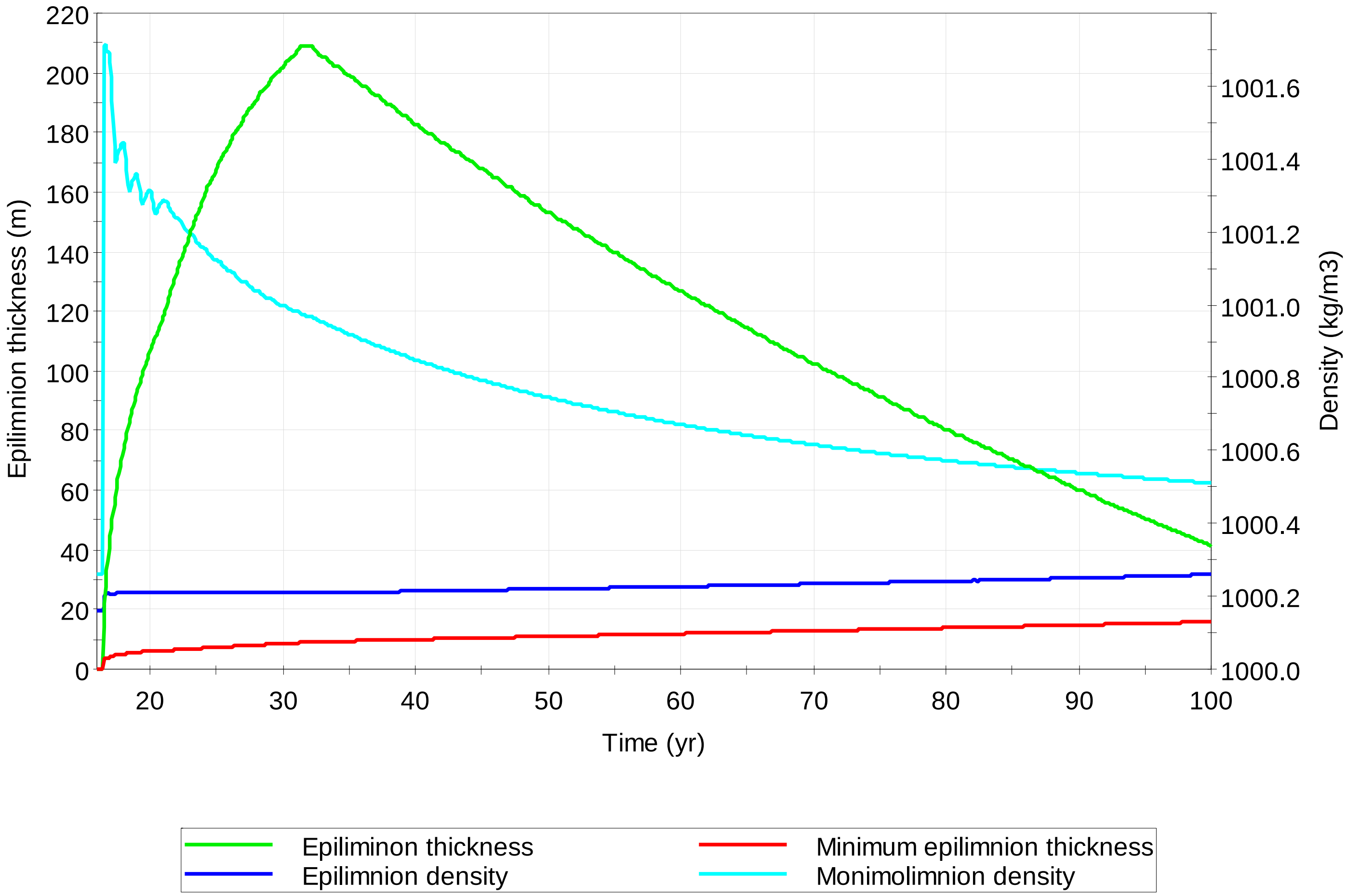

Figure D.2. Modeled thickness and densities of pit lake layers.