APPENDIX 7A

Water Quantity and Water Quality Modelling Report: Leprechaun Complex and Processing Plant & TMF Complex

Stantec

Valentine Gold Project (VGP) Water Quantity and Water Quality Modelling Report: Leprechaun Complex and Processing Plant & TMF Complex

Final Report

September 23, 2020

Prepared for:

Marathon Gold Corporation
36 Lombard Street
Suite 600, Toronto, ON M5C 2X3

Prepared by:

Stantec Consulting Ltd.
141 Kelsey Drive
St. John’s, NL A1B 0L2
Tel: (709) 574-1458
Fax: (709) 576-2126

File No: 121416408

This document entitled Valentine Gold Project (VGP) Water Quantity and Water Quality Modelling Report: Leprechaun Complex and Processing Plant & TMF Complex was prepared by Stantec Consulting Ltd. (“Stantec”) for the account of Marathon Gold Corporation (the “Client”). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Stantec’s professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. In preparing the document, Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

Prepared by ______________________________
(signature)

Gonzalo Donoso M.Sc.E., P.Eng. Senior Water Resources Engineer

2020.09.24
12:58:43 -05'00'

Prepared by ______________________________
(signature)

Nikolay Sidenko PhD., P.Geo., Senior Geochemist

Digitally signed by
Sheldon Smith
Date: 2020.09.24
13:16:43 -04'00'

Reviewed by ______________________________
(signature)

Sheldon Smith MES., P.Geo. Principal, Senior Hydrologist

Jonathan Keizer
2020.09.24
15:06:06 -03'00'

Reviewed by ______________________________
(signature)

Jonathan Keizer, M.Sc.E., P.Eng., Senior Hydrogeologist

Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Executive Summary

The Valentine Gold Project mine site is subdivided into three complexes, from north to south, the Marathon Complex, the Process Plant and Tailings Management Facility (TMF) Complex, and the Leprechaun Complex. This report discusses an integrated water balance and water quality model prepared for the Leprechaun Complex and the Process Plant and TMF Complex. The major Project facilities include the Leprechaun open pit mine, process plant, TMF, waste rock piles, and low-grade ore (LGO), topsoil, and overburden stockpiles. Ore from the open pit will be mined for nine years and will be stockpiled and processed at the plant. The plant will operate for another three years by processing ore from the LGO stockpiles of Leprechaun and Marathon deposits. Tailings will be deposited in the TMF for the first nine years of operation, and into the exhausted Leprechaun pit for the last three years of operation.

The model incorporates the relevant water management infrastructure designs to simulate watershed areas, volume capacities, flow diversions and flow paths for major mine components of the Leprechaun complex and Process Plant and TMF Complex. Main concepts of the water management included in the model are:

- Perimeter ditches around the stockpiles will flow into water management ponds and discharge to local Final Discharge Points (FDPs). Progressive rehabilitation and closure activities will include adding a soil cover and vegetating the waste rock pile. Water management ponds and perimeter seepage collection ditches will be maintained until water quality meets objectives and assumed to be functional during closure in the model.
- Mine water from dewatering the open pit will be collected in sumps and pumped to a water management pond prior to discharge to the environment until year 10. Accelerated filling of the pit will start in year 10.
- The TMF receives water from the processing plant via tailings slurry water (only years 1 to 10), seepage collection pond discharge (intercepting tailings seepage from the T tailings pond and pumping back into the pond for reuse) and runoff. In Year 10, tailings deposition to the TMF will switch to deposition in the Leprechaun pit. Outflows/losses from the tailings pond include reclaim water to the process plant, water retained in the tailings matrix, deep groundwater seepage, evaporation and excess water (tailings pond overflow). The excess of water will be treated in a water treatment plant prior to discharge to the polishing pond during 8 months of the year (only years 1 to 10). From year 10 to 12, all tailings pond water above dead storage is reclaimed to the processing plant. After year 12 and until end of closure, excess TMF water will be discharged to the Leprechaun pit. The TMF will be rehabilitated during closure, and seepage recirculation will cease during closure. Post-closure, toe seepage and runoff from the TMF will be allowed to drain downgradient to pre-development catchments.

- Water withdrawal from Victoria Lake Reservoir is proposed as a freshwater make-up source for processing ore at the mill during operation, and to accelerate filling of the Leprechaun pit. Accelerated pit filling is considered to be the base case scenario because it allows submergence of Potentially Acid Generating (PAG) materials exposed on pit walls limiting ARD/ML. This scenario also increases the safety of the Leprechaun pit in post-closure.

The model results show that during the first nine years of operation, under average climate conditions, the maximum water deficit of the plant (i.e., difference between the demand and the reclaim) is 2,900 m^3/d. The deficit reaches a maximum of approximately 5,000 m^3/day and 3,600 m^3/day in mine years 11 and 12, respectively, when the tailings are deposited in the Leprechaun pit during the last three years of operation.

The model predicts that filling of the Leprechaun pit will take around 40 years after pit closure, including the deposition of tailings in the pit during mine years 10 to 12 and overflow from the tailings pond during closure (mine years 13 to 18). Additionally, an acceleration of pit filling was modelled in the 8 years after mining of the pit ceases (mine years 10 to end 17), using water from Victoria Lake Reservoir and the tailings pond excess water. In this scenario, the total water intake rate form Victoria Lake Reservoir is 16,000 m^3/day in the last three years of operation when there is a demand to supply plant deficit and pit filling, under average climate conditions. During closure, the Victoria Lake Reservoir intake will decline to 10,950 m^3/day for average climate conditions of pit filling. Accelerated pit filling is considered to be the base case scenario because it allows submergence of PAG materials exposed on pit walls limiting ARD/ML. This scenario also increases the safety of the Leprechaun mine in post-closure.

The model was set to activate treatment when the tailings pond level reaches 70% of its volume capacity. With this assumption, the capacity of the treatment plant will not be exceeded for the 95th percentile corresponding to a 1:25 year return period wet year. Results from the probabilistic analysis indicate no release of untreated water during operations (before year 13) for percentile 95th. This condition could change depending on future operation management philosophy between the tailings pond and the treatment plant.

Generally, the simulation flow results on the water management ponds and the FDPs, from 5th to 95th percentile results, range from approximately -25% to +25% of the mean results within each mine phase. This is consistent with the range of precipitation and approximately represents the 1:25 return period wet year to the 1:5 dry year.

The major objective of the water quality model is to predict concentrations of potential contaminants in mine water management facilities and at FDPs. The contaminant transport module of GoldSim is used to build a water quality model directly linked to the water quantity model, which provides direct inputs to volume and inflow/outflow rates to/from facilities. The inputs to the model are associated with the concentration or mass-rate (loading) addition to the mine facilities. Scaled mass-rates from laboratory kinetic tests and production tonnages are used as inputs for waste rock lithologies, ores and tailings exposed to weathering in mine facilities. Loadings of nitrogen species leached from undetonated explosives were estimated from empirical data from other open pit mines. Chemistry of process water and TMF seepage were evaluated from laboratory ageing tests and subaqueous columns, respectively.

Unimpacted groundwater, runoff from undisturbed areas, covers and overburden and soil stockpiles were represented by respective concentration inputs. To address variability and uncertainty of the inputs, probabilistic distributions were assigned to most inputs including scaleup factors. The parameters included in the model have criteria listed in *Canadian Water Quality Guidelines* (CWQG) for the Protection of Freshwater Aquatic Life (FAL) and limits in *Metal and Diamond Mining Effluent Regulations of the Fisheries Act* (MDMER). Only the MDMER limits are directly applicable to the discharges. The CWQG-FAL guidelines are not applicable to discharges, as these guidelines are developed for the receiving environment and are used for screening and providing inputs to assimilative capacity assessments.

The water quality model shows that there are no MDMER exceedances predicted at facilities (stockpiles, pit, ponds) and final discharge points and LP-FDP-01 to LP-FDP-05) in the Leprechaun mine complex during all mine phases at 95th percentile confidence level.

Long-term CWQG-FAL are not applicable to discharges but were used to screen parameters of potential concern for receivers. In FDPs located near the Leprechaun pit, parameters predicted to exceed the respective long-term CWQG-FAL are P, Cr, Zn, Al, Mn, and Fe at baseline conditions and during construction. During operations, the highest number of long-term CWQG-FAL exceedances were predicted for LP-FDP-03 and associated with seepage from waste rock. In addition to the parameters exceeding at baseline conditions, Cu, Hg, F, $N\text{-}NO_2$, Ag, $N\text{-}NH_{3\ UN}$, As, $N\text{-}NH_{3\ T}$, Cd, Pb, U, Se, and $N\text{-}NO_3$ are predicted to be above the respective long-term CWQG-FAL for LP-FDP-03. These parameters decline during closure and stabilize in post-closure with Cu, Hg, Ag, and F remaining above CWQG-FAL. Seepage from waste rock and LGO also affects LP-FDP-01 and LP-FDP-02, but these discharges have better water quality than LP-FDP-03 resulting in less exceedances of CWQG-FAL.

LP-FDP-04 has better water quality compared to other discharge points. In addition to the parameters exceeding at baseline conditions (P, Cr, Zn, Al, Mn, and Fe). Only Pb is predicted to be marginally above its long-term CWQG-FAL threshold during construction and operation. During closure, Pb concentrations decline and stabilize in post-closure below CWQG-FAL.

LP-FDP-05 receives water from open pit dewatering and overflow from the pit lake. During the first 9 years of operation, $N\text{-}NO_2$, Cu, $N\text{-}NH_{3\ UN}$, F, $N\text{-}NH_{3\ T}$, Hg, Ag, and As are predicted to exceed the respective long-term CWQG-FAL in addition to the parameters elevated at baseline conditions. In the last three years of operation and during closure there will be no discharge from the pit as it fills with water. Cu, $N\text{-}NH_{3\ UN}$, $N\text{-}NH_{3\ T}$, and F are predicted to be above the long-term CWQG-FAL when the pit lake starts to discharge in post-closure (mine year 18). These parameters are related to tailings deposition and discharge from TMF to the pit and show gradual decline in post-closure.

PP-FDP-05 represents the water quality of the TMF polishing pond. During construction, water quality of the pond is similar to the chemistry of undisturbed runoff, which showed exceedances of the long-term CWQG-FAL for P, Zn, Cr, Mn, As, Al, Fe, and Cu considering 95th percentile concentrations. The model predicts exceedances of MDMER limits for $CN_{\ T}$, Cu, and $N\text{-}NH_{3\ UN}$ in the tailings pond indicating that these parameters may require treatment in mine years 1 to 10. At that time, the polishing pond receives treated effluent. During operation, Cu, $N\text{-}NH_{3\ UN}$, F, $N\text{-}NH_{3\ T}$, $CN_{\ WAD}$, Hg, $N\text{-}NO_2$, Se and Cd are predicted to be above the respective long-term CWQG-FAL in addition to baseline exceedances. There is no inflow from the TMF to the polishing pond starting in mine year 10 and until end of the closure, and therefore, the discharge for the polishing pond returns to baseline conditions during this period. In post closure, Cu is predicted to exceed the MDMER limit due to an elevated concentration of this metal in TMF toe seepage. Therefore, a mitigation such as passive treatment of seepage should be considered. In addition to the MDMER exceedance for Cu and baseline indicated above, CN_{WAD}, $N\text{-}NH_{3\ UN}$, and $N\text{-}NH_{3\ T}$, are predicted to be above long-term CWQG-FAL in post-closure.

Abbreviations

AEP	Annual Exceedance Probability
ARD	Acid Rock Drainage
AET	Actual Evapotranspiration
CaCO3	calcium carbonate
CCME	Canadian Council of Ministers of the Environment
CEAA	Canadian Environmental Assessment Act
Client	Marathon Gold Corporation
EIS	Environmental Impact Statement
ET	Evapotranspiration
FDP	Final Discharge Point
HGO	High-Grade Ore
Km	Kilometers
LGO	Low-Grade Ore
LAA	Local Assessment Area
M	Meter
MAF	mean annual flow
Masl	Meters above de sea level
ML	Metal Leaching
Mt/a	Million tons per annum
Mm^3	Million cubic meters
NL	Newfoundland and Labrador
NLDMAE	NL Department of Municipal Affairs and Environment
NLEPA	Newfoundland and Labrador Environmental Protection Act
NTU	Nephelometric Turbidity Units
PAG	Potentially Acid Generating
PoPC	Parameters of Potential Concern
OB	Overburden
Plant	Mill and Processing Plant
RDL	Reportable Detection Limit
TMF	Tailings Management Facility
TS	Topsoil

TSS	Total Suspended Solids
WMP	Water Management Plan
WS	Watershed (areas)
WSC	Water Survey of Canada
°C	Degrees Celsius
μS	microsiemens
μg	micrograms

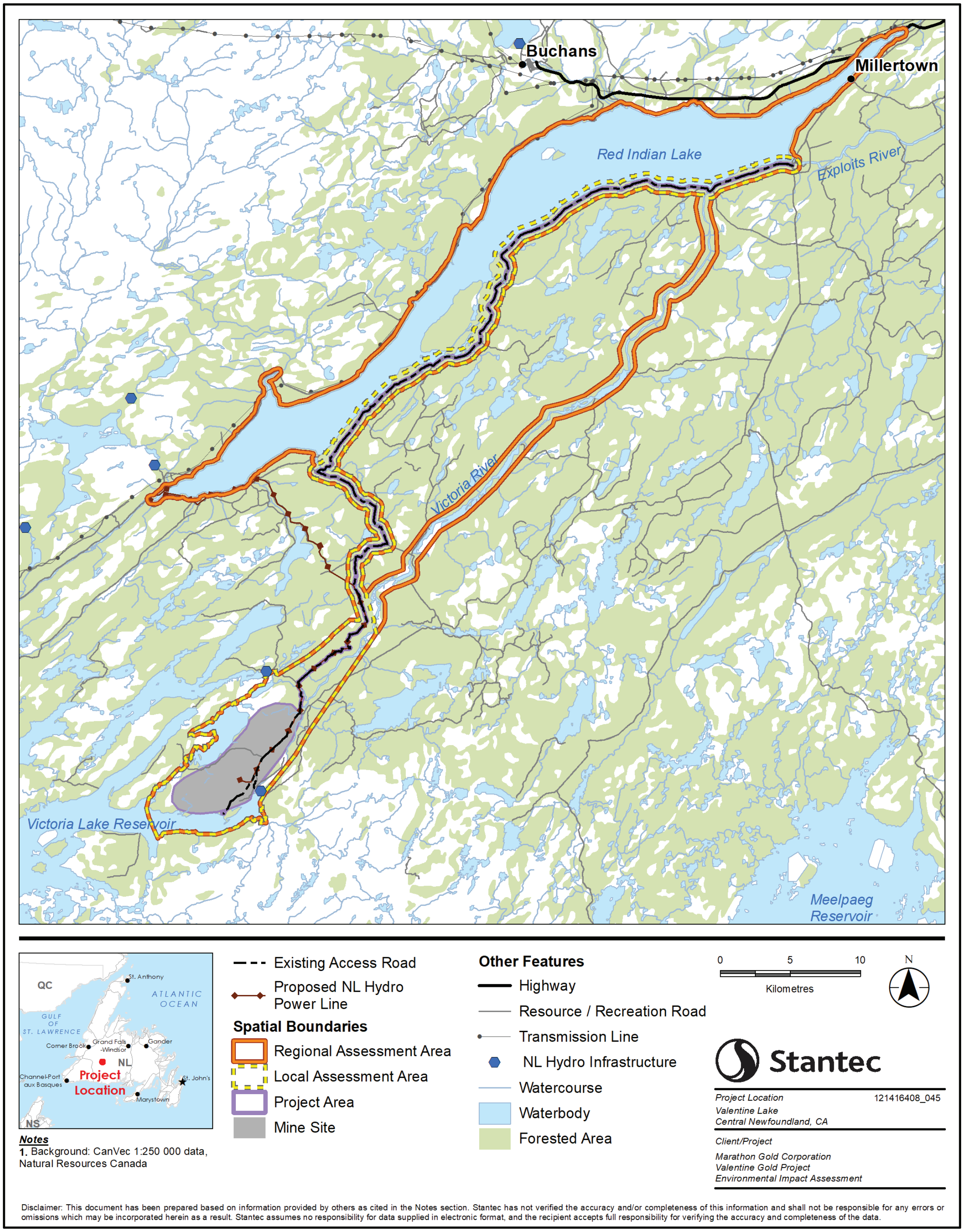
1.0 INTRODUCTION

Marathon Gold Corporation (Marathon) is planning to develop an open pit gold mine at Valentine Lake, located in the west-central region of the Island of Newfoundland, approximately 60 kilometers (km) southwest of the Town of Millertown, Newfoundland and Labrador (NL) (Figure 1-1). The Valentine Gold Project (the Project) includes the construction, operation and decommissioning, rehabilitation and closure of an open pit gold mine and associated ancillary activities. Two open pits are proposed at the mine site: the Marathon and Leprechaun pits. As part of the environmental assessment for the Project, Marathon is preparing an environmental impact statement (EIS) and has commissioned Stantec Consulting Ltd. (Stantec) to develop a water quantity and water quality model to predict potential changes in flow and water quality as a result of the Project. In support of the Application/EIS, Marathon commissioned Stantec to develop a water quantity and water quality model to predict potential changes in flow and water quality as a result of the Project.

As presented in Figure 1-2, the Project is geographically divided in three complexes, from northeast to southwest including the Marathon Complex, the TMF and Processing Plant Complex, and the Leprechaun Complex. This report describes the inputs and assumptions used to develop water quantity and water quality predictions prepared in support of the EIS for both the Leprechaun Complex and the TMF and Processing Plant Complex. The operation of the Leprechaun Complex and TMF and Processing Plant Complex will include interaction between these two complexes, therefore these complexes were combined into one model. The Marathon Complex is described under a separate cover (Stantec 2020a).

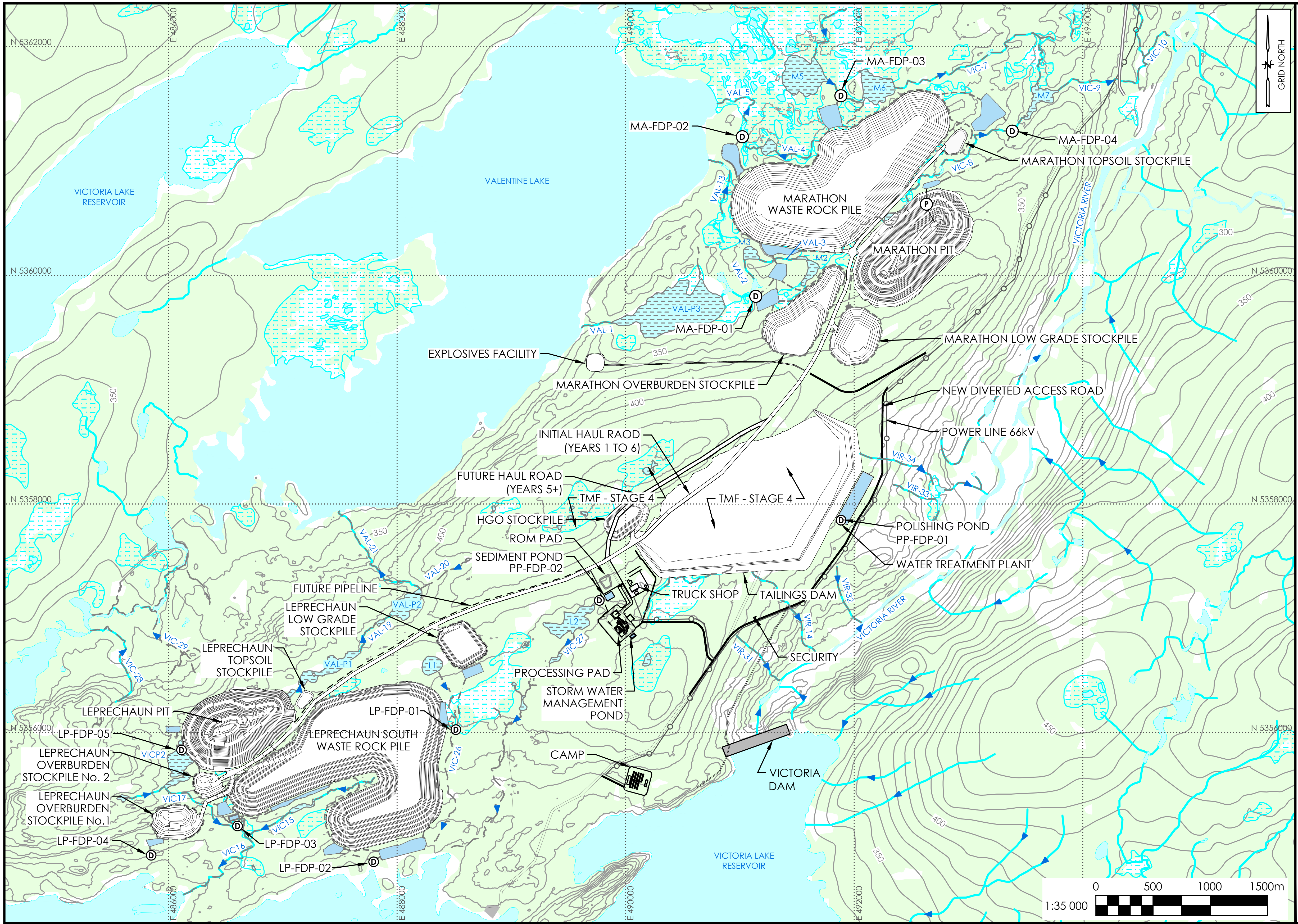
1.1 SITE LOCATION

The Project is situated amidst gentle to moderately steep, hilly terrain and the ground surface elevation ranges from approximately 320 m to 480 metres above sea level (masl) relative to the Canadian Geodetic Vertical Datum of 1928. Victoria Lake Reservoir, a hydroelectric reservoir forming part of the Bay d’Espoir Hydroelectric Development, is adjacent to the Project on the west. The Victoria Dam diverts flow that would otherwise flow to the Victoria River to the White Bear drainage basin to the south. Valentine Lake lies north of the Project and drains to the Victoria River. An overview of the mine complexes and the Project facilities is presented in Figure 1-2.



Notes
1. Background: CanVec 1:250 000 data, Natural Resources Canada

Figure 1-1 Project Location and Spatial Boundaries for Surface Water Resources VC



LEGEND

―	EXISTING CONTOURS, m
═	PROPOSED MINE PIT / STOCKPILE
―	WATERCOURSE
– –	FISH BEARING WATERCOURSE
🟩	WOODED AREA
▨	WETLAND
🟦	WATERBODY
▨	FISH BEARING WATERBODY
🟦	PROPOSED POND
– · –	PROPOSED DRAINAGE CHANNEL
- - - -	PROPOSED DITCH
–··–··–	FUTURE PIPELINE
–○–	POWER LINE
Ⓓ	FINAL DISCHARGE POINT

NOTE:
COORDINATES ARE NAD83(CSRS) UTM ZONE 21.

THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC CONSULTING LTD. REPORT AND MUST NOT BE USED FOR OTHER PURPOSES.

Reference:

1. EXISTING CONTOURS AND PROPOSED INFRASTRUCTURE: AUSENCO; PROJECT No. 104878-01; DRAWING No. 104878-0000-G-001; 2020-05-11; PRELIMINARY.
2. WATERCOURSES, WATERBODIES & WETLANDS: CANVEC DATABASE FROM NATURAL RESOURCES CANADA.
3. FISH BEARING WATERCOURSES AND WATERBODIES: SURVEYED FISH BEARING OR HAS CONNECTIVITY TO FISH BEARING WATER (STANTEC 2012, 2019, 2020).

SITE LAYOUT

WATER QUANTITY AND QUALITY MODELLING REPORT
VALENTINE GOLD PROJECT, NL

Client: MARATHON GOLD CORP

Job No.:	121416408
Scale:	1 : 35 000
Date:	28-SEP-2020
Dwn. By:	JL
App'd By:	NS

Fig. No.: 1-2

Stantec

V:\1214\active\121416408\03_data\gis_cad\1_CAD\4_Sheet_Files\03_WQQ\121416408C_WQQ_Fig1-2.dwg

1.2 STUDY OBJECTIVES

The model considers both the quantity and quality of water under management and is used to support the prediction of potential environmental effects in the EIS.

The objectives of the Leprechaun model are to:

- Estimate the quantity and quality of surface water runoff associated with the Project facilities including the open pit, ore stockpiles, overburden stockpiles, topsoil stockpile, waste rock piles, and tailings management facility (TMF) during all phases of development
- Predict the quantity and quality of effluent discharge at each final discharge points (FDP) during all phases of development
- Aid in the development of the conceptual closure plan for the Project.

Effects of the Project on surface water quantity of the receiving environment are not simulated in this model. A separate assessment of the assimilative capacity of the receiving waters provides the surface water quality of the effluent discharge once mixed with the receiving waters. The model uses process plant water balance inputs and outputs provided in the Pre-Feasibility Study (Ausenco 2020)

1.3 PROJECT SPATIAL BOUNDARIES

The spatial boundaries for the Project include the Project Area, the Local Assessment Area (LAA), and the Regional Assessment Area (RAA) (Figure 1-1). Interactions between the Project and surface water may occur in all three of these defined areas.

Project Area: The Project Area encompasses the immediate area in which Project activities and facilities occur and is comprised of two distinct areas: the mine site and the access road. The mine site includes the area within which Project infrastructure will be located. The access road is the existing road to the site plus a 20 m buffer. The Project Area is the anticipated area of direct physical disturbance associated with the construction and operation of the Project.

Local Assessment Area (LAA): The LAA for the Surface Water Resources Valued Component (VC) was considered to incorporate the Project Area and watersheds that intersect with the Project Area, as shown in Figure 1-1. The LAA also includes portions of Victoria Lake Reservoir in the expected effluent mixing zones, which are typically considered to be up to several hundred meters from points of discharge in the lake. The LAA includes all of Valentine Lake and the Victoria River to the point downstream where all Project-affected tributaries converge with the main branch of the river.

Regional Assessment Area (RAA): The RAA for surface water resources was considered to incorporate the Project Area, LAA, and to extend to include where potential Project interactions may be observed, as shown in Figure 1-1. This was considered to include all of the LAA, the Victoria River and Red Indian Lake, including its discharge at the head of the Exploits River. This area encompasses the potential downstream receivers of surface water that may flow from the Project Area. The model is limited to the Project Area, but receives inputs form Victoria Lake Reservoir, which is within the LAA.

1.4 PROJECT OVERVIEW

1.4.1 Project Facilities

The Leprechaun Complex consists of an open pit and stockpiles (i.e., waste rock pile, and topsoil, overburden and low-grade ore [LGO] stockpiles), and water management ponds. The Processing Plant and TMF Complex consists of the TMF (i.e., the tailings impoundment and polishing pond), water treatment plant, process plant, truck shop, run-of-mill (ROM) pad, and high-grade ore (HGO) stockpile. A description of the individual Project facilities at the TMF and Processing Plant Complex and the Leprechaun Complex are presented below and in the Water Management Plan (Stantec 2020b). The location of the facilities is shown on Figure 1-2.

Ore Milling and Processing Plant*:* Processing is proposed in two phases of operation, the initial processing period has a nominal throughput of 6,859 tonnes per day (t/d) or 2.5 million tonnes per year (Mt/a). As the mill feed grade decreases, and plant capacity is required to increase to maintain gold production, the mill will operate at full production rate of 10,960 t/d or 4.0 Mt/a. At full production, flotation equipment will be employed to recover the majority of the gold to a low mass concentrate stream, and ultra-fine grinding and cyanidation.

Fresh make-up water and elution water will be pumped from Victoria Lake Reservoir to the process plant, amounting to approximately 13% of process water for initial processing and 8% of process water for full production.

In the Leprechaun model, which includes a water linkage to the mill and processing plant, the mill and processing plant (the Plant) are represented in the model as water demand elements, reclaiming water from the tailings pond. Reclaim water demand information was taken from Golder (Golder 2020a) with details presented in section 3.3.2.3

Tailings Management Facility (TMF): The TMF is located northeast of the Plant along a natural topographic ridge. The TMF will receive direct precipitation, as well as the process water discharged with the tailings slurry. Excess water from the open pit dewatering and runoff from stockpiles at the Leprechaun Complex are managed separately and do not report to the TMF.

The tailings pond, with a maximum storage capacity of 1 million cubic metres (Mm^3), has been sized to store the excess TMF water during the non-discharge period (December to March). Reclaim water will be pumped from a floating barge in the TMF to the Plant. The process water demand will primarily be supplied with reclaimed water from the TMF to reduce the need for fresh surface water demand.

A continuous downstream raise of the tailings impoundment will be constructed to meet requirements for water and tailings storage. The primary construction material for the TMF is the waste rock from the open pits. Dam runoff and seepage will be captured in the perimeter seepage collection ditches and pumped back to the TMF.

A water treatment plant will treat excess tailings pond water prior to discharge to Victoria Lake Reservoir. A polishing pond will provide final adjustments of the water quality of the treated effluent prior to release to the natural environment. The polishing pond will be lined with a geomembrane, similar to the upstream slope of the tailings dam embankment. The polishing pond is designed to provide sufficient residence time for the settlement of solids. It will be constructed with perimeter embankments above the natural topography; therefore, run-off from upstream of the polishing pond will be diverted away from the pond.

Leprechaun Open Pit: The open pit will be progressively expanded over the 9 years of mining. The Marathon and Leprechaun pits will be mined simultaneously with plans for the ore stream to be blended and processed together. Ore extracted from the open pits will be hauled to stockpiles or to the Plant. Ore grading between 0.33 and 0.50 grams per tonne (g/t) of gold (Au) will be stockpiled in the associated LGO stockpiles. Cut-off grade optimization on the mine production schedule will also send ore above 0.50 g/t Au to an HGO stockpile in certain planned periods.

The Leprechaun open pit will be dewatered throughout operation by pumping from sumps at the base of the pit. The collected contact water will be stored in a sump pump prior to being pumped to a water management pond at the surface. Water from the water management ponds will be used supplement mill demand or discharged to the environment following treatment in the water management ponds as needed to meet discharge quality criteria.

The anticipated depth under the projected spillway of the Leprechaun open pit is approximately 380 m, with a maximum area of 0.5 square kilometres (km^2). After completion of mining, the Leprechaun pit will be filled with tailings and water to a depth of 380 m at the crest of the spillway and an associated maximum storage volume of 53.3 Mm^3. Once full, the pit lake will be spilled through a discharge channel toward the existing FDP.

Active mining extraction of ore and waste rock will cease in year 9, however ore processing is anticipated to continue from years 10 to 12. During years 10 to 12, tailings produced from ore processing will be deposited in the Leprechaun pit and thus the need to link the Leprechaun water model with the Processing Plant and TMF Complex.

Low-grade ore Stockpile, Overburden Stockpile, Topsoil Stockpile and Waste Rock Pile: The Leprechaun waste rock pile is located southeast of the pit limits and built up to a crest elevation of 430 m. Topsoil from the pit will be stored in a topsoil stockpile directly west of the pit limits and overburden will be stored in the overburden stockpile directly southwest of the pit limits. The LGO stockpile will be located northeast of the pit. These piles are separated to avoid local natural water courses.

The waste rock pile will be constructed from the existing ground surface and will be sloped and benched as it is developed, creating overall safe slopes for final closure of three horizontal to one vertical (3H:1V). In addition, the pile will be progressively rehabilitated during operation and closure by covering slopes and benches with a vegetated soil cover to reduce infiltration and increase evapotranspiration.

Final Discharge Points: The FDPs receive the water management ponds outflows. Watershed areas upstream of each FDP associated with the Project water management infrastructure were developed using available public topographic information and LiDAR data collected for the Project.

1.4.2 Water Management Infrastructure

Water management infrastructure includes the water treatment plant and polishing pond constructed downstream of the tailings impoundment and the water management ponds constructed upstream of each FDP. Excess water from the tailings pond that is not reclaimed to the Plant, will be treated in the water treatment plant prior to discharge to the polishing pond and finally to Victoria Lake Reservoir. At the Leprechaun Complex, collection ditches will be installed around the perimeter of Project facilities to intercept surface water and toe seepage and convey to the water management ponds. Further details regarding water management infrastructure is described in Section 3.3.

A water treatment plant and polishing pond allow for the treatment and discharge of the excess TMF water to Victoria Lake Reservoir. Water quality treatment for the tailings process water effluent involves a cyanide (CN) destruction circuit in the mill circuit; sedimentation of suspended solids, and supplemental natural cyanide degradation in the tailings pond; copper and ammonia removal, and pH adjustment in the water treatment plant; and peak effluent flow equalization and sedimentation in the polishing pond. Coagulant polymer will be added at the water treatment plant to facilitate the removal of colloidal sized suspended matter. Treatment and discharge from the TMF excess water will occur for eight months each year. Design of the decant structure system was based on the required capacity of the maximum water treatment plant rate of 10,800 cubic metres per day (m^3/d) and the average reclaim flows to the mill for process use.

A polishing pond will further reduce the concentrations of contaminants to much lower than the MDMER effluent limit, via solid settling and degradation of ammonia and cyanide. Water will be retained in the polishing pond for up to five days, providing adequate time for addition of lime slurry and coagulant for pH adjustment and enhanced particulate sedimentation, respectively.

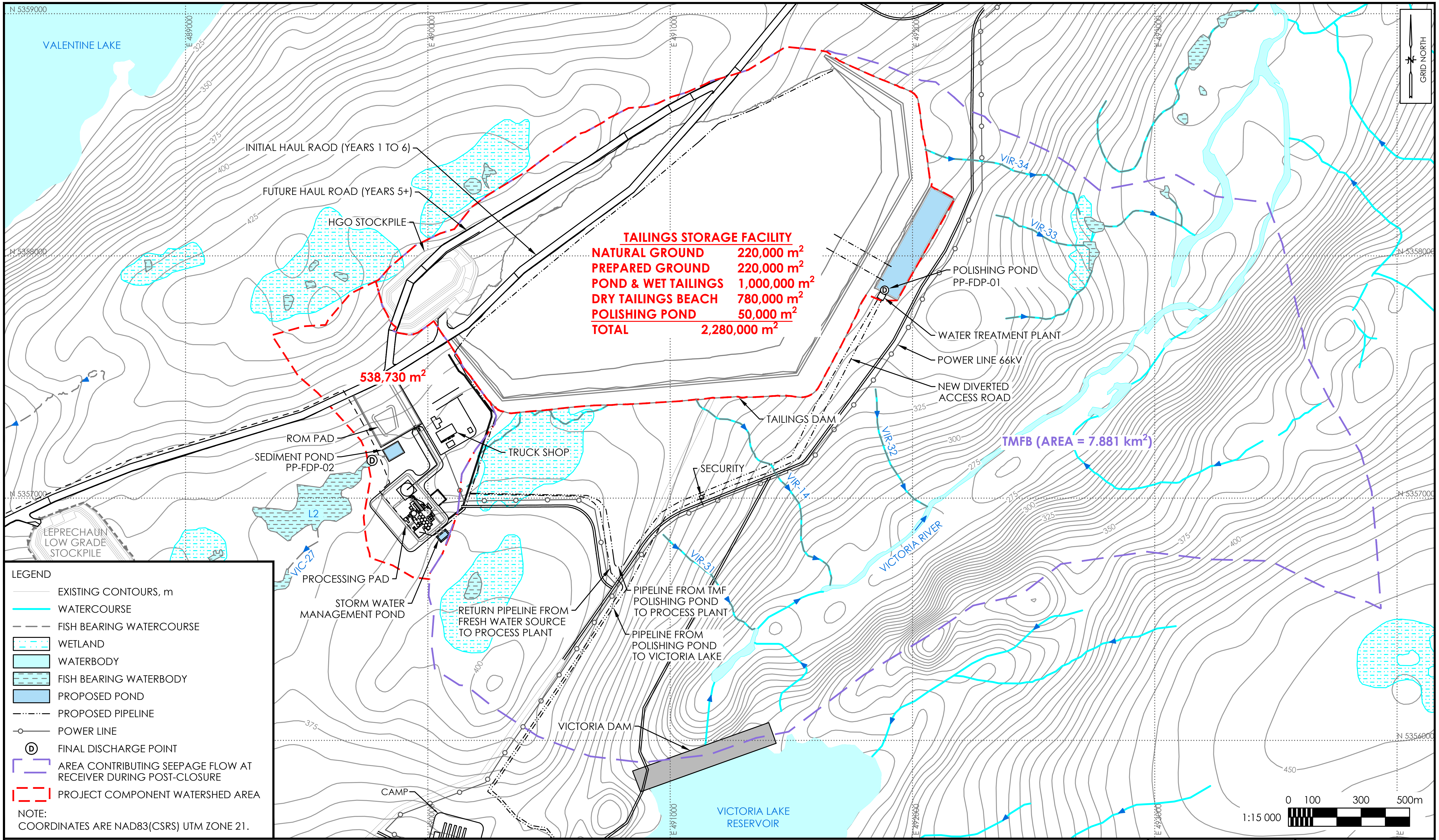
The water management ponds at the Leprechaun Complex are intended to control the sediment contained in contact water discharges from mine facilities. Each water management pond collects runoff, toe seepage, and groundwater infiltration through a series of ditches. The ditches may capture flow from waste rock piles, LGO, topsoil, or overburden stockpiles, or water from pit dewatering. These water management features (ditches and water management ponds) were designed under a decentralized water treatment framework, operating under gravity drainage to reduce the need for pumping when managing flows.

Table 1-1 shows a list of the ditches and water management ponds in the Leprechaun Complex and TMF Processing Plant Complex that capture runoff and toe seepage from each mine facility, as well as catchment area and volume of the water management ponds. Figure 1-2 provides location of the water management ponds and ditches. The water management ponds discharge to the FDPs. Figure 1-3 to 1-4 show flow pathways between the mine facilities, water management ponds, and FDPs and watershed areas.

Table 1-1 Water Management Ponds and Approximate Ultimate Surface Areas

Mine Facility	Ditch Name	Water Management Pond Name	Water Management Pond Watershed Area (m^2)	Pond Volume (m^3)	Pond Area (m^2)
TMF	PP-PR-01	Not Applicable	Polishing Pond		
Process Plant Pad	PP-DR-01	100	PP-SP-01		
LGO Stockpile	LP-DR-01	LP-SP-01A	115,080	11,600	19,795
	LP-DR-02				
Waste Rock Pile	LP-DR-03	LP-SP-01B	290,770	29,500	17,975
	LP-DR-04	LP-SP-02A	471,100	46,600	47,239
	LP-DR-05				
	LP-DR-06	LP-SP-02B	145,000	14,700	15,400
	LP-DR-07	LP-SP-03A	444,700	44,400	16,985
	LP-DR-08	LP-SP-03C	37,570	3,800	14,900
	LP-DR-09				
	LP-DR-10	LP-SP-03B	224,540*	22,700	16,775
Topsoil Stockpile	LP-DR-11		45,150*		
Overburden Stockpile	LP-DR-12	LP-SP-04	104,855	10,600	13,120
	LP-DR-13				
Pit	Dewatering	LP-SP-05	520,000**	4,500	20,600

Notes:
* This area is divided in two portions. The smallest portion is diverted to the pit at closure.
** Ultimate watershed area (final year of development)



TAILINGS STORAGE FACILITY

NATURAL GROUND	220,000 m²
PREPARED GROUND	220,000 m²
POND & WET TAILINGS	1,000,000 m²
DRY TAILINGS BEACH	780,000 m²
POLISHING POND	50,000 m²
TOTAL	2,280,000 m²

NOTE:
COORDINATES ARE NAD83(CSRS) UTM ZONE 21.

THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC CONSULTING LTD. REPORT AND MUST NOT BE USED FOR OTHER PURPOSES.

Reference:
1. EXISTING CONTOURS AND PROPOSED INFRASTRUCTURE: AUSENCO; PROJECT No. 104878-01; DRAWING No. 104878-0000-G-001; 2020-05-11; PRELIMINARY.
2. WATERCOURSES, WATERBODIES & WETLANDS: CANVEC DATABASE FROM NATURAL RESOURCES CANADA.
3. FISH BEARING WATERCOURSES AND WATERBODIES: SURVEYED FISH BEARING OR HAS CONNECTIVITY TO FISH BEARING WATER (STANTEC 2012, 2019, 2020).

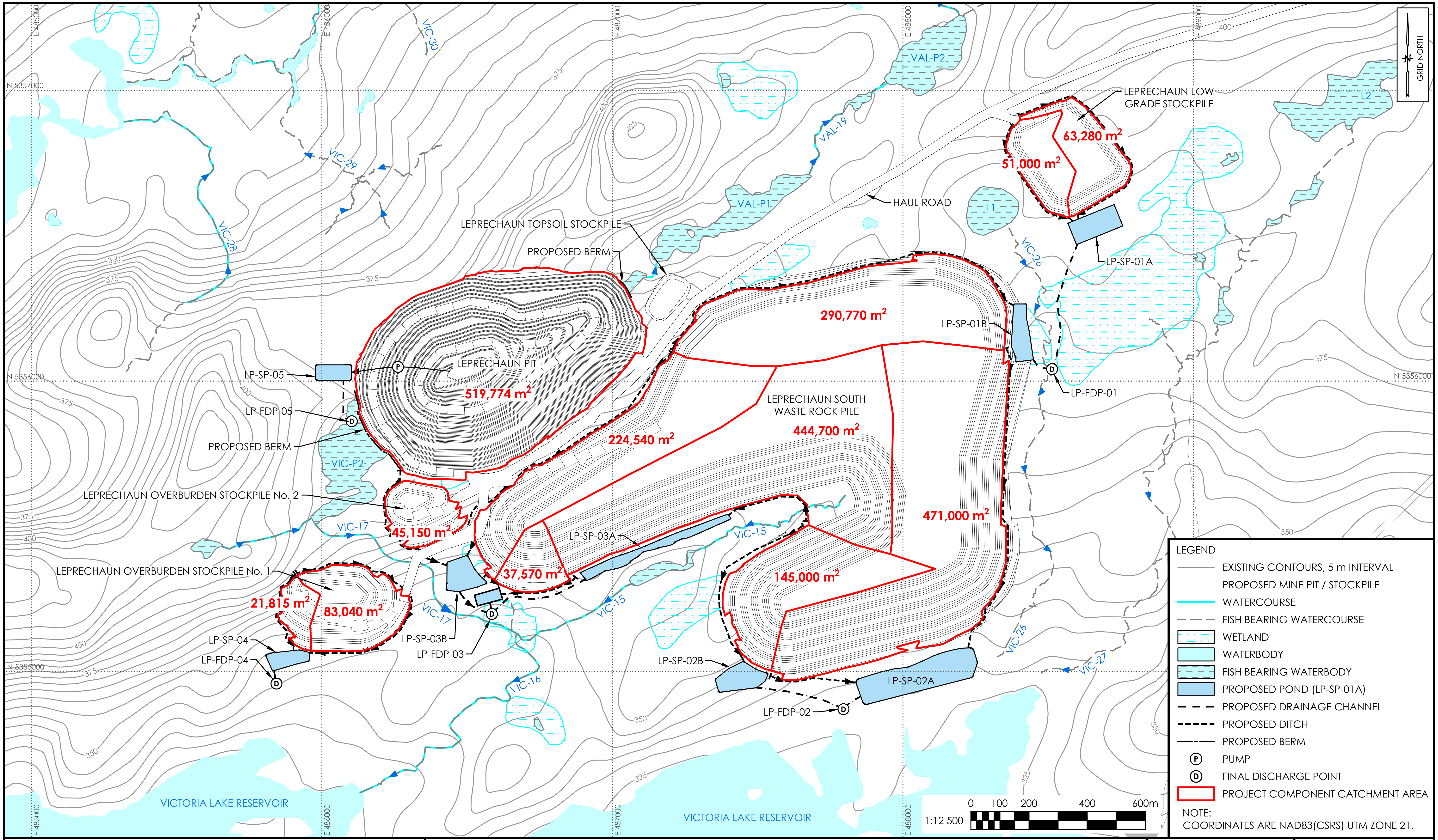
TMF AND PROCESSING PLANT PROJECT FACILITIES
WATER QUANTITY AND QUALITY MODELLING REPORT
VALENTINE GOLD PROJECT, NL

Client: MARATHON GOLD CORP

Job No.:	121416408
Scale:	1 : 15 000
Date:	28-SEP-2020
Dwn. By:	JL
App'd By:	NS
Fig. No.:	1-3

Stantec

V:\1214\active\121416408\03_data\gis_cad\1_CAD\4_Sheet_Files\03_WQQ\121416408C_WQQ_LEP_Fig1-3.dwg



THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC CONSULTING LTD. REPORT AND MUST NOT BE USED FOR OTHER PURPOSES.

Reference:

1. EXISTING CONTOURS AND PROPOSED INFRASTRUCTURE: AUSENCO; PROJECT No. 104878-01; DRAWING No. 104878-0000-G-001; 2020-05-11; PRELIMINARY.
2. WATERCOURSES, WATERBODIES & WETLANDS: CANVEC DATABASE FROM NATURAL RESOURCES CANADA.
3. FISH BEARING WATERCOURSES AND WATERBODIES: SURVEYED FISH BEARING OR HAS CONNECTIVITY TO FISH BEARING WATER (STANTEC 2012, 2019, 2020).

LEPRECHAUN WATER MANAGEMENT DESIGN AND CATCHMENT AREAS
WATER QUANTITY AND QUALITY MODELLING REPORT
VALENTINE GOLD PROJECT, NL

Client: MARATHON GOLD CORP

Job No.:	121416408
Scale:	1 : 12 500
Date:	28-SEP-2020
Dwn. By:	JL
App'd By:	NS

Fig. No.: 1-4

Stantec

V:\1214\active\121416408\03_data\gis_cad\1_CAD\4_Sheet_Files\03_WQQ\121416408C_WQQ_LEP_Fig1-4.dwg

1.4.3 Project Phases

The overall Project development schedule will consist of three primary phases: construction, operation, and decommissioning, rehabilitation and closure. Project activities within these phases are further subdivided for the purposes of this report as shown in Table 1-2. For convenience, "closure" in this document refers to the first five years of the decommissioning, rehabilitation and closure phase, while "post-closure" refers to the remainder of this phase.

The time frame for the Project phases in years, and the corresponding model year (at the beginning of the model year), are presented on Figure 1-5. The model assumes that construction starts in model Year 0 and operation commences in model Year 1.

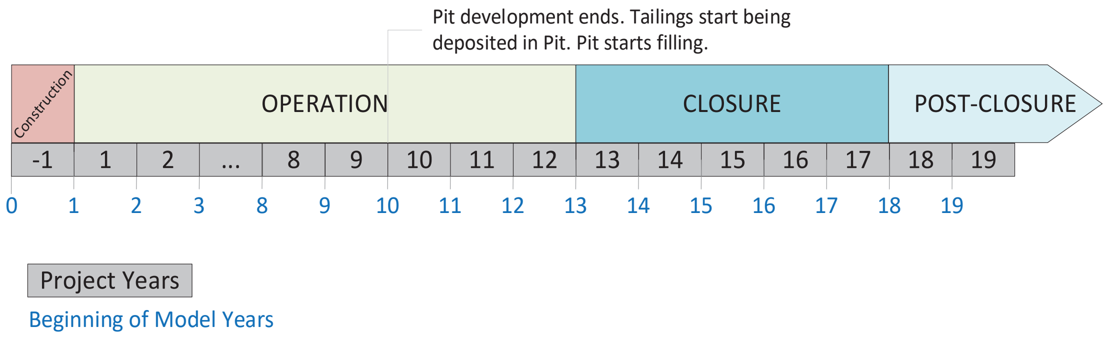


Figure 1-5 Project Phases of Development (Project Year versus Model Year)

Table 1-2 Description of Project Phases and Sub-Phases

Project Phase	Time Frames Incorporated into the Model	Description
Construction	Year -1*	Construction activities will occur over 16 -20 months, for simplicity associated to mine Year -1. The processing plant and TMF are not operating during this phase. Mining activity has commenced during construction to provide material for TMF and road construction. Topsoil and overburden stockpiles will be developed during construction, as well as the ground preparation for the waste rock pile footprint for the first year of operation.
Operation	Year 1 – Year 9 (9 years)	During Years 1 – 9, the open pits will be mined, waste rock piles will be extended to their full footprint and constructed vertically, ore will be processed, and the mill plant and TMF will be operational. The processing plant and TMF will operate as a circuit with tailings being deposited in the TMF as a thickened slurry (60% to 75%) and process water being reclaimed via a pump and pipeline from a decant barge in the TMF. Mining activities cease at the end of Year 9.
	Year 10 – Year 12 (3 years)	In Year 10, tailings deposition is switched from the TMF to the Leprechaun open pit. Process water will then be reclaimed from the pit. However, the reclaim from the TMF will remain active for the last years of mine life to supplement the process water supply from the pit to the process plant. During Years 10 – 12, mining activities will cease, as will tailings deposition to the TMF. Continued milling operations will deposit tailings in the Leprechaun pit. The TMF and waste rock piles will be recontoured and rehabilitated with vegetated soils covers, and HGO and LGO stockpiles will be consumed. Waste rock piles are designed for closure and the slopes and benches will be progressively rehabilitated. Minor recontouring of the upstream areas of the TMF may be required to facilitate positive gravity drainage over the vegetated soil cover toward a natural ground outlet from the TMF. The model does not account for progressive rehabilitation vegetated soil covering activities that will begin during operation, representing a conservative estimate of environmental effects during operations. The Marathon pit will commence filling with water as dewatering activities during Years 10 – 12 in that pit will cease.

Table 1-2 Description of Project Phases and Sub-Phases

Project Phase	Time Frames Incorporated into the Model	Description
Decommissioning, Rehabilitation and Closure	Closure: Year 13 – Year 17 (5 years)	During first 18 months of closure, the processing plant will be decommissioned, the overburden topsoil, and HGO and LGO stockpiles will be used up and the footprint areas stabilized with vegetation, and the waste rock piles will be rehabilitated with vegetated soil covers. Existing Project buildings and associated infrastructure will be dismantled, removed for disposal, and/or demolished. The open pits will be filled naturally from incidental precipitation and groundwater inflows as well as accelerated by directing runoff from upgradient portions of their catchments, pumping from the TMF (Marathon pit) and pumping from Valentine Lake (Marathon pit) and Victoria Lake Reservoir (Leprechaun pit). The pit lakes will be filled to allow development of stratified pit lakes and eventual discharge to the Victoria River and Victoria Lake Reservoir. Unless otherwise stated in this report, water management infrastructure will remain in place at closure until the water quality is such that removal of such infrastructure is acceptable.
	Post-Closure: from Year 18 onward	During this phase, the open pit will continue to fill and eventually discharge to the environment. Other discharges to the environment include groundwater and surface water runoff from the waste rock pile.

Note:

* For simplicity, modelling considered a one-year construction period rather than 16 – 20 months, as the majority of construction activities are schedule to occur in 2022.

1.4.4 Post-Development Watershed Areas

The water management design diverts non-contact water from the natural water drainage areas associated with the mine facilities, where possible. Diversion of surface flows using channels and berms constructed around the crest of open pits or up-gradient of waste rock piles, stockpiles, and other developed areas will reduce the contact water inventory. Figure 1-6 presents the post-development watershed areas, flow directions, locations of FDPs, historical surface water hydrology and quality monitoring stations details on the mine facilities.

As presented in Table 1-3 and Figure 1-6, the TMF and Processing Plant and Leprechaun complexes have seven FDPs. The Processing Plant and TMF Complex has two FDPs that flow or are pumped to Victoria Lake Reservoir. This includes the TMF effluent pipeline to Victoria Lake Reservoir and runoff from the processing complex. Five FDPs are associated with the Leprechaun Complex that ultimately drain to Victoria Lake Reservoir, either directly to the lake or through tributaries. MDMER limits will be met prior to release of water from the FDPs.

During operation, the Leprechaun waste rock pile will be graded to maintain pre-development watershed areas, where possible. The waste rock pile is divided to drain to three water management ponds. During operation, perimeter berms will be installed where required around the Leprechaun pit to prevent surface water runoff from flowing into the pit. During closure, these berms will be removed allowing surface water runoff to flow into the pit in an effort to accelerate pit filling and reestablish pre-development drainage conditions. Similarly, a portion of the overburden stockpile runoff will be allowed to return to pre-development drainage conditions once the water management ponds have been decommissioned and removed.

Table 1-3 Post-Development Watershed Areas

Final Discharge Point	Watershed ID	Watershed area (km^2) During Construction/Operation	Watershed areas (km^2) During Closure/Post-Closure
PP-FDP-01	WS-23	2.304	2.304
PP-FDP-02	WS-11	0.538	0.538/0.307
LP-FDP-01	WS-9	0.913	0.913
LP-FDP-02	WS-7	0.743	0.743
LP-FDP-03	WS-2	1.912	1.912
LP-FDP-04	WS-1	0.394	0.394/0.487
LP-FDP-05	WS-3	0.558	0.765/0.558

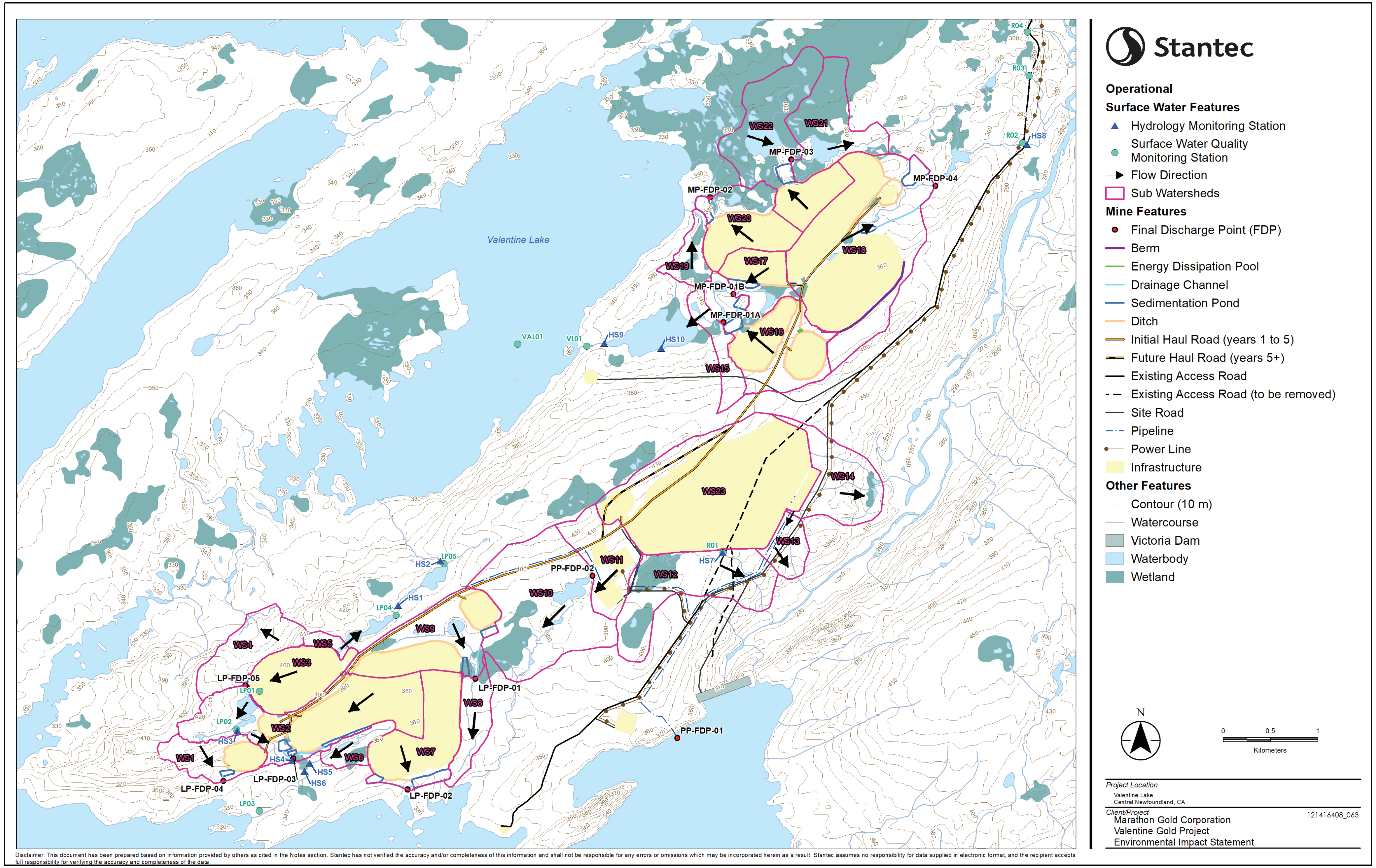


Figure 1-6 **Mine Construction and Operation Watershed Areas**

2.0 MODELLING APPROACH

The model was constructed using GoldSim simulation software (GoldSim) with the contaminant transport module extension. GoldSim is commonly used in the mining industry to develop water balance models and predict water quality at user-defined modelling nodes by combining system dynamics with discrete event simulations. The model was run dynamically with a monthly time step for the construction, operation, and decommissioning, rehabilitation and closure (sub-divided into closure and post-closure) phases of the Project, as defined on Table 1-2.

The model includes a water quantity component (Sections 3 and 4) and a water quality component (Section 5 and 6). Water quantity is calculated incorporating defined inputs, such as inflow rates and outflow rates. These inflows and outflows are based on precipitation, evapotranspiration, infiltration and runoff rates, catchment and facility areas and volumes, groundwater inflow rates, operational water management strategies and the movement of materials within the site. The water quality predictions are calculated at the model nodes by integrating source terms developed for mass loading sources into the water quantity component.

An average climate condition (i.e., based on Climate Normals) was considered to evaluate the potential effects of the Project on surface water as a base case. Building from this base case, a probabilistic Monte Carlo analysis was conducted to simulate the variability in climate in a wet and dry year. This allows for the prediction of runoff, seepage and water quality behavior and characteristics over this range of climatic conditions.

The Monte Carlo analysis consisted of series runs of randomly generated yearly precipitation totals using a probabilistic precipitation distribution throughout the year based on a monthly time step. A single run in this model consisted of 100 years with different annual precipitation values for each year. This approach enabled the analysis of a range of climate scenarios and the development of statistical frequencies and confidence intervals for the flow rates and water quality predicted by the model. The Monte Carlo analysis was set for 100 runs, i.e., running the model 100 times, for different annual precipitation each year. Results of the Monte Carlo analysis are presented as percentiles from the whole range of model results, from percentile 5% (equivalent to a 1:5 dry year) to 95% (equivalent to 1:25 wet year).

The water quantity model and climate scenarios are discussed in more detail in Section 3.3.1. Results are provided for the average scenario and for the probabilistic analysis. the model was adjusted to predict mean and standard deviation baseline conditions based on observed mean and standard deviation (from historical data) and assumptions of a log-normal distribution based on the frequency analysis of the data. This range of model results was intended to account for the variability in climate, runoff, and the highly adapted and manipulated mine site.,

3.0 WATER QUANTITY MODEL

3.1 CONCEPTUAL WATER QUANTITY MODEL

The water quantity model relies on climate and hydrological inputs, drainage areas, and characteristics of mine facilities during different phases of the Project. The water quantity model is developed to predict outflow rates of the mine site, including the water management pond discharges to the FDPs, within the LAA. The LAA for the Surface Water Resources VC is shown in Figure 1-1. The Leprechaun Complex drains and discharges ultimately to Victoria Lake Reservoir through direct lake tributaries. During operation Years 1 – 9, the process plant area and TMF will drain and discharge to Victoria Lake Reservoir as well, however during Years 10 – 12 excess TMF water will be reclaimed to the process plant with no discharge to Victoria Lake Reservoir.

Figure 3-1 presents the schematic structure of the water quantity model, the Leprechaun FDPs/receivers and identifies the Project facilities, contact water (i.e., water that is in contact with the Project facilities) and non-contact water (i.e., water not affected by the Project) flow pathways. The modelled Project facilities identified in Section 1.4, including the processing plant, TMF, open pit and stockpiles will have drainage and diversion controls that prevent external natural drainage from coming into contact with Project facilities and becoming contact water.

Watershed areas for the Project facilities were delineated based on the site layout (Figure 1-2) and existing ground surface topography. The watershed areas were delineated where seepage from the bases of the waste rock piles, ore stockpiles and overburden stockpiles are expected to report to the collection ditches and then to the water management pond. It is assumed that these watershed areas are at the ultimate footprint stage of mine development at the beginning of each Project phase. For example, the model assumes that contact water from stockpiles starts flowing to the water management ponds at the beginning of operation with the exception of the open pit, which has been set as a gradually expanding area over Years 1 – 9.

Conceptual models showing the interactions of the Project facilities during construction, operation, and decommissioning, rehabilitation and closure (sub-divided into closure and post-closure) are presented in Figure 3-1 to Figure 3-4. The flow arrows show the direction of flow accounted for in the water quantity model, either to or away from the Project facility. To simulate post-closure, the water quantity model was extended to run until the end of Year 100. Natural and accelerated pit filling scenarios were considered including natural seepage and runoff alone and two accelerated pit filling cases where water will be pumped from local lakes: one taking place during the eight years from Year 10 to Year 18 (Year 5 of Closure) and a second where accelerated filling takes place at a slower rate. The GoldSim water quantity model simulated the accelerated 8 year filling scenario for the Leprechaun pit.

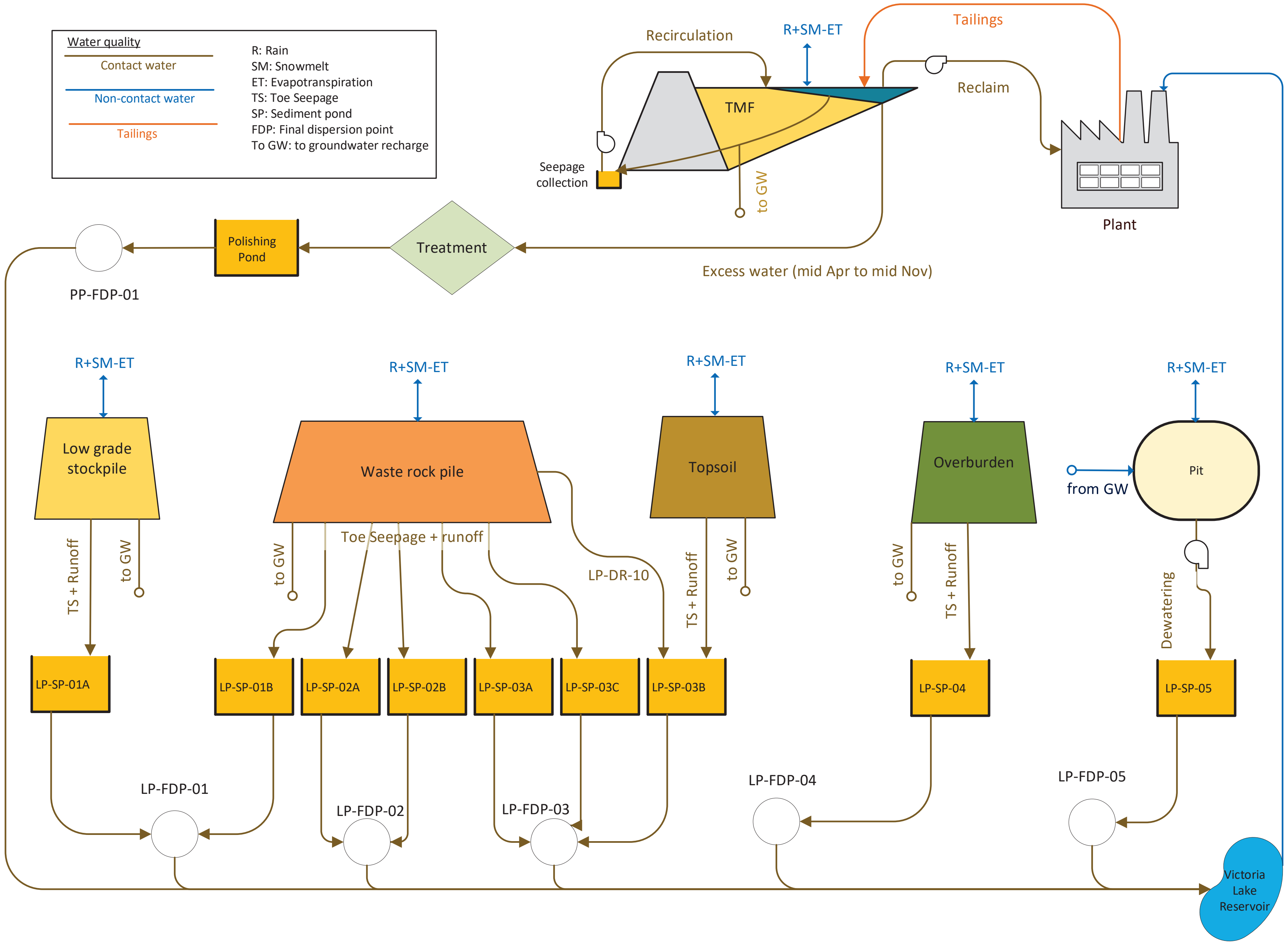


Figure 3-1 Conceptual Model of Mine Water Management – Construction/Operation (Year -1 to 9)

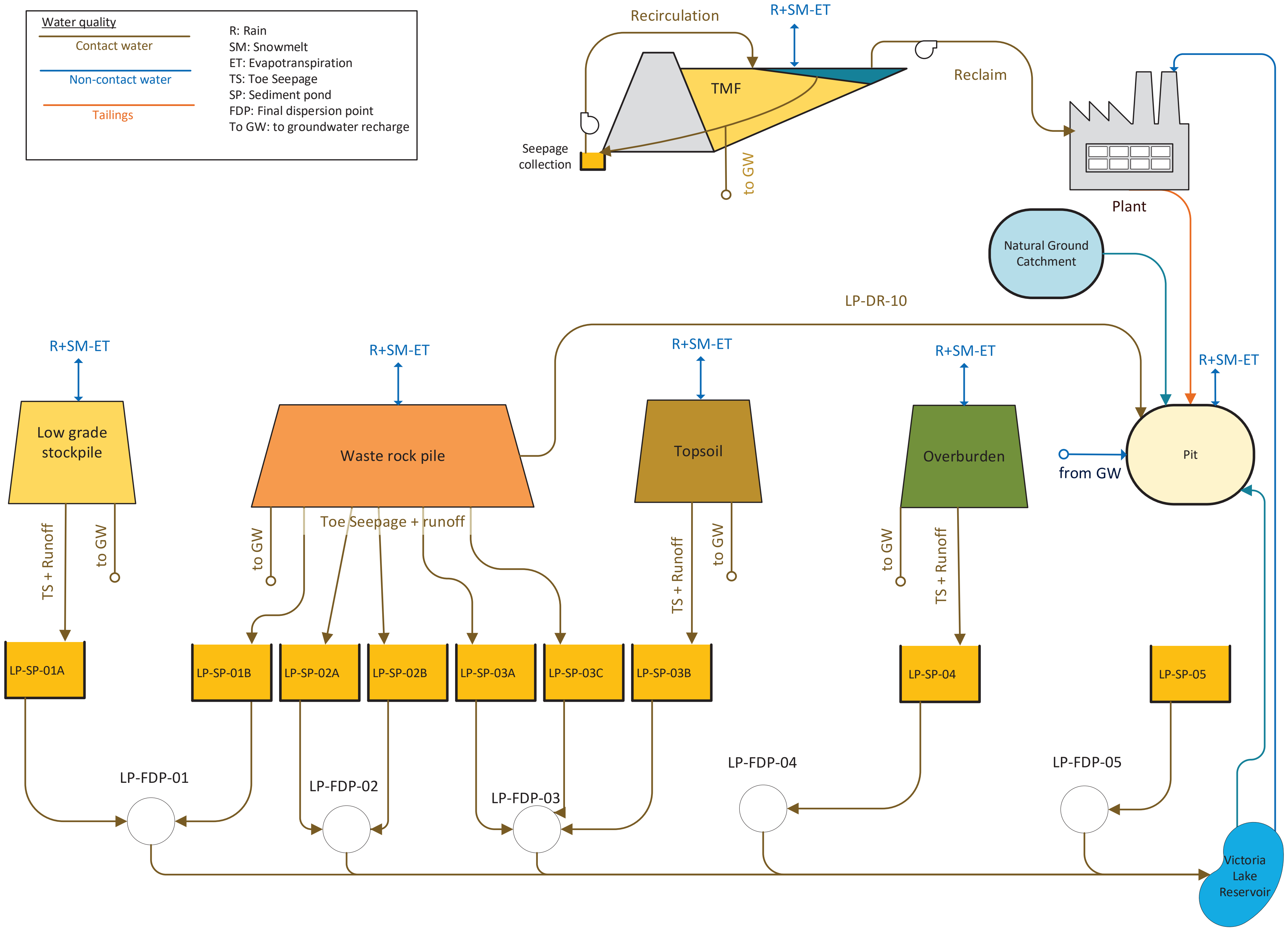


Figure 3-2 Conceptual Model of Mine Water Management – Operation (Year 10 to 12)

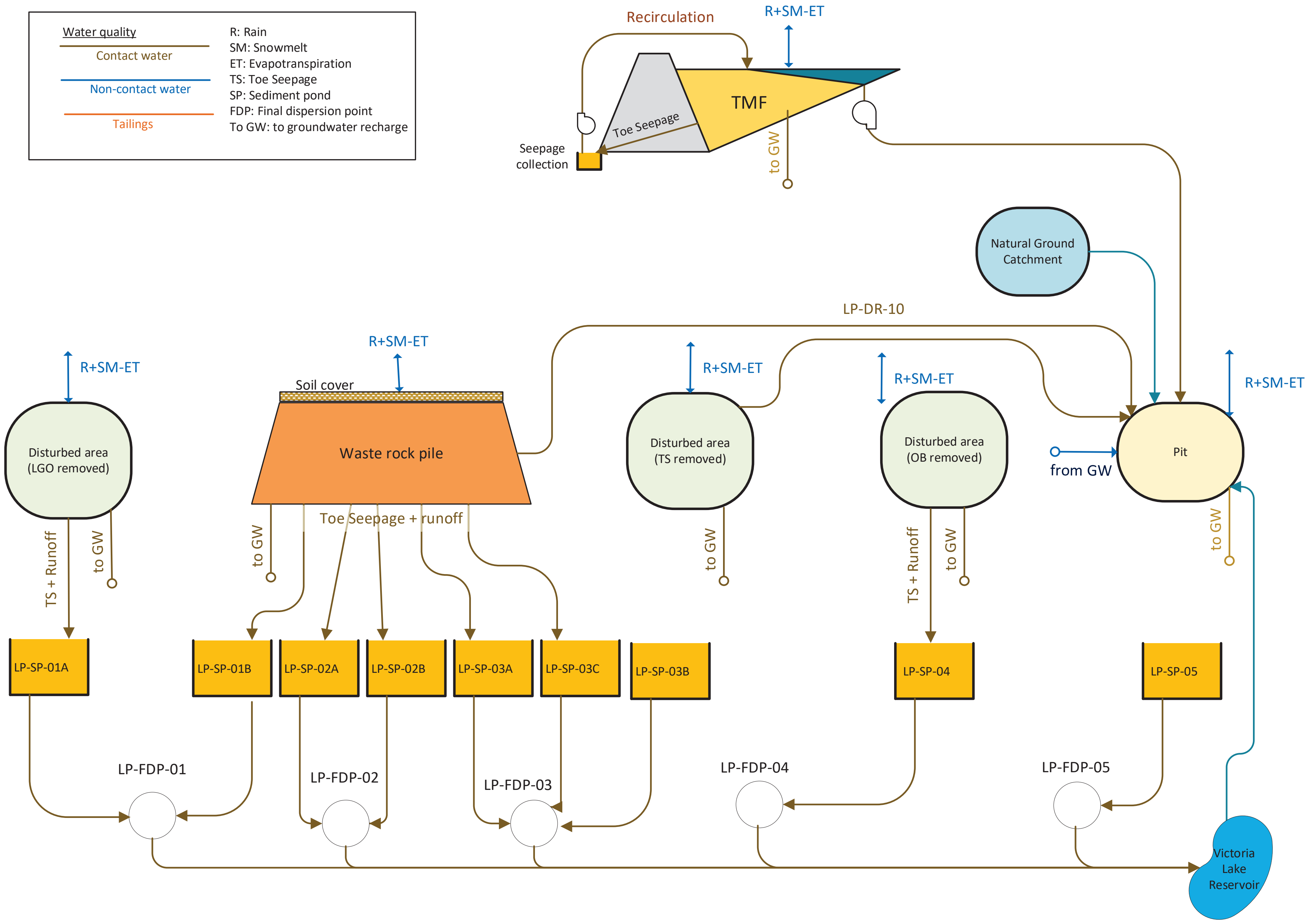


Figure 3-3 **Conceptual Model of Mine Water Management – Closure (Year 13 until Pit is full)**

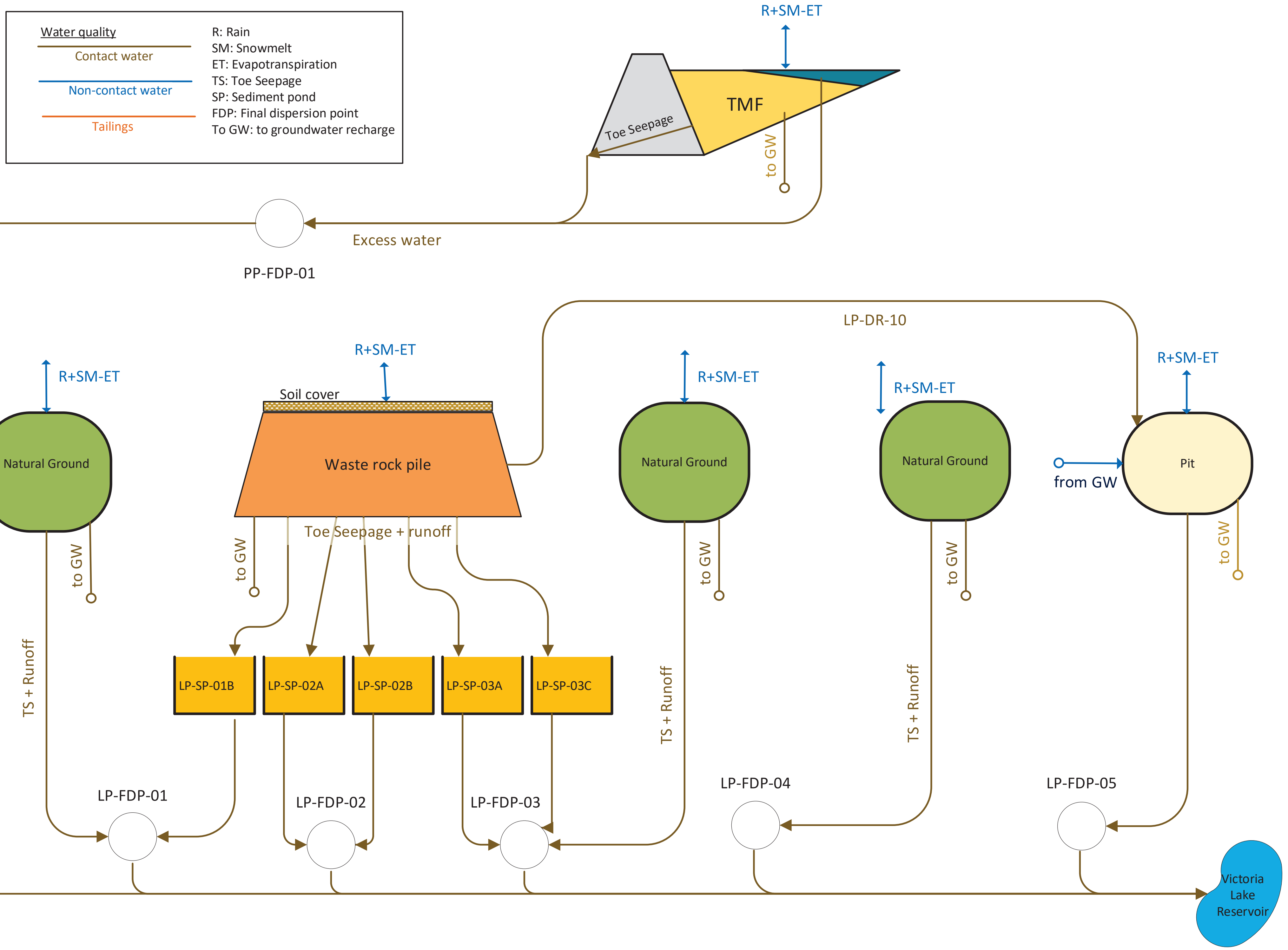


Figure 3-4 **Conceptual Model of Mine Water Management – Post-Closure (Pit is full)**

3.2 WATER QUANTITY APPROACH

The water quantity model was developed using the GoldSim contaminant transport module. The water quantity model accounted for the precipitation, evapotranspiration, infiltration and groundwater gains and runoff at each identified mine facility, with the exception of the pit and TMF, which are discussed separately.

The conceptual flowpaths for precipitation on a stockpile or waste rock pile are presented in Figure 3-5. The percentage of precipitation that results in runoff of the pile facility areas was accounted for in the water quantity model by a water balance approach. These inputs to the model are summarized in Table 3-1, showing the monthly totals in mm and the percent monthly distribution. For the purposes of the model, it was assumed that the pore space in the waste rock pile was fully saturated during operation, and therefore did not require accounting for the initial saturation of the pile. Equation 3-1 presents the accounting of runoff from stockpiles and the waste rock pile collected in the seepage collection ditches and water management ponds based on the hydrological inputs:

Equation 3-1

Runoff to Water Management Ponds = Precipitation
– ET (%F)
– Snow Storage
+ Snow Melt and Runoff (%F)
– Net infiltration
+ Toe Seepage
+ Shallow Groundwater Infiltration (%F)

Where,
%F = Adjustment factor applied as % of precipitation
Net Infiltration = Toe Seepage + Shallow Groundwater + Deep Groundwater

The water balance of the TMF was based on a runoff coefficient approach. Runoff from the tailings and polishing pond was estimated in the model based on the proportion of total precipitation (rainfall plus snow melt runoff) on the catchment multiplied by a runoff coefficient. This method is consistent with the prefeasibility level water balance model conducted by Golder for design (Golder 2019).

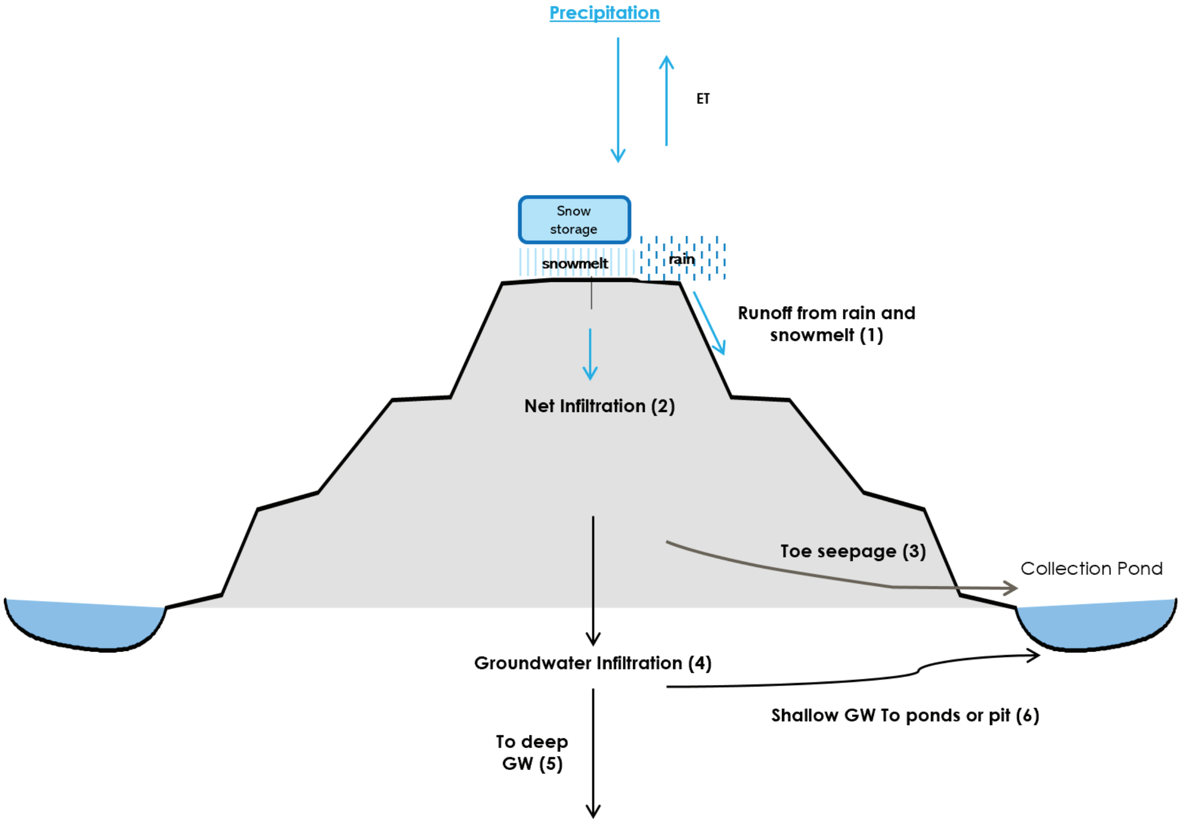


Figure 3-5 Conceptual Stockpile or Waste Rock Pile Flow Pathways

The proportion of net infiltration that integrates with basal seepage and becomes part of deeper regional groundwater flow (flow 5 in Figure 3-5) will not report to seepage collection ditches and is not carried through in the model to water management ponds and FDPs. The proportion of net infiltration that reports as seepage to perimeter ditching is carried through the model to the water management ponds (flows 3 and 6 in Figure 3-5). The net infiltration reporting as seepage to the collection ditches, water management ponds, and FDPs is the primary groundwater seepage included in the model. The percentage of net infiltration reporting to the ditches as toe seepage is included in Section 3.3.1.1 .

3.3 WATER BALANCE INPUTS

3.3.1 Climate and Hydrology

An evaluation of climate hydrologic data for the Project was presented in the Hydrology baseline report (Stantec 2020c). Climate and hydrology inputs to the model are summarized in Table 3.1. Monthly distributions and totals for climate and hydrology inputs at the mine site were represented by precipitation from the Climate Normals (1981-2010) at the Environment and Climate Change Canada (ECCC) Buchans climate station (Station ID 8400698) (ECCC 2020).

Average precipitation at the mine site was input to allow for both probabilistic and stochastic model extractions. The probability distribution function that best fits the annual precipitation data at the Buchans station is a Log-Normal distribution with mean and standard deviation values of 1236.6 mm and 187 mm, respectively. This probability distribution function was used in GoldSim for the Monte Carlo simulation. The results of the entire set of 100 runs are presented as percentiles, from 5th to 95th. The 95th and 5th percentile annual precipitation totals are approximately equivalent to the 1:25 year wet and 1:5 year dry years, respectively.

Under average climate conditions, the coldest month is February with an average monthly temperature of -8.4°C and the warmest month is July with an average monthly temperature of 16.3°C. The average annual temperature is 3.8°C. Average monthly temperatures typically drop below freezing in December and remain below freezing until April.

The average annual snowfall recorded at Buchans is 359.3 cm with month end snow depths typically highest in February. The average climate snow depth on ground in February was recorded at 67 cm. No snow on ground was reported for the months of May to October, inclusive. The extreme snow depth recorded was in March 1982 at 210 cm. The estimate of snow storage and snow melt was designed to replicate the average climate conditions at the Buchans climate station. The total snow storage was based on the March storage of 60 cm (average climate conditions) converted to snow-water-equivalent. A snow density of 0.35 was used, based on the reported snow density in the Newfoundland region increasing from 0.1 to 0.35 over the winter to account for ice and melt in snow (Strum et al. 1995). The proportion of precipitation in the cold months was assumed to be stored as snow for the months of November through March and with the majority of melt occurring in the months of April through June. A proportion of the snow melt was assumed to runoff into the collection ditches, and the remainder was assumed to infiltrate into the pile. The percentage of snow melt as snow melt runoff is summarized in Table 3-1. Although the mine site is inland, the Project Area is influenced by Newfoundland's maritime climate, which produces melting conditions throughout the winter and rainfall in all months of the year. Thus, snowmelt can and is expected to occur in all winter months.

Mean annual potential evapotranspiration for the Island of Newfoundland has been mapped. The potential mean annual evapotranspiration for the Project Area ranges from 450 to 474 mm (NLDOEC 1992). The evaporation from ponds at the site was represented by the average lake evaporation rate (mm/month) reported at the Stephenville and Gander ECCC climate stations (Station IDs 8401700 and

8403800). Actual evapotranspiration (AET) at the site was based on a USGS Thornthwaite model (Thornthwaite 1948). Inputs to the USGS Thornthwaite model included average climate precipitation and temperature data at Buchans, local soil conditions, and recommended values provided by the USGS (McCabe and Markstrom 2007).

The amount of AET was adjusted in the model based on Project facility and Project phase. These adjustments were applied to account for the characteristics of stockpile slope, soil storage, and infiltration of each Project facility. During operation, 90% of AET was represented as the transpiration loss in the water quantity model, as the stockpiles are un-vegetated, and the uptake and transpiration of precipitation will not occur, hereafter referred to as ET for un-vegetated piles.

As you can see in Table 3-1, in the months of November – February (inclusive), snow storage is greater than snow melt resulting in snow accumulation on ground. In March, the snow storage is less than the snow melt, meaning that the snow on the ground begins to decrease at the start of spring runoff.

Table 3-1 Water Balance Elements (mm) and Monthly Distribution

Parameter Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Precipitation													
mm	122.0	98.1	95.0	85.7	86.6	87.8	95.3	123.0	110.4	97.5	111.8	123.1	1236.3
Distribution	9.9%	7.9%	7.7%	6.9%	7.0%	7.1%	7.7%	9.9%	8.9%	7.9%	9.0%	10.0%	0.0%
ET													
mm	8.8	9.2	15.3	25.6	44.0	62.6	81.3	71.6	44.6	26.5	15.2	10.5	415.2
Distribution	0.7%	0.7%	1.2%	2.1%	3.6%	5.1%	6.6%	5.8%	3.6%	2.1%	1.2%	0.8%	33.6%
Lake Evaporation													
mm	0.0	0.0	0.0	0.0	46.5	100.5	110.1	96.1	63.0	20.2	0.0	0.0	436.3
Distribution	0.0%	0.0%	0.0%	0.0%	3.8%	8.1%	8.9%	7.8%	5.1%	1.6%	0.0%	0.0%	35.3%
Snow Storage													
mm	83.3	67.0	66.6	26.2	4.4	0.1	0.0	0.0	0.1	5.0	30.4	76.9	360.0
Distribution	6.7%	5.4%	5.4%	2.1%	0.4%	0.0%	0.0%	0.0%	0.0%	0.4%	2.5%	6.2%	29.1%
Snow Melt runoff													
mm	25.1	40.9	67.2	151.0	14.9	0.1	0.0	0.0	0.1	5.0	20.4	35.3	360.0
Distribution	2.0%	3.3%	5.4%	12.2%	1.2%	0.0%	0.0%	0.0%	0.0%	0.4%	1.7%	2.9%	29.1%

3.3.1.1 Pile Runoff and Net Infiltration

The saturated-unsaturated hydrologic model - Hydrologic Evaluation for Landfill Performance (HELP, US Environmental Protection Agency 1994) was run for the waste rock piles to simulate infiltration through piles and the proportion of toe seepage collected in the perimeter ditching. The HELP model input included precipitation, temperature, solar radiation, AET, and characteristics of the waste rock pile itself, such as pile height, bench slope, ground slope and ground soil conditions. Based on results of the HELP model, 50% of AET during operation was applied in the water quantity model for the waste rock pile, as the voids spacing in the rock is not conducive to soil storage and water wetting the pile surfaces will evaporate over the month.

To represent vegetated covers during the closure and post-closure sub-phases on the waste rock pile stabilized with vegetation, the water quantity model assumed 100% of AET and 90% of snowmelt runoff from the pile, resulting in a decrease of the net infiltration, and therefore a reduction on the seepage. The percent of total AET applied in the model is summarized in Table 3-2.

The LGO, topsoil and overburden stockpiles are assumed to be removed at closure. LGO will be processed at the mill, and the topsoil and overburden stockpiles will be used for progressive rehabilitation of rock slopes. Respective areas of these pile are modelled as “prepared ground” during closure and “natural ground” during post-closure, using runoff coefficients presented in Table 3-4.

It was assumed that during the first year (modelled during Year -1) net infiltration will be consumed in wetting the pile. Therefore, there is no seepage during that period.

Table 3-2 Adjustment Factor (%) in the Water quantity model by Project Facility

Project Facility	Adjustment Factors			
	Percent of Total AET	Percent of Snow Melt as Runoff	Percent of Rain as Runoff	Percent of NI as Toe Seepage
Operation Project Phase				
Low grade stockpile	50%	50%	0%	18%
Topsoil	90%	90%	90%	0%
Overburden	90%	90%	90%	0%
Waste rock pile	50%	50%	0%	18%
Open Pit	0%	100%	100%	0%
Rehabilitation & Closure/ Closure Project Phase				
waste rock pile (i.e. Vegetated Cover)	100%	90%	40%	18%[1]
Open Pit	95%	100%	100%	0%

Note:

[1] Net infiltration within the stockpile reduces with the application of the vegetated soil cover. The proportion of net infiltration reporting as toe seepage remains the same.

The net infiltration that percolates through the waste rock pile and LGO stockpiles reports to the perimeter collection ditches as toe seepage and shallow groundwater infiltration or will be lost to deeper regional groundwater flow not intercepted by the seepage collection ditches. Based on the HELP model, the percent of net infiltration reporting to the ditch as toe seepage is included in Table 3-2. The percent of groundwater intercepted by the collection ditches/ponds (i.e., shallow groundwater infiltration or groundwater recharge to the ditches) was simulated in a groundwater model for the site (Stantec 2020d). The percent of total groundwater infiltration that could intercept this recharge is summarized in Table 3-3 for the water management pond infrastructure, TMF infrastructure, and open pits.

Different from the waste rock and LGO stockpiles, the topsoil and overburden stockpiles are fine-grained, which limits infiltration. As a result of the soil material combined with the steep pile slopes, the net infiltration through the piles was assumed to be negligible.

3.3.1.2 Groundwater Infiltration

Groundwater infiltration at the bottom of the piles is flow 6 in Figure 3-5, the shallow groundwater infiltration or groundwater recharge to the seepage collection ditches opposed to toe seepage. The percent of groundwater infiltration at the bottom of the Leprechaun complex and Polishing Plant & TMF complex piles that is intercepted by the collection ditches/ponds, was simulated in a groundwater model for the Project Area (Stantec 2020d). The percent of net infiltration recharging to deeper regional groundwater (flow 5 in Figure 3-5), perimeter ditches, the pit and tailings pond seepage sumps is summarized in Table 3-3. It is assumed that during the first year of operation, net infiltration will be consumed in wetting the pile; therefore, there is no seepage during that period. Groundwater infiltration of the TMF (tailings impoundment and polishing pond) are discussed separately. Figure 3-6 present a schematic of the groundwater infiltration intercepted by water management infrastructure receptors represented by the percentages in Table 3-3.

Table 3-3 Groundwater Recharge by Water Management Receptor During Operation (as percentage of total infiltration to pile)

Receptor	Waste Rock Pile	Low-Grade Ore Stockpile*	Overburden Stockpile*	Topsoil Stockpile*
Leprechaun Pit	8.2%	0.0%	0.0%	88.7%
Tailings Pond Seepage Collection Ditch	0.0%	0.0%	0.0%	0.0%
LP-SP-01A	0.0%	54.0%	0.0%	0.0%
LP-SP-01B	0.3%	20.5%	0.0%	0.0%
LP-SP-02A	26.1%	7.5%	0.0%	0.0%
LP-SP-02B	4.3%	0.0%	0.0%	0.0%
LP-SP-03A	8.0%	0.0%	0.0%	0.0%
LP-SP-03B	4.5%	0.0%	0.0%	0.0%

Table 3-3 Groundwater Recharge by Water Management Receptor During Operation (as percentage of total infiltration to pile)

Receptor	Waste Rock Pile	Low-Grade Ore Stockpile*	Overburden Stockpile*	Topsoil Stockpile*
LP-SP-04	0.0%	0.0%	12.8%	3.8%
Other (deep groundwater)	30.6%	0.0%	87.2%	7.5%
Total Leprechaun Pile Groundwater Recharge (% of Net Infiltration) **	**82.0%**	**82.0%**	**100.0%**	**100.0%**

Notes:

*These values become 0% at closure since stockpiles are removed. Source: Stantec 2020d.

** Total % of net infiltration does not account for toe seepage, which is the difference to 100% (18% for waste rock pile and LGO).

The groundwater recharge to receptors increases after the pit is full during post-closure and monitoring, as groundwater flow paths and gradients will stabilize locally, and the pit filling will no longer exercise influence on local groundwater flows. Table 3-4 summarizes the simulated groundwater recharge from the waste rock pile to receptors post-closure (Stantec 2020d). The other piles were not modelled as these Project facilities no longer remain during post-closure and long-term monitoring.

Table 3-4 Groundwater Recharge to Water Management Receptors after the Pit is Full (as % of Total Groundwater Infiltration)

Water Management Receptor	Percentage of Recharge from Waste Rock Pile
Leprechaun Pit	0.1%
LP-SP-01A	0.0%
LP-SP-01B	0.1%
LP-SP-02A	34.7%
LP-SP-02B	0.0%
LP-SP-03A	8.6%
LP-SP-03B	6.7%

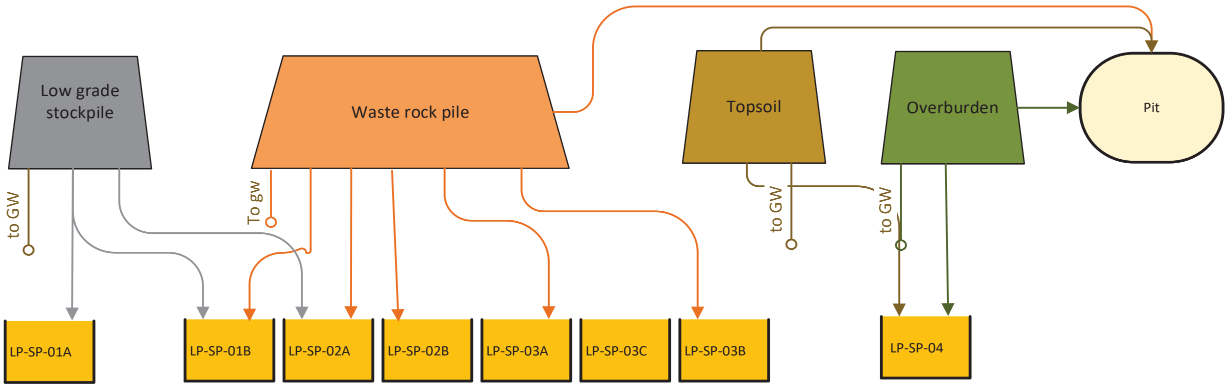


Figure 3-6 Shallow Groundwater Infiltration from Stockpiles to Receptors

3.3.2 Tailings Management Facility

3.3.2.1 Net Runoff

The net runoff within the TMF catchment was based on a runoff coefficient applied to total precipitation. The runoff coefficients were assigned by land use type in the water quantity model and were selected to be consistent with the pre-feasibility design of the TMF (Golder 2020a). The following land use types were included:

- Natural or undisturbed ground upgradient of the TMF that will continue to drain into the tailings pond during operation
- Prepared ground associated with areas that have been grubbed and/or graded, such as the perimeter haul roads and tailings dam embankments
- TMF dry tailings beach along the north dam and the tailings water pond at the south

The total area of the TMF presented in the pre-feasibility study (Golder 2020a) was 223 hectares (ha). The runoff coefficients selected by land use type for use in the water quantity model are presented in Table 3-5 with the watershed areas associated with the land uses during the operation, closure, and post-closure sub-phases of the Project.

Table 3-5 Runoff Coefficients by Land Use Type Applied to the TMF Watershed Area

Land Use Type	Runoff Coefficient	Operation Watershed Area (ha)*	Closure Watershed Area (ha)
Natural ground	63%	22	202
Prepared Ground	85%*	22	---
Dry Tailings	40%*	100	---
Tailings Water Pond and Wet Tailings	100%*	78	20
Source*: Golder (2020b)			

During operation, it was assumed that approximately 20% of the tailings beaches were wet and the remaining 80% of the tailings beaches were dry (Golder 2020b). The natural ground runoff coefficient for all Project phases was based on the USGS Thornthwaite model discussed in Section 3.3.1 and included inputs of local climate and soil conditions and guidance provided by USGS (McCabe and Markstrom 2007). Additional details on this analysis are presented in the 2019 Hydrology Baseline Report (Stantec 2020c).

The prepared surface including the tailings dam embankments and dry tailings beaches will be rehabilitated with a vegetated soil cover after which runoff conditions during the closure and post-closure subphases. The runoff coefficients are assumed to natural ground during these subphases.

3.3.2.2 Groundwater Infiltration

Toe seepage from the tailings pond will be intercepted by seepage collection ditches along the downgradient perimeter of the dam. This water will then be recirculated back into the TMF by pumping. The basal seepage, or the proportion of seepage assumed to infiltrate to deeper regional groundwater flow from the base of the dam, were modelled as contact water outflow rates from the tailings impoundment based on the groundwater modelling (Stantec 2020d). Seepage rates from the groundwater model used in the water quantity model are presented in Table 3-6 for the operation, closure and post-closure subphases of the Project.

Table 3-6 Tailings Pond Seepage Flow Rates

Tailings Pond Seepage	Operation (m^3/day)	Closure and Post-Closure (m^3/day)
Seepage Collection	705.5	541.8
Basal Seepage	2295.5	1069.2

3.3.2.3 Process Flows

In addition to direct precipitation on the TMF watershed, the TMF receives a tailings slurry discharge via a pipeline and spigot during operation until the end of Year 9. This water is reclaimed from the TMF to the Plant during Years 1 to 12. Tailings deposition and reclaimed water rates used in the water quantity model are presented in Table 3-7.

Table 3-7 Plant Production and Water Reclaim

Project Year	Model Year	Tailings (ktonnes)	Tailings (m^3/year)	Water in tailings leaving the Plant (m^3/year)	Reclaim to mill (m^3/year)	Water retained in tailings (m^3/year)
-1	0	0	0	0	0	0
1	1	1,875	1,329,574	1,009,830	881,438	629,798
2	2	2,500	1,772,668	1,346,367	1,175,186	839,685
3	3	2,500	1,772,437	1,346,191	1,175,033	839,575
4	4	3,250	2,304,114	1,750,008	1,527,507	1,091,423
5	5	4,000	2,835,892	2,153,900	1,880,047	1,343,317
6	6	4,000	2,836,100	2,154,058	1,880,185	1,343,416
7	7	4,000	2,835,892	2,153,900	1,880,047	1,343,317
8	8	4,000	2,835,892	2,153,900	1,880,047	1,343,317
9	9	4,000	2,835,492	2,153,597	1,879,782	1,343,128
10	10	4,000	2,835,821	2,153,846	1,880,000	1,343,284
11	11	4,000	2,835,821	2,153,846	1,880,000	1,343,284
12	12	2,923	2,072,150	1,573,827	1,373,726	981,545

Note:
Project year and model year are based on the beginning of the year.
Source Golder 2020

The maximum tailings pond water capacity is 1,100,000 m^3 (Golder 2020), and the minimum capacity is assumed to be 200,000 $m^{3.}$ Inflows and outflows of the pit depend on the phase/functional period as follows:

Operation (Year 1 to Year 9):

Excess water in the tailings pond during Years 1 to 9 is pumped to the water treatment plant and then discharged to the polishing pond. The maximum treatment rate from the water treatment plant of 83,809 cubic metres per month (m^3/mon), was modelled from April to November based on the TMF design (Golder 2020). No discharge is simulated for the other months of year. It was assumed that the water treatment plant will begin operating when 70% of the total pond water capacity in the tailings pond is filled. This allows storage of flood flows to be accommodated while maintaining freeboard without activating the emergency spillway or overtopping. The model should be updated in the future based on TMF design refinements and the operation philosophy of the water treatment plant.

Based on the dimensions presented in the TMF design (Golder 2020), it is assumed that the polishing pond will have a water area of 40,000 m^2 and a volume of 44,000 m^3.

Operation (Year 10 to 12):

From Year 10 to 12, tailings from the Plant are deposited in the Leprechaun pit. This will result in a reduction of flow from the Plant to the TMF, and consequently a deficit on the reclaimed water from the tailings pond to the Plant to meet the water demand at the Plant. Therefore, there is no excess of water during Years 10 to 12 going to the water treatment plant. Additional details are provided in Section 4.4.

Closure and Post-Closure (From Year 13):

From Year 13, with no reclaim demand, all the excess water from the tailings pond (overflow) is directed to the open pit until it is filled to the design elevation of 380 masl. In the model, the tailings pond overflow has been set as a direct pit inflow. After the pit is full, the overflow will be directed to the polishing pond. Table 3-7 presents the annual tailings production, water content, and Plant demand. The Plant water demand was used to calculate the required dewatering rate from the tailings pond. The Plant water demand is sourced first by reclaiming water from the tailings pond, then using fresh water from Victoria Lake Reservoir (Golder 2020). The water demand from the Plant and the tailings production (reclaim to the mill) are presented for the life of mine in Table 3-7.

3.3.3 Open Pit Runoff

3.3.3.1 Area and Volume

The Leprechaun open pit will be developed over time throughout the nine years of active mining. The surface area of the pit by Project year is summarized in Table 3-8.

Table 3-8 Surface Area of the Pit during Mining

Project Year	-1	1	2	3	4	5	6	7	8	9	10
Surface Area (Ha)	21.2	21.2	34.9	52	52	52	52	52	52	52	52

Based on the ultimate pit footprint at the end of Year 9, and the topographic information in the area surrounding the pit, a pit overflow elevation of 380 m was assigned. The relationship between pit stage (i.e., water elevation inside the pit as it is filled), the surface area of the pit at that stage, and the volume in the pit below that stage are presented on Table 3-8.

Table 3-9 Water Elevation – Area – Volume Table (at end of Project Year 9)

Stage (masl)	Projected Surface Area (m²)	Pit Volume Below Stage (m³)
380	475,685	53,274,375
375	461,811	50,930,336
370	447,382	48,660,513
365	435,496	46,452,770
360	424,475	44,302,831
355	411,735	42,209,885
350	400,276	40,180,821
345	390,112	38,205,399
340	378,888	36,282,013
335	365,931	34,420,800
330	355,183	32,618,391
325	345,237	30,867,032
320	333,464	29,169,003
315	322,456	27,530,885
310	311,553	25,945,528
305	298,279	24,418,003
300	281,259	22,972,783
295	272,242	21,589,325
290	263,882	20,248,526
285	254,405	18,952,183
280	242,752	17,711,533
275	234,194	16,519,576
270	225,629	15,369,663
265	214,666	14,266,660
260	205,978	13,216,582
255	197,792	12,207,846
250	188,862	11,240,520
245	177,984	10,324,617
240	169,894	9,454,294
235	161,255	8,625,389
230	148,499	7,847,950
225	138,905	7,132,967
220	131,245	6,457,924
215	122,717	5,822,771
210	112,596	5,234,214
205	105,900	4,688,570
200	100,094	4,173,402
195	92,706	3,690,290
190	84,268	3,251,725
185	78,078	2,845,123
180	71,192	2,472,017
175	63,071	2,134,657
170	57,012	1,836,632
165	52,499	1,563,623
160	47,205	1,314,514
155	40,999	1,094,147
150	36,936	899,282
145	33,057	723,933
140	27,940	570,685
135	23,642	443,183
130	20,578	332,742
125	17,563	237,210
120	13,537	159,274
115	10,918	98,597
110	7,852	50,807
105	5,093	19,305
100	1,530	1,106

Note:
Assumed Leprechaun pit overflow channel invert at 380 masl

.

3.3.3.2 Net Runoff

Model inputs and outputs to the open pit include groundwater inflow, precipitation, and runoff that will flow into the open pit, and dewatering and evaporation losses from the open pit. Schematics of flows to and from the open pit are presented in Figure 3-1 to Figure 3-4. Storage and surface area of the pit for various pit stages are presented in Table 3-8.

3.3.3.3 Groundwater Infiltration

Groundwater inflow rates to the open pit were predicted using the numerical groundwater flow model developed for the Project (Stantec 2020d). The volume of groundwater inflow to the pit is dependent upon the pit stage, which represents the elevation of the bottom of the pit during pit development, and the water elevation in the pit during subsequent pit filling. Table 3.9 presents the groundwater inflow rate depending on the water level of the pit. Minimum stage (109.4 masl) applies when there is no water accumulated at the bottom of the fully excavated open pit.

Table 3.10 Groundwater Inflow to Leprechaun Pit

Pit Stage (masl)	Groundwater Inflow Rate (m³/d)
109.4	1350
125	1350
150	1350
175	1350
200	1350
225	1349
250	1349
275	1320
300	1246
325	1121
333	1060
350	918
375	596
380	468
Source: Stantec 2020d.	

3.3.3.4 Open Pit Inflows and Outflows

Operations (until Year 9)

Groundwater inflow, precipitation and runoff that accumulates in the open pit will be pumped to Water Management Pond LP-SP-05.

Operations (From Year 10), Closure, and Post-Closure

Consistent with operations (until Year 9), water is accumulated in the pit, with same inflows and additional flow from:

- Tailings from the Plant, until operations end (until end of Year 12)
- Water from ditch LP-DR-10, that conveys flow by gravity from the waste rock pile to the water management pond LP-SP-03B until Year 9
- Runoff from natural ground on the west side of the pit (area of 5 ha), that during the pit operations is diverted by berms along ditch LP-DR-10
- Excess water from the Tailings pond after operations (from Year 13), as explained in Section 3.3.2.3

Once the water level within the pit lake reaches the elevation of 380 m, water from the pit will overflow and discharge towards LP-FDP-05.

Natural and accelerated pit filling scenarios were considered where the model was run iteratively with different flow rates, and model runs where the pit can be filled to the design elevation of 380 masl. Accelerated pit filling was simulated by the addition of water pumped from Victoria Lake Reservoir. The preferred scenario required eight years to fill the pit, commencing in Project Year 10. The selected pumping rate from Victoria Lake Reservoir is presented in Section 4.7.

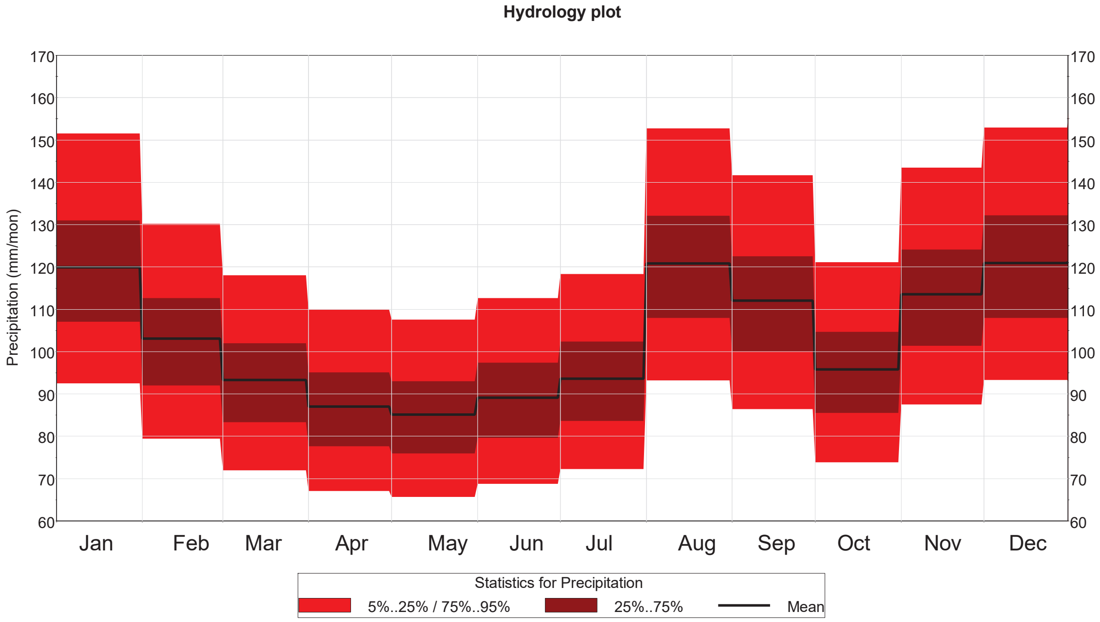
4.0 PROJECT WATER QUANTITY RESULTS

4.1 OVERVIEW

The water quantity model provides estimates of flows and storage volumes for mine facilities during the construction and operation phases, and the closure and post-closure sub-phases of the decommissioning, rehabilitation, and closure phase of the Project. It also incorporates the mine plan and water management features of the mine. The water quantity model also incorporates results from groundwater modelling (Stantec 2020d), and runoff and seepage from key Project facilities, as described in Chapter 3.

The results are presented for the average climate conditions, which includes the probabilistic distribution of climate inputs that on average match the average precipitation. As such, probabilistic results are generated based on the full range of the 100 Monte Carlo simulations for the probabilistic precipitation distribution. Each model was run for 100 years, and the precipitation was varied independently for each year of each of the simulations. Although the models were run for 100 years, the summary plots in this section are presented with a time range relevant to the results discussed.

As an illustrative example, Figure 4-1 presents the results of the Monte Carlo simulation for two years of precipitation using a colored scale. Probabilistic results are shown for three ranges from bottom to top for each month: the 5th to 25th percentile range at the bottom, the 25th to 75th percentile range in the middle, and the 75th to 95th percentile range at the top. Generally, results of the 5th to 95th percentile Monte Carlo realizations range from -25% to +25% of the mean values.



Note: The mean value presented in the probabilistic plots correspond to the mean of all Monte Carlo runs, and not to the average climate condition.

Figure 4-1 Probabilistic Precipitation results for generic 2 years

4.2 WATER MANAGEMENT PONDS

The water management ponds are influenced by climate inputs, and collect runoff, toe seepage, and shallow groundwater flow from the waste rock pile and LGO, overburden and topsoil stockpiles through seepage collection ditches around these facilities. The water quantity model simulated the function of the water management ponds, and the results indicate that the ponds tend to become full during the spring freshet of the first modelled year, and overflow to the FDPs thereafter. This is illustrated on Figure 4-2 which presents the timing of the flows and volume of the water stored in water management pond LP-SP-03A, which collects runoff from the Leprechaun waste rock pile.

The other water management ponds exhibit the same behaviour as water management pond LP-SP-03A, with the exception of the water management pond LP-SP-05, which captures flows from the pit dewatering. Flows to LP-SP-05 correlate to the timing of pit dewatering rates, which are less variable due to the relatively steady groundwater inflow to the pit. Water management pond LP-SP-05 becomes full after only a few days of commencement of the pit dewatering, as presented in Figure 4-3.

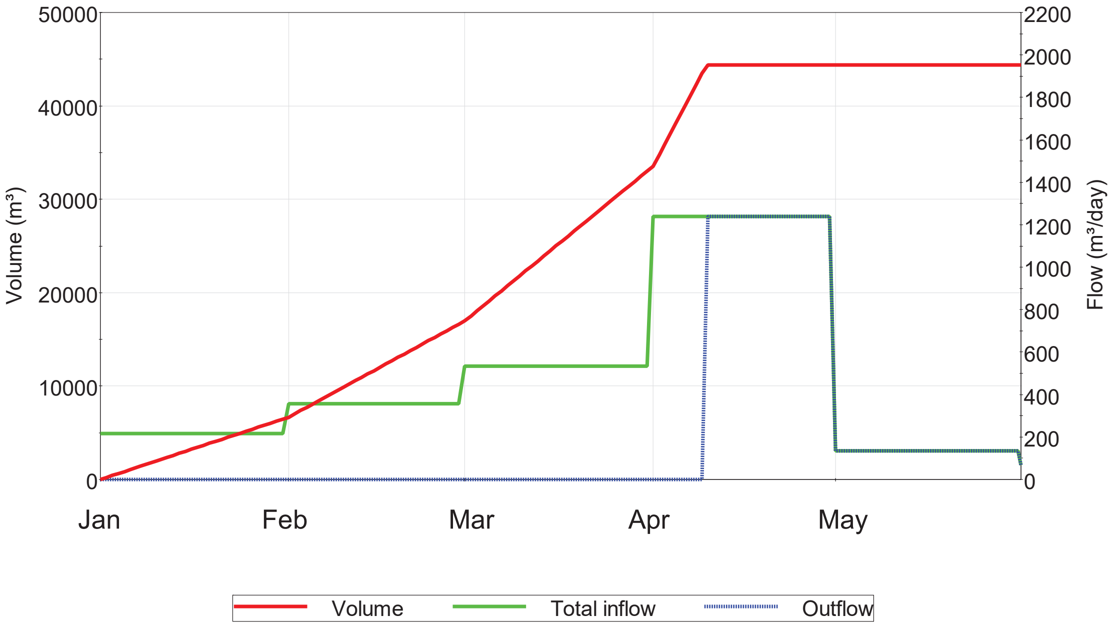


Figure 4-2 Volume, Inflow and Outflow of Water Management Pond LP-SP-03A

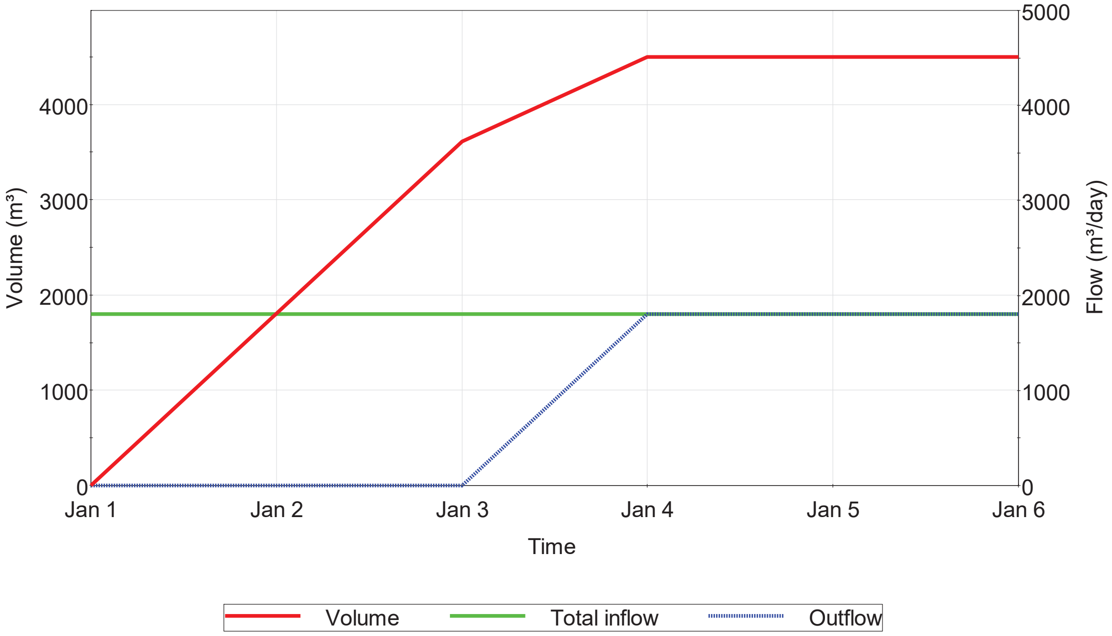


Figure 4-3 Volume, Inflow and Outflow of Water Management Pond LP-SP-05

The magnitude of the flow to a water management pond depends on the watershed area and characteristics draining to the pond, and the groundwater infiltration reporting to the pond. In general, the water management ponds will discharge to the FDPs when the pond water level rises above the low-level outlet.

Figure 4-4 presents the average annual inflow collected in water management pond LP-SP-03A from ditches (runoff + toe seepage), the groundwater discharge to the pond, and the total sum of inflows. Direct precipitation represents only a small proportion of the total inflow to the pond.

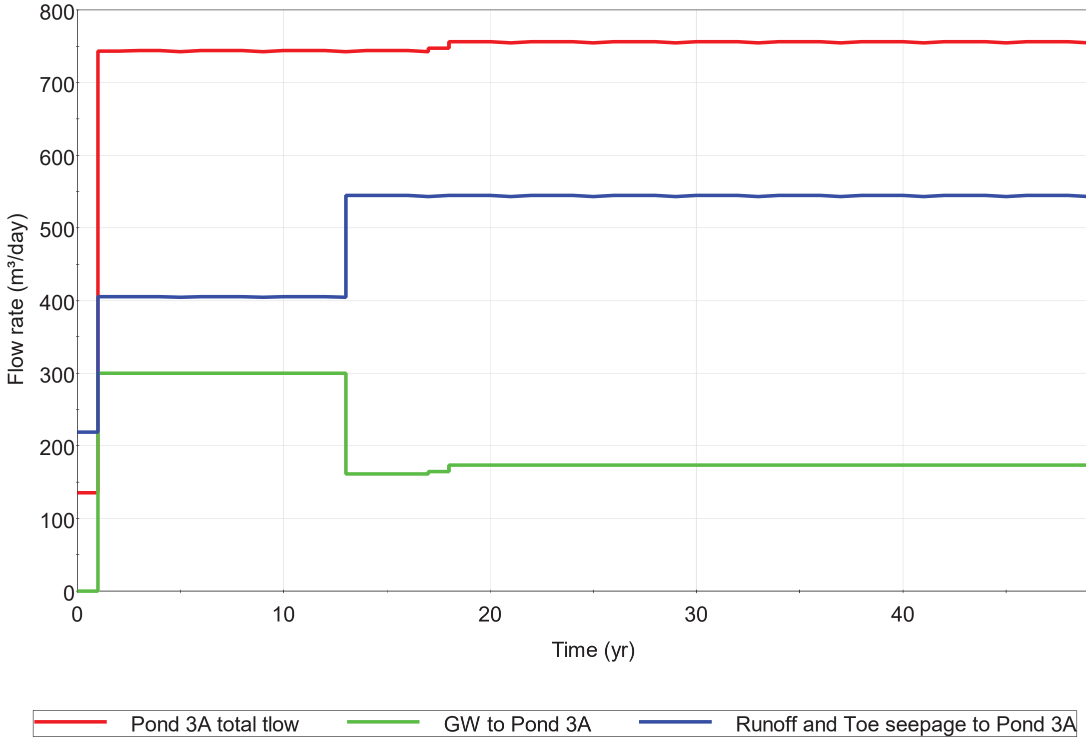


Figure 4-4 **Annual Average Flows to Water Management Pond LP-SP-03A**

Table 4-1 presents average inflows to the water management ponds for each phase and subphase of the Project. Average outflows mimic the average inflows from the ponds. Tables presenting inflows at the water management ponds for the range of probabilities using the Monte Carlo analysis are presented in Appendix A. Figure 4-5 to Figure 4-12 present the probabilistic results for all the ponds from operation to post-closure sub-phases.

Generally, the minimum and maximum simulation results (i.e., 5th to 95th percentile results) range from approximately -25% to +25% of the mean results. This is consistent with the range for precipitation explained in Section 4.1 and approximately represents the 1: 25 return period wet year to the 1:5 dry year.

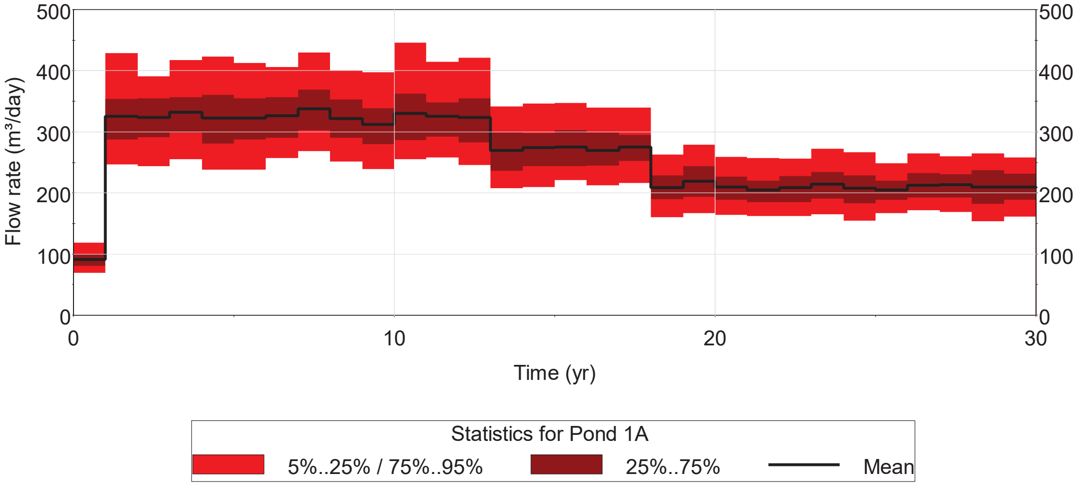
Table 4-1 Monthly Average Inflows/Outflows to/from Water Management Ponds (m^3/day)

Pond	Phase	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
LP-SP-01A	Operations (Year 1 to 9)	233	295	355	822	271	182	170	289	315	313	377	300	326
	Operations (Year 10 to 12)	233	293	355	822	271	182	170	289	315	313	377	300	326
	Closure (Year 13 to 17)	217	272	319	750	214	103	70	202	260	282	355	279	276
	Post-Closure (from Year 18)	171	214	252	592	167	76	52	154	201	222	280	221	216
LP-SP-0 1B	Operations (Year 1 to 9)	285	400	521	1208	287	162	152	257	281	295	401	375	384
	Operations (Year 10 to 12)	285	398	521	1208	287	162	152	257	281	295	401	375	384
	Closure (Year 13 to 17)	323	415	496	1172	299	127	68	265	359	394	512	419	402
	Post-Closure (from Year 18)	320	411	492	1162	295	125	67	262	355	389	506	415	398
LP-SP-0 2A	Operations (Year 1 to 9)	416	603	805	1863	375	160	150	280	324	380	558	553	536
	Operations (Year 10 to 12)	416	601	805	1863	375	160	150	280	324	380	558	553	536
	Closure (Year 13 to 17)	553	710	850	2001	506	201	108	438	600	672	878	716	683
	Post-Closure (from Year 18)	553	709	850	2001	506	201	108	438	600	672	878	716	683
LP-SP-0 2B	Operations (Year 1 to 9)	235	303	372	862	268	180	168	282	305	302	369	304	328
	Operations (Year 10 to 12)	235	302	372	862	268	180	168	282	305	302	369	304	328
	Closure (Year 13 to 17)	240	303	357	844	225	97	52	205	277	303	389	303	298
	Post-Closure (from Year 18)	172	220	264	622	157	62	33	136	186	209	273	223	212

Table 4-1 Monthly Average Inflows/Outflows to/from Water Management Ponds (m^3/day)

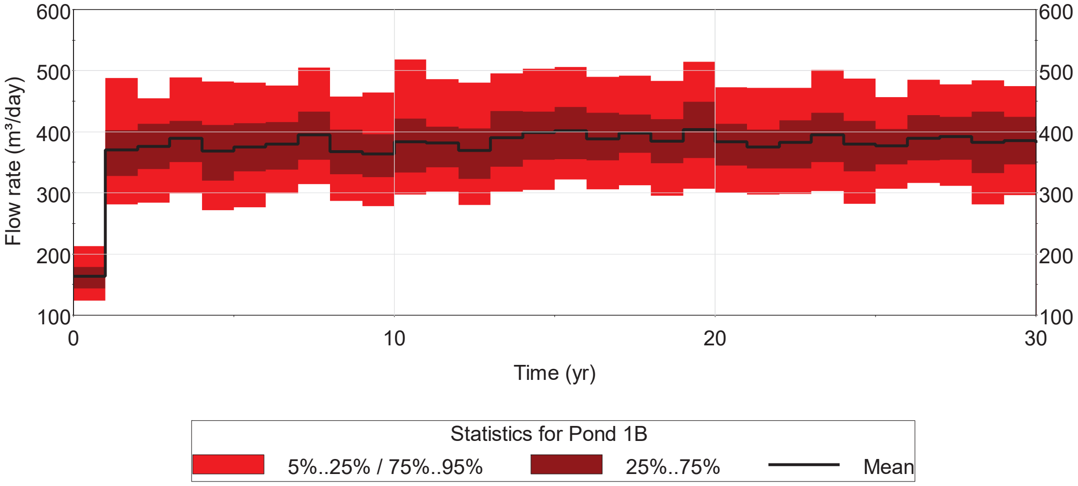
Pond	Phase	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
LP-SP-0 3A	Operations (Year 1 to 9)	1184	1432	1658	3850	1533	1207	1130	1818	1909	1769	2004	1510	1747
	Operations (Year 10 to 12)	1184	1427	1658	3850	1533	1207	1130	1818	1909	1769	2004	1510	1747
	Closure (Year 13 to 17)	1007	1255	1453	3454	972	467	251	937	1247	1313	1651	1313	1272
	Post Closure (from Year 18)	1153	1430	1652	3928	1117	542	291	1085	1442	1515	1898	1485	1456
LP-SP-0 3B	Operations (Year 1 to 9)	370	486	601	1397	403	256	228	409	454	455	569	480	507
	Operations (Year 10 to 12)	370	484	601	1397	403	256	228	409	454	455	569	480	507
	Closure (Year 13 to 17)	184	230	269	635	172	71	38	155	212	235	300	241	228
	Post Closure (from Year 18)	219	272	317	749	207	89	48	190	259	284	360	282	272
LP-SP-0 4	Operations (Year 1 to 9)	200	250	294	691	199	101	68	193	245	261	326	257	256
	Operations (Year 10 to 12)	200	249	294	691	199	101	68	193	245	261	326	257	256
	Closure (Year 13 to 17)	188	235	276	649	187	93	64	180	230	245	306	242	240
	Post Closure (from Year 18)	146	183	215	505	144	69	47	136	176	190	239	188	186
LP-SP-0 5	Operations (Year 1 to 9)	2305	2533	2781	4607	2773	2648	2714	3128	3015	2796	2925	2570	2898
	Operations (Year 10 to 12)	42	52	64	145	34	0	0	18	33	51	70	54	47
	Closure (Year 13 to 17)	42	53	64	145	34	0	0	18	33	51	70	536	88
	Post Closure (from Year 18)	1783	2105	2443	4989	1618	504	448	1272	1663	2100	2624	2151	1969

Note: Outflows are equal to inflows



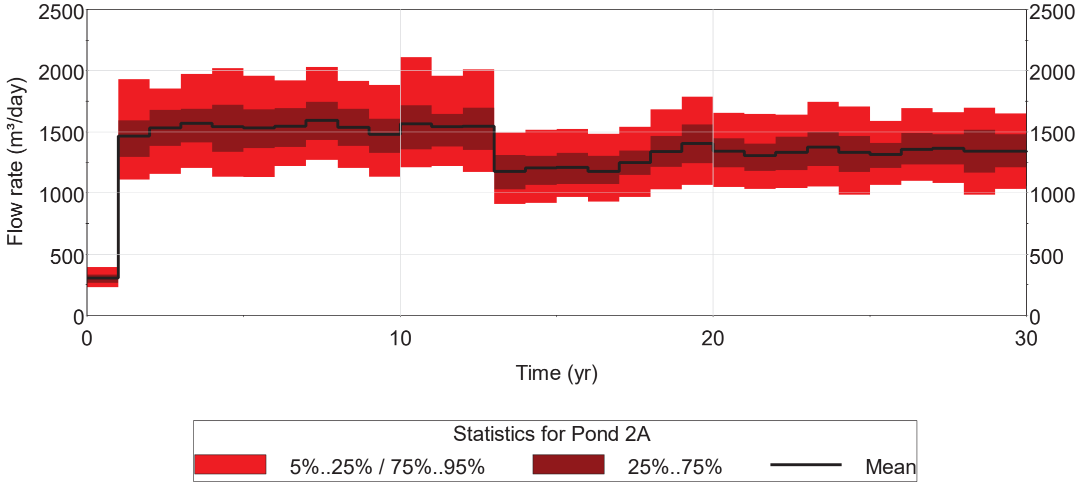
Note: Water management pond LP-SP-01A collects runoff from the LGO stockpile. The LGO stockpile is removed at closure (end of Year 12). Prepared ground is assumed during closure (from Year 13) and natural ground during post-closure (from Year 18).

Figure 4-5 Water Management Pond LP-SP-01A Annual Average Inflow/Outflows - Probabilistic Analysis



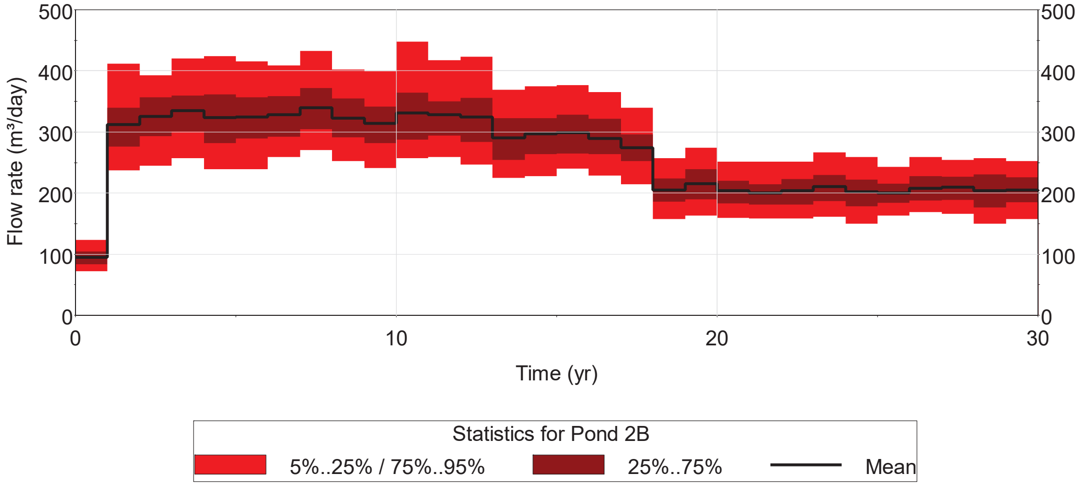
Note: Water management pond 1B collects water from the waste rock pile and shallow groundwater from the LGO stockpile and waste rock pile. At closure, LGO stockpile is removed, decreasing the groundwater inflow, and the waste rock pile is covered by vegetated soil, increasing the surface runoff.

Figure 4-6 Water Management Pond LP-SP-01B Annual Average Flows - Probabilistic Analysis



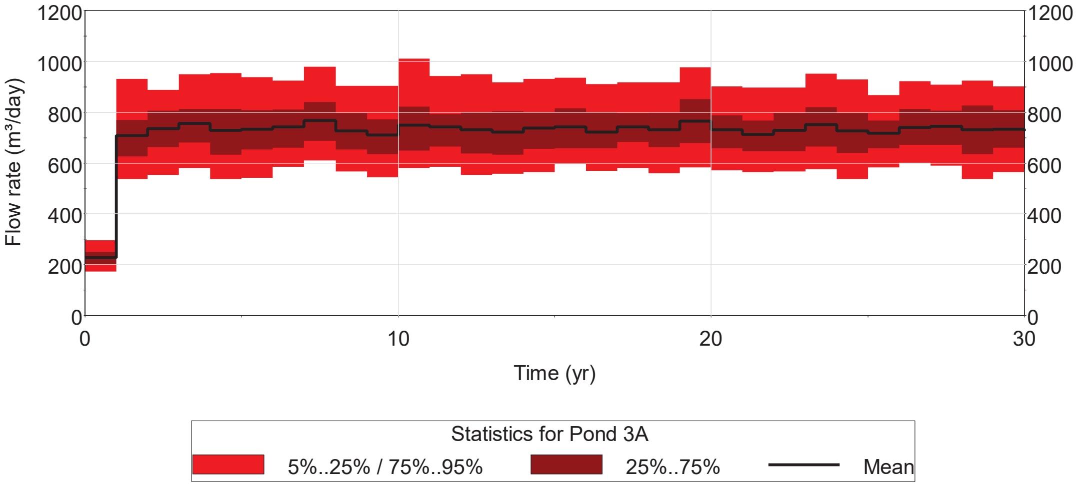
Note: Water management pond 2A collects water from the waste rock pile. At closure, the waste rock pile is covered by vegetated soil, increasing the surface runoff.

Figure 4-7 **Water Management Pond LP-SP-02A Annual Average Flows - Probabilistic Analysis**



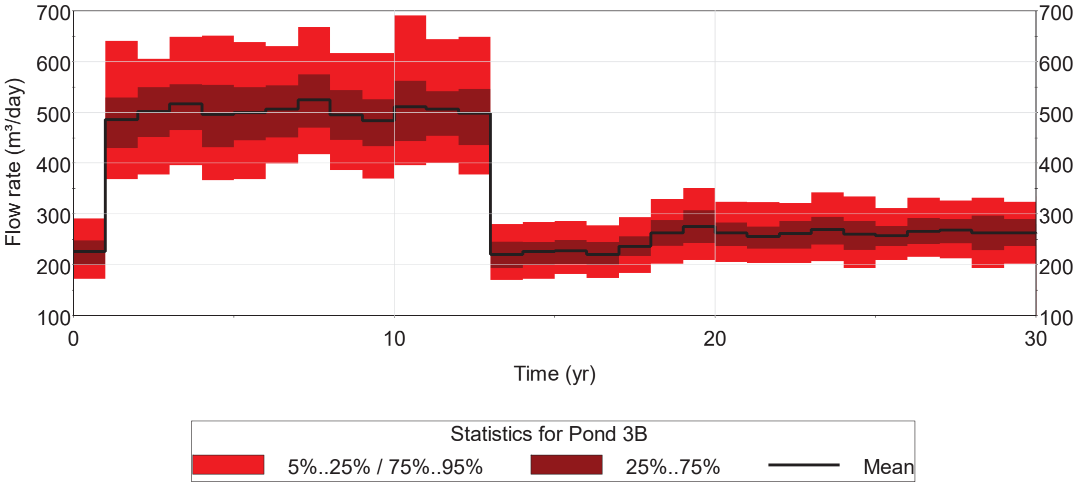
Note: Water management pond 2B collects water runoff and shallow groundwater from the waste rock pile. At closure, there is an increase of runoff due to the soil cover, but at the same time occurs a reduction in shallow groundwater inflow, which reduces to zero at post-closure.

Figure 4-8 **Water Management Pond LP-SP-02B Annual Average Flows - Probabilistic Analysis**



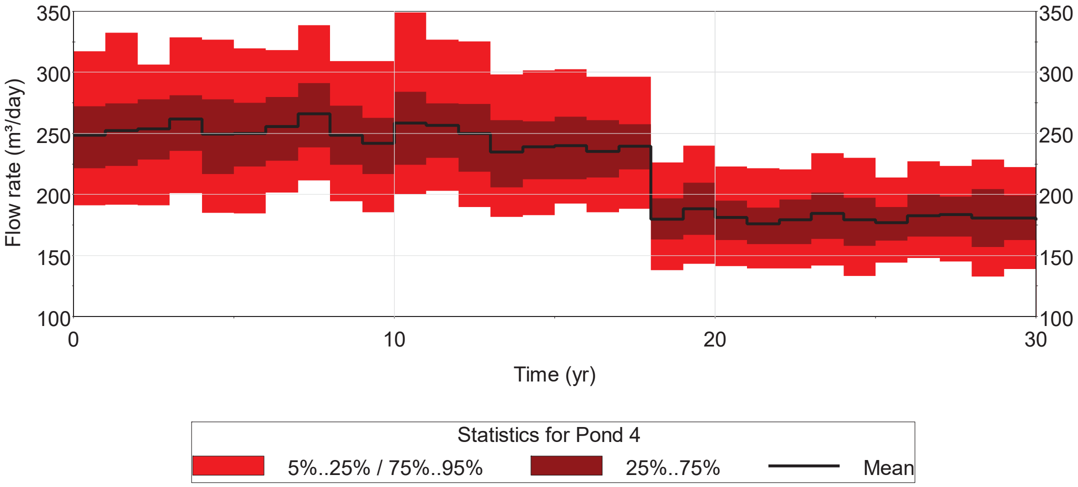
Note: Water management pond 2B collects runoff, and shallow groundwater from the waste rock pile and the LGO stockpile. At closure, there is an increase of runoff due to the soil cover, but at the same time occurs a reduction in shallow groundwater inflow, which increases again at post-closure.

Figure 4-9 Water Management Pond LP-SP-03A Annual Average Flows - Probabilistic Analysis



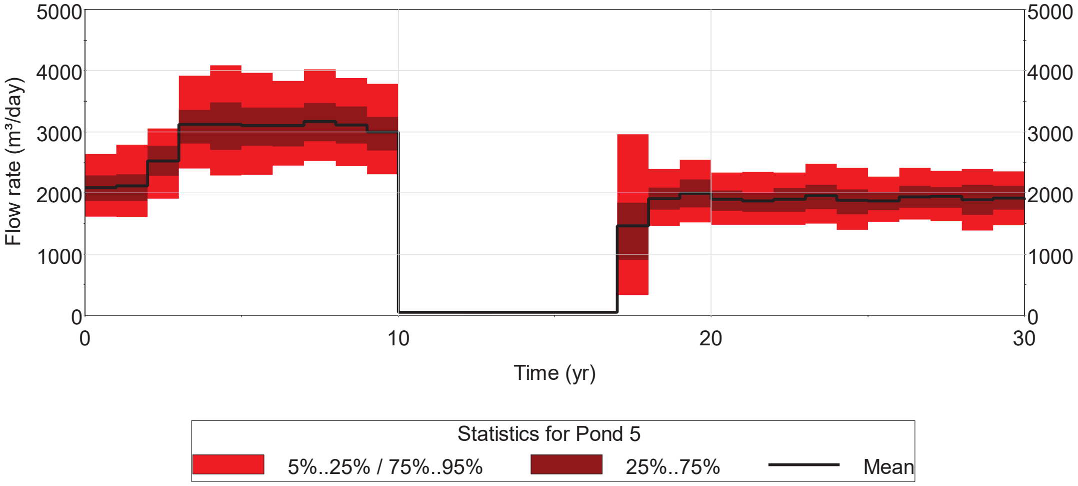
Note: Water management pond 3B collects runoff from the topsoil pile, and shallow groundwater from the waste rock pile and the LGO stockpile. At closure, there is an increase of runoff due to the soil cover, but at the same time occurs a reduction since the topsoil stockpile is removed in shallow groundwater inflow, which increases again at post-closure.

Figure 4-10 Water Management Pond LP-SP-03B Annual Average Flows - Probabilistic Analysis



Note: Water management pond 4 collects runoff from the overburden area. The overburden pile is removed at closure (end of Year 12). Prepared ground is assumed during closure (from Year 13) and natural ground during post-closure (from Year 18).

Figure 4-11 Water Management Pond LP-SP-04 Annual Average Flows - Probabilistic Analysis



Note: Water management pond 5 collects dewatering from the pit. At Year 10, the pit starts to be filling until the end of Year 17. In the plot there is a range of results around the Year 17 related the variability of the climate scenarios, and the constant flow rate from the Victoria Lake Reservoir. From Year 18, the pond receive overflow from the pit.

Figure 4-12 Water Management Pond LP-SP-05 Annual Average Flows - Probabilistic Analysis

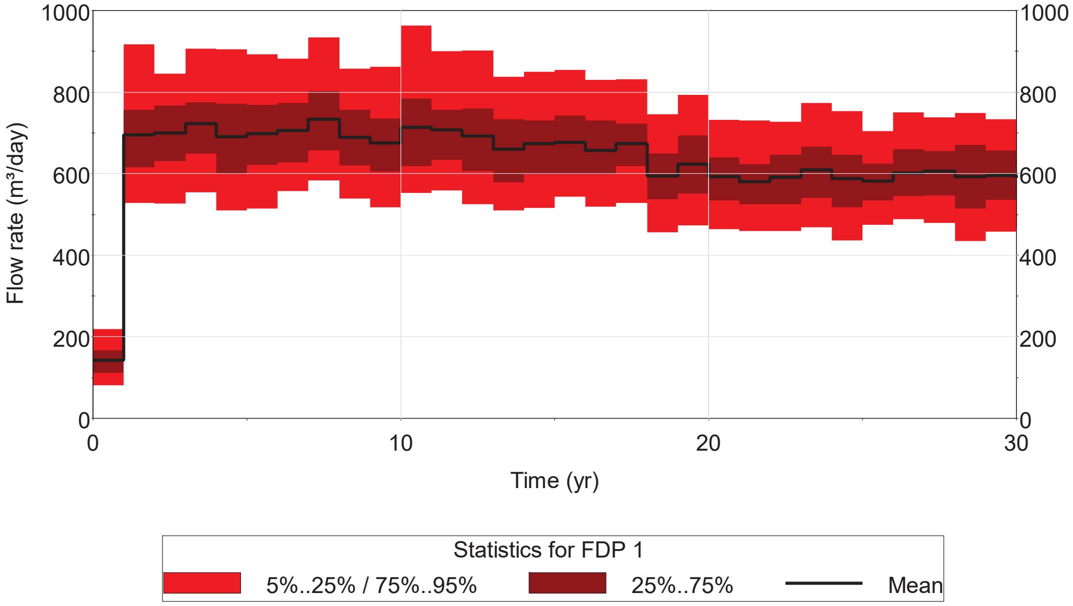
4.3 FINAL DISCHARGE POINTS (FDP)

FDPs receive flow from the water management ponds, and therefore present the similar seasonal behavior noted in Section 4.2.

Table 4-2 presents average monthly flows at the FDPs for each phase and subphase of the Project, including the discharges from the water management ponds. Tables presenting flow rates at the FDPs for the range of probabilities using the Monte Carlo analysis are presented in Appendix B. Figure 4-13 to Figure 4-17 presents the probabilistic annual flows results for all the FDPs from operations to post-closure. Generally, the minimum and maximum simulation results (i.e., 5th to 95th percentile results) range from approximately -25% to +25% of the mean monthly results.

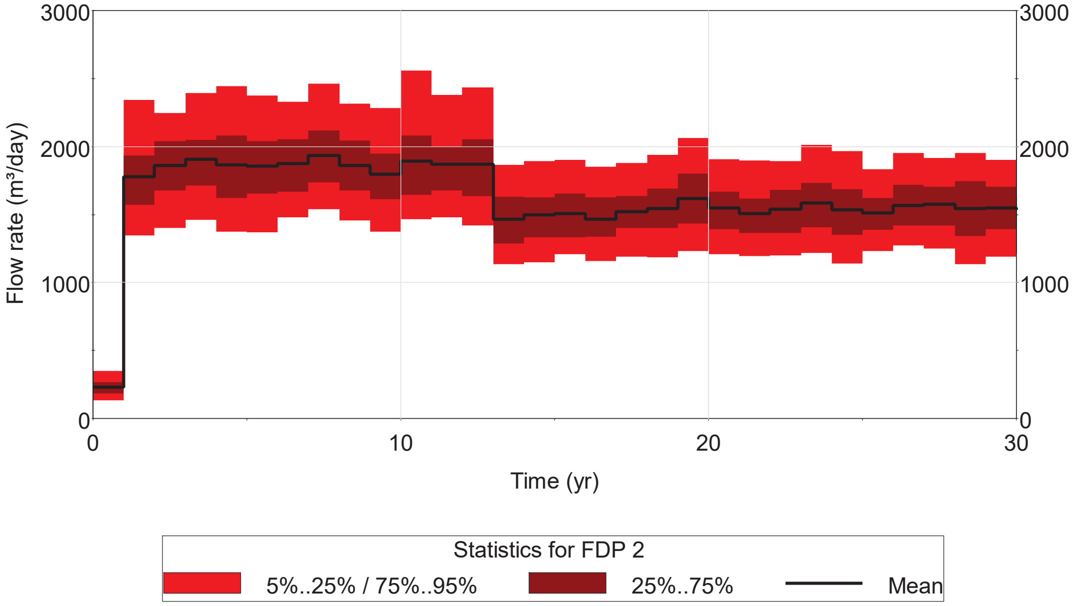
Table 4-2 Mean Monthly Flow Rates at FDPs (m^3/day)

FDP	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
LP-FDP-01	Operations (Year 1 to 9)	518	694	876	2030	557	344	322	546	596	608	777	675	712
	Operations (Year 10 to 12)	518	692	876	2030	557	344	322	546	596	608	777	675	712
	Closure (Year 13 to 17)	540	687	816	1923	512	229	138	467	619	675	865	698	681
	Post Closure (from Year 18)	492	625	745	1754	462	201	119	416	556	611	787	635	617
LP-FDP-02	Operations (Year 1 to 9)	1304	1625	1934	4484	1586	1153	1079	1776	1897	1820	2136	1673	22467
	Operations (Year 10 to 12)	1304	1619	1934	4484	1586	1153	1079	1776	1897	1820	2136	1673	22461
	Closure (Year 13 to 17)	1208	1515	1770	4191	1143	510	274	1062	1431	1560	1990	1575	18231
	Post Closure (from Year 18)	1276	1595	1863	4413	1211	545	293	1131	1523	1642	2083	1645	19220
LP-FDP-03	Operations (Year 1 to 9)	957	1276	1601	3715	1043	663	609	1045	1139	1143	1446	1247	1324
	Operations (Year 10 to 12)	957	1271	1601	3715	1043	663	609	1045	1139	1143	1446	1247	1323
	Closure (Year 13 to 17)	843	1069	1261	2981	789	342	184	717	970	1066	1373	1101	1058
	Post Closure (from Year 18)	888	1121	1321	3125	833	365	196	762	1029	1119	1433	1147	1112
LP-FDP-04	Operations (Year 1 to 9)	200	250	294	691	199	101	68	193	245	261	326	257	257
	Operations (Year 10 to 12)	200	249	294	691	199	101	68	193	245	261	326	257	257
	Closure (Year 13 to 17)	188	235	276	649	187	93	64	180	230	245	306	242	241
	Post Closure (from Year 18)	146	183	215	505	144	69	47	136	176	190	239	188	186
LP-FDP-05	Operations (Year 1 to 9)	2305	2533	2781	4607	2773	2648	2714	3128	3015	2796	2925	2570	2900
	Operations (Year 10 to 12)	42	52	64	145	34	0	0	18	33	51	70	54	47
	Closure (Year 13 to 17)	42	53	64	145	34	0	0	18	33	784	1399	1063	303
	Post Closure (from Year 18)	1783	2105	2443	4989	1618	504	448	1272	1663	2100	2624	2151	1975



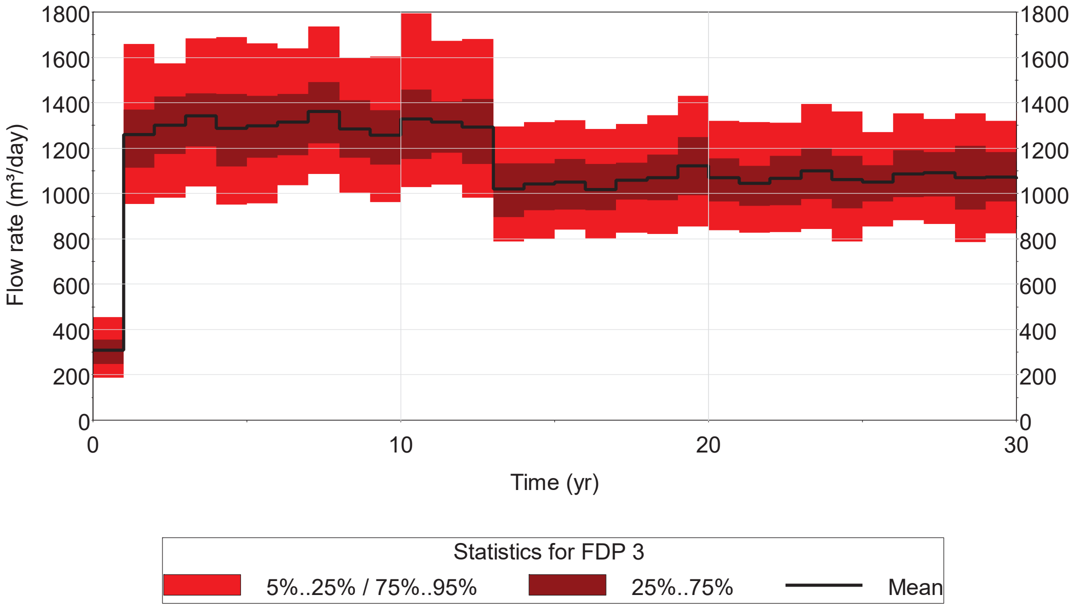
Note: LP-FDP-01 receives water from the water management ponds LP-SP-01A and LP-SP-01B (LGO stockpile and waste rock pile).

Figure 4-13 LP-FDP-01 Average Annual Flows - Probabilistic Analysis



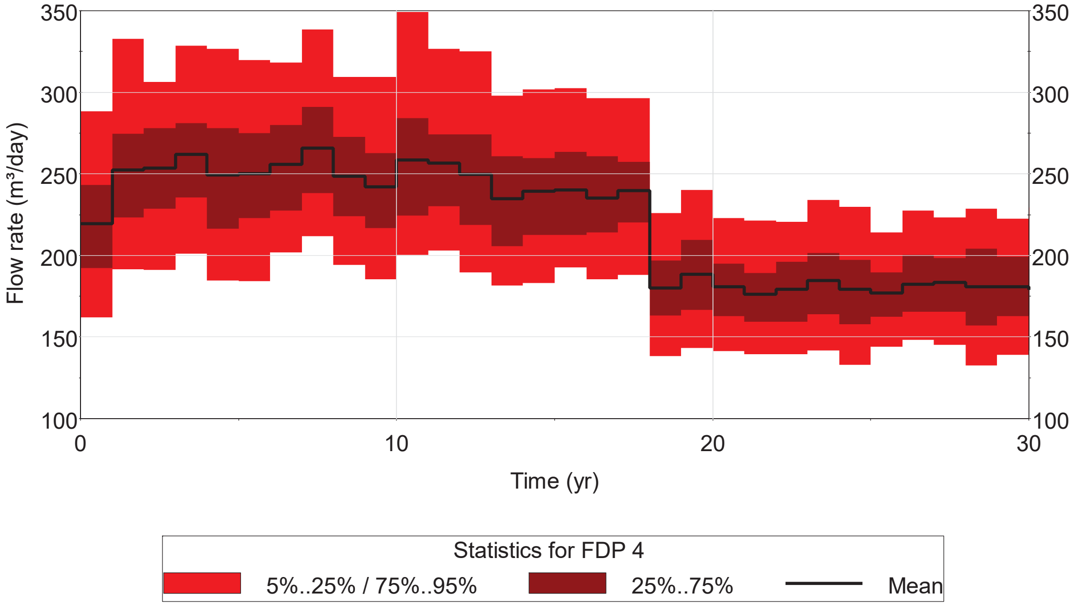
Note: LP-FDP-02 receives water from the water management ponds LP-SP-02A and LP-SP-02B (waste rock pile).

Figure 4-14 LP-FDP-02 Average Annual Flows - Probabilistic Analysis



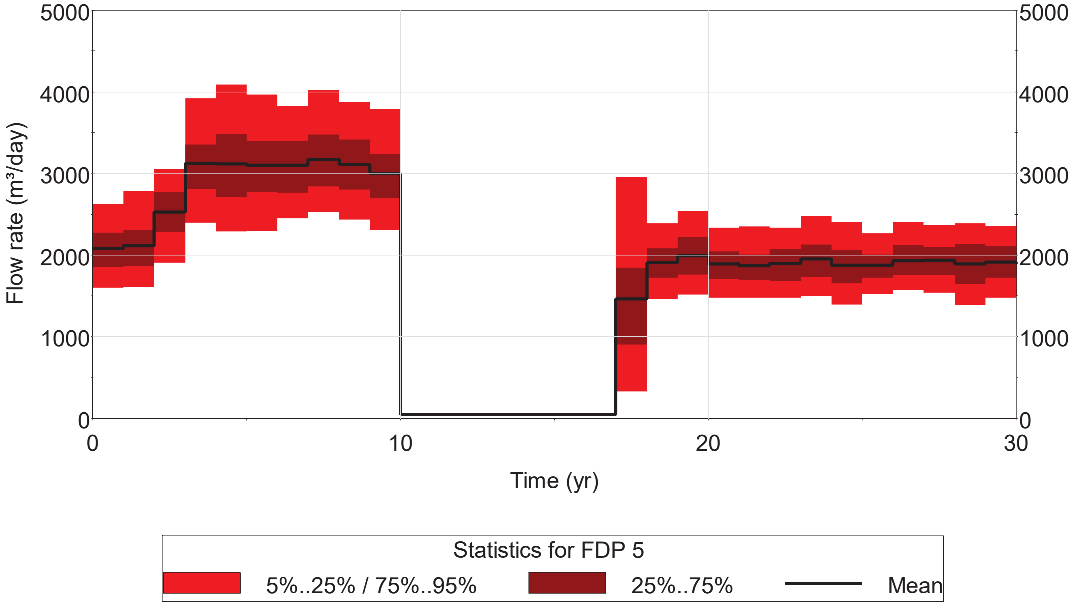
Note: LP-FDP-03 receives water from the water management ponds LP-SP-03A, LP-SP-03B and LP-SP-03C (waste rock pile and topsoil stockpile).

Figure 4-15 LP-FDP-03 Average Annual Flows - Probabilistic Analysis



Note: LP-FDP-04 receives water from the water management pond LP-SP-04 (overburden stockpile).

Figure 4-16 LP-FDP-04 Average Annual Flows - Probabilistic Analysis



Note: LP-FDP-05 receives water from water management pond LP-SP-05 (pit dewatering).

Figure 4-17 LP-FDP-05 Average Annual Flows - Probabilistic Analysis

4.4 TAILINGS MANAGEMENT FACILITY

The water quantity model was used to estimate the variations of volume of water within the TMF by balancing the TMF inflows and outflows, and mill demand from the TMF with use of other contact water from the Plant during operations. Figure 4-18 presents the simulated tailings pond volumes for the average climate condition. In this scenario, surpluses above the maximum TMF storage volume are simulated starting in Year 14, which are directed to the open pit to accelerate pit filling times. The flows to the polishing pond, the seepage collection flows, and basal seepage rates are also presented on the figure.

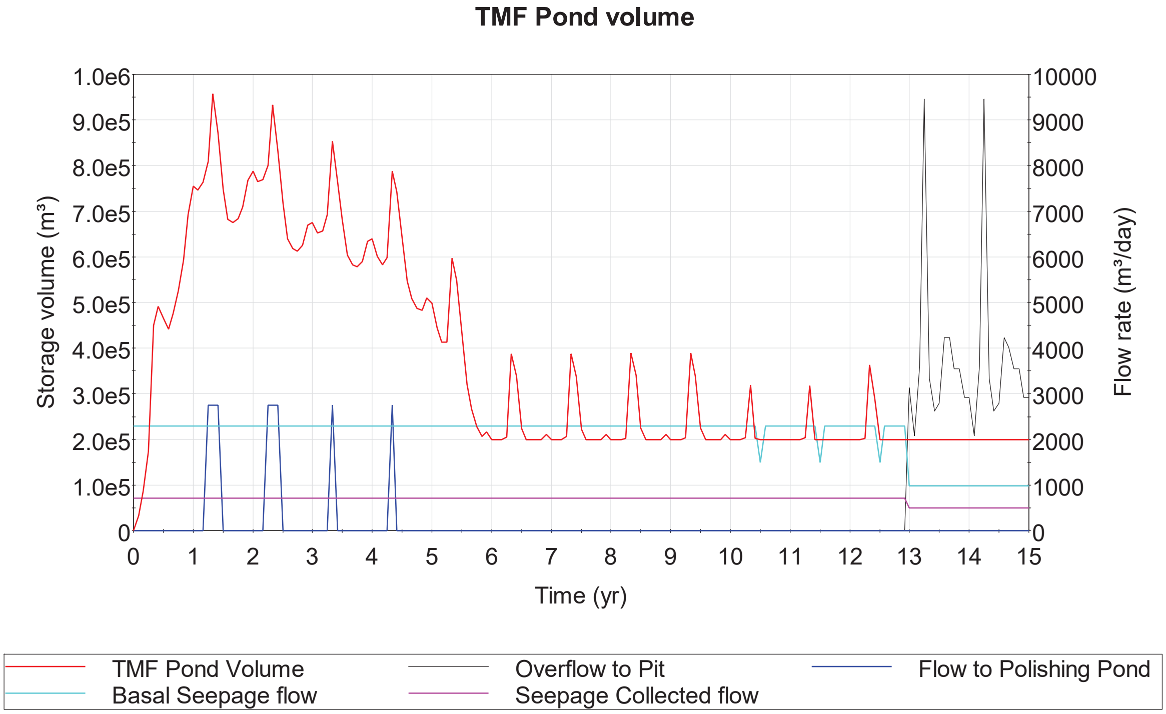


Figure 4-18 TMF Modelled Pond Storage and Outflows - Average Climate Condition

During operation (Year 1 to 9), the tailings pond volume does not completely meet the Plant reclaim demand (values presented in Table 3-6), therefore deficits for reclaim are simulated from Year 6 due to the increase of demand from the Plant, and especially during July due to climate conditions (Figure 3-10). During the Years 10 to 12, tailings are deposited in the pit, decreasing the water inflow to the tailings pond and increasing the deficit of TMF reclaim water. Figure 4-19 presents the water demand of the Plant and the actual water reclaim.

During operation (Year 1 to 9), the maximum water deficit (i.e., difference between the demand and the reclaim) is 2,900 m^3/day. This deficit in the model is covered by pumping fresh water from Victoria Lake Reservoir, as discussed in Section 4.6. The maximum deficits of approximately 5,000 m^3/day and 3,600 m^3/day in Years 11 and 12, respectively.

Figure 4-20 presents the probabilistic results for the water reclaim during the operation. The colored ranges represent the deficit of reclaim water. For simulations with high precipitation, the demand from the Plant is fully covered, and for low precipitation simulations (e.g., 5th percentile), only a portion of the demand is met by reclaim water.

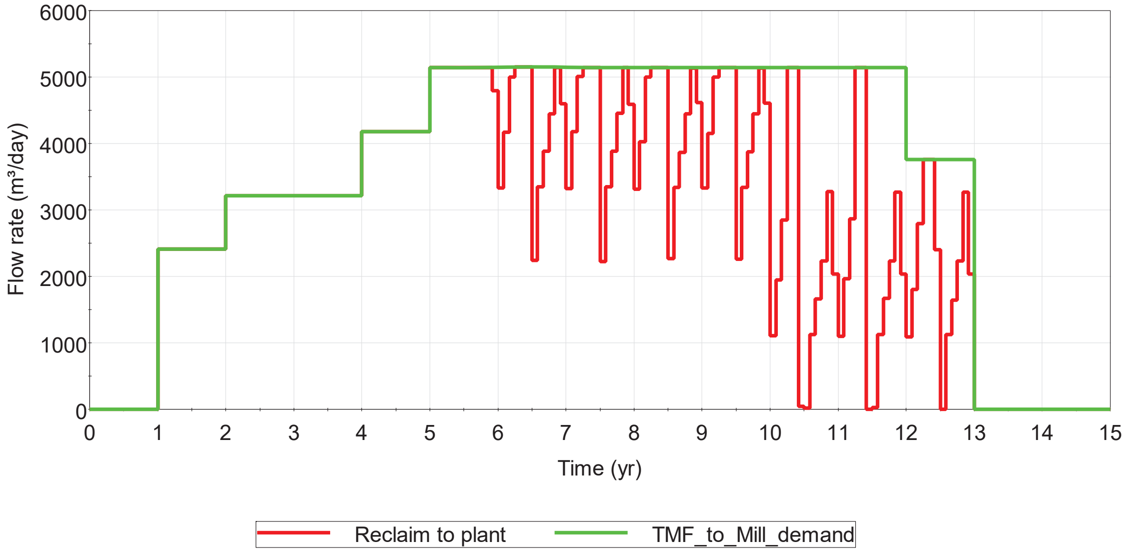


Figure 4-19 Tailings Pond Reclaim Flow Rates to Plant – Average Scenario.

Table 4-3 Monthly-average reclaim flows from Tailings Pond to the Plant, during Operation (Years 1 to 12) (m^3/day)

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average	2,811	3,178	3,590	4,063	4,063	3,196	2,331	2,721	2,972	3,282	3,741	3,283	39,231
Minimum	1,092	1,792	2,413	2,413	2,413	163	0	1,124	1,654	2,230	2,413	2,032	25,977
Maximum	5,148	5,148	5,148	5,148	5,148	5,148	5,148	5,147	5,147	5,147	5,148	5,147	61,767

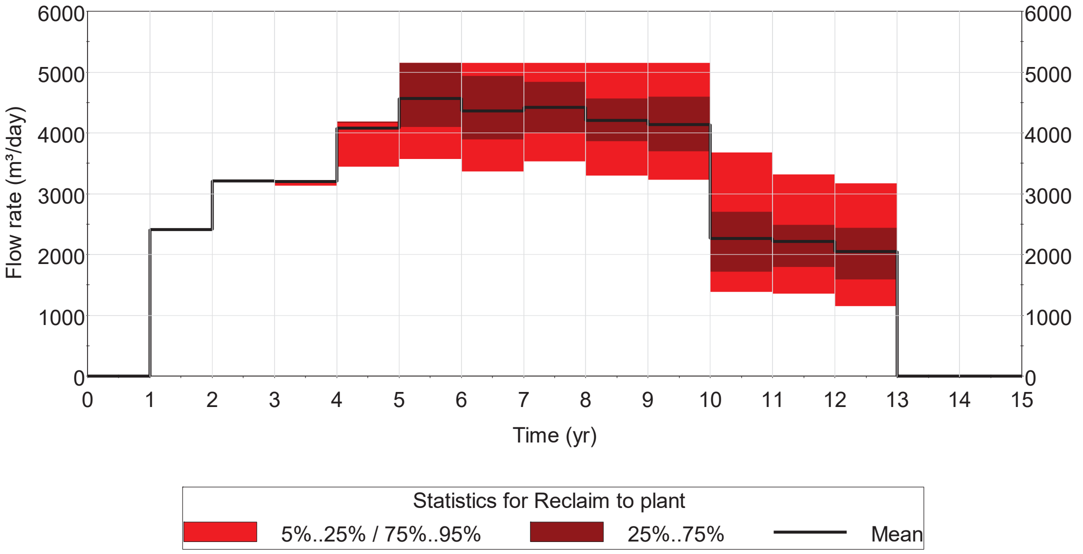


Figure 4-20 Tailings Pond Reclaim Flow Rates to Plant - Probabilistic Results for Annual Averages

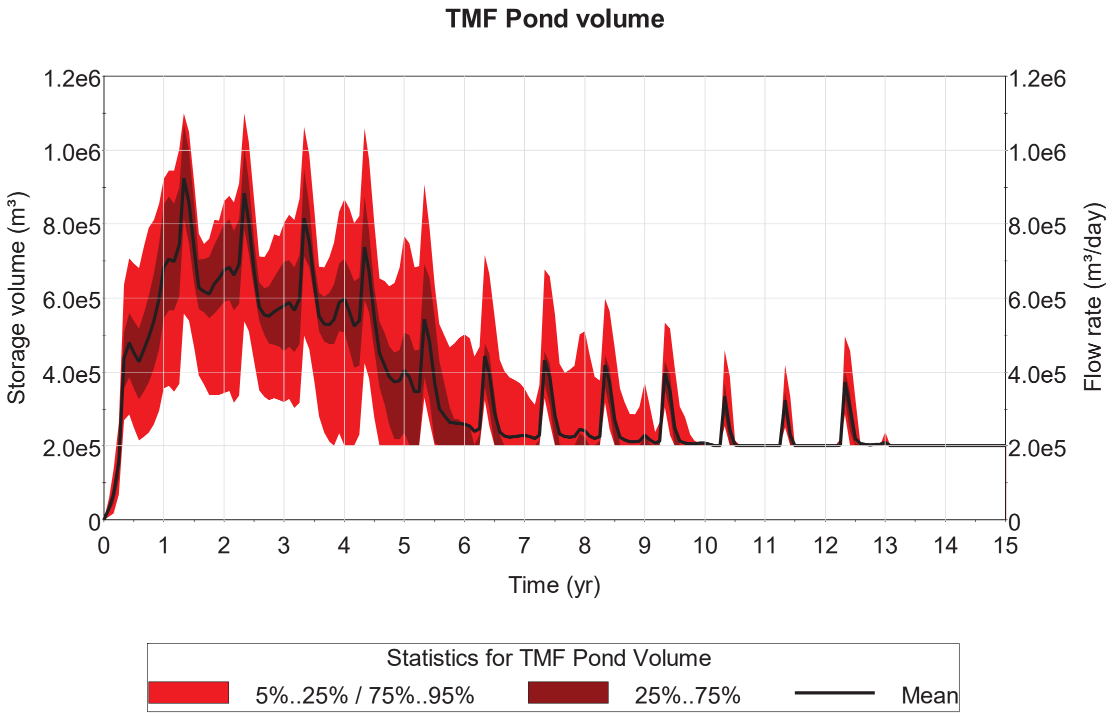


Figure 4-21 Modelled Tailings Pond Storage and Potential Storage - Probabilistic Results

Seepage through the tailing dam will be collected in the seepage collection ponds. During operation and closure, water from the tailings pond seepage collection ponds will be recirculated to the tailings pond. After closure, water from the seepage collection system is modelled to discharge to the open pit to augment pit filling

4.5 TMF WATER TREATMENT ACTIVATION

The model was run iteratively to analyze the volume of tailings pond excess water discharged to the environment prior to treatment by varying the tailings pond volume level at which the treatment is activated. In first instance, the model was set to instantaneously treat excess water from the tailings pond. However, the capacity of the treatment plant (83,809 m^3/mon) was exceeded, resulting in the discharge of untreated water for some simulations of the Monte Carlo analysis as it is presented in Figure 4-22. Excess water (untreated) for the range between 75% and 95% probability occurs during mine Years 1 and 2. From Year 13, all excess water is directed to the pit, and there is no treatment.

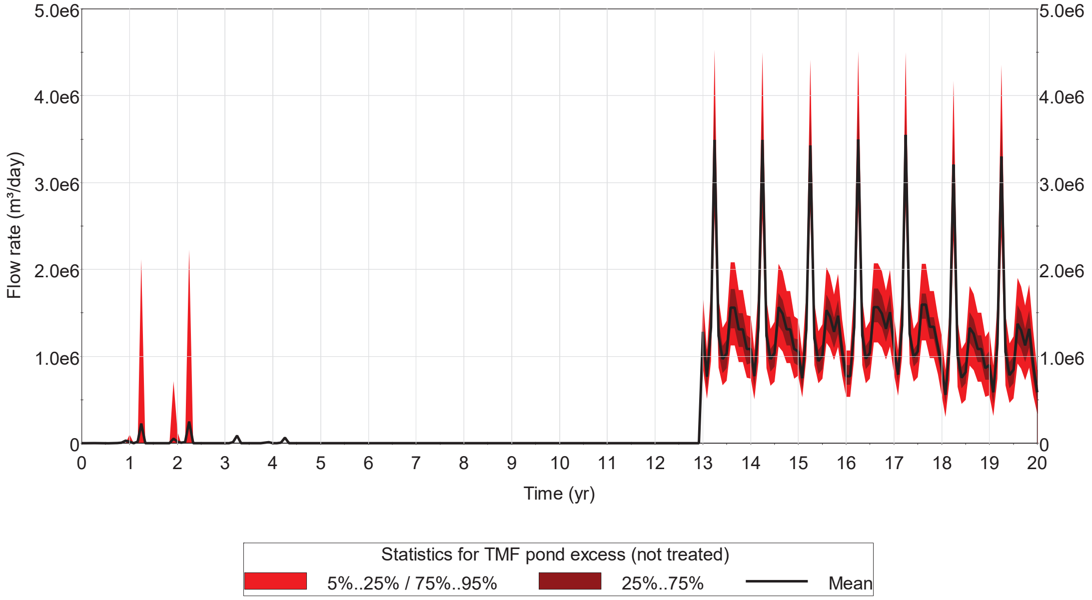


Figure 4-22 Tailings Pond Excess Water Over Treatment Capacity, for Treatment Starting when Pond Reaches Full Capacity – Probabilistic Analysis

The current model was set to activate treatment when the pond level reaches 70% of its volume capacity. With a 70% high operating water level, no untreated excess water occurs even for the 95th percentile simulation. Results from the probabilistic analysis for the tailings pond volume are provided in Figure 4-23, which indicates no release of untreated water during operation (before Year 13) under all simulation conditions.

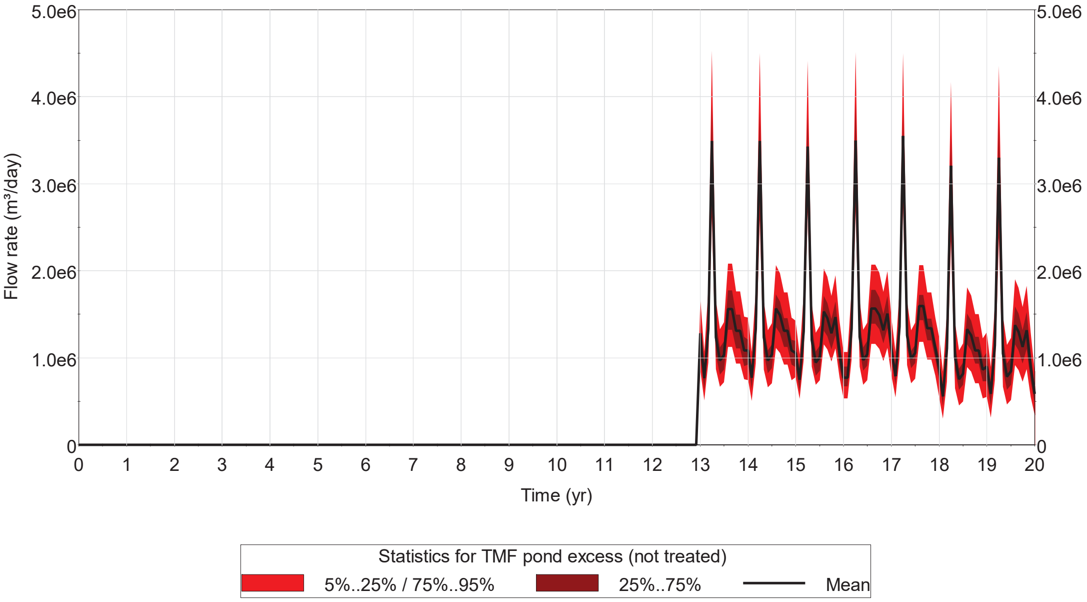


Figure 4-23 Tailings Pond Excess Water for Treatment Starting when Pond Reaches 70% Capacity – Probabilistic Analysis

4.6 FRESH WATER CONSUMPTION FROM VICTORIA LAKE RESERVOIR

The primary source of water to meet the plant water demand is the tailings pond; the secondary source is fresh water from Victoria Lake Reservoir. Additionally, accelerated pit filling using water taken from Victoria Lake Reservoir and the tailings pond during the closure and post-closure subphases was modelled. Without accelerated pit filling, it would take 40 years to fill the Leprechaun pit for average climate conditions (see Section 4.7). Based on water takings from Victoria Lake Reservoir and incorporation of tailings pond excess water starting in operation Year 10, it will take a significantly shorter period of eight years after end of pit mining (to the end of the closure period) to fill the Leprechaun pit. Figure 4-24 presents the yearly averaged flow rates of reclaim water from the tailings pond and fresh water from Victoria Lake Reservoir.

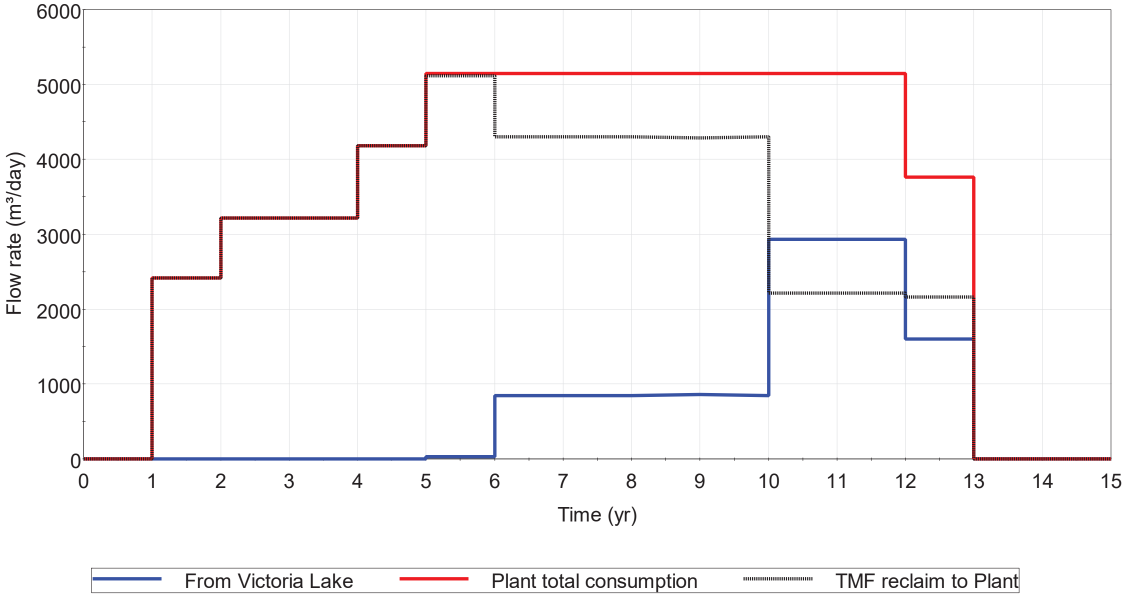


Figure 4-24 Plant Water Demand and Reclaim Water from Tailings Pond and Victoria Lake Reservoir (Yearly Averages)

Figure 4-25 shows the total water withdrawal from Victoria Lake Reservoir for both the plant demand and pit lake filling. The maximum flow rate from Victoria Lake Reservoir during Years 1 to 9 is around 3,000 m^3/day. From Year 10 to 12, the maximum flow rate is approximately 16,000 m^3/day and the minimum is 10,950 m^3/day, which corresponds to the constant flow rate to fill the pit in eight years (4 Mm^3/year).

Table 4-4 presents average, minimum and maximum monthly-average flows from Victoria Lake Reservoir.

Figure 4-26 shows the probabilistic results for the Victoria Lake Reservoir flow rates. Maximum flows are near to 16,000 m^3/day for Years 11 and 12, and minimum flow is 10,950 m^3/day, which is the rate to fill the pit in eight years (4 Mm^3/year).

Table 4-4 Monthly-average flows from Victoria Lake Reservoir from operation to closure (Years 1 to 17) (m^3/day)

Value	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average	6,108	5,826	5,506	5,154	5,154	5,836	6,489	6,184	5,987	5,751	5,405	5,749	5,762
Min	0	0	0	0	0	0	0	0	0	0	0	0	0
Max	14,998	14,152	13,254	10,951	10,951	16,097	16,078	14,974	14,436	13,869	12,831	14,066	13,884

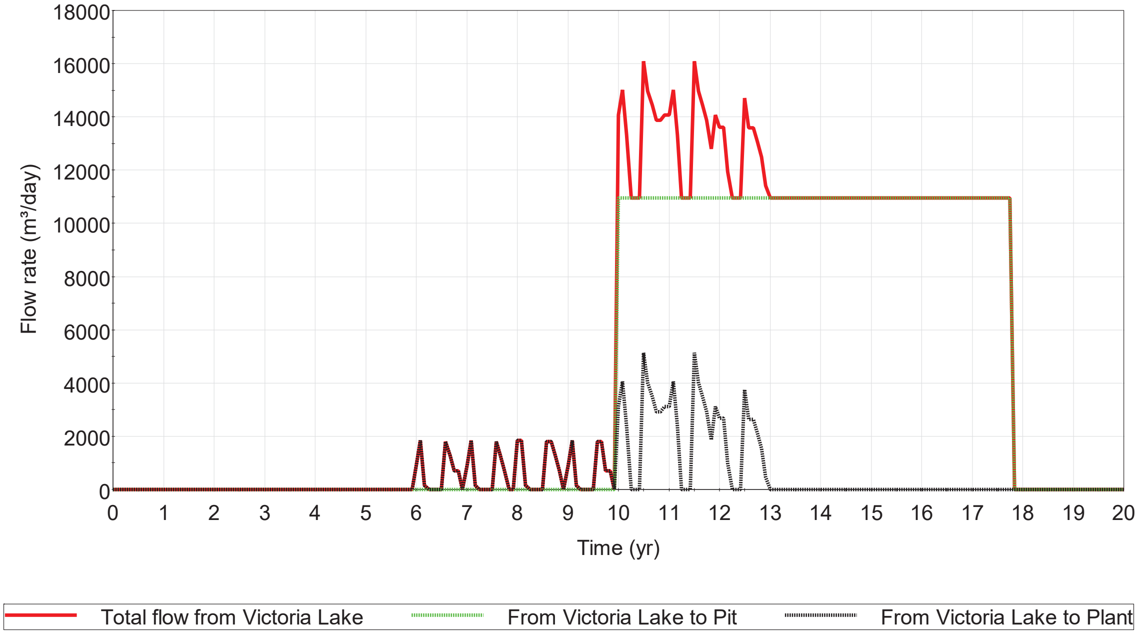


Figure 4-25 Water Flow Rates from Victoria Lake Reservoir – Average Scenario

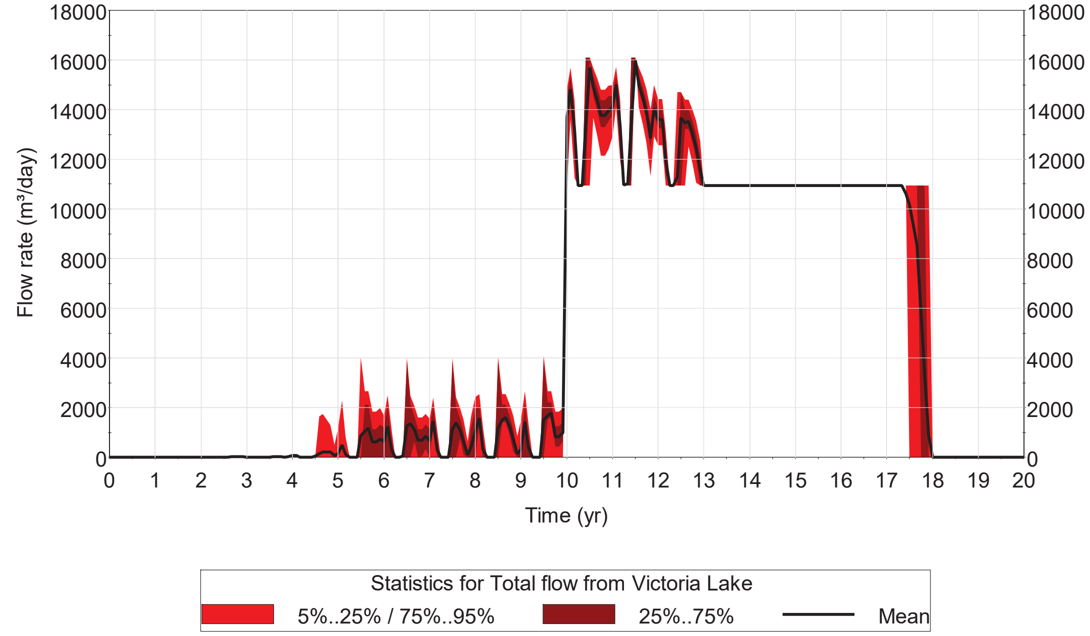


Figure 4-26 Water Flow Rates from Victoria Lake Reservoir – Probabilistic Results

4.7 OPEN PIT

During the operation phase (until end of Year 9), flows into (and from) the open pit include groundwater seepage, precipitation, surface runoff from natural areas, evaporation, and dewatering. From Year 10 to 12, tailings, excess water from the tailings pond, and water from Victoria Lake Reservoir are added to the pit with the objective to accelerate filling the pit. The flow rate intake from Victoria Lake Reservoir was set to 4 Mm^3/year to fill the pit in eight years based on iterative simulations using the water quantity model.

Figure 4-27 presents the average monthly groundwater inflow rate and runoff flows from incident precipitation and natural ground for the average climate scenario. The total dewatering rate includes groundwater inflows and net precipitation. The total flow rates from Victoria Lake Reservoir and the tailings pond, and the deposition of tailings are also presented. Table 4-5 presents average, maximum and minimum monthly-average dewatering flows.

Figure 4-28 presents the probabilistic dewatering results. Monthly dewatering rates from the open pit ranges from 1,360 m^3/day (5th percentile of the minimum monthly value) to 8,155 m^3/day (95th percentile of the maximum monthly value). Probabilistic pit filling results are shown in Figure 3-18.

The model predicts that filling of Leprechaun pit will take between 37 and 42 years (for the 95th and 5th percentiles, respectively) after the pit closure. This includes the deposition of tailings in the pit during mine Years 10 to 12 and the diversion of excess water from tailings pond during closure (mine Years 13 to 18). As discussed in Section 4.6, accelerated pit filling was modelled to require eight years after end of pit mining (Year 10 to end of Year 17) by using water from Victoria Lake Reservoir and the tailings pond. Figure 4-29 and Figure 4-30 present the probabilistic results for the water level in the pit for the natural case (i.e., without pumping water from Victoria Lake Reservoir), and the accelerated case, respectively.

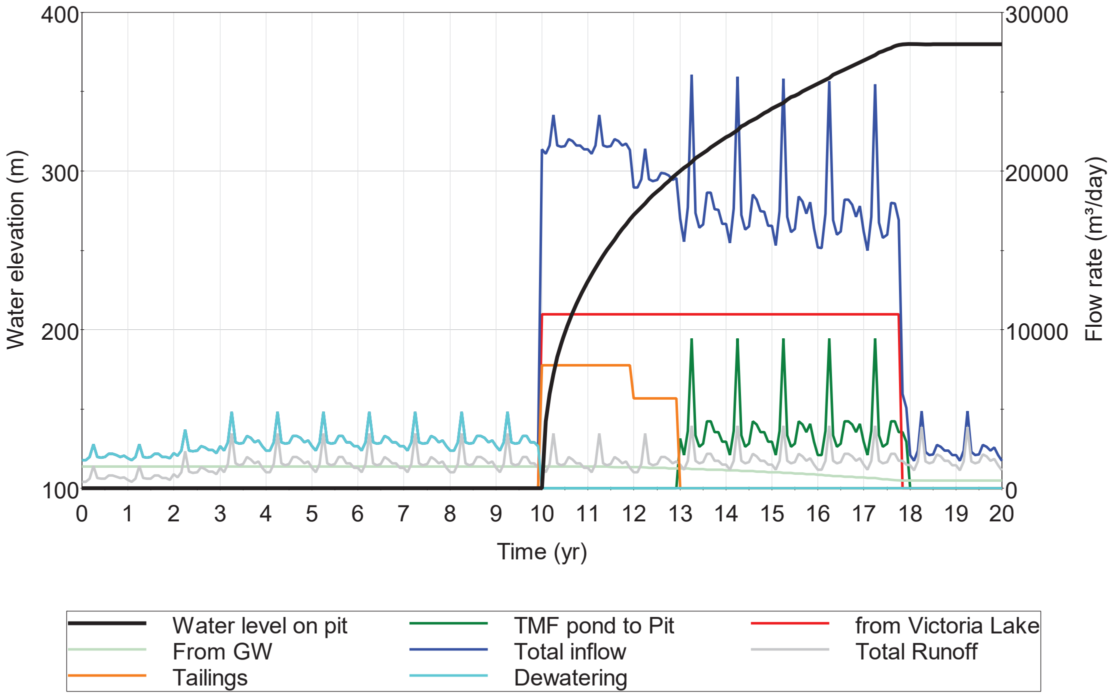
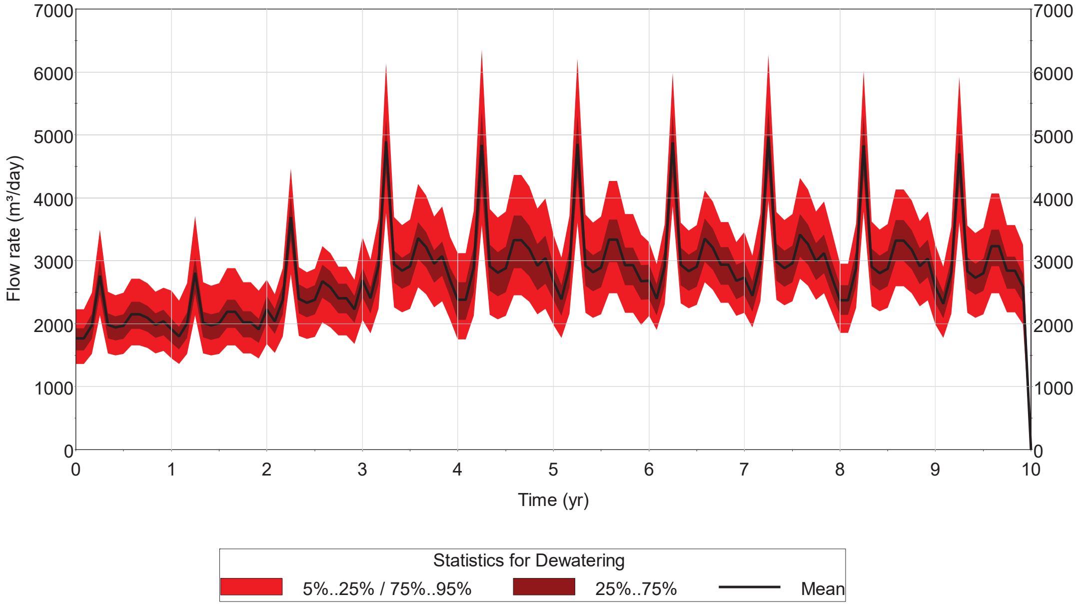


Figure 4-27 Pit Water Level, Inflows and Dewatering (Average scenario)

Table 4-5 Monthly Mean, Minimum (percentile 5th) and Maximum (percentile 95th) Pit Dewatering Flows during Pit Operations (m^3/day)

Value	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean	2,213	2,418	2,643	4,292	2,663	2,577	2,639	3,014	2,893	2,669	2,773	2,452	33,248
Min	1,765	1,850	1,971	2,764	1,981	1,940	1,969	2,149	2,091	1,984	2,034	1,880	24,377
Max	2,367	2,621	2,874	4,817	2,898	2,796	2,869	3,311	3,168	2,904	3,027	2,649	36,300



Note: The 95th and 5th percentile annual precipitation totals are approximately equivalent to the 1:25 year wet and 1:5 year dry years, respectively.

Figure 4-28 Pit Dewatering Rate (Probabilistic Analysis)

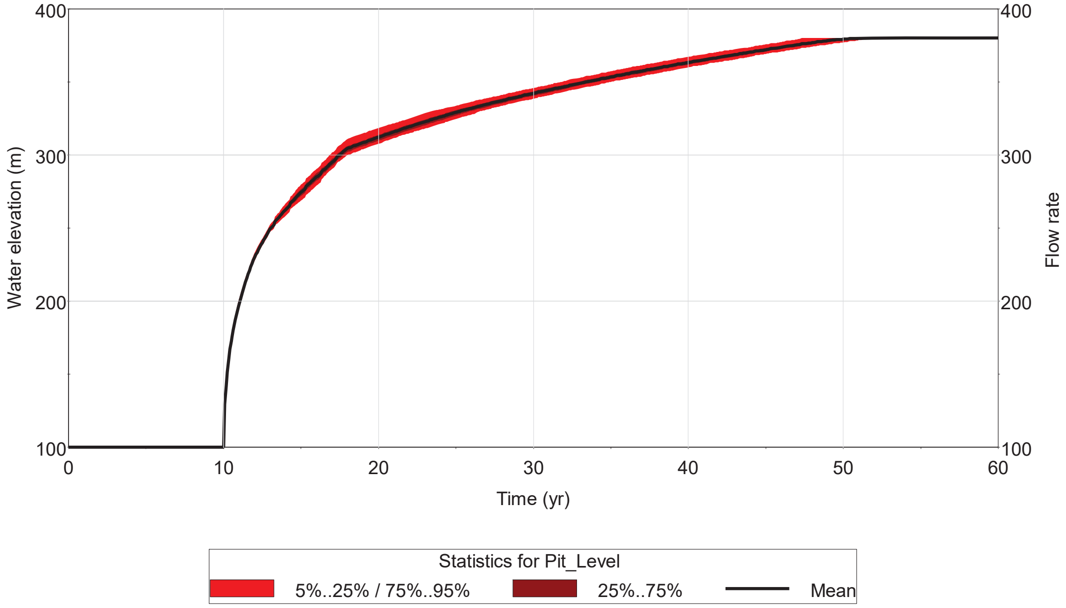


Figure 4-29 Natural Filling of the Open Pit (Without Adding Water from Victoria Lake Reservoir)- Probabilistic Analysis

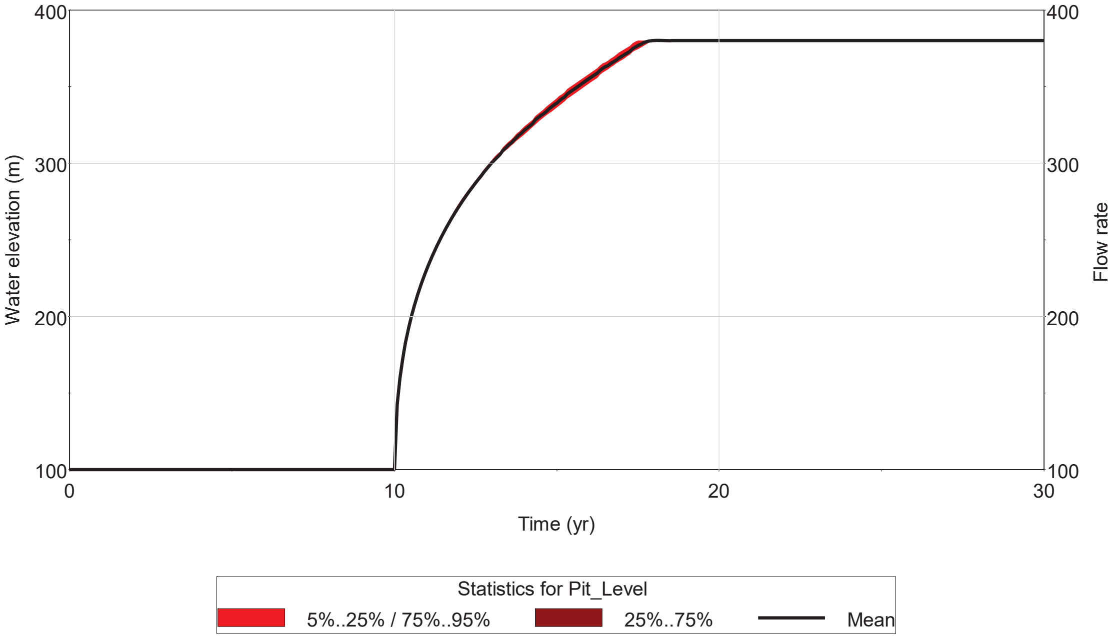


Figure 4-30 Accelerated Filling of the Open Pit Adding Water from Victoria Lake Reservoir- Probabilistic Analysis

5.0 WATER QUALITY MODEL

5.1 CONCEPTUAL MODEL

The major objective of a water quality model is to predict concentrations of potential contaminants in mine facilities and final discharge points. The contaminant transport module of GoldSim is used to build the water quality model directly linked to the water quantity model. The water quality model consists of the network of individual cells representing pore water of the waste rock pile, LGO stockpile, ponds and pit lakes (undeveloped areas and Project facilities) connected by links representing ditches and channels. The water quantity model provides direct inputs to storage volumes and water inflow/outflow rates at the cells. All the annual infiltration during the first year of the model (mine Year -1) was arbitrarily assigned to pore water in the waste rock pile and LGO stockpile to facilitate wetting of the piles. In subsequent years, the wetting is maintained for the period that the pile remains in place. Based on this assumption of simulating wetting of solids, no seepage drains from these sources to the water management ponds during the first year. The water quality inputs to the cells are associated with the concentration or mass-rate (loading) addition to the cell. The concentration in a cell is calculated by GoldSim as the mass retained in a cell divided by the volume of the cell at the end of each time step.

The selection of parameters for inclusion in the model is based on criteria listed in CWQG-FAL and MDMER. In addition to the parameters listed in these guidelines and regulations, the supporting parameters such as general water chemistry are added. The full list of parameters, their symbols and applicable reference values are provided in Table C-1 (Appendix C). Trace element concentrations are modelled as total. Temperature and pH are not modelled, but are required to calculate the CWQG-FAL values for aluminum (Al), manganese (Mn), un-ionized ammonia ($N\text{-}NH_{3\ UN}$), and zinc (Zn). Although pH and alkalinity are not modelled, they are tracked by the model for potential future geochemical modelling outside of GoldSim, if needed. It should be noted that pH values below 7.0 are not expected as discussed in Stantec (2020e).

Conservative inputs are used to calculate CWQG-FAL that are dependent on hardness, pH or/and temperature observed in the baseline dataset Table C-1 (Appendix C). For example, to calculate guidelines for cadmium (Cd), copper (Cu), lead (Pb), and nickel (Ni), the lowest hardness observed in baseline surface water (6.4 mg $CaCO_3$/L) is used. Dissolved zinc and dissolved manganese guidelines are conservatively applied to total concentrations of these metals predicted by the model. Phosphorus (P) CWQG-FAL guideline is narrative and is related to change of receptor's tropic status. In this report we conservatively applied the lowest threshold of 4 µg/L appropriate for screening purposes. This threshold corresponds to ultraoligotrophic water bodies, while current drainage from at the site likely has mesotrophic or eutrophic status.

5.2 BASELINE WATER QUALITY INPUTS

Data from surface water quality monitoring stations are assumed to represent the following baseline sources:

- LP-02 and LP-04 for undisturbed runoff from the Leprechaun Complex
- R-01 and LP-05 for undisturbed runoff for the Processing Plant and TMF Complex
- VICRV-01 make-up water and open pit filling water from Victoria Lake Reservoir.

The monitoring locations and the original data are shown in Stantec 2020c. The data for each source was aggregated and prepared using the following steps to calculate input statistics:

Step 1: Concentrations of some elements are reported below detection limits with some detection limits being above the respective CWQG-FAL (e.g., Zn and phosphorous (P) etc.). For concentrations below the detection limits, half detection limits are used for model inputs.

Step 2: Concentrations of some parameters (e.g., fluoride (F), total cyanide (CN_T) and weak-acid dissociable cyanide (CN_{WAD})) are not analyzed at some stations. These missing inputs are conservatively replaced with full detection limits observed in other station/water types. Un-ionized ammonia values are calculated from total ammonia ($N\text{-}NH_{3\ T}$) using maximum temperature and pH (19 °C and 7.8, respectively) values observed in surface water, where temperature and/or pH are not present in the input data set.

Step 3: Outliers are evaluated using 1.5 of the upper quartile rule (Tukey 1977). These included:

- Chromium (Cr): LP05, 5-Sep-11, 69.3 µg/L; R01, 7-Aug-11, 90.7 µg/L; R01, 6-Sep-11, 18.8 µg/L;
- Mn: LP04, 3-Feb-17, 1000 µg/L; LP05, 21-Feb-13, 724 µg/L;
- P: R01, 2-Aug-15, 150 µg/L; and
- Ni: R01, 10-Feb-18, 8.4 µg/L.

Step 4: Calculation of statistics for each parameter for probabilistic modelling.

The resulting statistics are presented in Table C-2 (Appendix C). Normal distribution is assumed using means and standard deviations as inputs. The distribution is truncated to minimum and maximum values.

Groundwater water quality in bedrock around the Leprechaun open pit is represented by monitoring wells VL-11-248-2017, VL-17-650-2017, and VL-09-134-2017, while overburden water quality is based on samples from wells MW3, MW6, and MW5. Well locations and water chemistry are shown in Gemtec (2019). The groundwater quality data is processed using the same steps as for surface water. However, due to limited data, a triangular distribution for probabilistic model runs is conservatively assumed (Table C-3, Appendix C). This distribution requires minimum, the most probable (mean), and maximum values as inputs.

5.3 PROJECT INPUTS

5.3.1 Waste Rock Pile, Ore Stockpiles, and Rubble in the Open Pit

Water infiltrating into waste rock pile, the LGO stockpile and precipitating in the open pit is conservatively assumed to have the quality of undisturbed runoff (i.e., baseline chemistry). In addition, waste rock source terms include leaching rates from the rock rubble from the pit and pit walls as a result of weathering and nitrogen species leached from undetonated explosives.

5.3.1.1 Weathering (Metal) Leaching Rates

Weathering (metal) leaching rates are calculated from humidity cell tests containing representative samples of different rock lithologies and ores Stantec (2020e). The leaching rates are assumed to have triangular distributions requiring inputs for minimum, most probable (mean), and maximum values. These statistics are calculated for the first month of the tests to represent construction, operation, while the last month of testing reflects conditions during closure and post-closure when rates have stabilized (Table C-4, Appendix C). The leaching rates (R_{HC}) are proportioned by the volume or area of lithology exposed in a stockpile or open pit, respectively. The percentages of lithologies and showed in Table 5-1.

Table 5-1 Percentages and Inputs for Different Lithologies/Materials

Lithology	% of Lithology	% PAG in Lithology	Humidity Cell ID in Table C-4
Waste Rock Pile			
Trondhjemite/Granodiorite	76	0	L TRJ
Sediments	24	0	L SED
Low-Grade Ore Stockpile			
Low-grade ore	100	13	LLGO-Met
Open Pit Rubble and Walls			
Trondhjemite/Granodiorite	57	0	L TRJ
Sediments	35	0	L SED
Low-grade ore	3	13	LLGO-Met
High-grade ore	5	67	L QZ-QTP

The leaching rates are multiplied by the mass of the lithology or material present in a mine component and by applying scaling factors (SF) to convert the laboratory rates to full scale field components. The scale up factors have stochastic inputs assuming a triangular distribution. Leaching rates are calculated using Equation 5-1:

$$R = M \times R_{HC} \times SF_{TEMPERATURE} \text{ x } SF_{SURFACE\ AREA} \times SF_{CONTACT} \times SF_{POSTCLOSURE} \qquad \textit{Equation 5-1}$$

where

- M = rock/ore mass of rock exposed. Stockpile mass balances from the mine schedule (Table C-5, Appendix C). For the rubble mass, the pit wall area is assumed to be covered, fractured down to 1 m of rubble with the grain size the same as in the stockpile;
- R_{HC} = leaching rate of a humidity cell (Table C-4, Appendix C);
- $SF_{TEMPERATURE}$ = scaling factor for the temperature;
- $SF_{GRAIN\ SIZE}$ = scaling factor for a grain size distribution;
- $SF_{CONTACT}$ = contact factor accounting for reduction in solute leaching (flushing) due to hydraulic isolation, which is limited in laboratory tests; and
- $SF_{POSTCLOSURE}$ = reduction of an element leaching rates starting in closure due to placement of covers.

A summary of the scaling factor ranges applied to each mine component, for which the mined material is a source, is provided in Table 5-2.

Table 5-2 Ranges and Sources of Scale up Factors

Factor	Range	Source
SF TEMPERATURE	0.2 - 0.4	Arrhenius's equation assuming temperature range 6-7.4 ºC (bedrock groundwater temperatures) and activation energies 47 to 58 kJ/mol for pyrite
SF GRAIN SIZE	0.062 - 0.07	Fragmentation analysis. Percent of minus 10 mm mass fraction in blasted rock
SF CONTACT	0.34 - 0.65	Kempton (2012)
SF CLOSURE	0.53	During closure and post-closure only, Steinepreis (2017)

All leaching rates are obtained from neutral drainage, because none of the geochemical tests have developed acidic leachate. However, some lithologies are expected to generate acidic drainage resulting in increase in metal leaching in pockets of PAG materials. In order to account of this increase, neutral leaching rates are inflated by a factor of 10 for arsenic (As), silver (Ag), barium (Ba), boron (B), calcium (Ca), Cd, Cr, Cu, magnesium (Mg), Mn, potassium (K), sodium (Na), Ni, selenium (Se), sulfate (SO_4), uranium (U), and Zn in PAG rock at acid rock drainage (ARD) onset time. PAG rock volumes and ARD times are discussed in the geochemistry report (Stantec 2020e). The inflated rates are calculated using Equation 5-1 for the mass of PAG rock in each lithology of waste rock, low-grade ore, and rubble.

5.3.1.2 Nitrogen Rates

The blasting of waste rock will release nitrite, nitrate, and ammonia, which subsequently will be rinsed from the rock and contribute loads to contact water. The mass rate of lost (non-exploded) nitrogen (R_N, in grams per year (g/yr)) is calculated using *Equation 5-2*:

$$R_N = MR \times PF \times F_N \times L_N \times FR_N \qquad \textit{Equation 5-2}$$

where

- MR = total mining rate of ore and waste rock for pit or just waste rock, or ore for stockpiles t/yr (Table C-5, Appendix C);
- PF = 300 grams per tonne (g/t), powder factor based on Ausenco (2020);
- F_N = 0.333, based on 1/3 of nitrogen in the explosive (Bailey et al. 2012), dimensionless;
- L_N = 0.001 to 0.043 with the likely values of 0.002 for the expected and upper cases, respectively, based on 0.2% nitrogen of total nitrogen used from Ferguson and Leask (1988) and 4.3% as maximum observed in dry open pit mines from Golder (2008); and
- FR_N = 0.1 (or 10%), fraction of nitrogen released from rock and ore while in the open pit, prior to material transfer to storage areas and 0.9 for the waste rock pile and low-grade ore stockpile assuming that another 90% will be leached later based on Golder (2007).

The release of nitrogen species is assumed to be instant and the leached nitrogen is speciated as follows based on recommendations from Ferguson and Leask (1988): N-NH_3 - 11%, nitrate (N-NO_3) - 87%, nitrite (N-NO_2) - 2%.

Weathering and nitrogen leaching rates are released to porewater cells of rock and ore stockpiles. Pore water from these cells becomes seepage collected in ditches and ponds.

Runoff Quality from Piles

Runoff from the waste rock pile and the ore and overburden stockpiles during operation is assumed to have quality obtained from shake flask tests of the respective materials (Table C-6, Appendix C). In post closure, runoff quality from covered and rehabilitated areas is assumed to be similar to baseline chemistry. The runoff is mixed with seepage at the nodes representing water management ponds, which are connected to a specific FDP to the environment. An additional load in equivalent of 15 mg/L of total suspended solids (TSS) of waste rock or ore is added to the respective water management ponds, conservatively assuming MDMER limit for TSS in the discharges. Input concentrations in these solids are presented in Table C-7 (Appendix C).

5.3.2 TMF and Polishing Pond

5.3.2.1 Inputs Rates

During operation, the tailings pond will receive mass loadings from the following sources:

- Discharge from the Plant based on chemistry of the ageing tests at day zero for all parameters, except for ammonia, which is selected for day 28 to account for ammonia generation in the tailings pond as a result of cyanide degradation (Table C-8, Appendix C). The aging test data is processed using the same steps as for surface water quality prior to calculating statistics.
- Water from the tailings pond seepage collection system represented by leachate chemistry from sub-aqueous columns assuming a triangular probabilistic distribution with inputs shown in Table C-9 (Appendix C).
- Leaching of elements from tailings beaches exposed to the atmosphere as described below in *Equation 5-3*.

Element leaching rates from exposed tailings ($R_{TAILINGS}$) are calculated using *Equation 5-3*.

$$R_{TAILINGS} = R_{HC} \times \rho \times A_{BEACHES} \times D_{BEACHES} \times SF_{O_2} \times SF_T \qquad \text{Equation 5-3}$$

where

- R_{HC} = tailings humidity cell rates for closure and post-closure as shown in Table B-4. Considering that the mill is mill feed from two pits with average of 36% tailings originated from Leprechaun ore (sample CND-2) and the remainder from Marathon (sample CND-1)
- ρ = tailings density
- $A_{BEACHES}$ = the area of TMF beaches (Section 3.3.2.1)

- $D_{BEACHES}$ = the depth of active oxidation, which is equal to 0.5 m during operation and closure and 0.2 m in post-closure after placement of a vegetated soil cover over the exposed tailings beaches
- SF_{O2} = 0.3 unitless: oxygen scaling factor accounting for differences between fully oxygenated humidity cells and a decline in oxygen concentrations in pores with depth
- S_{FT} = temperature scaling factor reflecting differences in oxidation rates between laboratory (20°C) and field temperatures (ranges from 0 to 1 depending on a monthly mean ambient temperature, Table 5-3)

Table 5-3 Temperature of Scale Up Factor for TMF

Temperature	SF_T factor
-5	0
0	0.11
10	0.33
20	1
25	1.3

During operation, the polishing pond receives excess water from the tailings pond treated down to MDMER limits (see Section 5.3.4). During closure and post-closure, excess and seepage from the tailings pond are pumped to the Leprechaun open pit. In post-closure, seepage from the tailings pond is mixed with tailings pond overflow in the polishing pond without treatment.

5.3.2.2 Removal Rates

Mass is removed from surface water in the tailings pond due to solute precipitation, sorption, settling, and degradation of cyanide. The removal rate is based on the first order constant derived from the results of aging tests (e.g., 0.077 1/day for total cyanide). These laboratory derived rates are scaled to the field rates using *Equation 5-4*.

$$R_{DEGRADATION} = K_{AGEING} \times SF_T \times C \qquad \textit{Equation 5-4}$$

where

- K_{AGEING} = the first order constant derived from laboratory tests for the elements showing clear decline with time, otherwise, assumed to be zero (no attenuation, Table C-8, Appendix C). An example of regression used for derivation of the constant is illustrated on Figure 5-1.
- SF_T = temperature scaling factor reducing a removal rate (ranges from 0 to 1 depending on a monthly mean ambient air temperature as shown in Table 5-3).

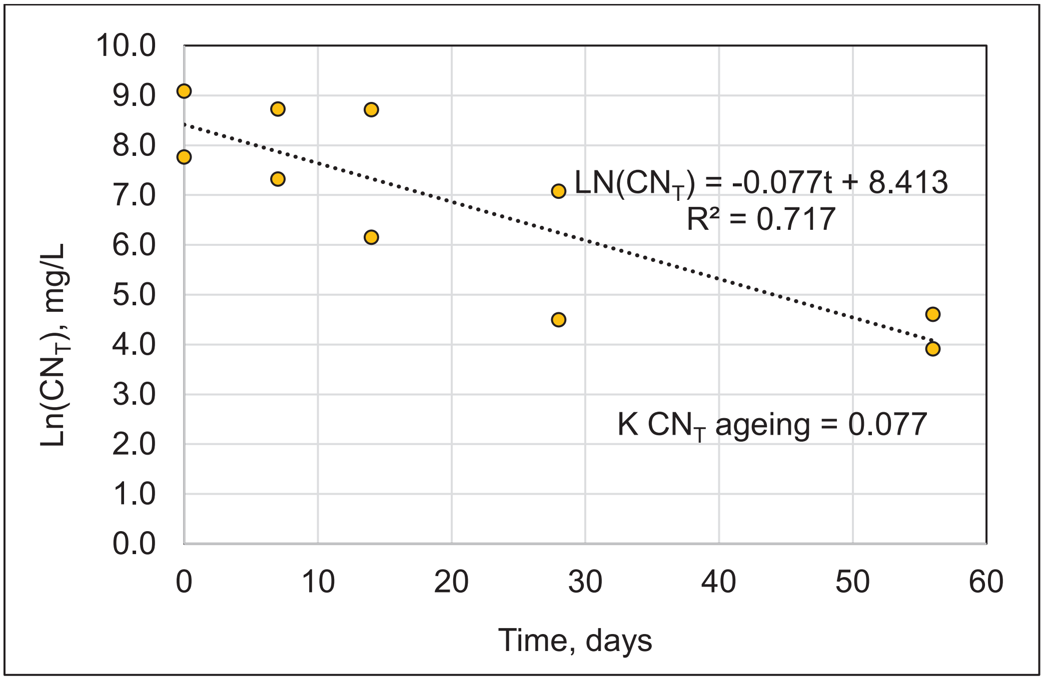


Figure 5-1 Regression Used for Derivation of K_{AGEING} CN_T

5.3.3 Open Pit

In the open pit, the leaching (input) rates from Equations 5-1 and 5-2 are applied to monthly dewatering volumes during mining or volumes of pit lake after mining ceases. During open pit development, 100% of groundwater originates from bedrock based on the groundwater modelling and, therefore, bedrock water quality is used for that period time. During pit filling, approximately 12% for groundwater is represented by overburden water quality and the remainder by bedrock water quality. Removal rates are applied to the Leprechaun pit lake when the open pit receives slurry for the mill during operation or overflow from the tailings pond. The model conservatively assumes a fully mixed pit lake.

5.3.4 Solubility Controls

The model conservatively passes a mass through the cells (nodes), except for parameters with solubility limits (caps). Because concentrations of some elements are often limited by mineral saturation, these solubility caps are included in the model and applied to the model nodes. The global solubility caps are derived based on the following assumptions:

- In neutral water, dissolved concentrations of Al and iron (Fe) are limited by low solubility of hydroxides of these elements (generally below 100 µg/L). In baseline samples, concentrations of total Al and Fe are much higher and are likely controlled by concentration of TSS (Figure 5-2). It is assumed that TSS of discharges will be below the MDMER limit of 15 mg/L. Therefore, limits for Al

(600 µg/L) and Fe (900 µg/L) are based on total concentrations of metals in the baseline sample having 14 mg/L of TSS, which is almost at the MDMER limit.

- Other solubility limits are explored by equilibrating simulated pore water with calcite and atmospheric air in geochemical software, PHREEQC. Pore water is found to be slightly supersaturated with rhodochrosite, apatite, and fluoride. These minerals are allowed to precipitate to determine equilibrium concentrations for Mn (1300 µg/L), P (50 µg/L), and F (1600 µg/L), which are set as solubility caps in GoldSim.

Local solubility caps are set for the polishing pond during operations assuming that the discharge to this pond will be treated down to MDMER limits for CN_T (500 µg/L), Cu (100 µg/L), and $N\text{-}NH_{3\,T}$ (4500 µg/L) conservatively assuming that 1/9 of total ammonia will be unionized.

All solubility caps, global and local, are above the respective CWQGs.

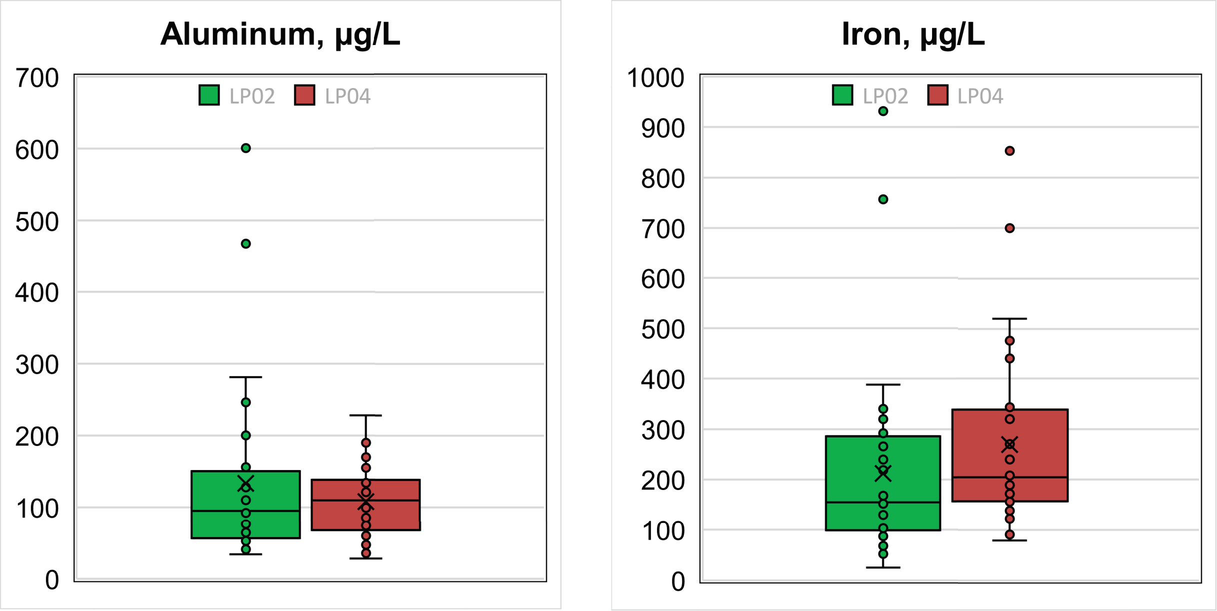


Figure 5-2 Box Plots for Total Al and Fe in Surface Water Stations, LP02 and LP04

6.0 WATER QUALITY PREDICTIONS

6.1 MODEL RUNS AND OUTPUTS

The water quality model is run in a probabilistic mode with 100 realizations. Each realization is run for 100 years in a monthly timestep. Probabilistic water quality inputs are sampled monthly using the Latin Hypercube method (GoldSim 2018). Monthly mean and monthly 95th percentile concentrations are calculated in GoldSim for baseline water, selected Project facilities (waste rock pile, LGO stockpile, and the open pit and tailings pond), and all FDPs. The monthly mean and monthly 95th percentile concentrations are calculated for each mine period (construction, operation, closure, and post-closure). The highest of the monthly statistics (mean and 95th percentile) for each mine phase is conservatively selected and presented in a summary of outputs for the Project results or baseline (Appendix D). The Project results are compared to the respective statistics for probabilistically simulated baseline surface water. The results of the model are also compared to the MDMER limits and CWQG-FAL guidelines shown in Table C-1 (Appendix C). Only the MDMER limits are directly applicable to the discharges. The CWQGs are not applicable to discharges, as these guidelines are developed for the receiving environment and are used for screening to update the parameters of potential concern (PoPC) identified in the ARD/ML report (Stantec 2020e). The time series plots for monthly mean and monthly 95th percentile concentrations of select parameters in mine components and specific discharges are presented in Appendix E.

6.2 PROJECT COMPONENTS

6.2.1 Waste Rock

Seepage from waste rock is an important source of contact water collected in water management ponds LP-SP-01b, LP-SP-02a, LP-SP-02b, LP-SP-03a, LP-SP-03b, LP-SP-03c, and open pit. No exceedances of the MDMER limits are predicted in the seepage/waste rock pore water when considering the 95% percentile levels. Concentrations of Zn, Cu, mercury (Hg), F, P and N-NO_2 may exceed the long-term CWQG-FAL over an order of magnitude (Appendix D). Exceedances of Hg, F, and P are modelling artifacts related to high detection limits in humidity cells. Half of the value of the detection limits are used in calculations of leaching rates, which are scaled up to a full-size waste rock pile. Concentrations of Zn and Cu increase during operation, peaking at the end of operation when the mass of waste rock is the greatest (Figure 6-1). Metal concentrations decline during closure, because metal leaching is partially reduced due to soil cover, and stabilize during post-closure. Concentrations of N-NO_2, as well as other nitrogen species, peak in mine Year 5 when the rate of waste rock blasting and disposal are the highest. During closure, N-NO_2 is flushed from the pile decreasing below the CWQG-FAL and stabilizing at background levels. Other parameters exceeding their long-term CWQG-FAL are Cr, Ag, N-$NH_{3\ UN}$, As, Mn, Al, N-$NH_{3\ T}$, Pb, Cd, Fe, U, Se, N-NO_3. Most of the trace elements from this list generally follow a trend similar to Cu and Zn, except for Al, Fe and Mn, which may remain at their solubility limits for many years (Appendix E). Nitrogen species have patterns similar to N-NO_2. The long-term CWQG-FAL could be exceeded for P, Cr, Zn, Al, Mn, and Fe at baseline conditions (Appendix D). In baseline dataset, artificial P exceedances are related to detection limit (100 ug/L) being more that 20x over the most CWQG-FAL guideline for P (4 ug/L).

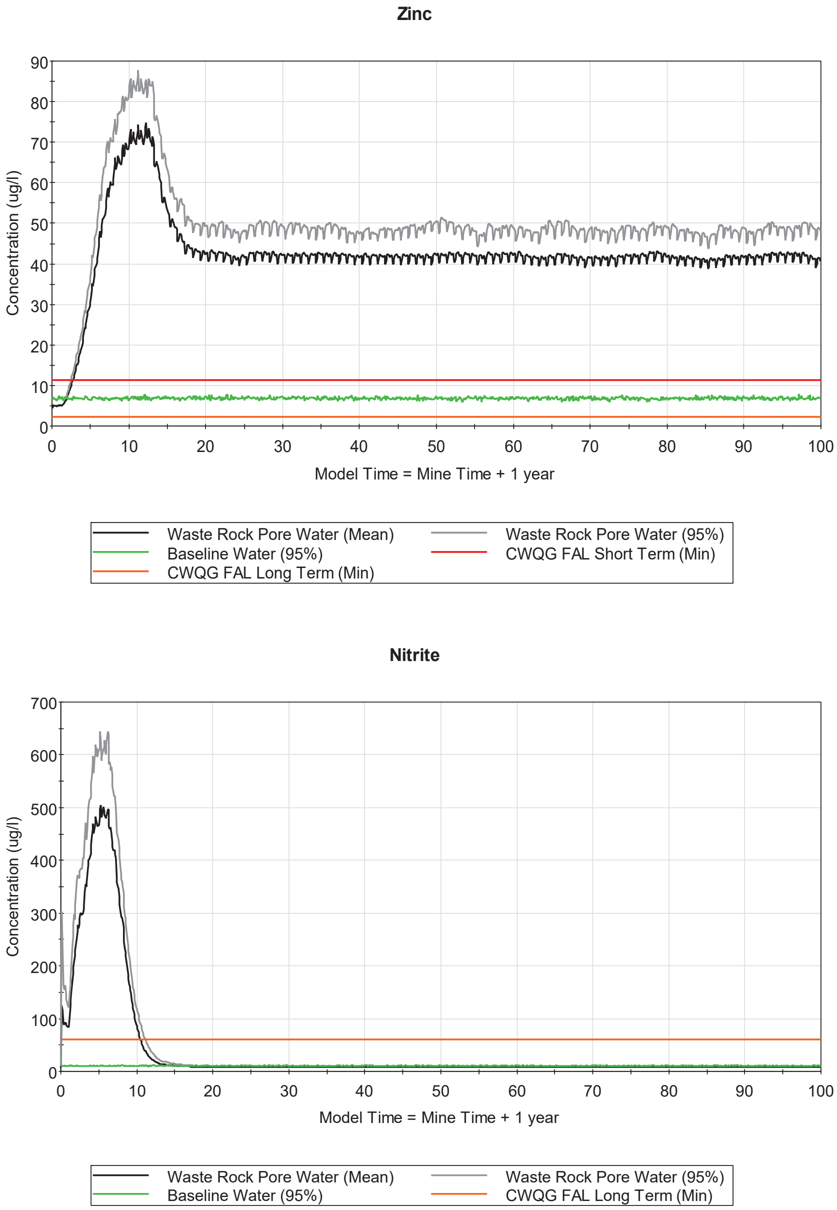


Figure 6-1 Concentration Trends of Zn and N-NO$_2$.

6.2.2 Low-Grade Ore

Seepage from the LGO stockpile will be collected in LP-SP-01a, LP-SP-02a, and LP-SP-02b water management ponds and discharged to the environment through LP-FDP-01. Similar to the waste rock pile, no exceedances of MDMER guidelines are predicted in the seepage from the LGO stockpile, considering 95% percentile concentrations. Overall, concentrations of elements in LGO are lower than in waste rock. Zn may exceed the short-term CWQG-FAL value over an order of magnitude. Concentrations of Zn and other trace elements peak around mine Year 7 when the mass of low-grade ore in the stockpile is the greatest (Appendix E). Afterwards, concentrations decline as LGO from the stockpile is transferred to the mill and then reach background levels during closure. Other parameters exceeding their long-term CWQG-FAL are F, Al, $N\text{-}NO_2$, Se, Hg, Cr, $N\text{-}NH_{3\ UN}$, Cd, Cu, Mn, Ag, $N\text{-}NH_{3\ T}$, As, Fe, and $N\text{-}NO_3$. Most of the trace elements from this list generally follow a trend similar to Zn, except for Al, Fe, P and Mn. Concentrations of nitrogen species peak in mine Year 2, following the highest rate of LGO deposition, and then decline down to background levels as the pile is mined out at the end of operation.

6.2.3 Tailings Pond

In the tailings pond, the model predicts exceedances of MDMER limits for CN_T, Cu, and $N\text{-}NH_{3\ UN}$ during operation (Appendix D). These parameters may require treatment in mine Years 1 to 10. Major sources for these parameters during operation are discharges from the Plant and recirculation of tailings pond toe seepage. Concentrations of CN_T and $N\text{-}NH_{3\ UN}$ decline below the respective MDMER limits when discharge from the Plant is diverted to the Leprechaun pit (Figure 6-2). Concentrations of Cu are predicted to persist above MDMER limits by the end of active closure because tailings pond toe seepage is pumped back to the tailings pond at that time. However, treatment is not required starting in Year10 until the end of closure because excess water from the tailings pond (potential overflow) is directed to the mill as reclaim make up and then to the Leprechaun pit in tailings slurry. In post closure, the seepage is not pumped back to the tailings pond but directed to the polishing pond instead. As a result, Cu concentrations in the tailings pond quickly decline to near background levels (Figure 6-3). In addition to predicted MDMER exceedances, Al, As, Cd, Cr, Fe, Mn, Hg, Pb, P, Se, Ag, F, Zn, CN_{WAD}, $N\text{-}NO_3$, $N\text{-}NH_{3\ T}$, and are predicted to be above long-term CWQG. These elements are elevated during operation, but rapidly decline in post-closure except for P, which is artificially high in baseline conditions.

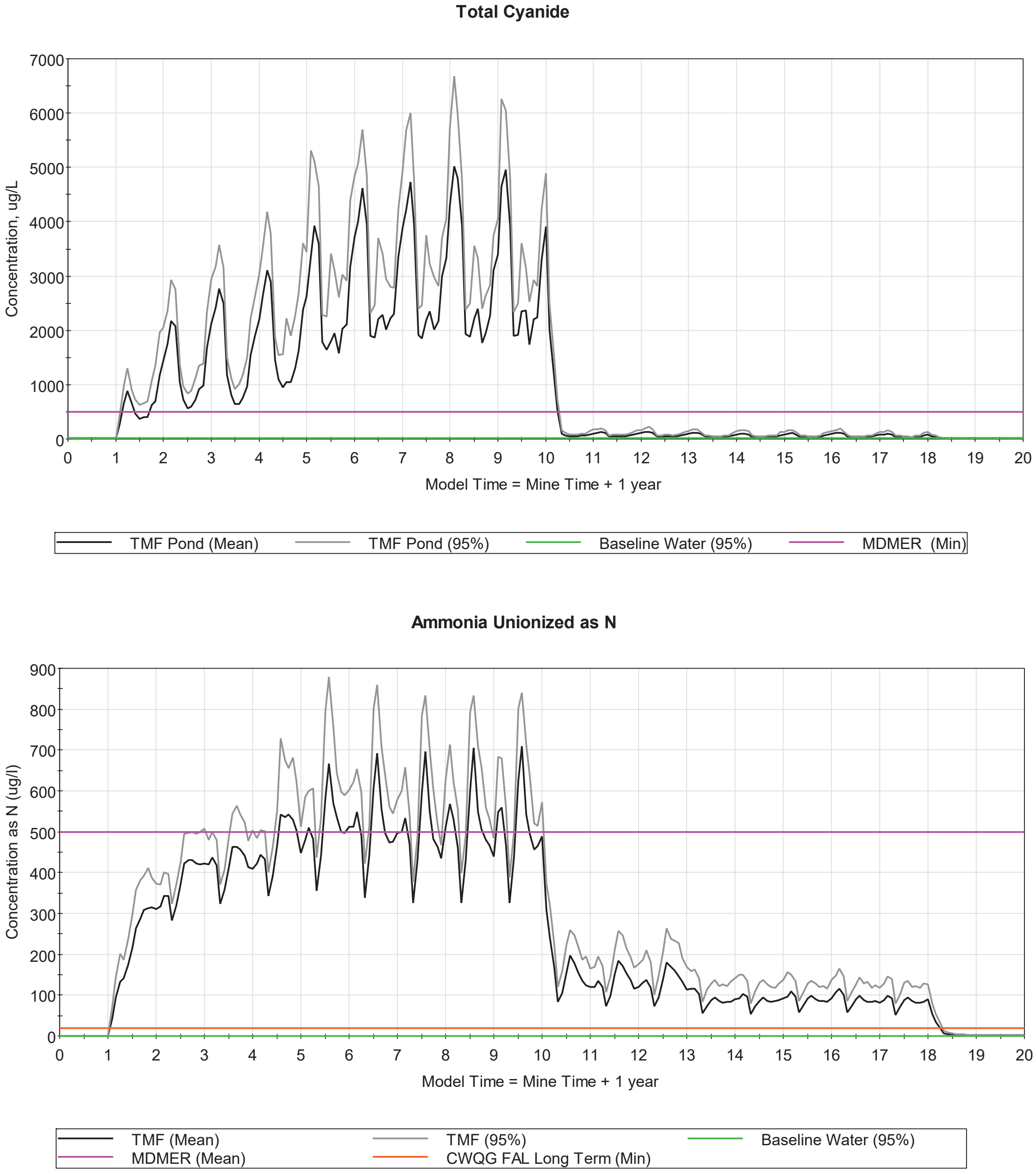


Figure 6-2 Concentration of CN_T and $N\text{-}NH_3$ in the Tailings Pond

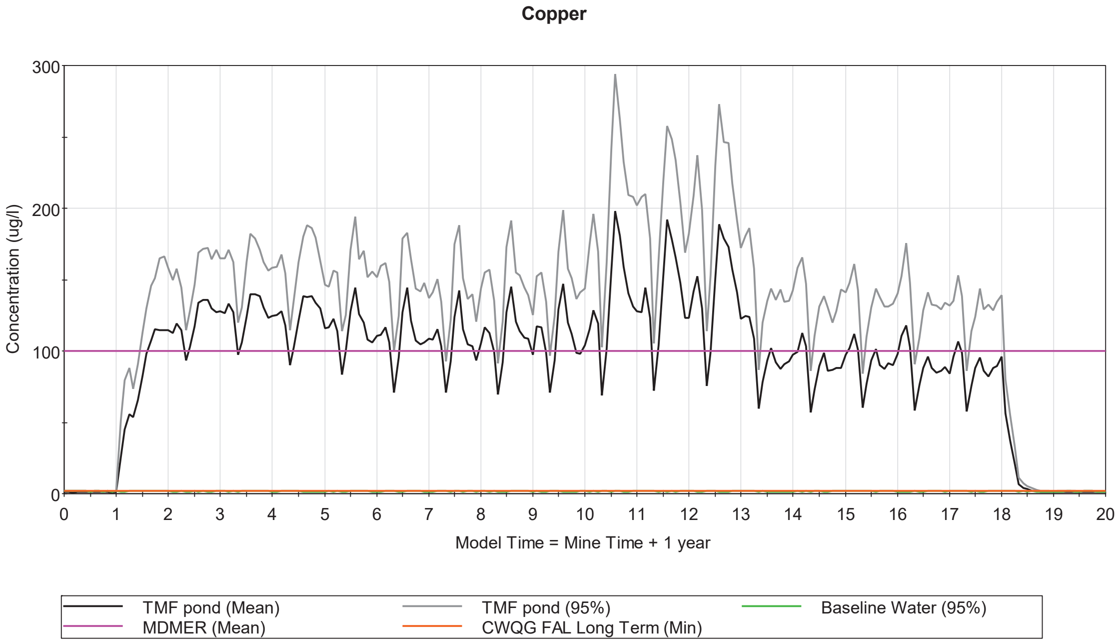


Figure 6-3 Concentration of Cu in the Tailings Pond

6.2.4 Open Pit

No exceedances of MDMER guidelines are predicted in mine water or pit lake overflow at 95% percentile concentrations. Concentrations of Cu, N-$NH_{3\ UN}$, CN_{WAD}, P, Hg, and N-$NH_{3\ T}$ may exceed the long-term CWQG-FAL over 10x (Appendix D). Exceedance of P are modelling artifact as discussed in Section 6.2.1. Elevated concentrations of Cu, N-$NH_{3\ UN}$, CN_{WAD}, and N-$NH_{3\ T}$ are observed in modelled pit lake water during the discharge of tailings slurry from the Plant and overflow from tailings pond in the final years of operation (Figure 6-4). Concentrations of these parameters show a significant decline during closure before the pit lake is full. Additional parameters exceeding long-term CWQG-FAL are Zn, Cr, Mn, F, N-NO_2, Fe, Al, Se, As, and Ag. These parameters are high during operation and decline in closure as a result of reclamation activities (Appendix D). Mine water and pit overflow are discharged to the environment through water management pond LP-SP-05 to LP-FDP-05.

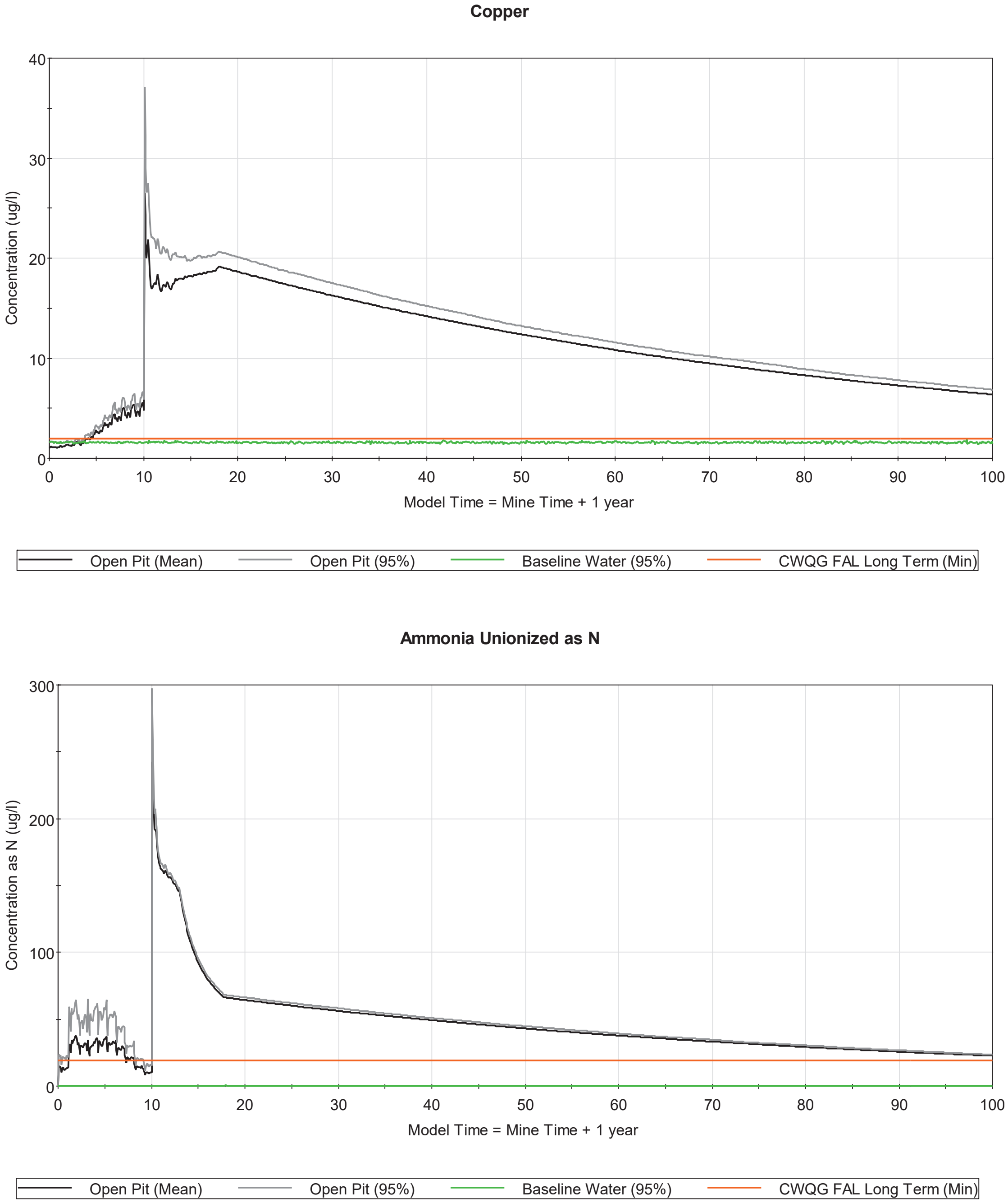


Figure 6-4 Concentration of Cu and N-NH_3 UN in Mine Water and the Pit Lake

6.3 FINAL DISCHARGE POINTS

6.3.1 LP-FDP-01

LP-FDP-01 receives water from LP-SP-01a and LP-SP-01b, which collect runoff and seepage from the LGO stockpile and waste rock pile. No MDMER exceedances are predicted in the discharge considering 95% level of confidence. The long-term CWQG-FAL could be exceeded for P, Cr, Zn, Al, Mn, and Fe at baseline conditions represented by undisturbed runoff (Appendix D). Water quality during construction is similar to the baseline conditions when there is no discharge from the piles due to wetting of rock and LGO. During operation, F, Cu, Hg, $N\text{-}NO_2$, Se, Ag, $N\text{-}NH_{3\ UN}$, As, Cd, $N\text{-}NH_{3\ T}$, and U are predicted to be above the respective long-term CWQG, in addition to the parameters exceeding at the baseline conditions. These parameters decline during closure and stabilize below the guidelines in post closure, except for F stabilizing at approximately twice the CWQG.

6.3.2 LP-FDP-02

LP-FDP-02 receives water from sedimentation LP-SP-02a and LP-SP-02b ponds, which collect runoff and seepage from the waste rock pile. No MDMER exceedances are predicted in the discharge considering 95% level of confidence. At baseline conditions and during construction, parameters predicted to exceed the respective CWQG-FAL are the same as for LP-FDP-01 (P, Cr, Zn, Al, Mn, and Fe) and other discharge points located near the Leprechaun pit. During operation, Cu, Hg, F, $N\text{-}NO_2$, Ag, $N\text{-}NH_{3\ UN}$, As, $N\text{-}NH_{3\ T}$, Cd, Pb, U, Se, and $N\text{-}NO_3$ are predicted to be above the respective long-term CWQG-FAL in addition to the parameters exceeding at baseline conditions (Appendix D). These parameters decline during closure and stabilize in post-closure with Cd, Cu, Hg, Ag, and F remaining above CWQG.

6.3.3 LP-FDP-03

LP-FDP-03 receives water from water management ponds LP-SP-03a, LP-SP-03b and LP-SP-03b, which collect runoff and seepage generally from the waste rock pile and a minor amount from the overburden and topsoil stockpiles. No MDMER exceedances are predicted in the discharge considering 95% level of confidence. At baseline conditions and during construction, parameters predicted to exceed long-term CWQG-FAL are P, Cr, Zn, Al, Mn, and Fe. During operation, Cu, Hg, F, $N\text{-}NO_2$, Ag, $N\text{-}NH_{3\ UN}$, As, $N\text{-}NH_{3\ T}$, Cd, Pb, U, Se, and $N\text{-}NO_3$ are predicted to be above the respective long-term CWQG-FAL in addition to the parameters exceeding at baseline conditions (Appendix D). These parameters decline during closure and stabilize in post-closure with Cu, Hg, Ag, and F remaining above CWQG.

6.3.4 LP-FDP-04

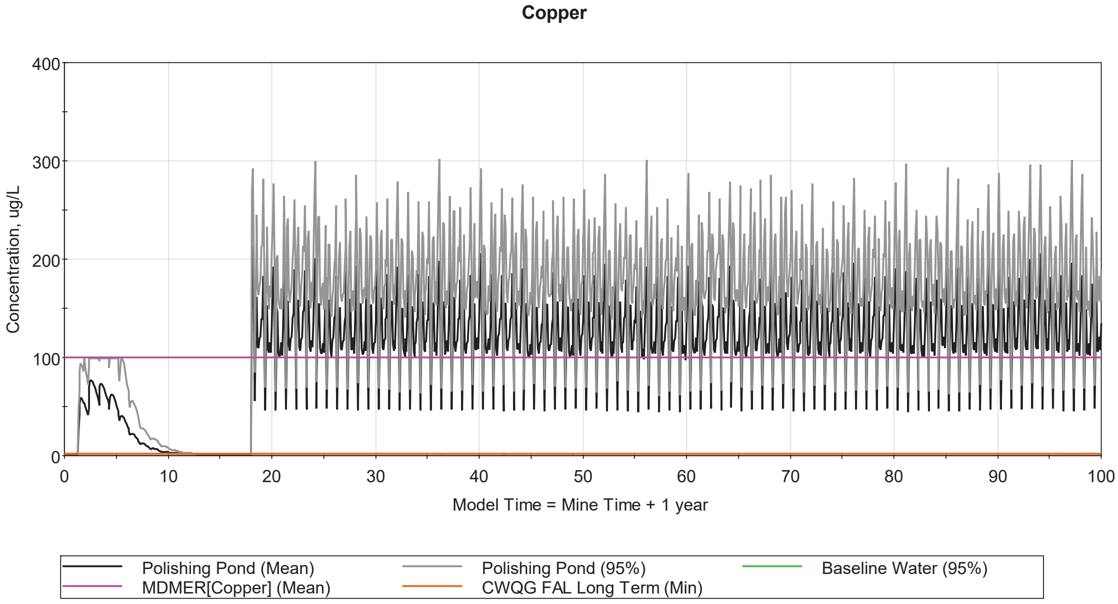
LP-FDP-04 receives runoff and seepage from the overburden stockpile, which has better water quality compared to other discharge points. No MDMER exceedances are predicted for this discharge. At baseline conditions, parameters predicted to exceed long-term CWQG-FAL are P, Cr, Zn, Al, Mn, and Fe. During construction and operation, only Pb is predicted to be marginally above its CWQG-FAL threshold in addition to the parameters exceeding at baseline conditions (Appendix D). During closure, Pb concentrations decline and stabilize in post-closure below CWQG.

6.3.5 LP-FDP-05

LP-FDP-05 receives water from LP-SP-04 water management pond, representing open pit dewatering and overflow from the pit lake. No MDMER exceedances are predicted at this discharge point considering 95% level of confidence. At baseline conditions and construction, parameters predicted to exceed CWQG-FAL are P, Cr, Zn, Al, Mn, and Fe. During construction and operation, $N\text{-}NO_2$, Cu, $N\text{-}NH_{3\ UN}$, F, $N\text{-}NH_{3\ T}$, Hg, Ag, and As are predicted to exceed the respective long-term CWQG-FAL in addition to the parameters elevated at baseline conditions (Appendix D). These parameters decline during closure and post-closure with Cu, $N\text{-}NH_{3\ UN}$, $N\text{-}NH_{3\ T}$, and F remaining above the long-term CWQG.

6.3.6 PP-FDP-01

PP-FDP-01 represents water quality of the polishing pond. During construction, water quality of the pond is similar to chemistry of undisturbed runoff, which showed exceedances of the long-term CWQG-FAL for P, Zn, Cr, Mn, As, Al, Fe, and Cu considering 95th percentile concentrations. The polishing pond receives treated effluent during operation assuming treatment targets set at MDMER limits. During operation, $N\text{-}NH_{3\ UN}$, F, $N\text{-}NH_{3\ T}$, CN_{WAD}, Hg, $N\text{-}NO_2$, Se and Cd are predicted to be above the respective long-term CWQG-FAL in addition to baseline exceedances. There is no inflow from the tailings pond to the polishing pond starting in Year 10 and until end of the closure. Therefore, the discharge for the polishing pond returns to baseline conditions from Year 10 to the end of active closure. In post-closure, excess water and seepage from the tailings ponds are major inflows into the polishing pond. In post closure, Cu is predicted to exceed the MDMER limit due to an elevated concentration of this metal in tailings pond toe seepage (Figure 6-5). Therefore, a mitigation such as passive treatment of seepage should be considered. The estimated time to displace one of tailings pore water volume with infiltrating rainwater is approximately 30 years (i.e., until about mine Year 40), based on $10Mm^3$ of pore volume and rate of seepage (bed and toe) of approximately 1500 m^3/day. After displacement, Cu concentration in seepage will decline, but still expected to stay above the MDMER for many years based of subaqueous column tests. This decline was not reflected in the model. In addition to the MDMER exceedance for Cu and baseline indicated above, CN_{WAD}, $N\text{-}NH_{3\ UN}$, and $N\text{-}NH_{3\ T}$, are predicted to be above long-term CWQG. A groundwater attenuation assessment is being conducted to define if treatment for these parameters is required.



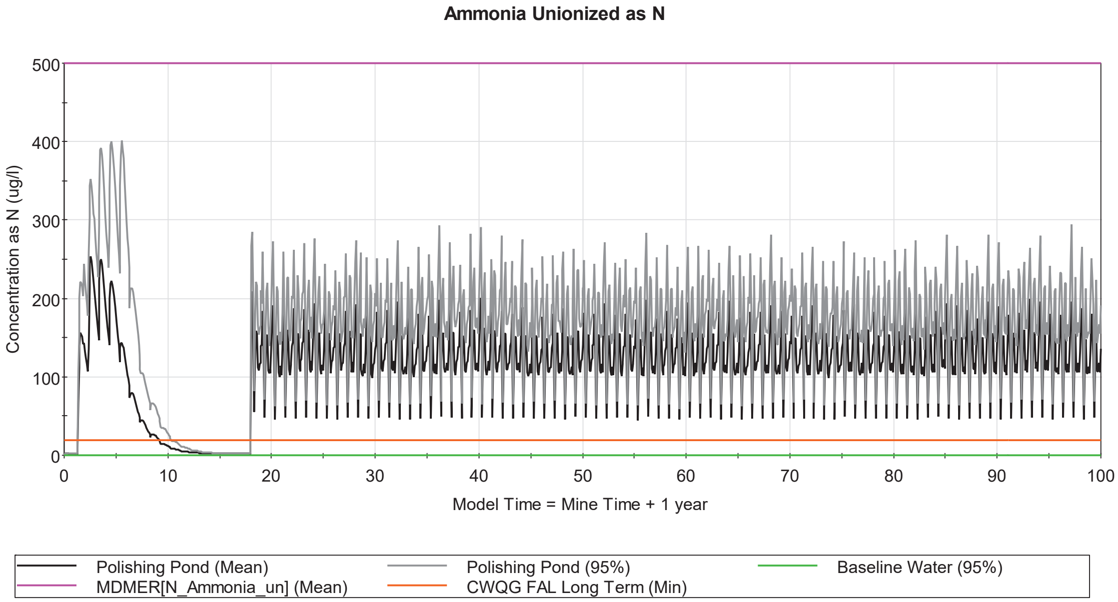


Figure 6-5 Concentration of Cu and N-$NH_{3\ UN}$ in the Polishing Pond

7.0 CONCLUSIONS

The primary source of water to meet the plant water demand is the reclaim from tailings pond; the secondary source is fresh water from Victoria Lake Reservoir to balance plant water demand deficit (i.e., difference between the demand and the reclaim). During the first nine years of operation, under average climate conditions, the maximum water deficit is 2,900 m^3/d. The deficit reaches a maximum of approximately 5,000 m^3/day and 3,600 m^3/day in mine Years 11 and 12, respectively, when the tailings are deposited in the Leprechaun open pit during the last three years of operation.

Model probabilistic analysis predicts that filling of the Leprechaun open pit will take between 37 and 42 years (for the 95th and 5th percentiles, respectively) after the end of mining, including the deposition of tailings in the pit during mine Years 10 to 12 and overflow from the tailings pond during closure (mine Years 13 to 18). Additionally, an acceleration of open pit filling was modelled for the 8 years after mining of the open pit ceases (mine Years 10 to end 17), using water from Victoria Lake Reservoir and the excess water from the tailings pond. In this scenario, the total water intake rate from Victoria Lake Reservoir is 16,000 m^3/day in the last three years of operation when there is a demand to supply plant deficit and pit filling, under average climate conditions. During closure, the Victoria Lake Reservoir intake will decline to 10,950 m^3/day for average climate conditions during open pit filling.

The model was run iteratively to analyze the volume of excess water from the TMF requiring treatment prior to discharge to the environment. The tailings pond volume level at which the treatment is activated was varied for two primary cases. In the first instance, the model was set to treat instantaneous excess water from the tailings pond, but the capacity of the water treatment plant (83,809 m^3/mon) was exceeded, producing untreated water for some probabilistic simulations. After several iterations, the current model was set to activate treatment when the tailings pond level reaches 70% of its volume capacity. With this assumption, the capacity of the water treatment plant will not be exceeded for the 95th percentile corresponding to a 1:25 year return period wet year. Results from the probabilistic analysis indicate no release of untreated water during operation (before Year 13) for the 95th percentile. This condition could change depending on future operation management philosophy between the tailings pond and the water treatment plant.

The magnitude of the flow to the water management ponds depends on the watershed area, changes in drainage characteristics from sources (e.g., waste rock pile, undisturbed runoff) and the addition of groundwater seepage reporting to the ponds, which also vary through the mine phases. Generally, the simulation flow results on the water management ponds and the FDPs, from 5th to 95th percentile results, range from approximately -25% to +25% of the mean results within each mine phase. This is consistent with the range of precipitation and approximately represents the 1:25 return period wet year to the 1:5 dry year.

The water quality model shows that there are no MDMER exceedances predicted at facilities and discharges in the Leprechaun Complex (waste rock pile, stockpiles, open pit, ponds and LP-FDP-01 to LP-FDP-05) during all mine phases at 95th percentile confidence level.

Long-term CWQG-FAL are not applicable to discharges but were used to screen PoPC for receivers. In FDPs located near the Leprechaun open pit, parameters predicted to exceed the respective long-term CWQG-FAL are P, Cr, Zn, Al, Mn, and Fe at baseline conditions and during construction. During operation, the highest number of long-term CWQG-FAL exceedances were predicted for LP-FDP-03 and associated with seepage from waste rock. In addition to the parameters exceeding at baseline conditions, Cu, Hg, F, $N\text{-}NO_2$, Ag, $N\text{-}NH_{3\ UN}$, As, $N\text{-}NH_{3\ T}$, Cd, Pb, U, Se, and $N\text{-}NO_3$ are predicted to be above the respective long-term CWQG-FAL for LP-FDP-03. These parameters decline during closure and stabilize in post-closure with Cu, Hg, Ag, and F remaining above CWQG-FAL. Seepage from waste rock and LGO also affects LP-FDP-01 and LP-FDP-02, but these discharges have better water quality than LP-FDP-03 resulting in less exceedances of CWQG-FAL.

LP-FDP-04 has better water quality compared to other discharge points. In addition to the parameters exceeding at baseline conditions (P, Cr, Zn, Al, Mn, and Fe), only Pb is predicted to be marginally above its long-term CWQG-FAL threshold during construction and operation. During closure, Pb concentrations decline and stabilize in post-closure below CWQG-FAL.

LP-FDP-05 receives water from open pit dewatering and overflow from the pit lake. During the first nine years of operation, $N\text{-}NO_2$, Cu, $N\text{-}NH_{3\ UN}$, F, $N\text{-}NH_{3\ T}$, Hg, Ag, and As are predicted to exceed the respective long-term CWQG-FAL in addition to the parameters elevated at baseline conditions. In the last three years of operation and during closure, there will be no discharge from the open pit as it fills with water. Cu, $N\text{-}NH_{3\ UN}$, $N\text{-}NH_{3\ T}$, and F are predicted to be above the long-term CWQG-FAL when the pit lake starts to discharge in post closure (mine Year 18). These parameters are related to tailings deposition and discharge from TMF to the pit and show gradual decline in post-closure.

PP-FDP-01 represents the water quality of the polishing pond. During construction, water quality of the polishing pond is similar to the chemistry of undisturbed runoff, which showed exceedances of the long-term CWQG-FAL for P, Zn, Cr, Mn, As, Al, Fe, and Cu considering 95th percentile concentrations. The model predicts exceedances of MDMER limits for $CN_{\ T}$, Cu, and $N\text{-}NH_{3\ UN}$ in the tailings pond, indicating that these parameters may require treatment in mine Years 1 to 10. At that time, the polishing pond receives treated effluent. During operation, Cu, $N\text{-}NH_{3\ UN}$, F, $N\text{-}NH_{3\ T}$, $CN_{\ WAD}$, Hg, $N\text{-}NO_2$, Se and Cd are predicted to be above the respective long-term CWQG-FAL, in addition to baseline exceedances. There is no inflow from the tailings pond to the polishing pond starting in mine Year 10 and until end of the closure, and therefore, the discharge for the polishing pond returns to baseline conditions during this period. In post closure, Cu is predicted to exceed the MDMER limit due to an elevated concentration of this metal in tailings pond toe seepage. Therefore, a mitigation such as passive treatment of seepage should be considered. In addition to the MDMER exceedance for Cu and baseline indicated above, $CN_{\ WAD}$, $N\text{-}NH_{3\ UN}$, and $N\text{-}NH_{3\ T}$, are predicted to be above long-term CWQG-FAL in post-closure.

8.0 REFERENCES

Ausenco Engineering Canada. (Ausenco). 2020. N.I. 43-101 Technical Report & Pre-Feasibility Study On The Valentine Gold Project. Newfoundland and Labrador, Canada. April 2020.

Canadian Council of Ministers of the Environment (CCME). 2010. Canadian water quality guidelines for the protection of aquatic life: Ammonia. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

Canadian Council of Ministers of the Environment (CCME). 2019. Canadian water quality guidelines for the protection of aquatic life: Manganese (Dissolved) 2019. In: Canadian environmental quality guidelines, Canadian Council of Ministers of the Environment, Winnipeg.

Canadian Council of Ministers of the Environment (CCME). 2020. Canadian water quality guidelines for the protection of aquatic life: Summary Table. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg, MB. Accessed from http://st-ts.ccme.ca/en/index.html in January 2020.

ECCC. 2020. National Long-term Water Quality Monitoring Data. Retrieved from Environment and Climate Change Canada: https://open.canada.ca/data/en/fgpv_vpgf/67b44816-9764-4609-ace1-68dc1764e9ea

Gemtec. 2019. Limited Geotechnical Investigation, Draft Proposed Site Development Valentine Gold Project. Draft factual report prepared for Marathon Gold Corporation, 2 December 2019.

Golder Associates. (Golder). 2020a. Marathon Gold, Prefeasibility Study for Tailings Disposal at the Valentine Gold Project, Newfoundland. March, 2020.

Golder Associates Ltd. (Golder). 2020b. Technical Memorandum. Valentine Gold Project -Water Balance and Hydraulic Design for Tailings Management Facility submitted as part of the Prefeasibility Study for Tailings Disposal at the Valentine Gold Project, Newfoundland submitted by Golder March 2020

GoldSim 2018. GoldSim User's Manual. Can be found at the following address: https://www.goldsim.com/Web/Customers/Education/Documentation/

Government of Alberta. 2018. Environmental Quality Guidelines for Alberta Surface Waters. Water Policy Branch, Alberta Environment and Parks. Edmonton, Alberta.

McCabe, G. & and Markstrom, S. A Monthly Water-Balance Model Driven By a Graphical User Interface. U.S. Department of the Interior. U.S. Geological Survey. 2007.

SOR/2002-222. 2020. Metal and Diamond Mining Effluent Regulations. Published by the Minister of Justice at the following address: http://laws-lois.justice.gc.ca Last amended on June 25, 2019.

Stantec Consulting Ltd. (Stantec) 2020a. Valentine Gold Project (VGP) Water Quantity And Water Quality Modelling Report: Marathon Site. September 2020.

Stantec Consulting Ltd. (Stantec). 2020b. Water Management Plan, Marathon Valentine Gold Project. . September 2020.

Stantec Consulting Ltd. (Stantec) 2020c. Valentine Gold Project Hydrology and Surface Water Quality Monitoring Baseline Report. September 2020.

Stantec Consulting Ltd. (Stantec). 2020d. Hydrogeology Modelling, Valentine Gold Project". September 2020.

Stantec Consulting Ltd. (Stantec) 2020e. Valentine Gold Project (VGP): Valentine Gold Project: Acid Rock Drainage/Metal Leaching (ARD/ML) assessment report. September 2020.

Steinepreis, M (2017). Investigation of Gas Transport Rates Through a Covered Waste Rock Pile and Synchrotron Studies on the Sulfide Oxidation Reaction. MS thesis. Department of Earth and Environmental Sciences, University of Waterloo, Ontario, Canada.

Sturm, M & Holmgren, J & Liston, G. E. 1995. A Seasonal Snow Cover Classification System for Local to Global applications. US Army Cold Regions Research and Engineering Laboratory Ft. Wainwright, Alaska. Department of Atmospheric Science, Colorado State University, Fort Collins, Colorado.

Sturm, M & Holmgren, J & Liston, G. E. 1995. A Seasonal Snow Cover Classification System for Local to Global applications. US Army Cold Regions Research and Engineering Laboratory Ft. Wainwright, Alaska. Department of Atmospheric Science, Colorado State University, Fort Collins, Colorado.

Thornthwaite, C.W. 1948. An approach toward a rational classification of climate. Geographical Review v. 38, p. 55-94.

Tukey, J. W. 1977. Exploratory Data Analysis. Addison-Wesley. ISBN 978-0-201-07616-5. OCLC 3058187.

US Environmental Protection Agency, 1994. The Hydrologic Evaluation of Landfill Performance (HELP) Model. September, 1994

APPENDICES

Appendix A WATER MANAGEMENT PONDS FLOW RESULTS

Montlhy Average Flow from Sediment Ponds (m3/day) - Average Climate Scenario

	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Pond 1A	Operations (Year 1 to 9)	233	295	355	822	271	182	170	289	315	313	377	300	327
	Operations (Year 10 to 12)	233	293	355	822	271	182	170	289	315	313	377	300	327
	Closure (Year 13 to 17)	217	272	319	750	214	103	70	202	260	282	355	279	277
	Post Closure (from year 18)	171	214	252	592	167	76	52	154	201	222	280	221	217
Pond 1B	Operations (Year 1 to 9)	285	400	521	1208	287	162	152	257	281	295	401	375	385
	Operations (Year 10 to 12)	285	398	521	1208	287	162	152	257	281	295	401	375	385
	Closure (Year 13 to 17)	323	415	496	1172	299	127	68	265	359	394	512	419	404
	Post Closure (from year 18)	320	411	492	1162	295	125	67	262	355	389	506	415	400
Pond 2A	Operations (Year 1 to 9)	416	603	805	1863	375	160	150	280	324	380	558	553	539
	Operations (Year 10 to 12)	416	601	805	1863	375	160	150	280	324	380	558	553	539
	Closure (Year 13 to 17)	553	710	850	2001	506	201	108	438	600	672	878	716	686
	Post Closure (from year 18)	553	709	850	2001	506	201	108	438	600	672	878	716	686
Pond 2B	Operations (Year 1 to 9)	235	303	372	862	268	180	168	282	305	302	369	304	329
	Operations (Year 10 to 12)	235	302	372	862	268	180	168	282	305	302	369	304	329
	Closure (Year 13 to 17)	240	303	357	844	225	97	52	205	277	303	389	303	300
	Post Closure (from year 18)	172	220	264	622	157	62	33	136	186	209	273	223	213
Pond 3A	Operations (Year 1 to 9)	1184	1432	1658	3850	1533	1207	1130	1818	1909	1769	2004	1510	1750
	Operations (Year 10 to 12)	1184	1427	1658	3850	1533	1207	1130	1818	1909	1769	2004	1510	1750
	Closure (Year 13 to 17)	1007	1255	1453	3454	972	467	251	937	1247	1313	1651	1313	1277
	Post Closure (from year 18)	1153	1430	1652	3928	1117	542	291	1085	1442	1515	1898	1485	1461
Pond 3B	Operations (Year 1 to 9)	370	486	601	1397	403	256	228	409	454	455	569	480	509
	Operations (Year 10 to 12)	370	484	601	1397	403	256	228	409	454	455	569	480	509
	Closure (Year 13 to 17)	184	230	269	635	172	71	38	155	212	235	300	241	229
	Post Closure (from year 18)	219	272	317	749	207	89	48	190	259	284	360	282	273
Pond 4	Operations (Year 1 to 9)	200	250	294	691	199	101	68	193	245	261	326	257	257
	Operations (Year 10 to 12)	200	249	294	691	199	101	68	193	245	261	326	257	257
	Closure (Year 13 to 17)	188	235	276	649	187	93	64	180	230	245	306	242	241
	Post Closure (from year 18)	146	183	215	505	144	69	47	136	176	190	239	188	186
Pond 5	Operations (Year 1 to 9)	2305	2533	2781	4607	2773	2648	2714	3128	3015	2796	2925	2570	2900
	Operations (Year 10 to 12)	42	52	64	145	34	0	0	18	33	51	70	54	47
	Closure (Year 13 to 17)	42	53	64	145	34	0	0	18	33	51	70	538	87
	Post Closure (from year 18)	1783	2105	2443	4989	1618	504	448	1272	1663	2100	2624	2151	1975

Montlhy Average Flow from Sediment Ponds (m3/day) - Probabilistic Result Percentile 5%

	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Pond 1A	Operations (Year 1 to 9)	180	228	275	635	209	141	132	223	243	242	291	232	253
	Operations (Year 10 to 12)	183	230	278	643	212	142	133	226	246	245	295	235	256
	Closure (Year 13 to 17)	172	215	253	594	169	81	55	160	206	223	281	221	219
	Post Closure (from year 18)	132	165	195	457	129	59	40	119	155	171	216	170	167
Pond 1B	Operations (Year 1 to 9)	180	228	275	635	209	141	132	223	243	242	291	232	253
	Operations (Year 10 to 12)	183	230	278	643	212	142	133	226	246	245	295	235	256
	Closure (Year 13 to 17)	172	215	253	594	169	81	55	160	206	223	281	221	219
	Post Closure (from year 18)	132	165	195	457	129	59	40	119	155	171	216	170	167
Pond 2A	Operations (Year 1 to 9)	322	466	623	1440	290	124	116	216	251	293	431	427	417
	Operations (Year 10 to 12)	326	470	630	1458	294	126	117	219	254	297	437	433	422
	Closure (Year 13 to 17)	438	562	673	1585	400	159	86	347	475	532	695	567	543
	Post Closure (from year 18)	427	547	655	1544	390	155	83	338	463	519	677	553	529
Pond 2B	Operations (Year 1 to 9)	182	235	288	667	208	139	130	218	236	234	285	235	255
	Operations (Year 10 to 12)	184	237	291	675	210	141	132	221	239	236	289	238	258
	Closure (Year 13 to 17)	190	240	283	668	178	77	41	161	217	234	296	234	235
	Post Closure (from year 18)	133	170	204	480	121	48	26	105	143	161	211	172	164
Pond 3A	Operations (Year 1 to 9)	915	1108	1282	2977	1186	933	874	1406	1476	1368	1549	1167	1353
	Operations (Year 10 to 12)	926	1117	1298	3013	1200	944	884	1423	1494	1384	1568	1181	1369
	Closure (Year 13 to 17)	797	994	1150	2735	769	370	199	742	987	1040	1315	1035	1011
	Post Closure (from year 18)	886	1103	1274	3030	862	418	225	837	1112	1169	1464	1145	1127
Pond 3B	Operations (Year 1 to 9)	286	375	464	1081	312	198	177	317	351	352	440	371	394
	Operations (Year 10 to 12)	289	379	470	1094	316	200	179	320	355	356	445	376	398
	Closure (Year 13 to 17)	146	182	213	503	136	56	30	122	168	186	239	189	181
	Post Closure (from year 18)	168	210	244	578	159	69	37	147	199	219	277	217	210
Pond 4	Operations (Year 1 to 9)	155	193	227	535	154	78	53	149	190	202	252	199	199
	Operations (Year 10 to 12)	156	195	230	541	156	79	54	151	192	204	255	201	201
	Closure (Year 13 to 17)	149	186	218	514	148	74	50	142	182	194	243	191	191
	Post Closure (from year 18)	113	141	166	390	111	53	36	105	135	146	184	145	144
Pond 5	Operations (Year 1 to 9)	1783	1960	2152	3564	2145	2048	2099	2420	2332	2163	2263	1988	2243
	Operations (Year 10 to 12)	33	41	50	113	26	0	0	14	25	40	55	42	37
	Closure (Year 13 to 17)	34	42	50	114	27	0	0	14	26	41	56	43	37
	Post Closure (from year 18)	1266	1495	1880	3849	1248	389	346	981	1283	1620	2024	1659	1503

Montlhy Average Flow from Sediment Ponds (m3/day) - Probabilistic Result Percentile 25%

	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Pond 1A	Operations (Year 1 to 9)	210	265	320	740	244	164	153	260	283	282	339	270	294
	Operations (Year 10 to 12)	207	261	315	730	240	162	151	256	280	278	335	267	290
	Closure (Year 13 to 17)	197	246	289	679	194	93	63	183	236	255	321	253	251
	Post Closure (from year 18)	153	191	225	527	149	68	46	137	179	197	249	196	193
Pond 1B	Operations (Year 1 to 9)	256	360	470	1088	258	146	136	232	253	266	361	338	347
	Operations (Year 10 to 12)	253	354	463	1073	255	144	135	229	250	262	356	333	342
	Closure (Year 13 to 17)	293	376	449	1061	270	115	62	240	325	356	463	379	366
	Post Closure (from year 18)	285	366	438	1035	263	111	60	233	316	347	451	369	356
Pond 2A	Operations (Year 1 to 9)	375	543	725	1678	338	144	135	252	292	342	502	498	485
	Operations (Year 10 to 12)	370	534	715	1655	334	142	133	248	288	337	496	491	479
	Closure (Year 13 to 17)	501	643	769	1812	458	182	98	396	543	609	795	649	621
	Post Closure (from year 18)	493	631	756	1782	450	179	96	390	534	599	781	638	611
Pond 2B	Operations (Year 1 to 9)	211	273	335	776	242	162	152	254	275	272	332	273	296
	Operations (Year 10 to 12)	209	268	331	766	238	160	150	251	271	268	328	270	292
	Closure (Year 13 to 17)	218	275	323	764	204	88	47	185	250	269	343	268	269
	Post Closure (from year 18)	154	197	235	554	140	55	30	121	166	186	243	198	190
Pond 3A	Operations (Year 1 to 9)	1066	1290	1493	3467	1381	1087	1018	1637	1719	1593	1804	1359	1576
	Operations (Year 10 to 12)	1052	1268	1473	3420	1362	1072	1004	1615	1696	1571	1780	1341	1554
	Closure (Year 13 to 17)	912	1136	1315	3127	880	423	227	848	1129	1191	1496	1185	1156
	Post Closure (from year 18)	1021	1271	1470	3498	995	483	259	966	1284	1349	1690	1322	1301
Pond 3B	Operations (Year 1 to 9)	333	437	541	1258	363	230	206	369	409	409	513	432	458
	Operations (Year 10 to 12)	328	430	534	1241	358	227	203	364	403	404	506	427	452
	Closure (Year 13 to 17)	167	208	244	575	156	64	35	140	192	213	273	217	207
	Post Closure (from year 18)	193	242	282	667	184	79	43	169	230	252	320	251	243
Pond 4	Operations (Year 1 to 9)	180	225	264	623	180	91	62	173	221	235	294	232	232
	Operations (Year 10 to 12)	178	221	261	614	177	89	61	171	218	232	290	229	228
	Closure (Year 13 to 17)	170	213	250	588	169	85	58	163	208	221	277	219	218
	Post Closure (from year 18)	130	163	191	450	128	62	42	121	156	169	213	167	166
Pond 5	Operations (Year 1 to 9)	2076	2281	2504	4148	2497	2384	2443	2816	2714	2518	2634	2314	2611
	Operations (Year 10 to 12)	38	47	56	128	30	0	0	16	29	46	62	48	42
	Closure (Year 13 to 17)	38	48	58	131	30	0	0	16	29	47	64	50	43
	Post Closure (from year 18)	1533	1856	2172	4442	1441	449	399	1132	1481	1870	2337	1916	1752

Montlhy Average Flow from Sediment Ponds (m3/day) - Probabilistic Result Percentile 75%

	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Pond 1A	Operations (Year 1 to 9)	257	325	392	906	298	201	188	318	347	345	415	331	360
	Operations (Year 10 to 12)	256	322	390	903	297	200	187	317	346	344	414	330	359
	Closure (Year 13 to 17)	240	300	353	830	236	113	77	223	288	312	392	309	306
	Post Closure (from year 18)	187	233	275	644	181	83	56	168	219	241	305	240	236
Pond 1B	Operations (Year 1 to 9)	314	441	575	1332	316	179	167	284	310	325	442	414	425
	Operations (Year 10 to 12)	313	438	573	1328	315	178	167	283	309	324	440	413	423
	Closure (Year 13 to 17)	357	459	549	1296	330	140	75	293	397	435	565	463	447
	Post Closure (from year 18)	348	447	535	1264	321	136	73	285	386	423	551	451	435
Pond 2A	Operations (Year 1 to 9)	459	665	888	2054	414	177	165	308	358	419	615	610	594
	Operations (Year 10 to 12)	457	660	885	2048	413	176	164	307	357	417	613	608	592
	Closure (Year 13 to 17)	612	785	939	2213	559	222	120	484	663	743	970	792	759
	Post Closure (from year 18)	602	771	924	2177	550	219	118	476	652	731	955	779	746
Pond 2B	Operations (Year 1 to 9)	259	335	410	951	296	198	186	311	336	333	407	335	363
	Operations (Year 10 to 12)	258	332	409	948	295	198	185	310	335	332	406	334	362
	Closure (Year 13 to 17)	266	335	395	933	249	107	58	226	306	333	426	336	331
	Post Closure (from year 18)	189	241	287	677	171	67	36	147	202	227	297	242	232
Pond 3A	Operations (Year 1 to 9)	1305	1579	1829	4245	1691	1331	1246	2005	2105	1950	2210	1665	1930
	Operations (Year 10 to 12)	1301	1568	1823	4231	1686	1327	1242	1998	2098	1944	2202	1659	1923
	Closure (Year 13 to 17)	1113	1388	1606	3818	1074	516	278	1036	1388	1470	1857	1462	1417
	Post Closure (from year 18)	1252	1553	1796	4273	1215	590	317	1180	1569	1648	2064	1615	1589
Pond 3B	Operations (Year 1 to 9)	408	535	662	1541	445	282	252	451	501	501	628	530	561
	Operations (Year 10 to 12)	406	532	660	1536	443	281	251	450	499	500	626	528	559
	Closure (Year 13 to 17)	203	254	298	702	190	78	42	171	236	264	340	269	254
	Post Closure (from year 18)	238	295	344	814	225	97	52	207	281	308	391	306	297
Pond 4	Operations (Year 1 to 9)	220	276	324	763	220	111	76	212	271	287	360	284	284
	Operations (Year 10 to 12)	220	274	323	760	219	111	75	212	270	286	359	283	283
	Closure (Year 13 to 17)	208	260	305	718	207	103	70	199	254	270	339	267	267
	Post Closure (from year 18)	159	199	234	549	157	75	51	148	191	206	260	205	203
Pond 5	Operations (Year 1 to 9)	2542	2793	3067	5079	3058	2920	2992	3449	3324	3083	3225	2834	3197
	Operations (Year 10 to 12)	47	58	70	159	37	0	0	20	36	57	77	60	52
	Closure (Year 13 to 17)	47	58	70	160	37	0	0	20	36	58	943	1220	221
	Post Closure (from year 18)	1931	2286	2656	5427	1760	548	487	1383	1809	2285	2855	2340	2147

Montlhy Average Flow from Sediment Ponds (m3/day) - Probabilistic Result Percentile 95%

	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Pond 1A	Operations (Year 1 to 9)	297	375	452	1047	345	232	217	368	401	399	480	382	416
	Operations (Year 10 to 12)	308	388	469	1086	358	240	225	382	416	414	498	397	432
	Closure (Year 13 to 17)	276	346	406	955	272	131	89	257	331	359	451	356	352
	Post Closure (from year 18)	213	266	313	734	207	94	64	191	249	275	348	274	269
Pond 1B	Operations (Year 1 to 9)	363	509	664	1539	365	207	193	328	358	376	510	478	491
	Operations (Year 10 to 12)	376	526	689	1597	379	214	200	340	372	390	530	496	509
	Closure (Year 13 to 17)	411	529	632	1492	380	161	87	338	457	501	651	532	514
	Post Closure (from year 18)	397	510	610	1441	367	155	83	325	440	483	628	515	496
Pond 2A	Operations (Year 1 to 9)	530	768	1026	2373	478	204	191	356	413	484	711	704	687
	Operations (Year 10 to 12)	550	794	1064	2462	496	212	198	370	429	502	738	731	712
	Closure (Year 13 to 17)	704	903	1081	2547	644	256	138	557	763	856	1117	912	873
	Post Closure (from year 18)	686	879	1054	2483	627	250	134	543	744	834	1089	889	851
Pond 2B	Operations (Year 1 to 9)	299	386	474	1098	342	229	215	359	388	385	470	387	419
	Operations (Year 10 to 12)	310	399	492	1140	355	238	223	373	403	399	488	401	435
	Closure (Year 13 to 17)	306	386	454	1074	286	123	66	259	351	384	492	387	381
	Post Closure (from year 18)	217	275	328	772	195	77	41	168	231	259	339	276	265
Pond 3A	Operations (Year 1 to 9)	1508	1825	2113	4905	1954	1538	1440	2316	2432	2253	2553	1923	2230
	Operations (Year 10 to 12)	1565	1886	2192	5088	2027	1595	1494	2403	2523	2338	2648	1995	2313
	Closure (Year 13 to 17)	1281	1597	1849	4395	1236	594	320	1192	1590	1689	2142	1688	1631
	Post Closure (from year 18)	1430	1773	2049	4873	1386	672	362	1346	1789	1879	2354	1842	1813
Pond 3B	Operations (Year 1 to 9)	471	619	765	1781	514	326	291	522	578	579	725	612	649
	Operations (Year 10 to 12)	489	639	794	1847	533	338	302	541	600	601	752	635	673
	Closure (Year 13 to 17)	234	293	343	808	219	90	49	197	270	303	392	311	292
	Post Closure (from year 18)	271	337	393	929	256	110	59	236	321	352	446	349	338
Pond 4	Operations (Year 1 to 9)	255	319	374	881	254	128	87	245	313	332	416	328	328
	Operations (Year 10 to 12)	264	329	388	914	263	133	91	255	324	345	431	340	340
	Closure (Year 13 to 17)	239	299	351	826	238	119	81	229	292	311	390	308	307
	Post Closure (from year 18)	181	226	267	627	179	86	59	169	218	235	296	233	231
Pond 5	Operations (Year 1 to 9)	2935	3225	3540	5862	3529	3371	3454	3981	3837	3559	3723	3272	3691
	Operations (Year 10 to 12)	56	69	84	191	44	0	0	24	43	68	92	72	62
	Closure (Year 13 to 17)	54	67	81	184	43	0	0	23	812	1312	1825	1509	492
	Post Closure (from year 18)	2211	2610	3030	6189	2007	625	556	1577	2063	2606	3256	2669	2450

Appendix B FDP FLOW RESULTS

Montlhy Average FDPs flows (m^3/day) - Average Climate Scenario

FDP	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1	Operations (Year 1 to 9)	518	694	876	2030	557	344	322	546	596	608	777	675	712
	Operations (Year 10 to 12)	518	692	876	2030	557	344	322	546	596	608	777	675	712
	Closure (Year 13 to 17)	540	687	816	1923	512	229	138	467	619	675	865	698	681
	Post Closure (from year 18)	492	625	745	1754	462	201	119	416	556	611	787	635	617
2	Operations (Year 1 to 9)	1304	1625	1934	4484	1586	1153	1079	1776	1897	1820	2136	1673	22467
	Operations (Year 10 to 12)	1304	1619	1934	4484	1586	1153	1079	1776	1897	1820	2136	1673	22461
	Closure (Year 13 to 17)	1208	1515	1770	4191	1143	510	274	1062	1431	1560	1990	1575	18231
	Post Closure (from year 18)	1276	1595	1863	4413	1211	545	293	1131	1523	1642	2083	1645	19220
3	Operations (Year 1 to 9)	957	1276	1601	3715	1043	663	609	1045	1139	1143	1446	1247	1324
	Operations (Year 10 to 12)	957	1271	1601	3715	1043	663	609	1045	1139	1143	1446	1247	1323
	Closure (Year 13 to 17)	843	1069	1261	2981	789	342	184	717	970	1066	1373	1101	1058
	Post Closure (from year 18)	888	1121	1321	3125	833	365	196	762	1029	1119	1433	1147	1112
4	Operations (Year 1 to 9)	200	250	294	691	199	101	68	193	245	261	326	257	257
	Operations (Year 10 to 12)	200	249	294	691	199	101	68	193	245	261	326	257	257
	Closure (Year 13 to 17)	188	235	276	649	187	93	64	180	230	245	306	242	241
	Post Closure (from year 18)	146	183	215	505	144	69	47	136	176	190	239	188	186
5	Operations (Year 1 to 9)	2305	2533	2781	4607	2773	2648	2714	3128	3015	2796	2925	2570	2900
	Operations (Year 10 to 12)	42	52	64	145	34	0	0	18	33	51	70	54	47
	Closure (Year 13 to 17)	42	53	64	145	34	0	0	18	33	784	1399	1063	303
	Post Closure (from year 18)	1783	2105	2443	4989	1618	504	448	1272	1663	2100	2624	2151	1975

Montlhy Average FDPs flows (m^3/day) - Probabilistic Result Percentile 5%

FDP	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1	Operations (Year 1 to 9)	400	537	678	1570	431	266	249	422	461	470	601	522	551
	Operations (Year 10 to 12)	405	541	686	1589	436	269	252	427	466	476	608	529	557
	Closure (Year 13 to 17)	428	544	646	1522	406	182	109	370	490	535	685	553	539
	Post Closure (from year 18)	379	482	574	1353	357	155	92	321	429	471	607	490	476
2	Operations (Year 1 to 9)	1008	1257	1496	3467	1226	891	834	1373	1467	1407	1652	1293	1448
	Operations (Year 10 to 12)	1020	1267	1514	3509	1241	902	844	1390	1484	1424	1672	1309	1465
	Closure (Year 13 to 17)	956	1200	1401	3319	905	404	217	841	1139	1233	1567	1244	1202
	Post Closure (from year 18)	984	1231	1437	3404	935	421	226	872	1175	1267	1607	1269	1236
3	Operations (Year 1 to 9)	740	987	1238	2872	806	513	471	808	881	884	1118	964	1023
	Operations (Year 10 to 12)	749	995	1252	2907	816	519	477	817	891	894	1132	976	1035
	Closure (Year 13 to 17)	668	846	998	2360	625	271	146	568	772	843	1081	870	837
	Post Closure (from year 18)	685	865	1019	2411	643	281	151	588	794	863	1105	885	858
4	Operations (Year 1 to 9)	155	193	227	535	154	78	53	149	190	202	252	199	199
	Operations (Year 10 to 12)	156	195	230	541	156	79	54	151	192	204	255	201	201
	Closure (Year 13 to 17)	149	186	218	514	148	74	50	142	182	194	243	191	191
	Post Closure (from year 18)	113	141	166	390	111	53	36	105	135	146	184	145	144
5	Operations (Year 1 to 9)	1783	1960	2152	3564	2145	2048	2099	2420	2332	2163	2263	1988	2243
	Operations (Year 10 to 12)	33	41	50	113	26	0	0	14	25	40	55	42	37
	Closure (Year 13 to 17)	34	42	50	114	27	0	0	14	26	41	58	723	94
	Post Closure (from year 18)	1375	1624	1884	3849	1248	389	346	981	1283	1620	2024	1659	1524

Montlhy Average FDPs flows (m3/s) - Probabilistic Result Percentile 25%

FDP	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1	Operations (Year 1 to 9)	466	625	789	1828	502	310	290	492	537	548	700	608	641
	Operations (Year 10 to 12)	460	614	779	1803	495	306	286	485	529	540	690	600	632
	Closure (Year 13 to 17)	489	622	739	1741	464	208	125	423	561	611	783	632	616
	Post Closure (from year 18)	438	556	663	1562	412	179	106	371	495	544	700	566	549
2	Operations (Year 1 to 9)	1174	1464	1742	4038	1428	1038	972	1600	1708	1639	1924	1506	1686
	Operations (Year 10 to 12)	1158	1438	1718	3983	1409	1024	959	1578	1685	1617	1898	1486	1663
	Closure (Year 13 to 17)	1094	1372	1602	3794	1035	462	248	961	1298	1407	1800	1427	1375
	Post Closure (from year 18)	1136	1420	1659	3929	1079	485	261	1007	1356	1462	1854	1465	1426
3	Operations (Year 1 to 9)	862	1149	1441	3345	939	597	548	941	1026	1029	1302	1123	1192
	Operations (Year 10 to 12)	850	1129	1422	3300	926	589	541	928	1012	1015	1285	1108	1175
	Closure (Year 13 to 17)	764	967	1142	2699	714	310	166	649	879	962	1242	997	958
	Post Closure (from year 18)	791	998	1176	2783	742	325	175	679	916	997	1276	1021	990
4	Operations (Year 1 to 9)	180	225	264	623	180	91	62	173	221	235	294	232	232
	Operations (Year 10 to 12)	178	221	261	614	177	89	61	171	218	232	290	229	228
	Closure (Year 13 to 17)	170	213	250	588	169	85	58	163	208	221	277	219	218
	Post Closure (from year 18)	130	163	191	450	128	62	42	121	156	169	213	167	166
5	Operations (Year 1 to 9)	2076	2281	2504	4148	2497	2384	2443	2816	2714	2518	2634	2314	2611
	Operations (Year 10 to 12)	38	47	56	128	30	0	0	16	29	46	62	48	42
	Closure (Year 13 to 17)	38	48	58	131	30	0	0	16	30	48	1031	970	200
	Post Closure (from year 18)	1587	1874	2175	4442	1441	449	399	1132	1481	1870	2337	1916	1759

Montlhy Average FDPs flows (m3/s) - Probabilistic Result Percentile 75%

FDP	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1	Operations (Year 1 to 9)	571	766	967	2239	615	379	355	602	657	671	857	745	785
	Operations (Year 10 to 12)	569	760	963	2231	613	378	354	600	655	669	854	742	782
	Closure (Year 13 to 17)	597	760	902	2126	567	253	152	516	684	746	957	771	753
	Post Closure (from year 18)	535	680	810	1908	503	219	129	453	605	665	856	691	671
2	Operations (Year 1 to 9)	1437	1792	2133	4945	1749	1271	1190	1959	2092	2007	2356	1845	2065
	Operations (Year 10 to 12)	1433	1779	2126	4929	1743	1267	1186	1952	2085	2001	2348	1839	2057
	Closure (Year 13 to 17)	1335	1675	1957	4633	1264	565	304	1180	1595	1729	2197	1741	1681
	Post Closure (from year 18)	1388	1735	2026	4800	1318	593	319	1230	1656	1786	2265	1790	1742
3	Operations (Year 1 to 9)	1055	1407	1765	4097	1150	731	672	1152	1256	1260	1595	1375	1460
	Operations (Year 10 to 12)	1052	1397	1759	4083	1146	729	669	1148	1252	1256	1590	1371	1454
	Closure (Year 13 to 17)	932	1181	1394	3296	872	378	204	797	1080	1181	1516	1217	1171
	Post Closure (from year 18)	966	1219	1437	3400	907	397	213	829	1120	1217	1559	1247	1209
4	Operations (Year 1 to 9)	220	276	324	763	220	111	76	212	271	287	360	284	284
	Operations (Year 10 to 12)	220	274	323	760	219	111	75	212	270	286	359	283	283
	Closure (Year 13 to 17)	208	260	305	718	207	103	70	199	254	270	339	267	267
	Post Closure (from year 18)	159	199	234	549	157	75	51	148	191	206	260	205	203
5	Operations (Year 1 to 9)	2542	2793	3067	5079	3058	2920	2992	3449	3324	3083	3225	2834	3197
	Operations (Year 10 to 12)	47	58	70	159	37	0	0	20	36	57	77	60	52
	Closure (Year 13 to 17)	47	58	70	160	37	0	0	20	944	1206	1502	1177	435
	Post Closure (from year 18)	1939	2289	2657	5427	1760	548	487	1383	1809	2285	2855	2340	2148

Montlhy Average FDPs flows (m3/s) - Probabilistic Result Percentile 95%

FDP	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1	Operations (Year 1 to 9)	660	885	1117	2587	710	438	410	696	759	775	990	861	907
	Operations (Year 10 to 12)	685	914	1159	2683	737	455	425	722	788	804	1027	893	941
	Closure (Year 13 to 17)	688	874	1038	2447	652	292	175	595	788	859	1101	888	866
	Post Closure (from year 18)	610	775	924	2176	573	249	148	516	689	758	976	788	765
2	Operations (Year 1 to 9)	1661	2070	2465	5713	2021	1469	1375	2263	2416	2319	2722	2131	2385
	Operations (Year 10 to 12)	1723	2140	2557	5927	2097	1524	1426	2348	2507	2406	2823	2211	2474
	Closure (Year 13 to 17)	1537	1928	2252	5333	1455	649	350	1356	1829	1985	2532	2004	1934
	Post Closure (from year 18)	1583	1978	2311	5474	1503	676	364	1403	1889	2037	2584	2041	1987
3	Operations (Year 1 to 9)	1219	1625	2039	4733	1329	845	776	1331	1451	1456	1843	1589	1686
	Operations (Year 10 to 12)	1265	1680	2116	4910	1378	876	805	1381	1505	1510	1912	1648	1749
	Closure (Year 13 to 17)	1073	1360	1604	3793	1004	435	234	916	1239	1356	1747	1401	1347
	Post Closure (from year 18)	1101	1390	1639	3877	1034	452	243	945	1277	1388	1778	1423	1379
4	Operations (Year 1 to 9)	255	319	374	881	254	128	87	245	313	332	416	328	328
	Operations (Year 10 to 12)	264	329	388	914	263	133	91	255	324	345	431	340	340
	Closure (Year 13 to 17)	239	299	351	826	238	119	81	229	292	311	390	308	307
	Post Closure (from year 18)	181	226	267	627	179	86	59	169	218	235	296	233	231
5	Operations (Year 1 to 9)	2935	3225	3540	5862	3529	3371	3454	3981	3837	3559	3723	3272	3691
	Operations (Year 10 to 12)	56	69	84	191	44	0	0	24	43	68	92	72	62
	Closure (Year 13 to 17)	54	67	81	184	43	227	658	1230	1287	1488	1807	1410	711
	Post Closure (from year 18)	2212	2610	3030	6189	2007	625	556	1577	2063	2606	3256	2669	2450

Appendix C WATER QUALITY MODEL INPUTS

Table C-1: List of input parameters and water quality guidelines

Parameter name	Parameter Symbol	Name in model	Parameter group	Units	Highest RDL	CWQG FAL Guidelines		MDMER Limits
						Short-term	Long-term	
Aluminum	Al	Aluminum	Trace elements	µg/L	5.0	n/v	5 or 100*	n/v
Antimony	Sb	Antimony	Trace elements	µg/L	1.0	n/v	n/v	n/v
Arsenic	As	Arsenic	Trace elements	µg/L	1.0	n/v	5	100
Barium	Ba	Barium	Trace elements	µg/L	1.0	n/v	n/v	n/v
Boron	B	Boron	Trace elements	µg/L	50	29000	1500	n/v
Cadmium	Cd	Cadmium	Trace elements	µg/L	0.017	0.13	0.04	n/v
Calcium	Ca	Calcium	Trace elements	µg/L	100	n/v	n/v	n/v
Chromium	Cr	Chromium	Trace elements	µg/L	1.0	n/v	1	n/v
Copper	Cu	Copper	Trace elements	µg/L	2.0	n/v	2	100
Iron	Fe	Iron	Trace elements	µg/L	50	n/v	300	n/v
Lead	Pb	Lead	Trace elements	µg/L	0.50	n/v	1	80
Magnesium	Mg	Magnesium	Trace elements	µg/L	100	n/v	n/v	n/v
Manganese	Mn	Manganese	Trace elements	µg/L	2.0	596	210	n/v
Mercury	Hg	Mercury	Trace elements	µg/L	0.013	n/v	0.026	n/v
Molybdenum	Mo	Molybdenum	Trace elements	µg/L	2.0	n/v	73	n/v
Nickel	Ni	Nickel	Trace elements	µg/L	2.0	n/v	25	250
Phosphorus	P	Phosphorus	Trace elements	µg/L	100	n/v	4	n/v
Potassium	K	Potassium	Trace elements	µg/L	100	n/v	n/v	n/v
Selenium	Se	Selenium	Trace elements	µg/L	1.0	n/v	1	n/v
Silver	Ag	Silver	Trace elements	µg/L	0.10	n/v	0.25	n/v
Sodium	Na	Sodium	Trace elements	µg/L	100	n/v	n/v	n/v
Thallium	Tl	Thallium	Trace elements	µg/L	0.10	n/v	0.8	n/v
Uranium	U	Uranium	Trace elements	µg/L	0.10	33	15	n/v
Zinc	Zn	Zinc	Trace elements	µg/L	5.0	11.3	2.2	400
Chloride	Cl	Chloride	General chemistry	µg/L	1000	640000	120000	n/v
Nitrate + Nitrite (as Nitrogen)	N-NO_3+NO_2	N_Nitrate_Nitrite	General chemistry	µg/L	50	n/v	n/v	n/v
Nitrite (as Nitrogen)	N-NO_2	N_Nitrite	General chemistry	µg/L	10	n/v	60	n/v
Nitrate (as Nitrogen)	N-NO_3	N_Nitrate	General chemistry	µg/L	50	550000	13000	n/v
Total Ammonia (as Nitrogen)	N-$NH_{3\ T}$	N_Ammonia_t	General chemistry	µg/L	50	n/v	689	n/v
Un-ionized Ammonia (as Nitrogen)	N-NH_3 un	N_Ammonia_un	General chemistry	µg/L	N/A	16	16	500
Cyanide, Total**	CN_T	Cyanide_t	General chemistry	µg/L	10	n/v	n/v	500
Cyanide, WAD**	CN_{WAD}	Cyanide_WAD	General chemistry	µg/L	1	n/v	5	n/v
Sulphate	SO_4	Sulphate	General chemistry	µg/L	2000	n/v	n/v	n/v
Fluoride**	F	Fluoride	General chemistry	µg/L	60.0	n/v	120	n/v
Radium-226**	Ra-226	Radium_226	Radioactivity	Bq/L	0.005	n/v	n/v	0.37
Temperature***	Temp	Temperature	General chemistry	°C	na	n/v	Narrative	n/v
Total Alkalinity (as $CaCO_3$)	Alk tot	Alkalinity	General chemistry	mg/L	5	n/v	n/v	n/v
pH	pH	pH	General chemistry	pH Unit	N/A	n/v	6.5-9.0	6.0-9.5
Hardness (as $CaCO_3$)	Hard	Hardness	General chemistry	mg/L	1	n/v	n/v	n/v
Dissolved Organic Carbon**	DOC	DOC	General chemistry	mg/L	1	n/v	n/v	n/v

See notes on next page

Table C-1: List of input parameters and water quality guidelines

Notes:

All concentrations are total (unfiltered) fraction

The most stringent guideline is selected when two or more guidelines are established for the same parameter under the same jurisdiction.
CWQG FAL - Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life by Canadian Council of Ministers of the Environment (CCME 2020).
MDMER - Metal and Diamond Mining Effluent Regulations (Canada), Schedule 4 Table 1 (amendment not yet in force) - Authorized Limits of Deleterious Substances, Maximum Authorized Monthly Mean Concentrations (SOR/2002-222 2020).
n/v = no value
*Equations are used to calculate hardness-, pH-, temperature-, and DOC-dependent guidelines for these parameters as per CCME (2020) or as otherwise noted:

Aluminium: guideline is 5 µg/L if pH < 6.5 or 100 µg/L if pH ≥ 6.5. 100 µg/L is used since pH ≥ 6.5 for surface water.
Cadmium (long-term): at hardness < 17 mg/L the guideline is 0.04 µg/L; at hardness between 17 and 280 mg/L the guideline is 10^{0.83(log[hardness]) – 2.46} µg/L; at hardness > 280 mg/L the guideline is 0.37 µg/L. For the most stringent guideline, minimum hardness (6.4 mg CaCO3/L for surface water) is used.
Cadmium (short-term): at hardness < 5.4 mg/L the guideline is 0.11 µg/L; at hardness between 5.3 and 360 the guideline is 10^{1.016(log[hardness]) – 1.71 } µg/L; at hardness > 360 the guideline is 7.7 µg/L. For the most stringent guideline, minimum hardness (6.4 mg CaCO3/L for surface water) is used.
Copper: at hardness < 82 mg/L the guideline is 2 µg/L; at hardness between 82 and 180 mg/L the guideline is 0.2 * e^{0.8545[ln(hardness)]-1.465} µg/L; at hardness > 180 mg/L the hardness is 4 µg/L; at an unknown hardness the guideline is 2 µg/L. For the most stringent guideline, minimum hardness (6.4 mg CaCO3/L for surface water) is used.
Lead: at hardness < 60 mg/L the guideline is 1 µg/L; at hardness between 60 and 180 mg/L the guideline is e^{1.273[ln(hardness)]-4.705} µg/L; at hardness > 180 mg/L the hardness is 7 µg/L; at an unknown hardness the guideline is 1 µg/L. For the most stringent guideline, minimum hardness (6.4 mg CaCO3/L for surface water) is used.
Manganese (long-term): dissolved manganese guideline is pH- and hardness-dependent and found using the CWQG FAL calculator in Appendix B of the Scientific Criteria Document for the Development of the Canadian Water Quality Guidelines for the Protection of Aquatic Life: Manganese (CCME 2019). For the most stringent guideline, minimum hardness (6.4 mg CaCO$_3$/L for surface water) is used. Values within pH range are tested (minimum of 6.5 and maximum of 7.8 for surface water) both giving most conservative guideline.
Manganese (short-term): dissolved managanese benchmark is found using the benchmark calculator in Appendix B (see Manganese (long-term)) or e^{0.878[ln(hardness)] + 4.76} µg/L.
Nickel: at hardness < 60 mg/L the guideline is 25 µg/L; at hardness between 60 and 180 mg/L the guideline is e^{0.76[ln(hardness)]+1.06} µg/L; at hardness > 180 mg/L the hardness is 150 µg/L; at an unknown hardness the guideline is 25 µg/L. For the most stringent guideline, minimum hardness (6.4 mg CaCO3/L for surface water) is used.
Phosphorus: trigger ranges for phosphorus are provided by Guidance Framework and depend upon trophic index of a water body. Phosphorus trigger range for freshwater nutrients in an ultra-oligotrophic environment is used.
Zinc (long-term): guideline for dissolved zinc is e^{0.947[ln(hardness)] - 0.815[pH] + 0.398[ln(DOC)] + 4.625} µg/L. The equation is valid between hardness 23.4 and 399 mg CaCO3/L, pH 6.5 and 8.13, and DOC 0.3 to 22.9 mg/L. DOC = dissolved organic carbon. The lowest hardness (23.4 mg CaCO3/L) and DOC (0.3 mg/L), for which equation is valid, and maximum pH (7.8 for surface water) is used.
Zinc (short-term): guideline for dissolved zinc is e^(0.833[ln(hardness mg·L-1)] + 0.240[ln(DOC)] + 0.526) µg/L. The benchmark equation is valid between hardness 13.8 and 250.5 mg CaCO3/L and DOC 0.3 and 17.3 mg/L. 'The lowest hardness (13.8 mg CaCO3/L) and DOC (0.3 mg/L), for which equation is valid is used.
Ammonia guideline is pH- and temperature-dependent and is taken from the Environmental Quality Guidelines for Alberta Surface Water (Government of Alberta 2018), which is similar to CCME (2010), but is calculated for smaller teperature (1 °C) and pH (0.1 pH unit) intervals. Maximum pH (7.8 for surface water) and maximum temperature (19 °C for surface water) is used.

Chromium long-term assumes Cr(VI).

Unionized ammonia values are calculated where temperature and/or pH are not present in the data set using maximum temperature and pH (19 °C and 7.8 for surface water).

Cyanide WAD is compared to the long-term for free cyanide.

**The highest Reportable Detection Limit (RDL) is used for modeling.

***Surface water temperature values are the mean daily air temperature, or 0 °C if air temperature is negative, on the day of sampling or the closest day with data available, taken from the Government of Canada Daily Data Reports (2011-2019) for Burnt Pond, NL, with values ranging from 0 to 18.5 °C. Groundwater temperature values are from field records where available, or are assumed to be 6.0 °C otherwise (average groundwater temperature (Stantec 2017)).

Table C-2: Inputs for background surface water quality

Parameter	**Units**	MDMER	CWQG	**CWQG**	**Combined statistics for LP02 and LP04**				**Combined statistics for R01 and LP05**				**Statistics for VICRV-01 (Victoria Lake)**			
Statistics			Short-term	Long-term	Min	Mean	Max	St. Dev.	Min	Mean	Max	St. Dev	Min	Mean	Max	St. Dev
Aluminum	µg/L	-	-	100	28	**107**	**281**	55	8.6	63	**187**	39	23	54	**130**	30
Antimony	µg/L	-	-	-	0.50	0.50	0.51	0.002	0.50	0.50	0.51	0.0017	0.50	0.50	0.51	0.002
Arsenic	µg/L	100	-	5	0.50	0.79	2.5	0.5	0.50	2.5	**9.1**	2.4	0.50	0.50	0.51	0.002
Barium	µg/L	-	-	-	0.50	2.9	13	2	0.50	1.6	4.9	0.66	2.30	5.6	16	4
Boron	µg/L	-	29000	1500	25	25	25	0.08	25	25	25	0.083	25	25	25	0.08
Cadmium	µg/L	-	0.13	0.04	0.0050	0.0080	0.025	0.003	0.0050	0.0081	0.038	0.0046	0.0050	0.0056	0.010	0.002
Calcium	µg/L	-	-	-	2400	7074	39000	4880	2100	6360	23000	3581	1400	2088	4700	1141
Chromium	µg/L	-	-	1	0.50	**1.1**	**8.2**	**1.6**	0.50	0.7	**4.0**	0.59	0.50	0.69	**1.4**	0.3
Copper	µg/L	100	-	2	0.25	0.99	**3.5**	0.4	0.25	1.0	**3.0**	0.41	0.25	0.60	1.1	0.3
Iron	µg/L	-	-	300	25	220	**757**	143	25	175	**460**	91	25	86	**310**	86
Lead	µg/L	80	-	1	0.25	0.26	0.59	0.04	0.25	0.25	0.25	0.00083	0.25	0.36	**1.1**	0.3
Magnesium	µg/L	-	-	-	340	1021	3100	495	300	848	2300	410	320	414	860	172
Manganese	µg/L	-	596	210	9.5	105	**681**	142	7.4	94	**494**	102	4.0	21	100	30
Mercury	µg/L	-	-	0.026	0.0065	0.0079	0.025	0.004	0.0065	0.0068	0.017	0.0015	0.0064	0.0065	0.0066	0.00002
Molybdenum	µg/L	-	-	73	1.0	1.0	2.5	0.2	1.0	1.0	1.0	0.0033	1.0	1.0	1.0	0.003
Nickel	µg/L	250	-	25	0.99	1.0	1.0	0.003	0.99	1.0	1.0	0.0033	0.99	1.0	1.0	0.003
Phosphorus	µg/L	-	-	4	**50**	**50**	**51**	0.2	**50**	**51**	**140**	**11**	**50**	**50**	**51**	0.2
Potassium	µg/L	-	-	-	50	280	867	172	50	129	330	59	170	198	220	16
Selenium	µg/L	-	-	1	0.25	0.48	0.50	0.06	0.25	0.48	0.50	0.061	0.25	0.25	0.25	0.0008
Silver	µg/L	-	-	0.25	0.050	0.050	0.050	6E-17	0.050	0.050	0.051	5E-17	0.050	0.050	0.051	7E-18
Sodium	µg/L	-	-	-	1030	2063	3490	554	1070	1646	2400	323	1400	1738	2100	187
Thallium	µg/L	-	-	0.8	0.050	0.050	0.050	6E-17	0.050	0.050	0.051	5E-17	0.050	0.050	0.051	7E-18
Uranium	µg/L	-	33	15	0.050	0.058	0.24	0.03	0.050	0.054	0.14	0.017	0.050	0.050	0.051	0
Zinc	µg/L	400	11.3	2.2	**2.5**	**3.7**	**8.5**	2	**2.5**	**3.6**	**10**	1.9	**2.5**	**2.5**	**2.5**	0.008
Chloride	µg/L	-	640000	120000	1000	2800	5000	881	500	2395	4200	825	2100	2988	4600	686
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	25	39	170	26	25	50	230	39	51	129	430	115
Nitrite (as Nitrogen)	µg/L	-	-	60	5.0	5.5	25	3	5.0	5.0	5.1	0.017	5.0	11	27	7
Nitrate (as Nitrogen)	µg/L	-	550000	13000	25	38	170	26	25	50	230	39	51	121	420	114
Total Ammonia (as Nitrogen)	µg/L	-	-	689	5.0	37	260	40	25.0	33	170	24	25	25	25	0.08
Un-ionized Ammonia (as Nitrogen)	µg/L	500	16	16	0.0070	0.096	0.38	0.1	0.0062	0.10	0.48	0.11	0.0088	0.032	0.12	0.04
Cyanide, Total	µg/L	500	-	-	9.9	10	10	0.03	9.9	10	10	0.033	9.9	10	10	0.03
Cyanide, WAD	µg/L	-	-	5	0.99	1.0	1.0	0.003	0.99	1.0	1.0	0.0033	0.99	1.0	1.0	0.003
Sulphate	µg/L	-	-	-	1000	1156	5500	698	1000	1079	2800	352	990	1000	1010	3
Fluoride	µg/L	-	-	120	59	60	61	0.2	59	60	61	0.20	59	60	61	0.2
Radium-226	Bg/L	0.37	-	-	0.0050	0.0050	0.0051	3E-18	0.0050	0.0050	0.0051	3E-18	0.0050	0.0050	0.0051	2E-05
Temperature	°C	-	-	-	0.0	7.3	19	7	0.0	7.5	19	6.8	3.5	11	18	7
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	5.4	21	99	14	5.0	18	62	11	2.5	5.5	10	3
pH	pH Unit	6.0-9.5	-	6.5-9.0	6.5	7.1	7.8	0.3	**6.5**	7.1	7.7	0.29	6.5	6.6	7.2	0.2
Hardness (as $CaCO_3$)	mg/L	-	-	-	7.3	22	110	14	6.4	19	64	10	4.7	6.9	15	3
Dissolved Organic Carbon	mg/L	-	-	-	0.99	1.0	1.0	0.003	0.99	1.0	1.0	0.0033	0.99	1.0	1.0	0.003

Notes: See Table C-1 notes for details on the parameters and guidelines.

Table C-3: Inputs for groundwater quality

Parameter	**Units**	MDMER	CWQG	**CWQG**	**Leprechaun bedrock**			**Leprechaun overburden (MW3, 6 and 5)**		
Statistics			Short-term	Long-term	Min	Median	Max	Min	Median	Max
Aluminum	µg/L	-	-	100	2.5	15	15	6.0	11	17
Antimony	µg/L	-	-	-	0.50	0.50	0.51	0.99	1.0	1.0
Arsenic	µg/L	100	-	5	0.50	0.50	4.4	0.99	1.0	**14**
Barium	µg/L	-	-	-	3.4	58	62	51	55	109
Boron	µg/L	-	29000	1500	25	25	25	2.5	2.5	7.0
Cadmium	µg/L	-	0.13	0.04	0.0084	0.0085	0.037	0.029	**0.045**	**0.051**
Calcium	µg/L	-	-	-	32000	43000	51000	29500	31600	39100
Chromium	µg/L	-	-	1	0.50	0.50	0.51	1.0	**2.0**	**3.0**
Copper	µg/L	100	-	2	0.99	1.0	1.0	0.99	1.0	**3.0**
Iron	µg/L	-	-	300	25	130	**520**	25	25	244
Lead	µg/L	80	-	1	0.25	0.25	0.25	0.25	0.25	0.25
Magnesium	µg/L	-	-	-	2300	2600	4300	1600	4500	5200
Manganese	µg/L	-	596	210	11	**550**	**1400**	9.0	**470**	**751**
Mercury	µg/L	-	-	0.026	0.0064	0.0065	0.0066	0.013	0.013	0.013
Molybdenum	µg/L	-	-	73	1.0	1.0	2.5	1.0	8.0	23
Nickel	µg/L	250	-	25	0.99	1.0	1.0	3.0	4.0	9.0
Phosphorus	µg/L	-	-	4	**50**	**50**	**51**	**140**	**190**	**780**
Potassium	µg/L	-	-	-	310	400	480	300	900	3700
Selenium	µg/L	-	-	1	0.50	0.50	0.51	0.50	0.50	0.51
Silver	µg/L	-	-	0.25	0.050	0.050	0.051	0.050	0.050	0.051
Sodium	µg/L	-	-	-	2500	3100	3700	5000	11700	11800
Thallium	µg/L	-	-	0.8	0.050	0.05	0.051	0.050	0.050	0.051
Uranium	µg/L	-	33	15	0.27	1.3	1.6	0.10	0.60	0.80
Zinc	µg/L	400	11.3	2.2	**2.5**	**2.5**	**2.5**	**2.5**	**2.5**	**2.5**
Chloride	µg/L	-	640000	120000	3000	3300	3600	3000	4000	7000
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	25	25	53	25	60	140
Nitrite (as Nitrogen)	µg/L	-	-	60	5.0	5.0	5.1	25	25	25
Nitrate (as Nitrogen)	µg/L	-	550000	13000	25	25	53	25	60	140
Total Ammonia (as Nitrogen)	µg/L	-	-	689	25	25	25	40	90	270
Un-ionized Ammonia (as Nitrogen)	µg/L	500	16	16	0.097	0.10	0.16	0.055	0.77	4.0
Cyanide, Total	µg/L	500	-	-	9.9	10	10	9.9	10	10
Cyanide, WAD	µg/L	-	-	5	1.5	1.5	1.5	0.99	1.0	1.0
Sulphate	µg/L	-	-	-	1000	2400	12000	1000	6000	21000
Fluoride	µg/L	-	-	120	59	60	61	59	60	61
Radium-226	Bq/L	0.37	-	-	0.0050	0.0050	0.0051	0.0025	0.0025	0.0400
Temperature	°C	-	-	-	5.9	6.0	6.1	6.0	6.4	9.1
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	81	130	140	105	114	130
pH	pH Unit	6.0-9.5	-	6.5-9.0	7.5	7.5	7.7	7.0	7.9	8.1
Hardness (as $CaCO_3$)	mg/L	-	-	-	89	130	140	49	100	126
Dissolved Organic Carbon	mg/L	-	-	-	0.99	1.0	1.0	0.99	1.0	1.0

Notes: See Table C-1 notes for details on the parameters and guidelines.

Table C-4: Input leaching rates (mg/kg/week) and pH values from humidity cells

Sample	Units	**L TRJ**	**L TRJ**	**L TRJ**	**L TRJ**	**L TRJ**	**L TRJ**	**L SED**	**L SED**	**L SED**	**L SED**
Period		1st Month	1st Month	1st Month	Last Month	Last Month	Last Month	1st Month	1st Month	1st Month	Last Month
Statictics		Min	Median	Max	Min	Median	Max	Min	Median	Max	Min
Aluminum	mg/kg/week	0.076	0.085	0.088	0.054	0.054	0.056	0.093	0.099	0.13	0.045
Antimony	mg/kg/week	0.00043	0.00043	0.00044	0.00043	0.00043	0.00044	0.00040	0.00041	0.00045	0.00042
Arsenic	mg/kg/week	0.00029	0.00029	0.00039	0.00010	0.00010	0.00010	0.00045	0.00050	0.00064	0.000094
Barium	mg/kg/week	0.0043	0.0045	0.0051	0.0060	0.0063	0.0067	0.00052	0.00057	0.00065	0.00016
Boron	mg/kg/week	0.00096	0.00097	0.0019	0.00096	0.00096	0.0010	0.00092	0.00099	0.0027	0.00094
Cadmium	mg/kg/week	0.0000014	0.0000014	0.0000015	0.0000014	0.0000014	0.0000015	0.0000013	0.0000014	0.0000015	0.0000014
Calcium	mg/kg/week	3.3	3.3	3.7	2.3	2.4	2.8	1.5	1.5	2.3	1.1
Chromium	mg/kg/week	0.000038	0.000039	0.000039	0.000039	0.000096	0.00012	0.000036	0.000037	0.000040	0.000038
Copper	mg/kg/week	0.00038	0.00039	0.00097	0.00010	0.00029	0.00038	0.000092	0.00036	0.00060	0.00028
Iron	mg/kg/week	0.0087	0.0087	0.012	0.0034	0.0034	0.011	0.0074	0.0089	0.010	0.0033
Lead	mg/kg/week	0.000010	0.000048	0.000058	0.0000048	0.0000048	0.0000049	0.0000046	0.000018	0.000030	0.0000094
Magnesium	mg/kg/week	0.24	0.30	0.33	0.16	0.16	0.18	0.14	0.16	0.17	0.10
Manganese	mg/kg/week	0.017	0.018	0.018	0.012	0.013	0.015	0.014	0.016	0.032	0.0086
Mercury	mg/kg/week	0.0000048	0.0000048	0.0000049	0.0000048	0.0000048	0.0000049	0.0000045	0.0000046	0.0000050	0.0000047
Molybdenum	mg/kg/week	0.00014	0.00018	0.00033	0.000019	0.00015	0.00037	0.000055	0.00013	0.00028	0.000019
Nickel	mg/kg/week	0.000048	0.000048	0.000049	0.000048	0.000048	0.000049	0.000045	0.000046	0.000050	0.000047
Phosphorus	mg/kg/week	0.0014	0.0014	0.0015	0.0014	0.0014	0.0015	0.0013	0.0014	0.0015	0.0014
Potassium	mg/kg/week	0.82	1.3	2.1	0.11	0.11	0.14	1.1	1.4	1.6	0.29
Selenium	mg/kg/week	0.000019	0.000019	0.000019	0.000019	0.000019	0.000019	0.000018	0.000018	0.000040	0.000019
Silver	mg/kg/week	0.000024	0.000024	0.000024	0.000024	0.000024	0.000024	0.000022	0.000023	0.000025	0.000023
Sodium	mg/kg/week	0.24	0.89	2.1	0.038	0.048	0.049	0.74	2.5	2.6	0.056
Thallium	mg/kg/week	0.0000024	0.0000024	0.0000024	0.0000024	0.0000024	0.0000048	0.0000022	0.0000023	0.0000025	0.0000023
Uranium	mg/kg/week	0.00045	0.00045	0.00082	0.00011	0.00029	0.00083	0.00022	0.00025	0.00030	0.00011
Zinc	mg/kg/week	0.00096	0.00096	0.00097	0.00096	0.00096	0.00097	0.00090	0.00092	0.00099	0.00094
Chloride	mg/kg/week	*0.000045*	*0.000050*	*0.000055*	*0.000045*	*0.000050*	*0.000055*	*0.000045*	*0.000050*	*0.000055*	*0.000045*
Nitrate + Nitrite (as Nitrogen)	mg/kg/week	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*
Nitrite (as Nitrogen)	mg/kg/week	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000050*
Nitrate (as Nitrogen)	mg/kg/week	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*
Total Ammonia (as Nitrogen)	mg/kg/week	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*
Un-ionized Ammonia (as Nitrogen)	mg/kg/week	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*
Cyanide, Total	mg/kg/week	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000050*
Cyanide, WAD	mg/kg/week	*0.00000050*	*0.00000055*	*0.00000061*	*0.00000050*	*0.00000055*	*0.00000061*	*0.00000050*	*0.00000055*	*0.00000061*	*0.00000050*
Sulphate	mg/kg/week	0.29	0.58	1.2	0.10	0.10	0.10	0.092	0.54	0.70	0.094
Fluoride	mg/kg/week	0.029	0.029	0.029	0.029	0.029	0.029	0.028	0.030	0.22	0.028
Radium-226	Bq/kg/week	*0.0000023*	*0.0000025*	*0.0000028*	*0.0000023*	*0.0000025*	*0.0000028*	*0.0000023*	*0.0000025*	*0.0000028*	*0.0000023*
Temperature	°C	*18*	*20*	*22*	*18*	*20*	*22*	*18*	*20*	*22*	*18*
Total Alkalinity (as $CaCO_3$)	mg/kg/week	13	13	16	7.7	8.7	8.8	7.4	9.0	12	3.7
pH	pH Unit	7.8	7.9	8.2	7.3	7.4	7.6	7.1	7.8	7.9	7.1
Hardness (as $CaCO_3$)	mg/kg/week	*0.00045*	*0.00050*	*0.00055*	*0.00045*	*0.00050*	*0.00055*	*0.00045*	*0.00050*	*0.00055*	*0.00045*
Dissolved Organic Carbon	mg/kg/week	*0.00045*	*0.00050*	*0.00055*	*0.00045*	*0.00050*	*0.00055*	*0.00045*	*0.00050*	*0.00055*	*0.00045*

Notes:

Values of the parameters shown in Italics and shaded are the respective detection limits conservatively used for modeling when laboratory measured values were not available.

Temperature and pH are shown for information; no calculations are applied for these parameters.

Table C-4: Input leaching rates (mg/kg/week) and pH values from humidity cells

Sample	Units	**L SED**	**L SED**	**L QZ-QTP**	**L QZ-QTP**	**L QZ-QTP**	**L QZ-QTP**	**L QZ-QTP**	**L QZ-QTP**	**L QZ-TQTP**	**L QZ-TQTP**
Period		Last Month	Last Month	1st Month	1st Month	1st Month	Last Month	Last Month	Last Month	1st Month	1st Month
Statictics		Median	Max	Min	Median	Max	Min	Median	Max	Min	Median
Aluminum	mg/kg/week	0.047	0.049	0.085	0.11	0.11	0.064	0.067	0.078	0.055	0.059
Antimony	mg/kg/week	0.00042	0.00042	0.00041	0.00042	0.00043	0.00042	0.00043	0.00043	0.00086	0.0013
Arsenic	mg/kg/week	0.000094	0.000094	0.000094	0.00027	0.00029	0.000094	0.00010	0.00010	0.00038	0.00040
Barium	mg/kg/week	0.00033	0.00035	0.0015	0.0016	0.0021	0.0011	0.0012	0.0012	0.0016	0.0021
Boron	mg/kg/week	0.00094	0.00094	0.00094	0.00096	0.0027	0.00094	0.00095	0.0010	0.00095	0.0050
Cadmium	mg/kg/week	0.0000014	0.0000014	0.0000014	0.0000014	0.0000014	0.0000014	0.0000014	0.0000014	0.0000014	0.0000015
Calcium	mg/kg/week	1.1	1.3	2.7	2.9	3.6	2.4	2.4	2.8	4.0	4.4
Chromium	mg/kg/week	0.00015	0.00023	0.000036	0.000037	0.000039	0.000038	0.000086	0.00013	0.000038	0.000040
Copper	mg/kg/week	0.00038	0.0015	0.00056	0.0022	0.0040	0.00019	0.00029	0.00038	0.00040	0.00048
Iron	mg/kg/week	0.0033	0.0033	0.0033	0.0064	0.010	0.0033	0.0033	0.0033	0.0033	0.0035
Lead	mg/kg/week	0.0000094	0.000028	0.0000047	0.000018	0.000029	0.0000048	0.000019	0.000019	0.0000048	0.000030
Magnesium	mg/kg/week	0.11	0.13	0.25	0.29	0.30	0.20	0.20	0.22	0.45	0.57
Manganese	mg/kg/week	0.0092	0.012	0.013	0.016	0.019	0.012	0.012	0.014	0.021	0.022
Mercury	mg/kg/week	0.0000047	0.0000047	0.0000046	0.0000047	0.0000048	0.0000047	0.0000048	0.0000048	0.0000048	0.0000050
Molybdenum	mg/kg/week	0.00010	0.00014	0.000073	0.000094	0.00014	0.000019	0.000066	0.00048	0.00013	0.00015
Nickel	mg/kg/week	0.000047	0.000047	0.000046	0.000047	0.000048	0.000047	0.000048	0.000048	0.000048	0.000050
Phosphorus	mg/kg/week	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0015
Potassium	mg/kg/week	0.30	0.36	0.81	1.4	1.7	0.10	0.11	0.14	1.0	1.9
Selenium	mg/kg/week	0.000019	0.000019	0.000018	0.000019	0.000048	0.000019	0.000019	0.000019	0.000019	0.000020
Silver	mg/kg/week	0.000023	0.000024	0.000023	0.000023	0.000024	0.000024	0.000024	0.000024	0.000024	0.000025
Sodium	mg/kg/week	0.056	0.066	0.31	1.2	1.9	0.048	0.057	0.066	0.57	2.4
Thallium	mg/kg/week	0.0000023	0.0000066	0.0000023	0.0000023	0.0000024	0.0000024	0.0000024	0.0000024	0.0000024	0.0000025
Uranium	mg/kg/week	0.00016	0.00018	0.00061	0.00078	0.0011	0.00017	0.00024	0.00039	0.00068	0.0012
Zinc	mg/kg/week	0.00094	0.00094	0.00091	0.00094	0.00096	0.00095	0.00095	0.0028	0.0010	0.0010
Chloride	mg/kg/week	*0.000050*	*0.000055*	*0.000045*	*0.000050*	*0.000055*	*0.000045*	*0.000050*	*0.000055*	*0.000045*	*0.000050*
Nitrate + Nitrite (as Nitrogen)	mg/kg/week	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*
Nitrite (as Nitrogen)	mg/kg/week	*0.0000055*	*0.0000061*	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000050*	*0.0000055*
Nitrate (as Nitrogen)	mg/kg/week	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*
Total Ammonia (as Nitrogen)	mg/kg/week	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*
Un-ionized Ammonia (as Nitrogen)	mg/kg/week	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*
Cyanide, Total	mg/kg/week	*0.0000055*	*0.0000061*	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000050*	*0.0000055*
Cyanide, WAD	mg/kg/week	*0.00000055*	*0.00000061*	*0.00000050*	*0.00000055*	*0.00000061*	*0.00000050*	*0.00000055*	*0.00000061*	*0.00000050*	*0.00000055*
Sulphate	mg/kg/week	0.094	0.094	0.28	0.55	1.1	0.094	0.10	0.10	0.95	1.7
Fluoride	mg/kg/week	0.028	0.028	0.027	0.028	0.058	0.028	0.029	0.029	0.029	0.030
Radium-226	Bq/kg/week	*0.0000025*	*0.0000028*	*0.0000023*	*0.0000025*	*0.0000028*	*0.0000023*	*0.0000025*	*0.0000028*	*0.0000023*	*0.0000025*
Temperature	°C	*20*	*22*	*18*	*20*	*22*	*18*	*20*	*22*	*18*	*20*
Total Alkalinity (as $CaCO_3$)	mg/kg/week	4.7	5.6	8.4	11	12	7.5	7.6	8.6	13	18
pH	pH Unit	7.1	7.2	7.3	8.1	8.2	7.3	7.4	7.4	7.6	7.9
Hardness (as $CaCO_3$)	mg/kg/week	*0.00050*	*0.00055*	*0.00045*	*0.00050*	*0.00055*	*0.00045*	*0.00050*	*0.00055*	*0.00045*	*0.00050*
Dissolved Organic Carbon	mg/kg/week	*0.00050*	*0.00055*	*0.00045*	*0.00050*	*0.00055*	*0.00045*	*0.00050*	*0.00055*	*0.00045*	*0.00050*

Notes:

Values of the parameters shown in Italics and shaded are the respective detection limits conservatively used for modeling when laboratory measured values were not available.

Temperature and pH are shown for information; no calculations are applied for these parameters.

Table C-4: Input leaching rates (mg/kg/week) and pH values from humidity cells

Sample	Units	**L QZ-TQTP**	**L QZ-TQTP**	**L QZ-TQTP**	**L QZ-TQTP**	**LLGO Met**	**LLGO Met**	**LLGO Met**	**LLGO Met**	**LLGO Met**	**LLGO Met**
Period		1st Month	Last Month	Last Month	Last Month	1st Month	1st Month	1st Month	Last Month	Last Month	Last Month
Statictics		Max	Min	Median	Max	Min	Median	Max	Min	Median	Max
Aluminum	mg/kg/week	0.059	0.046	0.046	0.047	0.083	0.11	0.13	0.071	0.076	0.081
Antimony	mg/kg/week	0.0019	0.00044	0.00044	0.00045	0.00042	0.0011	0.0012	0.00042	0.00042	0.00042
Arsenic	mg/kg/week	0.00050	0.00010	0.00029	0.00040	0.00028	0.00044	0.00048	0.000094	0.00014	0.00018
Barium	mg/kg/week	0.0023	0.00090	0.00093	0.0010	0.0011	0.0014	0.0027	0.00074	0.00080	0.00087
Boron	mg/kg/week	0.0050	0.00097	0.00098	0.0010	0.0038	0.0070	0.011	0.0018	0.0023	0.0028
Cadmium	mg/kg/week	0.0000015	0.0000015	0.0000015	0.0000015	0.0000013	0.0000028	0.0000096	0.0000014	0.0000014	0.0000014
Calcium	mg/kg/week	4.6	2.8	3.0	3.3	3.5	4.7	5.5	2.7	2.8	2.9
Chromium	mg/kg/week	0.000040	0.000039	0.000040	0.00017	0.000035	0.000038	0.00021	0.000037	0.000037	0.000037
Copper	mg/kg/week	0.00070	0.00010	0.00029	0.00050	0.000094	0.00010	0.00035	0.000092	0.000093	0.000094
Iron	mg/kg/week	0.0070	0.0034	0.0034	0.0035	0.0031	0.0033	0.0034	0.0032	0.0033	0.0033
Lead	mg/kg/week	0.000030	0.0000049	0.000019	0.000020	0.0000044	0.0000047	0.000019	0.0000046	0.0000047	0.0000047
Magnesium	mg/kg/week	0.67	0.29	0.30	0.33	0.37	0.51	0.63	0.34	0.38	0.41
Manganese	mg/kg/week	0.022	0.015	0.016	0.017	0.011	0.017	0.019	0.011	0.011	0.011
Mercury	mg/kg/week	0.0000050	0.0000049	0.0000049	0.0000050	0.0000044	0.0000047	0.0000048	0.0000046	0.0000046	0.0000047
Molybdenum	mg/kg/week	0.00026	0.000020	0.000088	0.00016	0.00030	0.0014	0.0041	0.00012	0.00023	0.00034
Nickel	mg/kg/week	0.000050	0.000049	0.000049	0.000050	0.000044	0.000047	0.00096	0.000046	0.000047	0.000047
Phosphorus	mg/kg/week	0.0015	0.0015	0.0015	0.0015	0.0014	0.0026	0.016	0.0014	0.0014	0.0014
Potassium	mg/kg/week	2.7	0.14	0.16	0.18	0.46	0.70	1.0	0.19	0.19	0.19
Selenium	mg/kg/week	0.000060	0.000019	0.000020	0.000020	0.000075	0.00016	0.00028	0.000018	0.000019	0.000019
Silver	mg/kg/week	0.000025	0.000024	0.000024	0.000025	0.000022	0.000024	0.000024	0.000023	0.000023	0.000023
Sodium	mg/kg/week	4.1	0.078	0.10	0.10	1.3	2.6	4.7	0.18	0.20	0.23
Thallium	mg/kg/week	0.0000025	0.0000024	0.0000024	0.0000025	0.0000022	0.0000024	0.000014	0.0000023	0.0000023	0.0000023
Uranium	mg/kg/week	0.0016	0.00017	0.00018	0.00020	0.00019	0.00048	0.00072	0.00023	0.00036	0.00048
Zinc	mg/kg/week	0.0019	0.00097	0.00099	0.0020	0.00088	0.00094	0.00096	0.00092	0.00093	0.00094
Chloride	mg/kg/week	*0.000055*	*0.000045*	*0.000050*	*0.000055*	*0.000045*	*0.000050*	*0.000055*	*0.000045*	*0.000050*	*0.000055*
Nitrate + Nitrite (as Nitrogen)	mg/kg/week	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*
Nitrite (as Nitrogen)	mg/kg/week	*0.0000061*	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000050*	*0.0000055*	*0.0000061*
Nitrate (as Nitrogen)	mg/kg/week	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*
Total Ammonia (as Nitrogen)	mg/kg/week	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*
Un-ionized Ammonia (as Nitrogen)	mg/kg/week	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*
Cyanide, Total	mg/kg/week	*0.0000061*	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000050*	*0.0000055*	*0.0000061*
Cyanide, WAD	mg/kg/week	*0.00000061*	*0.00000050*	*0.00000055*	*0.00000061*	*0.00000050*	*0.00000055*	*0.00000061*	*0.00000050*	*0.00000055*	*0.00000061*
Sulphate	mg/kg/week	2.9	0.68	0.78	0.80	1.4	4.3	8.3	0.37	0.37	0.37
Fluoride	mg/kg/week	0.030	0.029	0.029	0.030	0.026	0.028	0.029	0.027	0.028	0.028
Radium-226	Bq/kg/week	*0.0000028*	*0.0000023*	*0.0000025*	*0.0000028*	*0.0000023*	*0.0000025*	*0.0000028*	*0.0000023*	*0.0000025*	*0.0000028*
Temperature	°C	*22*	*18*	*20*	*22*	*18*	*20*	*22*	*18*	*20*	*22*
Total Alkalinity (as $CaCO_3$)	mg/kg/week	22	8.7	10	12	11	13	22	9	10	11
pH	pH Unit	8.1	7.3	7.4	7.4	7.9	8.0	8.5	7.7	7.7	9.1
Hardness (as $CaCO_3$)	mg/kg/week	*0.00055*	*0.00045*	*0.00050*	*0.00055*	*0.00045*	*0.00050*	*0.00055*	*0.00045*	*0.00050*	*0.00055*
Dissolved Organic Carbon	mg/kg/week	*0.00055*	*0.00045*	*0.00050*	*0.00055*	*0.00045*	*0.00050*	*0.00055*	*0.00045*	*0.00050*	*0.00055*

Notes:

Values of the parameters shown in Italics and shaded are the respective detection limits conservatively used for modeling when laboratory measured values were not available.

Temperature and pH are shown for information; no calculations are applied for these parameters.

Table C-4: Input leaching rates (mg/kg/week) and pH values from humidity cells

Sample	Units	**Marathon Tailings (CND1)**						**Leprechaun Tailings (CND2)**					
Period		1st 2 Months*	1st 2 Months*	1st 2 Months*	Last Month	Last Month	Last Month	1st 2 Months*	1st 2 Months*	1st 2 Months*	Last Month	Last Month	Last Month
Statictics		Min	Median	Max	Min	Median	Max	Min	Median	Max	Min	Median	Max
Aluminum	mg/kg/week	0.010	0.017	0.023	0.015	0.015	0.015	0.016	0.027	0.057	0.026	0.026	0.026
Antimony	mg/kg/week	0.00039	0.00042	0.00043	0.00045	0.00045	0.00045	0.00039	0.00041	0.00043	0.00044	0.00044	0.00044
Arsenic	mg/kg/week	0.00026	0.00065	0.0010	0.00030	0.00030	0.00030	0.000087	0.000091	0.000095	0.00010	0.00010	0.00010
Barium	mg/kg/week	0.0018	0.0026	0.0026	0.0017	0.0017	0.0017	0.0021	0.0029	0.0030	0.0031	0.0031	0.0031
Boron	mg/kg/week	0.00087	0.0048	0.0094	0.0010	0.0010	0.0010	0.00087	0.00095	0.0045	0.0020	0.0020	0.0020
Cadmium	mg/kg/week	0.0000014	0.0000028	0.0000094	0.0000090	0.0000090	0.0000090	0.0000013	0.0000063	0.000017	0.0000039	0.0000039	0.0000039
Calcium	mg/kg/week	18	37	47	42	42	42	11	17	27	31	31	31
Chromium	mg/kg/week	0.000035	0.000037	0.00020	0.00014	0.00014	0.00014	0.000035	0.000038	0.00018	0.000079	0.000079	0.000079
Copper	mg/kg/week	0.0014	0.0022	0.0055	0.0018	0.0018	0.0018	0.0013	0.0052	0.0068	0.0018	0.0018	0.0018
Iron	mg/kg/week	0.0078	0.019	0.027	0.017	0.017	0.017	0.015	0.036	0.075	0.051	0.051	0.051
Lead	mg/kg/week	0.0000046	0.000026	0.000047	0.000010	0.000010	0.000010	0.0000044	0.0000090	0.000047	0.000010	0.000010	0.000010
Magnesium	mg/kg/week	1.4	2.7	2.8	2.6	2.6	2.6	1.6	2.7	4.8	9.3	9.3	9.3
Manganese	mg/kg/week	0.050	0.096	0.14	0.17	0.17	0.17	0.018	0.031	0.039	0.046	0.046	0.046
Mercury	mg/kg/week	0.0000043	0.0000047	0.0000048	0.0000050	0.0000050	0.0000050	0.0000044	0.0000045	0.0000047	0.0000049	0.0000049	0.0000049
Molybdenum	mg/kg/week	0.00091	0.0015	0.0020	0.00097	0.00097	0.00097	0.00058	0.00061	0.00092	0.0012	0.0012	0.0012
Nickel	mg/kg/week	0.00029	0.00037	0.00037	0.00030	0.00030	0.00030	0.000047	0.000090	0.000095	0.000098	0.000098	0.000098
Phosphorus	mg/kg/week	0.0013	0.0014	0.0014	0.0015	0.0015	0.0015	0.0013	0.0014	0.0014	0.0015	0.0015	0.0015
Potassium	mg/kg/week	0.53	1.2	1.5	0.36	0.36	0.36	0.81	1.0	1.2	0.75	0.75	0.75
Selenium	mg/kg/week	0.000048	0.000094	0.00012	0.000070	0.000070	0.000070	0.000054	0.000090	0.00014	0.00017	0.00017	0.00017
Silver	mg/kg/week	0.000022	0.000023	0.000024	0.000025	0.000025	0.000025	0.000022	0.000023	0.000024	0.000025	0.000025	0.000025
Sodium	mg/kg/week	2.6	9.7	16	3.2	3.2	3.2	4.8	8.2	15	4.2	4.2	4.2
Thallium	mg/kg/week	0.0000022	0.0000023	0.0000024	0.0000025	0.0000025	0.0000025	0.0000022	0.0000023	0.0000024	0.0000025	0.0000025	0.0000025
Uranium	mg/kg/week	0.000073	0.00012	0.00016	0.000038	0.000038	0.000038	0.000068	0.00011	0.00068	0.00011	0.00011	0.00011
Zinc	mg/kg/week	0.00087	0.00094	0.00095	0.0010	0.0010	0.0010	0.00087	0.00095	0.0027	0.00098	0.00098	0.00098
Chloride	mg/kg/week	0.087	0.46	0.76	0.10	0.10	0.10	0.17	0.36	0.66	0.098	0.098	0.098
Nitrate + Nitrite (as Nitrogen)	mg/kg/week	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*
Nitrite (as Nitrogen)	mg/kg/week	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000050*	*0.0000055*	*0.0000061*
Nitrate (as Nitrogen)	mg/kg/week	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*
Total Ammonia (as Nitrogen)	mg/kg/week	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*
Un-ionized Ammonia (as Nitrogen)	mg/kg/week	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*
Cyanide, Total	mg/kg/week	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000050*	*0.0000055*	*0.0000061*
Cyanide, WAD	mg/kg/week	0.0043	0.0043	0.0043	0.0050	0.0050	0.0050	0.0044	0.0044	0.0044	0.0098	0.0098	0.0098
Sulphate	mg/kg/week	54	92	130	62	87	100	33	71	123	43	59	98
Fluoride	mg/kg/week	0.028	0.029	0.14	0.030	0.030	0.030	0.057	0.066	0.12	0.15	0.15	0.15
Radium-226	Bq/kg/week	*0.0000023*	*0.0000025*	*0.0000028*	*0.0000023*	*0.0000025*	*0.0000028*	*0.0000023*	*0.0000025*	*0.0000028*	*0.0000023*	*0.0000025*	*0.0000028*
Temperature	°C	*18*	*20*	*22*	*18*	*20*	*22*	*18*	*20*	*22*	*18*	*20*	*22*
Total Alkalinity (as $CaCO_3$)	mg/kg/week	5	8	14	7.0	8.0	8.2	7.8	10	21	10	11	14
pH	pH Unit	7.1	7.2	7.7	7.2	7.3	7.4	7.3	8.3	8.5	7.4	7.6	7.8
Hardness (as $CaCO_3$)	mg/kg/week	*0.00045*	*0.00050*	*0.00055*	*0.00045*	*0.00050*	*0.00055*	*0.00045*	*0.00050*	*0.00055*	*0.00045*	*0.00050*	*0.00055*
Dissolved Organic Carbon	mg/kg/week	*0.00045*	*0.00050*	*0.00055*	*0.00045*	*0.00050*	*0.00055*	*0.00045*	*0.00050*	*0.00055*	*0.00045*	*0.00050*	*0.00055*

Notes:

Values of the parameters shown in Italics and shaded are the respective detection limits conservatively used for modeling when laboratory measured values were not available.

Temperature and pH are shown for information; no calculations are applied for these parameters.

Table C-5. Leprechaun mine mass inputs

Mine Year End	Model year End	HGO mine rate	LGO mine rate	Waste rock mine rate	LGO stockpile balance	Waste rock storage balance	HGO stockpile balance	Mill feed from Leprechaun pit
Unit	Year	ktonnes/yr			ktonnes			%
Y-1	1	44	74	3686	74	180	406	0%
Y1	2	1407	1273	16881	1347	16969	1887	41%
Y2	3	1321	896	16502	2244	32556	2577	42%
Y3	4	267	288	25914	2532	57235	2177	17%
Y4	5	802	880	25117	3412	82352	1527	32%
Y5	6	1168	302	23871	3713	106223	152	42%
Y6	7	1741	460	17266	3723	123489	0	56%
Y7	8	1776	398	8834	4121	132324	0	44%
Y8	9	1429	228	2958	4349	135281	0	36%
Y9	10	844	0	606	4049	135888	0	29%
Y10	11	0	0	0	2549	135888	0	38%
Y11	12	0	0	0	1049	135888	0	38%
Y12	13	0	0	0	0	135888	0	36%
Y13	14	0	0	0	0	135888	0	36%
Y14	15	0	0	0	0	135888	0	36%
Y15	500	0	0	0	0	135888	0	36%

Notes:
HGO - High-Grade Ore
LGO - Low-Grade Ore
TMF - Tailings Management Facility

Table C-6: SFE as input of runoff from waste rock, ore and overburden piles.

Parameter	Units	MDMER	CWQG	CWQG	L QZ-QTP	L SED	L TRJ	LLGO Comp	Leprechaun OB			
Statistics			Short-term	Long-term	11-Mar-20	11-Mar-20	11-Mar-20	07-May-20	Min	Mean	Max	St. Dev.
Aluminum	µg/L	-	-	100	**1470**	**1480**	**1240**	**1520**	2.0	**149**	**359**	140
Antimony	µg/L	-	-	-	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.0008
Arsenic	µg/L	100	-	5	0.50	2.4	0.80	0.90	0.30	0.86	1.8	0.6
Barium	µg/L	-	-	-	3.7	2.1	7.3	2.7	1.0	4.4	12	4
Boron	µg/L	-	29000	1500	9.0	7.0	8.0	23	3.0	3.8	6.0	1
Cadmium	µg/L	-	0.13	0.04	0.0030	0.0015	0.0015	0.0040	0.0030	0.0058	0.011	0.003
Calcium	µg/L	-	-	-	5420	4250	5300	7970	80	292	480	175
Chromium	µg/L	-	-	1	0.040	0.080	0.040	0.040	0.040	0.29	0.73	0.3
Copper	µg/L	100	-	2	0.50	0.70	0.30	1.4	0.10	0.90	1.6	0.6
Iron	µg/L	-	-	300	3.5	28	3.5	3.5	3.5	143	**346**	135
Lead	µg/L	80	-	1	0.030	0.030	0.030	0.080	0.0050	0.57	**2.5**	1
Magnesium	µg/L	-	-	-	593	266	548	1020	46	179	525	181
Manganese	µg/L	-	596	210	1.3	1.6	1.3	2.0	2.0	39	98	33
Mercury	µg/L	-	-	0.026	0.0050	0.0050	0.0050	0.010	0.0050	0.0050	0.0050	0.000
Molybdenum	µg/L	-	-	73	0.090	0.12	0.080	0.21	0.070	0.12	0.19	0.04
Nickel	µg/L	250	-	25	0.20	0.40	0.10	0.050	0.20	0.52	0.90	0.256
Phosphorus	µg/L	-	-	4	**100**	**100**	**100**	**100**	**99**	**100**	**100**	0.2
Potassium	µg/L	-	-	-	3760	4480	3380	3630	48	298	638	201
Selenium	µg/L	-	-	1	0.040	0.020	0.020	0.15	0.040	0.070	0.10	0.02
Silver	µg/L	-	-	0.25	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.00004
Sodium	µg/L	-	-	-	7370	5880	7640	6790	750	1500	2300	509
Thallium	µg/L	-	-	0.8	0.0025	0.0025	0.0025	0.034	0.024	0.025	0.025	0.0004
Uranium	µg/L	-	33	15	0.63	0.28	0.24	0.31	0.0020	0.014	0.027	0.009
Zinc	µg/L	400	11.3	2.2	1.0	1.0	1.0	1.0	1.0	**9.0**	**29**	12
Chloride	µg/L	-	640000	120000	1000	1000	1000	1000	990	1000	1000	2
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	50	50	50	50	50	50	50	0.08
Nitrite (as Nitrogen)	µg/L	-	-	60	10	10	10	10	9.9	10	10	0.02
Nitrate (as Nitrogen)	µg/L	-	550000	13000	50	50	50	50	50	50	50	0.08
Total Ammonia (as Nitrogen)	µg/L	-	-	689	50	50	50	50	50	50	50	0.08
Un-ionized Ammonia (as Nitrogen)	µg/L	500	16	16	**29**	**29**	**29**	**22**	0.0063	0.021	0.037	0.01
Cyanide, Total	µg/L	500	-	-	10	10	10	10	9.9	10	10	0.02
Cyanide, WAD	µg/L	-	-	5	1.0	1.0	1.0	1.0	0.99	1.0	1.0	0.002
Sulphate	µg/L	-	-	-	1000	1000	1000	1000	1000	3000	6000	1897
Fluoride	µg/L	-	-	120	90	100	60	80	30	36	60	12
Radium-226	Bg/L	0.37	-	-	0.050	0.050	0.050	0.050	0.050	0.050	0.0500	0.00008
Temperature	°C	-	-	-	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.0002
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	39	33	38	37	990	1000	1000	2
pH	pH Unit	6.0-9.5	-	6.5-9.0	**9.6**	**9.6**	**9.6**	**9.3**	**5.5**	**6.0**	**6.3**	0.3
Hardness (as $CaCO_3$)	mg/L	-	-	-	1.0	1.0	1.0	1.0	0.99	1.0	1.0	0.002
Dissolved Organic Carbon	mg/L	-	-	-	1.0	1.0	1.0	1.0	0.99	1.0	1.0	0.002

Notes: See Table C-1 notes for details on the parameters and guidelines.

Table C-7: Total element concentrations in waste rock and ore (ppm).

Parameter	**L TRJ**	**L SED**	**L LGO**	**L Ore**
Statistics	Mean	Mean	Mean	Mean
Aluminum	6323	9268	6547	10303
Antimony	0.40	0.44	0.42	0.46
Arsenic	1.4	4.7	2.2	3.7
Barium	954	458	354	450
Boron	0.010	0.010	0	0
Cadmium	0.044	0.053	0.048	0.38
Calcium	3	15	10	10
Chromium	53	64	81	68
Copper	8	14	42	27
Iron	2721	11032	10457	14089
Lead	11.7	9.8	9.9	12
Magnesium	1042	4316	3037	5093
Manganese	486	938	512	603
Mercury	0.025	0.025	0.040	0.025
Molybdenum	0.35	0.74	0.83	1.0
Nickel	3	24	12	9.6
Phosphorus	23	75	47	41
Potassium	1048	1223	874	824
Selenium	0.48	0.46	0.44	0.44
Silver	0.044	0.037	0.12	0.14
Sodium	4113	1410	2710	3980
Thallium	0.21	0.18	0.15	0.16
Uranium	0.2	1.1	0.51	0.41
Zinc	33	69	41	110
Chloride	0.010	0.010	0.010	0.010
Nitrate + Nitrite (as Nitrogen)	0.010	0.010	0.010	0.010
Nitrite (as Nitrogen)	0.010	0.010	0.010	0.010
Nitrate (as Nitrogen)	0.010	0.010	0.010	0.010
Total Ammonia (as Nitrogen)	0.010	0.010	0.010	0.010
Un-ionized Ammonia (as Nitrogen)	0.010	0.010	0.010	0.010
Cyanide, Total	0.010	0.010	0.010	0.010
Cyanide, WAD	0.010	0.010	0.010	0.010
Sulphate	0.010	0.010	0.010	0.010
Fluoride	0.010	0.010	0.010	0.010
Radium-226	0.010	0.010	0.010	0.010
Temperature	0.010	0.010	0.010	0.010
Total Alkalinity (as $CaCO_3$)	0.010	0.010	0.010	0.010
pH	0.010	0.010	0.010	0.010
Hardness (as $CaCO_3$)	0.010	0.010	0.010	0.010
Dissolved Organic Carbon	0.010	0.010	0.010	0.010

Notes: See Table C-1 notes for details on the parameters and guidelines.

Table C-8: Inputs for process water quality and ageing constants

Parameter	**Units**	MDMER	CWQG	**CWQG**	**Ageing tests (CND 1 and CND 2) Day 0***			**K Ageing**
Statistics			Short-term	Long-term	Min	Median	Max	Mean
Aluminum	µg/L	-	-	100	96	98	100	0.021
Antimony	µg/L	-	-	-	11	14	16	0.014
Arsenic	µg/L	100	-	5	2.5	**9.5**	**16**	0.0043
Barium	µg/L	-	-	-	16	27	38	*0*
Boron	µg/L	-	29000	1500	87	89	91	*0*
Cadmium	µg/L	-	0.13	0.04	0.039	**0.042**	**0.044**	*0*
Calcium	µg/L	-	-	-	84500	108750	133000	*0*
Chromium	µg/L	-	-	1	0.47	**2.0**	**3.6**	0.047
Copper	µg/L	100	-	2	**10**	**13**	**15**	*0*
Iron	µg/L	-	-	300	**846**	**1928**	**3010**	0.070
Lead	µg/L	80	-	1	0.14	0.16	0.17	0.032
Magnesium	µg/L	-	-	-	4520	6265	8010	*0*
Manganese	µg/L	-	596	210	28	31	34	*0*
Mercury	µg/L	-	-	0.026	**0.23**	**0.50**	**0.77**	**0.073**
Molybdenum	µg/L	-	-	73	**74**	**80**	**85**	*0*
Nickel	µg/L	250	-	25	0.60	1.8	2.9	*0*
Phosphorus	µg/L	-	-	4	**31**	**31**	**31**	*0*
Potassium	µg/L	-	-	-	19500	20050	20600	*0*
Selenium	µg/L	-	-	1	**4.3**	**4.3**	**4.3**	0.031
Silver	µg/L	-	-	0.25	**0.45**	**0.49**	**0.52**	0.064
Sodium	µg/L	-	-	-	462000	474500	487000	*0*
Thallium	µg/L	-	-	0.8	0.0025	0.0025	0.0025	*0*
Uranium	µg/L	-	33	15	1.6	2.3	3.0	*0*
Zinc	µg/L	400	11.3	2.2	**3.0**	**4.5**	**6.0**	0.023
Chloride	µg/L	-	640000	120000	27000	31000	35000	*0*
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	297	300	303	*0*
Nitrite (as Nitrogen)	µg/L	-	-	60	**149**	**150**	**152**	*0*
Nitrate (as Nitrogen)	µg/L	-	550000	13000	297	300	303	*0*
Total Ammonia (as Nitrogen)	µg/L	-	-	689	**12100**	**12150**	**12200**	*0*
Un-ionized Ammonia (as Nitrogen)	µg/L	500	16	16	**477**	**770**	**1062**	*0*
Cyanide, Total	µg/L	500	-	-	2360	5600	8840	0.077
Cyanide, WAD	µg/L	-	-	5	**80**	**105**	**130**	0.032
Sulphate	µg/L	-	-	-	960000	970000	980000	*0*
Fluoride	µg/L	-	-	120	**560**	**855**	**1150**	*0*
Radium-226	Bg/L	0.37	-	-	0.0050	0.0050	0.0051	*0*
Temperature	°C	-	-	-	19	19	19	*0*
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	73	82	90	*0*
pH	pH Unit	6.0-9.5	-	6.5-9.0	7.9	8.0	8.0	*0*
Hardness (as $CaCO_3$)	mg/L	-	-	-	0.99	1.0	1.0	*0*
Dissolved Organic Carbon	mg/L	-	-	-	0.99	1.0	1.0	*0*

Notes:

* Total and un-ionized ammonia results for day 28 to account for ammonia formation in the TMF pond as a result of CN degradation.

See Table C-1 notes for details on the parameters and guidelines.

K Ageing = the first order constant derived from laboratory tests (see *Valentine Gold Project: Acid Rock Drainage/Metal Leaching (ARD/ML) assessment report* for complete test results).

Table C-9: Inputs for TMF seepage quality.

Parameter	**Units**	MDMER	CWQG	**CWQG**	**Construction operation**				**Closure and Post-closure**			
Statistics			Short-term	Long-term	Min	Mean	Max	St.dev.	Min	Mean	Max	St.dev.
Aluminum	µg/L	-	-	100	15	26	66	11	21	22	24	0.9
Antimony	µg/L	-	-	-	2.1	5.3	11	2	1.8	2.0	2.1	0.1
Arsenic	µg/L	100	-	5	2.2	**8.1**	**18**	6	1.5	**9.2**	**18**	8
Barium	µg/L	-	-	-	10	32	79	17	4.1	9.6	16	4
Boron	µg/L	-	29000	1500	60	76	89	8	23	31	36	5
Cadmium	µg/L	-	0.13	0.04	0.024	**0.062**	**0.12**	0.03	0.0050	0.016	0.033	0.009
Calcium	µg/L	-	-	-	32800	81106	199000	46276	22400	25750	28800	2270
Chromium	µg/L	-	-	1	0.040	0.20	**1.8**	0.4	0.040	0.090	0.28	0.09
Copper	µg/L	100	-	2	**40**	**936**	**1670**	435	**512**	**830**	**1130**	224
Iron	µg/L	-	-	300	13	32	96	21	32	70	96	21
Lead	µg/L	80	-	1	0.0050	0.058	0.20	0.06	0.020	0.023	0.030	0.005
Magnesium	µg/L	-	-	-	2430	9643	22900	5376	1720	2435	3290	654
Manganese	µg/L	-	596	210	28	96	**317**	82	23	27	33	3
Mercury	µg/L	-	-	0.026	0.0050	**0.19**	**1.0**	0.3	0.0050	0.0075	0.010	0.003
Molybdenum	µg/L	-	-	73	41	**80**	**106**	18	12	24	42	10
Nickel	µg/L	250	-	25	0.70	3.9	8.0	3	0.50	1.2	2.4	0.7
Phosphorus	µg/L	-	-	4	**13**	**35**	**191**	39	**5.0**	**9.0**	**17**	4
Potassium	µg/L	-	-	-	14800	23600	29500	3941	5910	9172	13900	2557
Selenium	µg/L	-	-	1	0.27	0.90	**3.4**	0.8	0.20	0.33	0.66	0.2
Silver	µg/L	-	-	0.25	0.025	**0.82**	**4.5**	1	0.025	0.025	0.025	3E-18
Sodium	µg/L	-	-	-	262000	448611	517000	69844	80600	116217	164000	32859
Thallium	µg/L	-	-	0.8	0.0025	0.0073	0.016	0.005	0.0025	0.0046	0.0090	0.002
Uranium	µg/L	-	33	15	2.1	3.6	5.0	0.8	0.96	1.9	3.3	0.8
Zinc	µg/L	400	11.3	2.2	2.0	**5.4**	**16**	3	1.0	1.5	2.0	0.5
Chloride	µg/L	-	640000	120000	15000	30222	40000	6434	4000	7767	13000	2872
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	297	300	300	0.5	297	300	300	1
Nitrite (as Nitrogen)	µg/L	-	-	60	**149**	**150**	**150**	0.3	**149**	**150**	**150**	0.3
Nitrate (as Nitrogen)	µg/L	-	550000	13000	297	300	300	0.5	297	300	300	1
Total Ammonia (as Nitrogen)	µg/L	-	-	689	**3100**	**23272**	**41600**	11460	**15200**	**21383**	**28400**	5000
Un-ionized Ammonia (as Nitrogen)	µg/L	500	16	16	**141**	**1485**	**2885**	851	**914**	**1290**	**1657**	291
Cyanide, Total	µg/L	500	-	-	10	753	1740	701	840	1317	1700	325
Cyanide, WAD	µg/L	-	-	5	1.0	**623**	**1710**	599	**600**	**945**	**1220**	263
Sulphate	µg/L	-	-	-	240000	927889	1200000	209046	180000	286667	410000	87114
Fluoride	µg/L	-	-	120	**530**	**1257**	**2220**	531	**560**	**1197**	**1800**	503
Radium-226	Bg/L	0.37	-	-	0.0050	0.0050	0.0050	9E-19	0.0050	0.0050	0.0050	0.000008
Temperature	°C	-	-	-	14	18	21	2	18	18	19	0.5
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	117	169	232	32	115	144	182	23
pH	pH Unit	6.0-9.5	-	6.5-9.0	8.0	8.2	8.4	0.1	8.2	8.3	8.3	0.03
Hardness (as $CaCO_3$)	mg/L	-	-	-	0.99	1.0	1.0	0.002	0.99	1.0	1.0	0.002
Dissolved Organic Carbon	mg/L	-	-	-	0.99	1.0	1.0	0.002	0.99	1.0	1.0	0.002

Notes: See Table C-1 notes for details on the parameters and guidelines.

Appendix D SUMMARIES OF WATER QUALITY PREDICTIONS

Table D-1: Baseline water quality in the area of the open pit and waste rock

Parameter	Units	MDMER	CWQG	**CWQG**	Baseline		
Statistics			Short-term	Long-term	mean	75 %ile	95 %ile (5 %ile for pH)
Aluminum	µg/L	-	-	100	**130**	**170**	**240**
Antimony	µg/L	-	-	-	0.50	0.50	0.50
Arsenic	µg/L	100	-	5	1.1	1.4	2.0
Barium	µg/L	-	-	-	3.8	5.0	7.4
Boron	µg/L	-	29000	1500	25	25	25
Cadmium	µg/L	-	0.13	0.04	0.0099	0.012	0.016
Calcium	µg/L	-	-	-	9700	13000	19000
Chromium	µg/L	-	-	1	**2.4**	**3.3**	**5.2**
Copper	µg/L	100	-	2	1.1	1.4	1.9
Iron	µg/L	-	-	300	290	**390**	**550**
Lead	µg/L	80	-	1	0.30	0.32	0.37
Magnesium	µg/L	-	-	-	1300	1600	2300
Manganese	µg/L	-	596	210	200	**300**	**460**
Mercury	µg/L	-	-	0.026	0.011	0.013	0.017
Molybdenum	µg/L	-	-	73	1.2	1.3	1.5
Nickel	µg/L	250	-	25	1.0	1.0	1.0
Phosphorus	µg/L	-	-	4	**50**	**50**	**50**
Potassium	µg/L	-	-	-	360	480	690
Selenium	µg/L	-	-	1	0.46	0.49	0.50
Silver	µg/L	-	-	0.25	0.050	0.050	0.050
Sodium	µg/L	-	-	-	2300	2700	3300
Thallium	µg/L	-	-	0.8	0.050	0.050	0.050
Uranium	µg/L	-	33	15	0.086	0.10	0.14
Zinc	µg/L	400	11.3	2.2	**4.9**	**6.0**	**7.9**
Chloride	µg/L	-	640000	120000	3100	3800	4700
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	58	74	100
Nitrite (as Nitrogen)	µg/L	-	-	60	7.9	9.3	12
Nitrate (as Nitrogen)	µg/L	-	550000	13000	59	72	100
Total Ammonia (as Nitrogen)	µg/L	-	-	689	63	88	140
Un-ionized Ammonia (as Nitrogen)	µg/L	500	16	16	0.15	0.22	0.32
Cyanide, Total	µg/L	500	-	-	10	10	10
Cyanide, WAD	µg/L	-	-	5	1.0	1.0	1.0
Sulphate	µg/L	-	-	-	1800	2200	3000
Fluoride	µg/L	-	-	120	60	60	60
Radium-226	Bg/L	0.37	-	-	0.0050	0.0050	0.0050
Temperature	°C	-	-	-	10	14	18
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	27	38	54
pH	pH Unit	6.0-9.5	-	6.5-9.0	7.2	7.4	6.8
Hardness (as $CaCO_3$)	mg/L	-	-	-	29	39	58
Dissolved Organic Carbon	mg/L	-	-	-	1.0	1.0	1.0

Notes: See Table C-1 notes for details on the parameters and guidelines.

Table D-2: Baseline water quality in the TMF area

Parameter	Units	MDMER	CWQG	**CWQG**	Baseline		
Statistics			Short-term	Long-term	mean	75 %ile	95 %ile (5 %ile for pH)
Aluminum	µg/L	-	-	100	79	**110**	**150**
Antimony	µg/L	-	-	-	0.50	0.50	0.50
Arsenic	µg/L	100	-	5	3.8	**5.5**	**8.0**
Barium	µg/L	-	-	-	1.9	2.4	3.3
Boron	µg/L	-	29000	1500	25	25	25
Cadmium	µg/L	-	0.13	0.04	0.011	0.014	0.019
Calcium	µg/L	-	-	-	8100	11000	16000
Chromium	µg/L	-	-	1	**1.2**	**1.5**	**2.2**
Copper	µg/L	100	-	2	1.2	1.5	2.0
Iron	µg/L	-	-	300	210	270	**380**
Lead	µg/L	80	-	1	0.25	0.25	0.25
Magnesium	µg/L	-	-	-	1000	1300	1800
Manganese	µg/L	-	596	210	150	**220**	**340**
Mercury	µg/L	-	-	0.026	0.0081	0.0091	0.011
Molybdenum	µg/L	-	-	73	1.0	1.0	1.0
Nickel	µg/L	250	-	25	1.0	1.0	1.0
Phosphorus	µg/L	-	-	4	**62**	**68**	**81**
Potassium	µg/L	-	-	-	160	200	270
Selenium	µg/L	-	-	1	0.46	0.49	0.50
Silver	µg/L	-	-	0.25	0.050	0.050	0.050
Sodium	µg/L	-	-	-	1800	2000	2300
Thallium	µg/L	-	-	0.8	0.050	0.050	0.050
Uranium	µg/L	-	33	15	0.068	0.078	0.096
Zinc	µg/L	400	11.3	2.2	**4.8**	**6.1**	**8.2**
Chloride	µg/L	-	640000	120000	2600	3300	4000
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	75	100	150
Nitrite (as Nitrogen)	µg/L	-	-	60	5.0	5.0	5.0
Nitrate (as Nitrogen)	µg/L	-	550000	13000	76	99	140
Total Ammonia (as Nitrogen)	µg/L	-	-	689	53	69	94
Un-ionized Ammonia (as Nitrogen)	µg/L	500	16	16	0.17	0.25	0.39
Cyanide, Total	µg/L	500	-	-	10	10	10
Cyanide, WAD	µg/L	-	-	5	1.0	1.0	1.0
Sulphate	µg/L	-	-	-	1400	1600	2100
Fluoride	µg/L	-	-	120	60	60	60
Radium-226	Bg/L	0.37	-	-	0.0050	0.0050	0.0050
Temperature	°C	-	-	-	10	14	18
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	24	31	44
pH (mean or 5 %ile)	pH Unit	6.0-9.5	-	6.5-9.0	7.2	7.4	6.8
Hardness (as $CaCO_3$)	mg/L	-	-	-	24	31	45
Dissolved Organic Carbon	mg/L	-	-	-	1.0	1.0	1.0

Notes: See Table C-1 notes for details on the parameters and guidelines.

Table D-3: The highest value of the monthly mean and 95th %-ile for each project phase in waste rock seepage

Parameter	Units	MDMER	CWQG	**CWQG**	Baseline		Construction		Operation		Closure		Post-closure	
Statistics			Short-term	Long-term	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile
Aluminum	µg/L	-	-	100	**130**	**240**	**140**	**210**	**600**	**600**	**600**	**600**	**600**	**600**
Antimony	µg/L	-	-	-	0.50	0.50	0.52	0.52	32	38	31	37	18	22
Arsenic	µg/L	100	-	5	1.1	2.0	1.2	1.8	**27**	**32**	**9.2**	**11**	**5.2**	**5.9**
Barium	µg/L	-	-	-	3.8	7.4	4.3	6.6	350	400	340	410	200	240
Boron	µg/L	-	29000	1500	25	25	25	25	120	140	95	110	66	74
Cadmium	µg/L	-	0.13	0.04	0.0099	0.016	0.011	0.015	**0.11**	**0.13**	**0.11**	**0.13**	**0.068**	**0.080**
Calcium	µg/L	-	-	-	9700	19000	11000	17000	220000	260000	170000	200000	99000	120000
Chromium	µg/L	-	-	1	**2.4**	**5.2**	**2.6**	**4.7**	**8.5**	**9.8**	**8.5**	**10**	**6.1**	**7.1**
Copper	µg/L	100	-	2	1.1	1.9	1.2	1.8	**37**	**46**	**28**	**34**	**16**	**19**
Iron	µg/L	-	-	300	290	**550**	**310**	**500**	**880**	**900**	**650**	**760**	**480**	**560**
Lead	µg/L	80	-	1	0.30	0.37	0.30	0.35	**2.6**	**3.3**	0.95	**1.1**	0.62	0.68
Magnesium	µg/L	-	-	-	1300	2300	1400	2000	19000	23000	12000	15000	7500	8700
Manganese	µg/L	-	596	210	200	**460**	**230**	**420**	**1300**	**1300**	**1100**	**1300**	**690**	**790**
Mercury	µg/L	-	-	0.026	0.011	0.017	0.011	0.017	**0.36**	**0.43**	**0.34**	**0.41**	**0.21**	**0.24**
Molybdenum	µg/L	-	-	73	1.2	1.5	1.2	1.4	15	18	12	15	7.7	9.2
Nickel	µg/L	250	-	25	1.0	1.0	1.0	1.0	4.6	5.2	4.4	5.1	3.0	3.4
Phosphorus	µg/L	-	-	4	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**
Potassium	µg/L	-	-	-	360	690	420	630	95000	120000	18000	24000	7900	9600
Selenium	µg/L	-	-	1	0.46	0.50	0.47	0.50	**1.9**	**2.2**	**1.8**	**2.1**	**1.3**	**1.4**
Silver	µg/L	-	-	0.25	0.050	0.050	0.051	0.051	**1.8**	**2.1**	**1.7**	**2.1**	**1.0**	**1.2**
Sodium	µg/L	-	-	-	2300	3300	2400	3200	90000	110000	12000	17000	4900	6200
Thallium	µg/L	-	-	0.8	0.050	0.050	0.050	0.050	0.290	0.33	0.28	0.33	0.19	0.22
Uranium	µg/L	-	33	15	0.086	0.14	0.10	0.13	**34**	**42**	**25**	**30**	14	**18**
Zinc	µg/L	400	11.3	2.2	**4.9**	**7.9**	**5.2**	**7.5**	**75**	**88**	**71**	**85**	**44**	**52**
Chloride	µg/L	-	640000	120000	3100	4700	3400	4600	3400	4600	3400	4600	3400	4700
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	58	100	5300	13000	22000	28000	330	640	90	150
Nitrite (as Nitrogen)	µg/L	-	-	60	7.9	12	**120**	**300**	**510**	**650**	14	21	9.0	12
Nitrate (as Nitrogen)	µg/L	-	550000	13000	59	100	5100	13000	**22000**	**28000**	320	620	89	150
Total Ammonia (as Nitrogen)	µg/L	-	-	689	63	140	**700**	**1600**	**2800**	**3600**	94	130	75	140
Un-ionized Ammonia (as Nitrogen)	µg/L	500	16	16	0.15	0.32	**27**	**61**	**110**	**140**	3.6	4.9	2.9	5.3
Cyanide, Total	µg/L	500	-	-	10	10	10	10	11	11	11	11	11	11
Cyanide, WAD	µg/L	-	-	5	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.1
Sulphate	µg/L	-	-	-	1800	3000	1900	2700	45000	55000	11000	14000	6000	6700
Fluoride	µg/L	-	-	120	60	60	62	62	**1600**	**1600**	**1600**	**1600**	**1600**	**1600**
Radium-226	Bg/L	0.37	-	-	0.0050	0.0050	0.0051	0.0051	0.1900	0.22	0.18	0.21	0.11	0.13
Temperature	°C	-	-	-	10	18	9.2	17	9.3	18	9.1	18	10	18
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	27	54	510	720	880000	1100000	550000	660000	310000	370000
pH (mean or 5 %ile)	pH Unit	6.0-9.5	-	6.5-9.0	7.2	6.8	7.9	7.8	7.9	7.8	7.4	7.3	7.4	7.3
Hardness (as $CaCO_3$)	mg/L	-	-	-	29	58	33	51	630	740	470	560	280	340
Dissolved Organic Carbon	mg/L	-	-	-	1.0	1.0	1.0	1.0	38	44	36	43	21	25

Notes: See Table C-1 notes for details on the parameters and guidelines.

Table D-4: The highest value of the monthly mean and 95th %-ile for each project phase in seepage from the low grade ore stockpile

Parameter	Units	MDMER	CWQG	**CWQG**	Baseline		Construction		Operation		Closure		Post-closure	
Statistics			Short-term	Long-term	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile
Aluminum	µg/L	-	-	100	**130**	**240**	**150**	**210**	**600**	**600**	**600**	**600**	**130**	**240**
Antimony	µg/L	-	-	-	0.50	0.50	0.69	0.74	23	27	5.5	7.2	0.50	0.50
Arsenic	µg/L	100	-	5	1.1	2.0	1.2	1.8	**11**	**13**	3.2	4	1.1	2.0
Barium	µg/L	-	-	-	3.8	7.4	4.3	6.6	47	54	13	16	4	7
Boron	µg/L	-	29000	1500	25	25	27	27	200	230	62	78	25	25
Cadmium	µg/L	-	0.13	0.04	0.0099	0.016	0.011	0.015	**0.12**	**0.15**	0.034	**0.043**	0.0099	0.016
Calcium	µg/L	-	-	-	9700	19000	11000	17000	120000	140000	34000	43000	9700	19000
Chromium	µg/L	-	-	1	**2.4**	**5.2**	**2.6**	**4.7**	**4.2**	**5.2**	**2.6**	**5**	**2.4**	**5.2**
Copper	µg/L	100	-	2	1.1	1.9	1.2	1.8	**5.3**	**6.3**	1.9	**2.3**	1.1	1.9
Iron	µg/L	-	-	300	290	**550**	**310**	**500**	**340**	**530**	280	**530**	290	**550**
Lead	µg/L	80	-	1	0.30	0.37	0.30	0.35	0.5	0.5	0.31	0.4	0.30	0.37
Magnesium	µg/L	-	-	-	1300	2300	1400	2000	14000	16000	3900	4900	1300	2300
Manganese	µg/L	-	596	210	200	**460**	**230**	**420**	**540**	**620**	**250**	**430**	200	**460**
Mercury	µg/L	-	-	0.026	0.011	0.017	0.012	0.017	**0.12**	**0.14**	**0.035**	**0.045**	0.011	0.017
Molybdenum	µg/L	-	-	73	1.2	1.5	1.6	1.7	50	61	12	17	1.2	1.5
Nickel	µg/L	250	-	25	1.0	1.0	1.1	1.1	9.8	13	2.9	3.9	1.0	1.0
Phosphorus	µg/L	-	-	4	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**
Potassium	µg/L	-	-	-	360	690	480	640	18000	22000	4400	5900	360	690
Selenium	µg/L	-	-	1	0.46	0.50	0.49	0.51	**4.6**	**5.4**	**1.4**	**1.7**	0.5	0.5
Silver	µg/L	-	-	0.25	0.050	0.050	0.055	0.056	**0.62**	**0.72**	0.18	0.22	0.050	0.050
Sodium	µg/L	-	-	-	2300	3300	2800	3200	74000	88000	18000	24000	2300	3300
Thallium	µg/L	-	-	0.8	0.050	0.050	0.051	0.052	0.200	0.24	0.08	0.09	0.05	0.05
Uranium	µg/L	-	33	15	0.086	0.14	0.18	0.21	12	14	2.7	3.5	0.086	0.14
Zinc	µg/L	400	11.3	2.2	**4.9**	**7.9**	**5.2**	**7.5**	**27**	**31**	**9.1**	**11**	**4.9**	**7.9**
Chloride	µg/L	-	640000	120000	3100	4700	3400	4600	3200	4600	3100	4600	3100	4700
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	58	100	1500	3800	10000	15000	86	140	58	100
Nitrite (as Nitrogen)	µg/L	-	-	60	7.9	12	40	**89**	**240**	**340**	7.9	12	7.9	12
Nitrate (as Nitrogen)	µg/L	-	550000	13000	59	100	1500	3700	10000	**15000**	82	140	59	100
Total Ammonia (as Nitrogen)	µg/L	-	-	689	63	140	230	480	**1300**	**1900**	66	130	63	140
Un-ionized Ammonia (as Nitrogen)	µg/L	500	16	16	0.15	0.32	8.7	**18**	**49**	**72**	2.5	4.9	0.2	0.3
Cyanide, Total	µg/L	500	-	-	10	10	10	10	10	10	10	10	10	10
Cyanide, WAD	µg/L	-	-	5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Sulphate	µg/L	-	-	-	1800	3000	2600	3000	120000	140000	29000	38000	1800	3000
Fluoride	µg/L	-	-	120	60	60	66	67	**750**	**860**	**210**	**270**	60	60
Radium-226	Bg/L	0.37	-	-	0.0050	0.0050	0.0055	0.0057	0.0670	0.08	0.019	0.024	0.0050	0.0050
Temperature	°C	-	-	-	10	18	9.2	17	9.3	18	9.1	18	10	18
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	27	54	3300	4100	390000	470000	90000	120000	27	54
pH (mean or 5 %ile)	pH Unit	6.0-9.5	-	6.5-9.0	7.2	6.8	8.1	7.9	8.2	7.9	8.2	7.8	7.2	6.8
Hardness (as $CaCO_3$)	mg/L	-	-	-	29	58	33	51	360	420	100	130	29	58
Dissolved Organic Carbon	mg/L	-	-	-	1.0	1.0	1.1	1.1	13	15	3.7	4.7	1.0	1.0

Notes: See Table C-1 notes for details on the parameters and guidelines.

Table D-5: The highest value of the monthly mean and 95th %-ile for each project phase in the TMF pond

Parameter	Units	MDMER	CWQG	**CWQG**	Baseline		Construction		Operation		Closure		Post-closure	
Statistics			Short-term	Long-term	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile
Aluminum	µg/L	-	-	100	79	**150**	79	**150**	**570**	**600**	**220**	**270**	91	**150**
Antimony	µg/L	-	-	-	0.50	0.50	0.50	0.50	17	20	2.2	2.9	1.0	1.2
Arsenic	µg/L	100	-	5	3.8	**8.0**	3.8	**8.0**	**17**	**21**	4.9	**8**	4.6	**8.0**
Barium	µg/L	-	-	-	1.9	3.3	1.9	3.3	48	59	8.9	12	5.3	7.3
Boron	µg/L	-	29000	1500	25	25	25	25	180	210	42	48	31	32
Cadmium	µg/L	-	0.13	0.04	0.0110	0.019	0.011	0.019	**0.09**	**0.11**	0.023	0.029	0.016	0.021
Calcium	µg/L	-	-	-	8100	16000	8100	16000	180000	210000	27000	37000	16000	20000
Chromium	µg/L	-	-	1	**1.2**	**2.2**	**1.2**	**2.2**	**2.6**	**3.3**	**1.2**	**2**	**1.3**	**2.2**
Copper	µg/L	100	-	2	1.2	2.0	1.2	2.0	**200**	**290**	**120**	**190**	**96**	**140**
Iron	µg/L	-	-	300	210	**380**	210	**380**	**580**	**630**	220	**350**	230	**380**
Lead	µg/L	80	-	1	0.25	0.25	0.25	0.25	0.3	0.4	0.25	0.3	0.25	0.25
Magnesium	µg/L	-	-	-	1000	1800	1000	1800	12000	15000	3200	4200	1900	2500
Manganese	µg/L	-	596	210	150	**340**	150	**340**	**310**	**480**	190	**320**	190	**340**
Mercury	µg/L	-	-	0.026	0.008	0.011	0.008	0.011	**0.48**	**0.63**	**0.05**	**0.09**	**0.04**	**0.06**
Molybdenum	µg/L	-	-	73	1.0	1.0	1.0	1.0	**120**	**150**	13	18	8.9	11.0
Nickel	µg/L	250	-	25	1.0	1.0	1.0	1.0	5.2	6.7	1.8	2.2	1.4	1.6
Phosphorus	µg/L	-	-	4	**62**	**81**	**62**	**81**	**61**	**79**	**61**	**78**	**62**	**81**
Potassium	µg/L	-	-	-	160	270	160	270	32000	39000	4000	5300	2500	3200
Selenium	µg/L	-	-	1	0.46	0.50	0.46	0.50	**4.5**	**5.6**	0.61	0.71	0.49	0.56
Silver	µg/L	-	-	0.25	0.050	0.050	0.050	0.050	**0.6**	**0.8**	0.22	**0.34**	0.16	0.25
Sodium	µg/L	-	-	-	1800	2300	1800	2300	670000	820000	62000	78000	46000	57000
Thallium	µg/L	-	-	0.8	0.050	0.050	0.050	0.050	0.100	0.11	0.055	0.060	0.058	0.058
Uranium	µg/L	-	33	15	0.068	0.10	0.068	0.10	5.4	6.6	1.4	2.0	0.42	0.52
Zinc	µg/L	400	11.3	2.2	**4.8**	**8.2**	**4.8**	**8.2**	**10**	**12**	**6.1**	**7.6**	**5.3**	**8.2**
Chloride	µg/L	-	640000	120000	2600	4000	2600	4000	46000	56000	6300	7400	5300	6500
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	75	150	75	150	490	590	110	150	94	140
Nitrite (as Nitrogen)	µg/L	-	-	60	5.0	5.0	5.0	5.0	**220**	**260**	25	30	20.0	23
Nitrate (as Nitrogen)	µg/L	-	550000	13000	76	140	76	140	490	600	110	140	91	140
Total Ammonia (as Nitrogen)	µg/L	-	-	689	53	94	53	94	**19000**	**23000**	**3100**	**4400**	**2400**	**3300**
Un-ionized Ammonia (as Nitrogen)	µg/L	500	16	16	0.17	0.39	0.17	0.39	**720**	**870**	**120**	**170**	**91**	**130**
Cyanide, Total	µg/L	500	-	-	10	10	10	10	5000	6700	120	190	81	130
Cyanide, WAD	µg/L	-	-	5	1.0	1.0	1.0	1.0	**170**	**230**	**96**	**160**	**64**	**110**
Sulphate	µg/L	-	-	-	1400	2100	1400	2100	1400000	1700000	130000	160000	94000	120000
Fluoride	µg/L	-	-	120	60	60	60	60	**1300**	**1400**	**290**	**370**	**190**	**250**
Radium-226	Bg/L	0.37	-	-	0.0050	0.0050	0.0050	0.0050	0.0280	0.033	0.011	0.014	0.0058	0.0058
Temperature	°C	-	-	-	10	18	9.8	18	9.3	18	9.1	18	10	18
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	24	44	24	44	93000	110000	28000	39000	37	48
pH (mean or 5 %ile)	pH Unit	6.0-9.5	-	6.5-9.0	7.2	6.8	7.2	6.8	8.2	8.0	8.2	7.9	8.2	7.9
Hardness (as $CaCO_3$)	mg/L	-	-	-	24	45	24	45	500	590	81	110	48	60
Dissolved Organic Carbon	mg/L	-	-	-	1.0	1.0	1.0	1.0	5.4	6.1	2.2	2.7	1.2	1.2

Notes: See Table C-1 notes for details on the parameters and guidelines.

Table D-6: The highest value of the monthly mean and 95th %-ile for each project phase in open pit discharge

Parameter	Units	MDMER	CWQG	**CWQG**	Baseline		Construction		Operation		Closure		Post-closure	
Statistics			Short-term	Long-term	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile
Aluminum	µg/L	-	-	100	**130**	**240**	**120**	**210**	**200**	**270**	**130**	**230**	**130**	**240**
Antimony	µg/L	-	-	-	0.50	0.50	0.50	0.50	7.7	9.1	1.1	1.1	0.50	0.50
Arsenic	µg/L	100	-	5	1.1	2.0	1.3	1.9	**6.2**	**8.2**	2.1	2.2	1.1	1.9
Barium	µg/L	-	-	-	3.8	7.4	5.3	7.3	36	43	19	20	13	13
Boron	µg/L	-	29000	1500	25	25	25	25	69	83	48	49	33	34
Cadmium	µg/L	-	0.13	0.04	0.0099	0.016	0.011	0.015	0.03	0.04	0.02	0.02	0.014	0.016
Calcium	µg/L	-	-	-	9700	19000	67000	96000	74000	97000	45000	46000	24000	24000
Chromium	µg/L	-	-	1	**2.4**	**5.2**	**2.1**	**4.6**	**2.4**	**5.2**	**2.3**	**5**	**2.4**	**5.1**
Copper	µg/L	100	-	2	1.1	1.9	1.2	1.7	**27**	**37**	**19**	**21**	**19**	**21**
Iron	µg/L	-	-	300	290	**550**	**480**	**830**	**480**	**850**	270	**530**	290	**550**
Lead	µg/L	80	-	1	0.30	0.37	0.29	0.35	0.46	0.64	0.29	0.35	0.30	0.37
Magnesium	µg/L	-	-	-	1300	2300	6400	9700	7100	10000	3300	3400	2100	2200
Manganese	µg/L	-	596	210	200	**460**	**610**	**1000**	**640**	**1000**	200	**430**	**240**	**460**
Mercury	µg/L	-	-	0.026	0.011	0.017	0.011	0.017	**0.23**	**0.29**	0.014	0.017	0.011	0.017
Molybdenum	µg/L	-	-	73	1.2	1.5	5.6	7.8	42	51	26	26	11	11
Nickel	µg/L	250	-	25	1.0	1.0	1.0	1.0	1.9	2.3	1.4	1.5	1.2	1.2
Phosphorus	µg/L	-	-	4	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**
Potassium	µg/L	-	-	-	360	690	610	840	13000	16000	7000	7200	3100	3200
Selenium	µg/L	-	-	1	0.46	0.50	0.45	0.50	**2.2**	**2.6**	0.45	0.50	0.46	0.50
Silver	µg/L	-	-	0.25	0.050	0.050	0.050	0.050	**0.30**	**0.33**	0.050	0.050	0.050	0.050
Sodium	µg/L	-	-	-	2300	3300	42000	69000	250000	290000	150000	150000	62000	63000
Thallium	µg/L	-	-	0.8	0.050	0.050	0.050	0.050	0.052	0.056	0.050	0.050	0.050	0.050
Uranium	µg/L	-	33	15	0.086	0.14	0.77	0.90	5.0	6.0	1.4	1.5	0.8	0.8
Zinc	µg/L	400	11.3	2.2	**4.9**	**7.9**	**4.7**	**7.5**	**11**	**12**	**4.7**	**7.6**	**4.9**	**7.9**
Chloride	µg/L	-	640000	120000	3100	4700	36000	58000	40000	61000	15000	15000	10000	10000
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	58	100	830	2000	6100	12000	220	240	160	180
Nitrite (as Nitrogen)	µg/L	-	-	60	7.9	12	22	49	**140**	**270**	54	55	28.0	29
Nitrate (as Nitrogen)	µg/L	-	550000	13000	59	100	810	2000	6000	12000	220	230	160	180
Total Ammonia (as Nitrogen)	µg/L	-	-	689	63	140	390	620	**6400**	**7800**	**3900**	**3900**	**1700**	**1800**
Un-ionized Ammonia (as Nitrogen)	µg/L	500	16	16	0.15	0.32	15	**24**	**240**	**300**	**150**	**150**	**65**	**68**
Cyanide, Total	µg/L	500	-	-	10	10	10	10	2400	3100	140	170	10	10
Cyanide, WAD	µg/L	-	-	5	1.0	1.0	1.1	1.2	**55**	**64**	3.7	4.2	1.0	1.0
Sulphate	µg/L	-	-	-	1800	3000	170000	290000	500000	600000	310000	310000	130000	130000
Fluoride	µg/L	-	-	120	60	60	60	60	**520**	**560**	**350**	**360**	**190**	**200**
Radium-226	Bg/L	0.37	-	-	0.0050	0.0050	0.0050	0.0050	0.026	0.031	0.0091	0.010	0.0076	0.0078
Temperature	°C	-	-	-	10	18	9.2	17	9.3	18	9.1	18	10	18
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	27	54	230	330	120000	140000	14000	16000	8100	8800
pH (mean or 5 %ile)	pH Unit	6.0-9.5	-	6.5-9.0	7.2	6.8	7.2	7.1	7.3	7.2	6.8	6.7	6.8	6.8
Hardness (as $CaCO_3$)	mg/L	-	-	-	29	58	190	280	210	280	130	130	69	69
Dissolved Organic Carbon	mg/L	-	-	-	1.0	1.0	1.0	1.0	5.2	6.1	1.8	1.9	1.4	1.5

Notes: See Table C-1 notes for details on the parameters and guidelines.

Table D-7: The highest value of the monthly mean and 95th %-ile for each project phase in FDP01

Parameter	Units	MDMER	CWQG	**CWQG**	Baseline		Construction		Operation		Closure		Post-closure	
Statistics			Short-term	Long-term	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile
Aluminum	µg/L	-	-	100	**130**	**240**	**370**	**470**	**600**	**600**	**600**	**600**	**400**	**410**
Antimony	µg/L	-	-	-	0.50	0.50	0.50	0.50	18	20	11	13	2.4	2.8
Arsenic	µg/L	100	-	5	1.1	2.0	1.1	1.8	**11**	**13**	4.7	**6**	1.3	1.9
Barium	µg/L	-	-	-	3.8	7.4	6.5	8.5	88	100	88	100	26	29
Boron	µg/L	-	29000	1500	25	25	25	25	130	150	68	79	25	25
Cadmium	µg/L	-	0.13	0.04	0.0099	0.016	0.010	0.015	**0.09**	**0.10**	**0.05**	**0.06**	0.013	0.016
Calcium	µg/L	-	-	-	9700	19000	9300	17000	110000	120000	64000	72000	16000	19000
Chromium	µg/L	-	-	1	**2.4**	**5.2**	**2.1**	**4.6**	**3.8**	**5.2**	**3.6**	**5.1**	**2.7**	**5.1**
Copper	µg/L	100	-	2	1.1	1.9	1.000	1.7	**11**	**12**	**7.8**	**8.9**	**2.5**	**2.9**
Iron	µg/L	-	-	300	290	**550**	260	**500**	**400**	**530**	**340**	**530**	**310**	**550**
Lead	µg/L	80	-	1	0.30	0.37	0.29	0.35	0.87	1.0	0.54	0.76	0.53	0.72
Magnesium	µg/L	-	-	-	1300	2300	1100	1900	11000	13000	5800	6600	1600	2200
Manganese	µg/L	-	596	210	200	**460**	180	**420**	**580**	**630**	**420**	**480**	**240**	**460**
Mercury	µg/L	-	-	0.026	0.011	0.017	0.011	0.017	**0.14**	**0.15**	**0.11**	**0.12**	**0.029**	**0.034**
Molybdenum	µg/L	-	-	73	1.2	1.5	1.2	1.4	29	34	12	15	1.6	1.7
Nickel	µg/L	250	-	25	1.0	1.0	1.0	1.0	6.1	7.3	3.1	3.6	1.0	1.0
Phosphorus	µg/L	-	-	4	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**
Potassium	µg/L	-	-	-	360	690	1700	2200	30000	35000	8700	11000	1100	1300
Selenium	µg/L	-	-	1	0.46	0.50	0.45	0.50	**2.8**	**3.2**	**1.4**	**1.6**	0.46	0.50
Silver	µg/L	-	-	0.25	0.050	0.050	0.050	0.050	**0.68**	**0.77**	**0.53**	**0.60**	0.15	0.17
Sodium	µg/L	-	-	-	2300	3300	3600	4600	57000	66000	18000	22000	2300	3300
Thallium	µg/L	-	-	0.8	0.050	0.050	0.050	0.050	0.15	0.18	0.12	0.13	0.052	0.055
Uranium	µg/L	-	33	15	0.086	0.14	0.14	0.18	13	15	7.9	9.1	1.7	2.0
Zinc	µg/L	400	11.3	2.2	**4.9**	**7.9**	**4.7**	**7.5**	**29**	**33**	**23**	**26**	**11**	**13**
Chloride	µg/L	-	640000	120000	3100	4700	2900	4600	3100	4600	3100	4600	3100	4700
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	58	100	55	93	8300	11000	170	300	59	100
Nitrite (as Nitrogen)	µg/L	-	-	60	7.9	12	7.7	11	**190**	**240**	10	13	7.9	12
Nitrate (as Nitrogen)	µg/L	-	550000	13000	59	100	56	94	8200	10000	170	300	60	100
Total Ammonia (as Nitrogen)	µg/L	-	-	689	63	140	59	120	**1100**	**1400**	74	130	68	140
Un-ionized Ammonia (as Nitrogen)	µg/L	500	16	16	0.15	0.32	2.2	4.6	**42**	**53**	2.8	4.9	2.6	5.3
Cyanide, Total	µg/L	500	-	-	10	10	10	10	10	10	10	10	10	10
Cyanide, WAD	µg/L	-	-	5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Sulphate	µg/L	-	-	-	1800	3000	1700	2700	69000	81000	24000	29000	2300	3000
Fluoride	µg/L	-	-	120	60	60	60	60	**760**	**810**	**530**	**560**	**220**	**230**
Radium-226	Bg/L	0.37	-	-	0.0050	0.0050	0.0230	0.030	0.079	0.089	0.061	0.070	0.035	0.037
Temperature	°C	-	-	-	10	18	9.2	17	9.3	18	9.1	18	10	18
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	27	54	27	47	380000	440000	200000	230000	35000	41000
pH (mean or 5 %ile)	pH Unit	6.0-9.5	-	6.5-9.0	7.2	6.8	7.9	7.8	7.9	7.8	7.4	7.3	7.4	7.3
Hardness (as $CaCO_3$)	mg/L	-	-	-	29	58	28	50	320	350	180	210	47	57
Dissolved Organic Carbon	mg/L	-	-	-	1.0	1.0	1.0	1.0	14	16	11	13	3.0	3.5

Notes: See Table C-1 notes for details on the parameters and guidelines.

Table D-8: The highest value of the monthly mean and 95th %-ile for each project phase in FDP02

Parameter	Units	MDMER	CWQG	**CWQG**	Baseline		Construction		Operation		Closure		Post-closure	
Statistics			Short-term	Long-term	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile
Aluminum	µg/L	-	-	100	**130**	**240**	**390**	**490**	**600**	**600**	**600**	**600**	**580**	**600**
Antimony	µg/L	-	-	-	0.50	0.50	0.50	0.50	28	33	26	32	10	12
Arsenic	µg/L	100	-	5	1.1	2.0	1.1	1.8	**23**	**27**	**8.4**	**10**	3.3	3.7
Barium	µg/L	-	-	-	3.8	7.4	9.4	12	310	360	290	350	110	130
Boron	µg/L	-	29000	1500	25	25	25	25	110	120	86	99	48	52
Cadmium	µg/L	-	0.13	0.04	0.0099	0.016	0.010	0.015	**0.10**	**0.12**	**0.10**	**0.11**	**0.042**	**0.049**
Calcium	µg/L	-	-	-	9700	19000	9300	17000	190000	230000	140000	180000	58000	68000
Chromium	µg/L	-	-	1	**2.4**	**5.2**	**2.1**	**4.6**	**7.8**	**8.8**	**7.5**	**8.6**	**4.4**	**5.6**
Copper	µg/L	100	-	2	1.1	1.9	1.000	1.7	**32**	**38**	**24**	**29**	**9.3**	**11**
Iron	µg/L	-	-	300	290	**550**	260	**500**	**800**	**850**	**600**	**700**	**400**	**550**
Lead	µg/L	80	-	1	0.30	0.37	0.29	0.35	**2.3**	**2.7**	0.89	**1.1**	0.72	0.93
Magnesium	µg/L	-	-	-	1300	2300	1100	1900	17000	19000	11000	13000	4600	5300
Manganese	µg/L	-	596	210	200	**460**	180	**420**	**1200**	**1200**	**990**	**1200**	**450**	**550**
Mercury	µg/L	-	-	0.026	0.011	0.017	0.011	0.017	**0.32**	**0.37**	**0.30**	**0.36**	**0.12**	**0.14**
Molybdenum	µg/L	-	-	73	1.2	1.5	1.2	1.4	14	16	11	13	4.7	5.6
Nickel	µg/L	250	-	25	1.0	1.0	1.0	1.0	4.1	4.6	3.9	4.5	2.1	2.3
Phosphorus	µg/L	-	-	4	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**
Potassium	µg/L	-	-	-	360	690	1800	2200	83000	100000	17000	23000	4500	5400
Selenium	µg/L	-	-	1	0.46	0.50	0.45	0.50	**1.8**	**2.0**	**1.6**	**1.9**	0.89	1.0
Silver	µg/L	-	-	0.25	0.050	0.050	0.050	0.050	**1.6**	**1.8**	**1.5**	**1.8**	**0.59**	**0.70**
Sodium	µg/L	-	-	-	2300	3300	3800	4700	80000	96000	13000	17000	3600	4200
Thallium	µg/L	-	-	0.8	0.050	0.050	0.050	0.050	0.26	0.30	0.25	0.29	0.13	0.14
Uranium	µg/L	-	33	15	0.086	0.14	0.13	0.17	**30**	**36**	**22**	**27**	8.0	10
Zinc	µg/L	400	11.3	2.2	**4.9**	**7.9**	**4.7**	**7.5**	**66**	**76**	**62**	**74**	**29**	**33**
Chloride	µg/L	-	640000	120000	3100	4700	2900	4600	3300	4600	3300	4600	3400	4700
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	58	100	55	93	19000	24000	350	650	75	110
Nitrite (as Nitrogen)	µg/L	-	-	60	7.9	12	7.7	11	**440**	**550**	15	22	9.3	12
Nitrate (as Nitrogen)	µg/L	-	550000	13000	59	100	56	94	**19000**	**24000**	340	630	75	120
Total Ammonia (as Nitrogen)	µg/L	-	-	689	63	140	60	120	**2400**	**3000**	95	130	75	140
Un-ionized Ammonia (as Nitrogen)	µg/L	500	16	16	0.15	0.32	2.3	4.6	**91**	**110**	3.6	4.9	2.9	5.3
Cyanide, Total	µg/L	500	-	-	10	10	10	10	11	11	11	11	11	11
Cyanide, WAD	µg/L	-	-	5	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.1
Sulphate	µg/L	-	-	-	1800	3000	1700	2700	41000	50000	11000	14000	4600	5200
Fluoride	µg/L	-	-	120	60	60	60	60	**1500**	**1500**	**1400**	**1400**	**930**	**940**
Radium-226	Bg/L	0.37	-	-	0.0050	0.0050	0.0250	0.030	0.17	0.19	0.16	0.19	0.078	0.087
Temperature	°C	-	-	-	10	18	9.2	17	9.3	18	9.1	18	10	18
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	27	54	28	47	770000	910000	480000	590000	170000	200000
pH (mean or 5 %ile)	pH Unit	6.0-9.5	-	6.5-9.0	7.2	6.8	7.9	7.8	7.9	7.8	7.4	7.3	7.4	7.3
Hardness (as $CaCO_3$)	mg/L	-	-	-	29	58	28	50	540	650	390	500	160	190
Dissolved Organic Carbon	mg/L	-	-	-	1.0	1.0	1.0	1.0	33	38	31	37	12	15

Notes: See Table C-1 notes for details on the parameters and guidelines.

Table D-9: The highest value of the monthly mean and 95th %-ile for each project phase in FDP03

Parameter	Units	MDMER	CWQG	**CWQG**	Baseline		Construction		Operation		Closure		Post-closure	
Statistics			Short-term	Long-term	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile
Aluminum	µg/L	-	-	100	**130**	**240**	**520**	**600**	**600**	**600**	**600**	**600**	**600**	**600**
Antimony	µg/L	-	-	-	0.50	0.50	0.50	0.50	26	30	27	31	6.8	7.9
Arsenic	µg/L	100	-	5	1.1	2.0	1.1	1.8	**22**	**25**	**9.1**	**11**	2.5	2.8
Barium	µg/L	-	-	-	3.8	7.4	11	15	290	330	290	340	76	89
Boron	µg/L	-	29000	1500	25	25	25	25	100	110	87	96	39	42
Cadmium	µg/L	-	0.13	0.04	0.0099	0.016	0.010	0.015	**0.10**	**0.11**	**0.10**	**0.11**	0.030	0.034
Calcium	µg/L	-	-	-	9700	19000	9300	17000	180000	210000	150000	170000	40000	47000
Chromium	µg/L	-	-	1	**2.4**	**5.2**	**2.1**	**4.6**	**7.4**	**8.3**	**7.6**	**8.4**	**3.6**	**5.3**
Copper	µg/L	100	-	2	1.1	1.9	1.00	1.7	**30**	**35**	**24**	**28**	**6.4**	**7.5**
Iron	µg/L	-	-	300	290	**550**	260	**500**	**790**	**850**	**640**	**740**	**360**	**550**
Lead	µg/L	80	-	1	0.30	0.37	0.33	0.45	**2.3**	**2.7**	**1.1**	**1.2**	0.80	1.0
Magnesium	µg/L	-	-	-	1300	2300	1100	1900	16000	18000	11000	13000	3300	3800
Manganese	µg/L	-	596	210	200	**460**	180	**420**	**1100**	**1200**	**1000**	**1200**	**360**	**460**
Mercury	µg/L	-	-	0.026	0.011	0.017	0.011	0.017	**0.29**	**0.34**	**0.30**	**0.34**	**0.079**	**0.09**
Molybdenum	µg/L	-	-	73	1.2	1.5	1.2	1.4	13	14	11	13	3.4	3.9
Nickel	µg/L	250	-	25	1.0	1.0	1.0	1.0	3.9	4.4	4.0	4.4	1.7	1.8
Phosphorus	µg/L	-	-	4	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**
Potassium	µg/L	-	-	-	360	690	2000	2700	78000	93000	20000	25000	3100	3700
Selenium	µg/L	-	-	1	0.46	0.50	0.45	0.50	**1.6**	**1.8**	**1.6**	**1.8**	0.73	0.79
Silver	µg/L	-	-	0.25	0.050	0.050	0.050	0.050	**1.5**	**1.7**	**1.5**	**1.7**	**0.39**	**0.46**
Sodium	µg/L	-	-	-	2300	3300	4300	5700	75000	88000	15000	21000	3100	3500
Thallium	µg/L	-	-	0.8	0.050	0.050	0.050	0.050	0.24	0.27	0.25	0.28	0.10	0.11
Uranium	µg/L	-	33	15	0.086	0.14	0.14	0.19	**28**	**33**	**22**	**26**	5.2	6.2
Zinc	µg/L	400	11.3	2.2	**4.9**	**7.9**	**5.0**	**7.5**	**63**	**71**	**64**	**73**	**23**	**26**
Chloride	µg/L	-	640000	120000	3100	4700	2900	4600	3400	4600	3400	4600	3400	4700
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	58	100	55	93	18000	22000	430	770	70	100
Nitrite (as Nitrogen)	µg/L	-	-	60	7.9	12	8.6	11	**410**	**510**	19	27	9.6	12
Nitrate (as Nitrogen)	µg/L	-	550000	13000	59	100	58	94	**18000**	**22000**	420	760	70	100
Total Ammonia (as Nitrogen)	µg/L	-	-	689	63	140	62	120	**2300**	**2800**	120	160	74	140
Un-ionized Ammonia (as Nitrogen)	µg/L	500	16	16	0.15	0.32	2.4	4.6	**87**	**110**	4.6	6.1	2.8	5.3
Cyanide, Total	µg/L	500	-	-	10	10	10	11	14	14	14	14	10	10
Cyanide, WAD	µg/L	-	-	5	1.0	1.0	1.0	1.1	1.4	1.4	1.4	1.4	1.0	1.0
Sulphate	µg/L	-	-	-	1800	3000	1700	2700	37000	45000	12000	15000	4100	4700
Fluoride	µg/L	-	-	120	60	60	61	67	**1400**	**1500**	**1400**	**1500**	**620**	**620**
Radium-226	Bg/L	0.37	-	-	0.0050	0.0050	0.0370	0.0480	0.1700	0.19	0.17	0.19	0.067	0.074
Temperature	°C	-	-	-	10	18	9.2	17	9.3	18	9.1	18	10	18
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	27	54	220	280	710000	840000	490000	560000	110000	130000
pH (mean or 5 %ile)	pH Unit	6.0-9.5	-	6.5-9.0	7.2	6.8	7.9	7.8	7.9	7.8	7.4	7.3	7.4	7.3
Hardness (as $CaCO_3$)	mg/L	-	-	-	29	58	28	50	520	600	420	480	110	130
Dissolved Organic Carbon	mg/L	-	-	-	1.0	1.0	1.0	1.1	31	35	31	36	8.3	10

Notes: See Table C-1 notes for details on the parameters and guidelines.

Table D-10: The highest value of the monthly mean and 95th %-ile for each project phase in FDP04

Parameter	Units	MDMER	CWQG	**CWQG**	Baseline		Construction		Operation		Closure		Post-closure	
Statistics			Short-term	Long-term	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile
Aluminum	µg/L	-	-	100	**130**	**240**	**180**	**300**	**190**	**280**	**180**	**280**	**170**	**260**
Antimony	µg/L	-	-	-	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Arsenic	µg/L	100	-	5	1.1	2.0	1.2	1.8	1.2	2.0	1.2	1.9	1.3	1.9
Barium	µg/L	-	-	-	3.8	7.4	5.7	9.5	6.0	9.2	5.9	8.9	5.5	7.9
Boron	µg/L	-	29000	1500	25	25	25	25	25	25	25	25	25	25
Cadmium	µg/L	-	0.13	0.04	0.0099	0.016	0.010	0.015	0.010	0.015	0.010	0.015	0.011	0.016
Calcium	µg/L	-	-	-	9700	19000	9300	17000	9600	18000	9300	18000	11000	19000
Chromium	µg/L	-	-	1	**2.4**	**5.2**	**2.1**	**4.6**	**2.4**	**5.2**	**2.3**	**5.1**	**2.9**	**5.1**
Copper	µg/L	100	-	2	1.1	1.9	1.2	1.7	1.2	1.8	1.2	1.8	1.2	1.9
Iron	µg/L	-	-	300	290	**550**	290	**500**	290	**530**	290	**530**	**330**	**550**
Lead	µg/L	80	-	1	0.30	0.37	0.92	**1.8**	1.0	**1.7**	0.93	**1.7**	0.88	**1.5**
Magnesium	µg/L	-	-	-	1300	2300	1100	1900	1300	2300	1200	2100	1400	2200
Manganese	µg/L	-	596	210	200	**460**	190	**420**	200	**440**	180	**430**	**240**	**460**
Mercury	µg/L	-	-	0.026	0.011	0.017	0.011	0.017	0.011	0.02	0.011	0.017	0.012	0.018
Molybdenum	µg/L	-	-	73	1.2	1.5	1.2	1.4	1.2	1.5	1.2	1.4	1.2	1.5
Nickel	µg/L	250	-	25	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Phosphorus	µg/L	-	-	4	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**
Potassium	µg/L	-	-	-	360	690	400	630	410	670	410	670	410	690
Selenium	µg/L	-	-	1	0.46	0.50	0.45	0.50	0.46	0.50	0.45	0.50	0.47	0.50
Silver	µg/L	-	-	0.25	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
Sodium	µg/L	-	-	-	2300	3300	2200	3100	2300	3200	2200	3100	2500	3300
Thallium	µg/L	-	-	0.8	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.05	0.050	0.050
Uranium	µg/L	-	33	15	0.086	0.14	0.082	0.13	0.084	0.14	0.084	0.14	0.093	0.14
Zinc	µg/L	400	11.3	2.2	**4.9**	**7.9**	**12**	**23**	**13**	**22**	**12**	**21**	**11**	**18**
Chloride	µg/L	-	640000	120000	3100	4700	2900	4600	3000	4600	3000	4600	3400	4700
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	58	100	61	93	62	97	62	98	65	100
Nitrite (as Nitrogen)	µg/L	-	-	60	7.9	12	10	11	10	12	10	12	9.7	12
Nitrate (as Nitrogen)	µg/L	-	550000	13000	59	100	61	94	61	99	61	98	66	100
Total Ammonia (as Nitrogen)	µg/L	-	-	689	63	140	66	120	69	130	67	130	77	140
Un-ionized Ammonia (as Nitrogen)	µg/L	500	16	16	0.15	0.32	2.5	4.6	2.6	4.9	2.5	4.9	2.9	5.3
Cyanide, Total	µg/L	500	-	-	10	10	10	10	10	10	10	10	10	10
Cyanide, WAD	µg/L	-	-	5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Sulphate	µg/L	-	-	-	1800	3000	3200	5000	3300	4800	3300	4600	3000	4300
Fluoride	µg/L	-	-	120	60	60	60	60	60	60	60	60	60	60
Radium-226	Bg/L	0.37	-	-	0.0050	0.0050	0.0470	0.047	0.047	0.047	0.047	0.047	0.044	0.044
Temperature	°C	-	-	-	10	18	9.2	17	9.3	18	9.1	18	10	18
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	27	54	930	940	930	940	930	930	870	880
pH (mean or 5 %ile)	pH Unit	6.0-9.5	-	6.5-9.0	7.2	6.8	**6.0**	**5.7**	**6.0**	**5.7**	**6.0**	**5.7**	**6.0**	**5.7**
Hardness (as $CaCO_3$)	mg/L	-	-	-	29	58	28	50	29	54	28	54	33	57
Dissolved Organic Carbon	mg/L	-	-	-	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Notes: See Table C-1 notes for details on the parameters and guidelines.

Table D-11: The highest value of the monthly mean and 95th %-ile for each project phase in FDP05

Parameter	Units	MDMER	CWQG	**CWQG**	Baseline		Construction		Operation		Closure		Post-closure	
Statistics			Short-term	Long-term	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile
Aluminum	µg/L	-	-	100	**130**	**240**	**120**	**210**	**190**	**260**	**140**	**230**	**130**	**240**
Antimony	µg/L	-	-	-	0.50	0.50	0.50	0.50	4.2	5.0	0.50	0.50	0.50	0.50
Arsenic	µg/L	100	-	5	1.1	2.0	1.3	1.8	4.3	**5.1**	1.2	1.9	1.1	1.9
Barium	µg/L	-	-	-	3.8	7.4	5.2	7.2	35	43	12	13	13	13
Boron	µg/L	-	29000	1500	25	25	25	25	27	30	33	34	33	34
Cadmium	µg/L	-	0.13	0.04	0.0099	0.016	0.011	0.015	0.020	0.024	0.013	0.015	0.014	0.016
Calcium	µg/L	-	-	-	9700	19000	65000	91000	73000	94000	22000	24000	23000	24000
Chromium	µg/L	-	-	1	**2.4**	**5.2**	**2.1**	**4.6**	**2.6**	**5.2**	**2.8**	**5.1**	**2.4**	**5.1**
Copper	µg/L	100	-	2	1.1	1.9	1.2	1.7	**5.4**	**6.5**	**17**	**20**	**19**	**20**
Iron	µg/L	-	-	300	290	**550**	**470**	**760**	**460**	**780**	**320**	**530**	290	**550**
Lead	µg/L	80	-	1	0.30	0.37	0.29	0.35	0.46	0.54	0.30	0.35	0.30	0.37
Magnesium	µg/L	-	-	-	1300	2300	6200	8600	6800	9300	1900	2100	2100	2200
Manganese	µg/L	-	596	210	200	**460**	**590**	**930**	**620**	**1000**	**230**	**430**	**240**	**460**
Mercury	µg/L	-	-	0.026	0.011	0.017	0.011	0.017	**0.047**	**0.056**	0.012	0.017	0.011	0.017
Molybdenum	µg/L	-	-	73	1.2	1.5	5.5	7.4	5.7	7.6	10	11	11	11
Nickel	µg/L	250	-	25	1.0	1.0	1.0	1.0	1.0	1.1	1.2	1.2	1.2	1.2
Phosphorus	µg/L	-	-	4	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**
Potassium	µg/L	-	-	-	360	690	600	780	13000	15000	2800	3100	3100	3100
Selenium	µg/L	-	-	1	0.46	0.50	0.45	0.50	0.49	0.52	0.47	0.50	0.46	0.50
Silver	µg/L	-	-	0.25	0.050	0.050	0.050	0.050	0.24	**0.29**	0.050	0.050	0.050	0.050
Sodium	µg/L	-	-	-	2300	3300	41000	65000	41000	63000	57000	63000	62000	63000
Thallium	µg/L	-	-	0.8	0.050	0.050	0.050	0.050	0.052	0.056	0.050	0.050	0.050	0.050
Uranium	µg/L	-	33	15	0.086	0.14	0.75	0.85	4.9	5.9	0.70	0.79	0.75	0.80
Zinc	µg/L	400	11.3	2.2	**4.9**	**7.9**	**4.7**	**7.5**	**10**	**12**	**5.2**	**7.6**	**4.9**	**7.9**
Chloride	µg/L	-	640000	120000	3100	4700	35000	54000	38000	56000	8300	9100	10000	10000
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	58	100	800	1900	6000	11000	150	170	160	180
Nitrite (as Nitrogen)	µg/L	-	-	60	7.9	12	22	47	**140**	**260**	26	29	28	29
Nitrate (as Nitrogen)	µg/L	-	550000	13000	59	100	790	1900	5800	11000	150	170	160	170
Total Ammonia (as Nitrogen)	µg/L	-	-	689	63	140	380	590	**970**	**1600**	**1600**	**1800**	**1700**	**1800**
Un-ionized Ammonia (as Nitrogen)	µg/L	500	16	16	0.15	0.32	14	**22**	**37**	**61**	**61**	**68**	**65**	**68**
Cyanide, Total	µg/L	500	-	-	10	10	10	10	10	10	10	10	10	10
Cyanide, WAD	µg/L	-	-	5	1.0	1.0	1.1	1.1	1.2	1.2	1.0	1.0	1.0	1.0
Sulphate	µg/L	-	-	-	1800	3000	170000	270000	170000	260000	120000	130000	130000	130000
Fluoride	µg/L	-	-	120	60	60	60	60	**280**	**320**	**180**	**200**	**190**	**200**
Radium-226	Bg/L	0.37	-	-	0.0050	0.0050	0.0050	0.0050	0.0260	0.030	0.0074	0.0078	0.0076	0.0078
Temperature	°C	-	-	-	10	18	9.2	17	9.3	18	9.1	18	10	18
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	27	54	230	320	110000	140000	7400	8800	8100	8800
pH (mean or 5 %ile)	pH Unit	6.0-9.5	-	6.5-9.0	7.2	6.8	7.2	7.1	7.3	7.2	6.8	6.7	6.8	6.8
Hardness (as $CaCO_3$)	mg/L	-	-	-	29	58	190	260	210	270	63	69	66	69
Dissolved Organic Carbon	mg/L	-	-	-	1.0	1.0	1.0	1.0	5.1	6.0	1.4	1.5	1.4	1.5

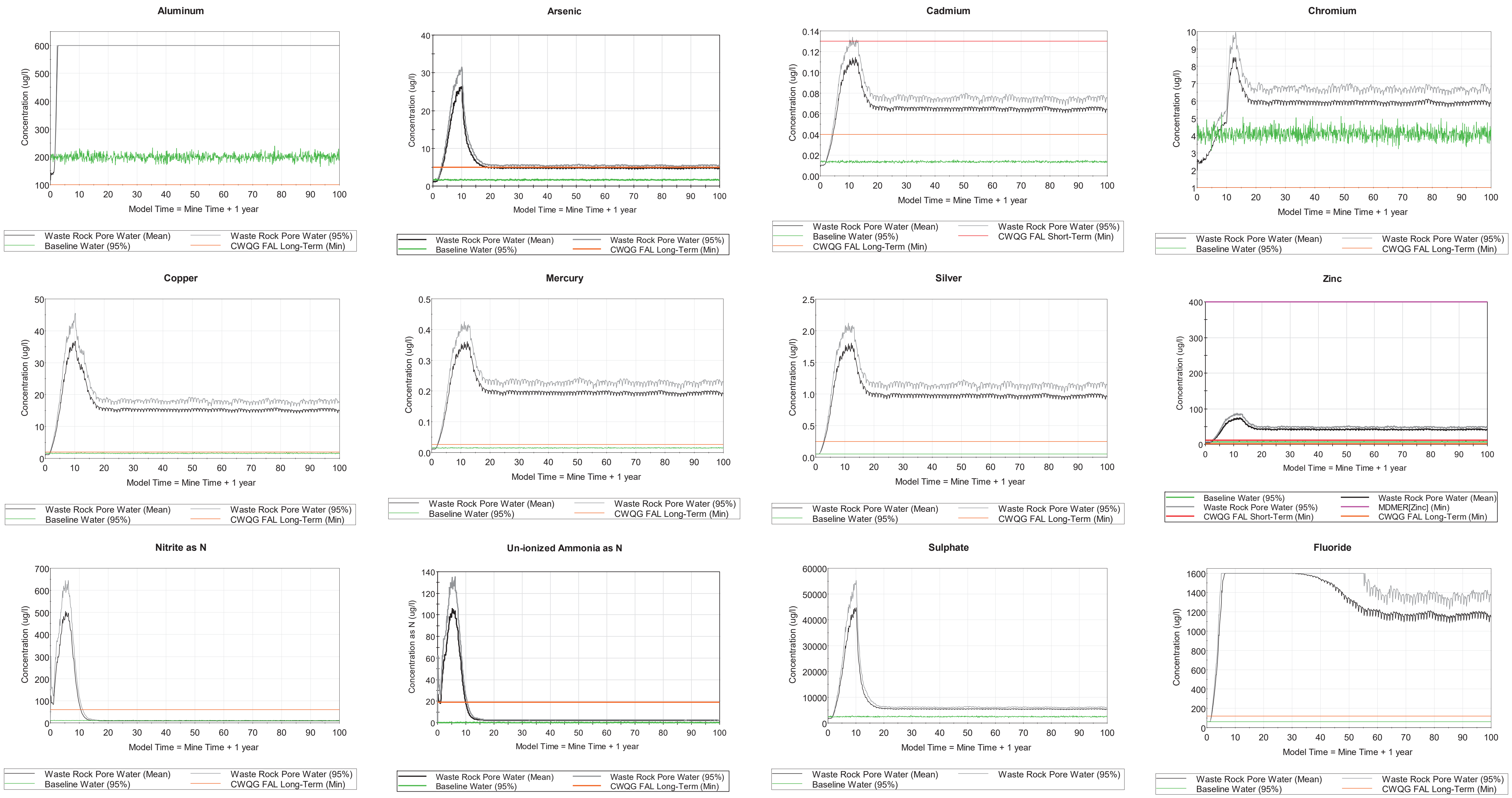
Notes: See Table C-1 notes for details on the parameters and guidelines.

Table D-12: The highest value of the monthly mean and 95th %-ile for each project phase in the polishing pond

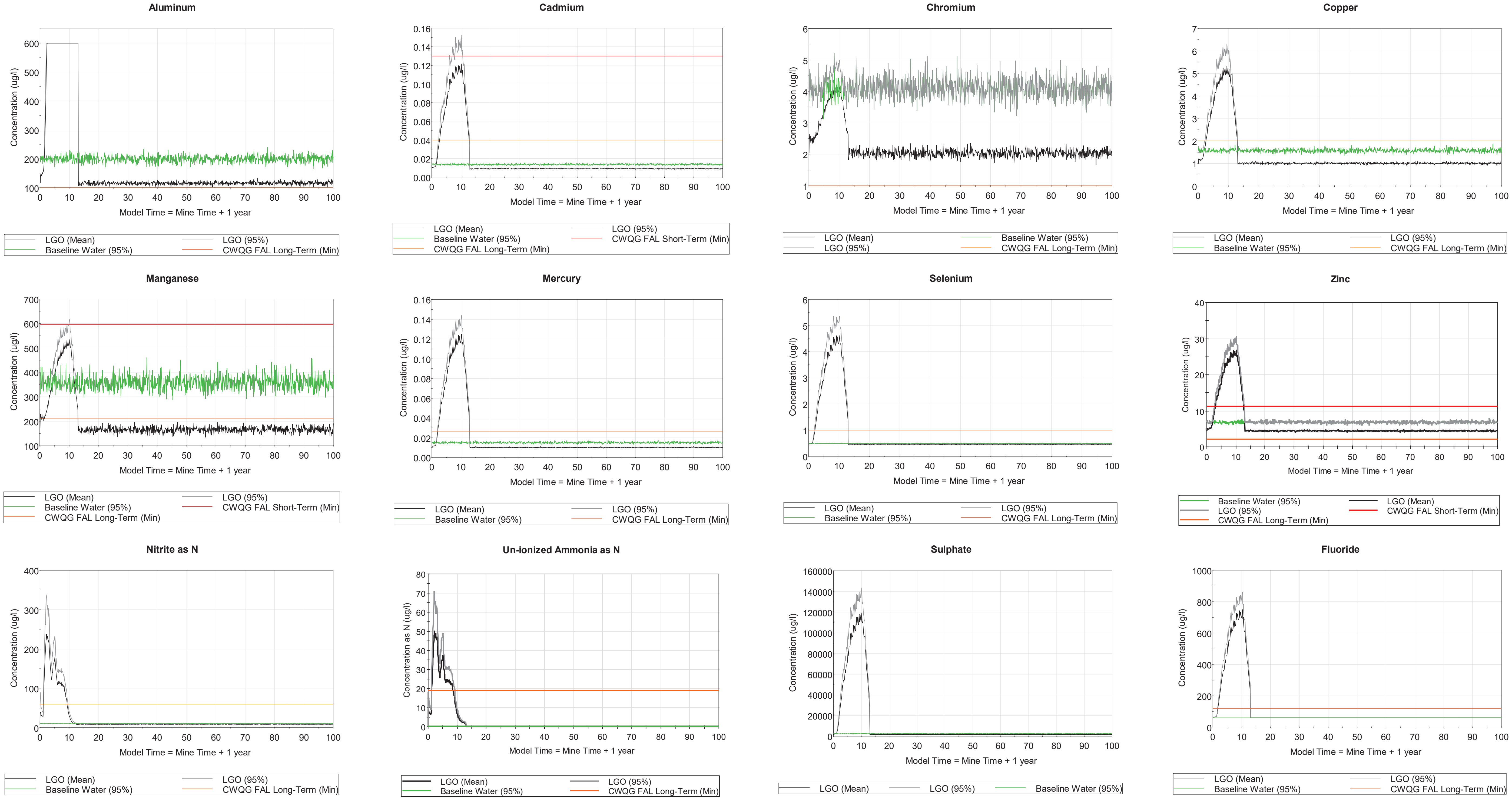
Parameter	Units	MDMER	CWQG	**CWQG**	Baseline		Construction		Operation		Closure		Post-closure	
Statistics			Short-term	Long-term	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile
Aluminum	µg/L	-	-	100	79	**150**	79	**150**	**150**	**280**	78	**150**	87	**150**
Antimony	µg/L	-	-	-	0.50	0.50	0.50	0.50	4	7	1	1	1	2
Arsenic	µg/L	100	-	5	3.8	**8.0**	3.8	**8.0**	**6**	**9**	3.9	**7**	**5.3**	**8.0**
Barium	µg/L	-	-	-	1.9	3.3	1.9	3.3	17	27	2	3	8	13
Boron	µg/L	-	29000	1500	25	25	25	25	72	100	25	26	35	37
Cadmium	µg/L	-	0.13	0.04	0.011	0.019	0.011	0.019	0.036	**0.051**	0.012	0.018	0.020	0.027
Calcium	µg/L	-	-	-	8100	16000	8100	16000	62000	97000	8900	15000	22000	30000
Chromium	µg/L	-	-	1	**1.2**	**2.2**	**1.2**	**2.2**	**1.1**	**2.1**	**1.2**	**2.1**	**1.2**	**2.2**
Copper	µg/L	100	-	2	1.2	2.0	1.2	2.0	**77**	**99**	1.4	2.0	**210**	**300**
Iron	µg/L	-	-	300	210	**380**	210	**380**	210	**360**	200	**350**	220	**380**
Lead	µg/L	80	-	1	0.25	0.25	0.25	0.25	0.3	0.3	0.25	0.3	0.25	0.25
Magnesium	µg/L	-	-	-	1000	1800	1000	1800	4700	7100	1100	1700	2600	4000
Manganese	µg/L	-	596	210	150	**340**	150	**340**	190	**310**	180	**320**	180	**340**
Mercury	µg/L	-	-	0.026	0.008	0.011	0.0081	0.011	**0.038**	**0.11**	0.0081	0.011	**0.060**	**0.14**
Molybdenum	µg/L	-	-	73	1.0	1.0	1.0	1.0	40	66	1	2	15.0	20.0
Nickel	µg/L	250	-	25	1.0	1.0	1.0	1.0	2.3	3.2	1.0	1.0	1.6	2.2
Phosphorus	µg/L	-	-	4	**62**	**81**	**62**	**81**	**61**	**79**	**61**	**78**	**62**	**81**
Potassium	µg/L	-	-	-	160	270	160	270	11000	18000	200	290	4400	5500
Selenium	µg/L	-	-	1	0.46	0.50	0.46	0.50	0.9	**1.4**	0.5	0.5	0.5	0.7
Silver	µg/L	-	-	0.25	0.050	0.050	0.050	0.050	0.1	0.2	0.1	0.1	**0.3**	**0.6**
Sodium	µg/L	-	-	-	1800	2300	1800	2300	220000	370000	2700	4900	82000	97000
Thallium	µg/L	-	-	0.8	0.050	0.050	0.050	0.050	0.054	0.06	0.05	0.05	0.05	0.05
Uranium	µg/L	-	33	15	0.068	0.10	0.068	0.10	1.9	2.8	0.075	0.10	0.70	0.94
Zinc	µg/L	400	11.3	2.2	**4.8**	**8.2**	**4.8**	**8.2**	**4.8**	**8.0**	**4.8**	**7.6**	**5.0**	**8.2**
Chloride	µg/L	-	640000	120000	2600	4000	2600	4000	17000	26000	2800	3900	7500	9300
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	75	150	75	150	200	310	85	150	130	160
Nitrite (as Nitrogen)	µg/L	-	-	60	5.0	5.0	5.0	5.0	**75**	**120**	5.3	6.0	41.0	54
Nitrate (as Nitrogen)	µg/L	-	550000	13000	76	140	76	140	200	300	82	130	120	160
Total Ammonia (as Nitrogen)	µg/L	-	-	689	53	94	53	94	**4500**	**4500**	80	130	**5500**	**7700**
Un-ionized Ammonia (as Nitrogen)	µg/L	500	16	16	0.17	0.39	0.17	0.39	**170**	**170**	3.0	4.9	**210**	**290**
Cyanide, Total	µg/L	500	-	-	10	10	10	10	330	480	10	10	320	490
Cyanide, WAD	µg/L	-	-	5	1.0	1.0	1.0	1.0	**16**	**29**	1.0	1.0	**230**	**360**
Sulphate	µg/L	-	-	-	1400	2100	1400	2100	450000	760000	3400	7800	170000	210000
Fluoride	µg/L	-	-	120	60	60	60	60	**530**	**840**	62	66	**350**	**530**
Radium-226	Bg/L	0.37	-	-	0.0050	0.0050	0.0050	0.0050	0.0140	0.020	0.0050	0.0051	0.0056	0.0057
Temperature	°C	-	-	-	10	18	9.8	18	9.3	18	9.1	18	10	18
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	24	44	24	44	20000	37000	74	170	54	68
pH (mean or 5 %ile)	pH Unit	6.0-9.5	-	6.5-9.0	7.2	6.8	7.2	6.8	8.2	8.0	8.2	7.9	8.2	7.9
Hardness (as $CaCO_3$)	mg/L	-	-	-	24	45	24	45	170	270	27	44	66	91
Dissolved Organic Carbon	mg/L	-	-	-	1.0	1.0	1.0	1.0	2.0	2.8	1.0	1.0	1.1	1.1

Notes: See Table C-1 notes for details on the parameters and guidelines.

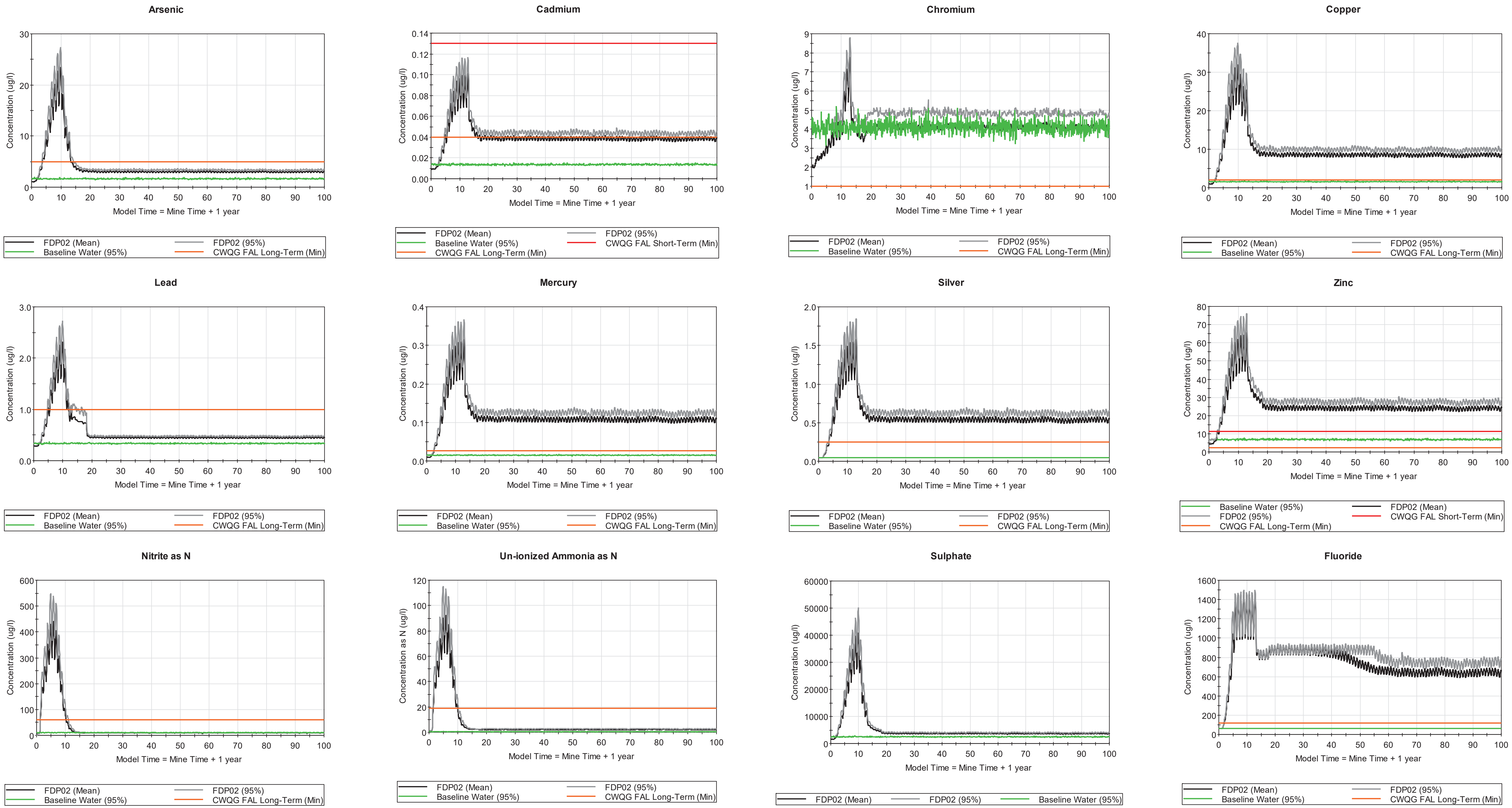
Appendix E TIME SERIES FOR SELECTED PARAMETERS



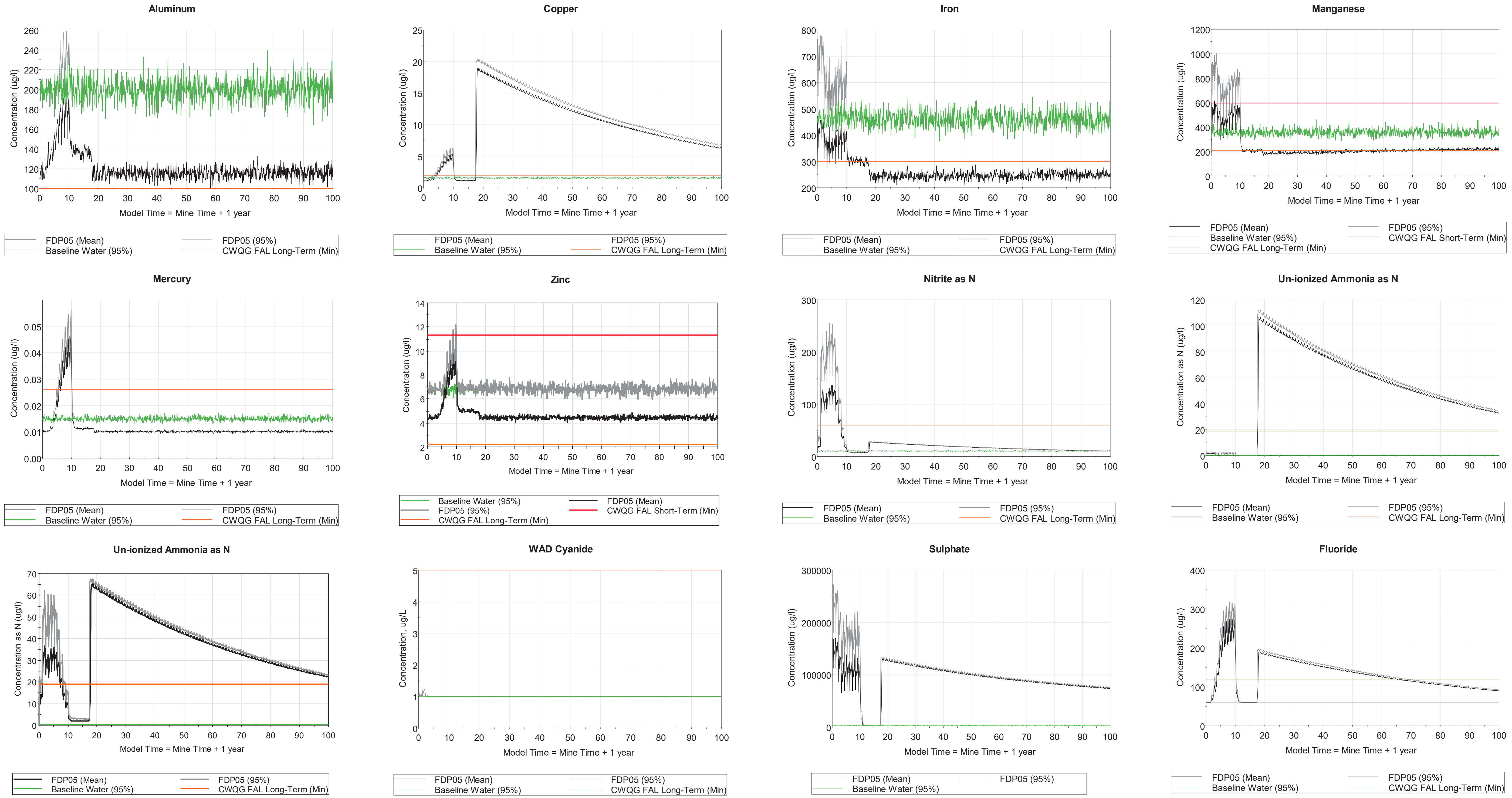
Waste Rock Pore Water Plots.



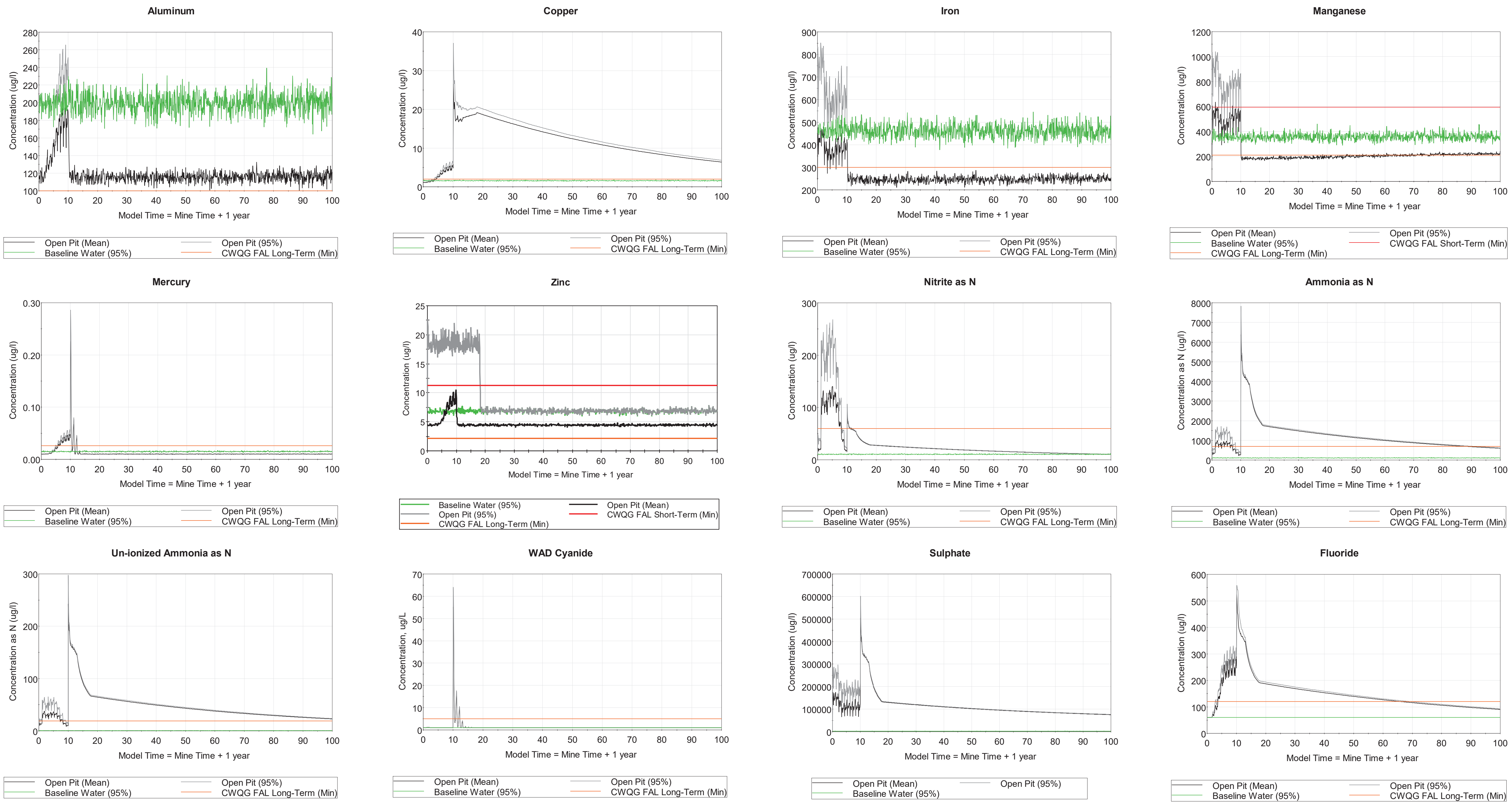
Low Grade Ore Plots.



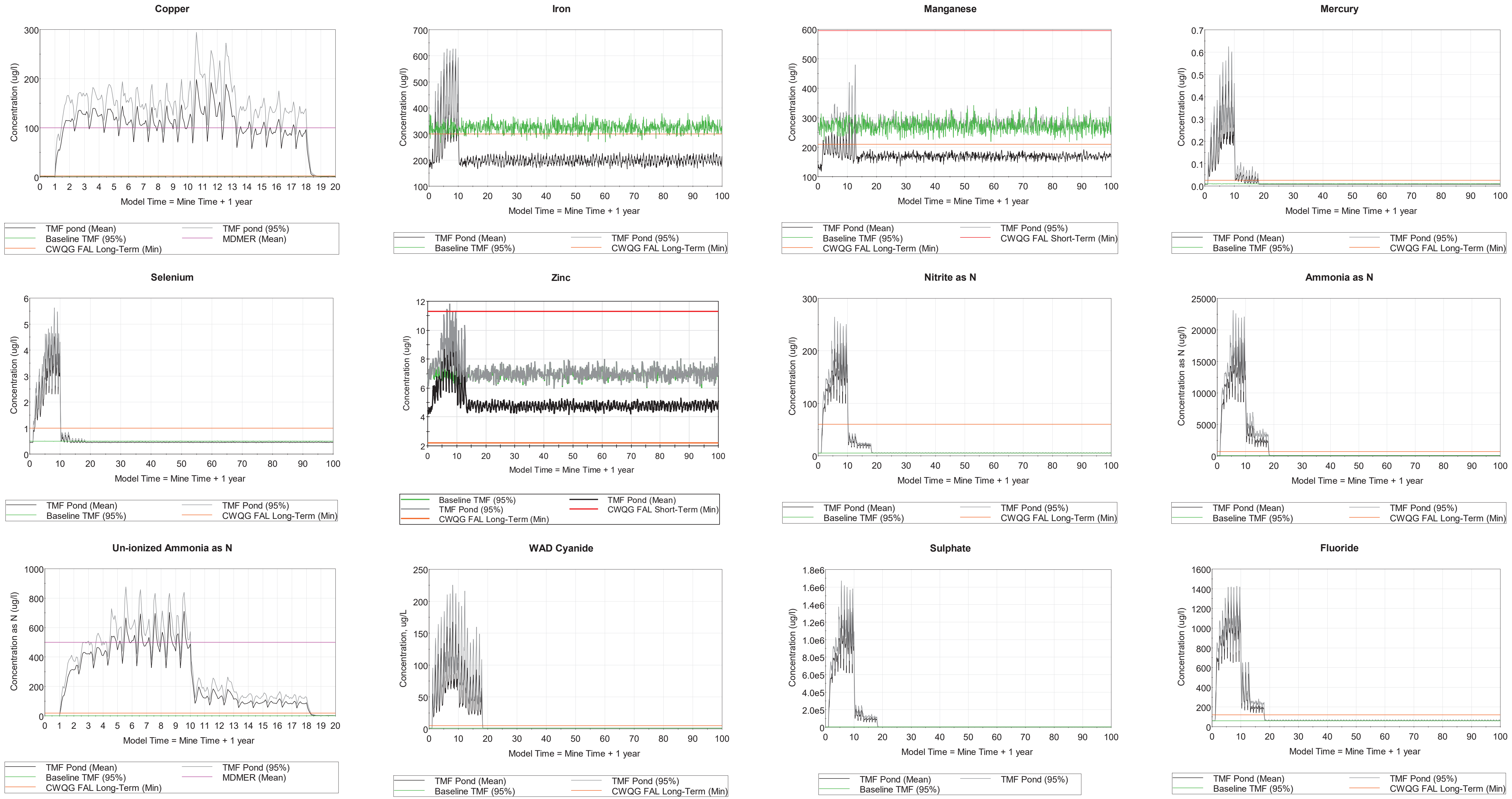
LP-FDP-02 Plots.



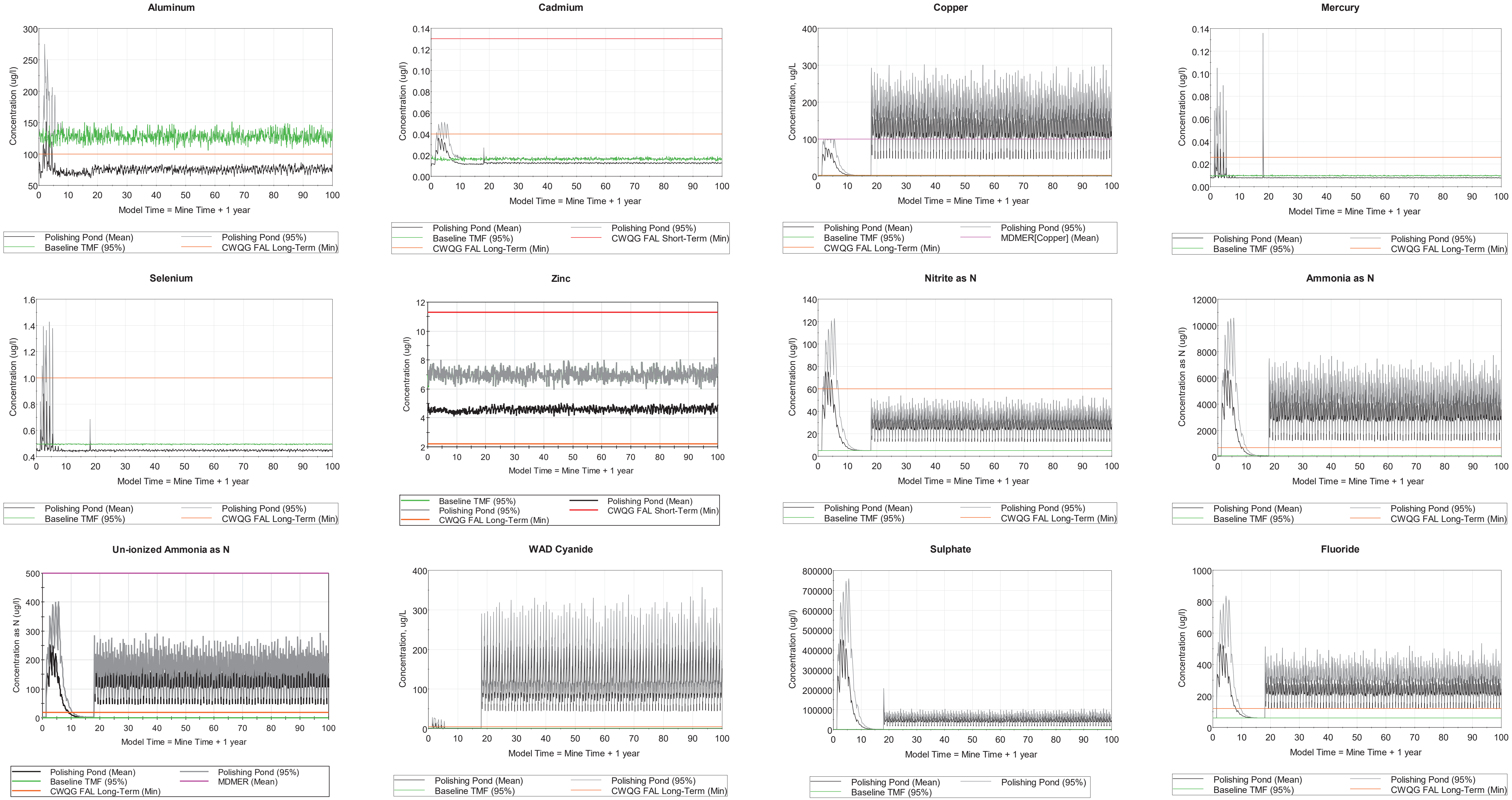
LP-FDP-05 Plots.



Open Pit Plots.



TMF Pond Plots.



Polishing Pond Plots.

APPENDIX 7B

Water Quantity and Water Quality Modelling Report: Marathon Complex

Valentine Gold Project (VGP) Water Quantity and Water Quality Modelling Report: Marathon Complex

FINAL

September 25, 2020

Prepared for:

Marathon Gold Corporation
36 Lombard Street
Suite 600, Toronto, ON M5C 2X3

Prepared by:

Stantec Consulting Ltd.
141 Kelsey Drive
St. John's, NL A1B 0L2
Tel: (709) 574-1458

File No: 121416408

This document entitled Valentine Gold Project (VGP) Water Quantity and Water Quality Modelling Report: Marathon Complex was prepared by Stantec Consulting Ltd. (“Stantec”) for the account of Marathon Gold Corporation (the “Client”). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Stantec’s professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. In preparing the document, Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

Prepared by ____
(signature)

Gonzalo Donoso MES., P.Eng., Senior Water Resources Engineer

Prepared by____
(signature)

Nikolay Sidenko PhD., P.Geo., Senior Geochemist

Reviewed by ____
(signature)

Sheldon Smith MES., P.Geo., Principal, Senior Hydrologist

Reviewed by ____
(signature)

Jonathan Keizer, M.Sc.E., P.Eng., Senior Hydrogeologist

Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Executive Summary

The Valentine Gold Project mine site is subdivided into three complexes, from north to south: the Marathon Complex; the Processing Plant and Tailings Management Facility (TMF) Complex; and the Leprechaun Complex. This report discusses an integrated water balance and water quality model prepared for the Marathon Complex. The major Project facilities include the Marathon open pit mine, waste rock pile, and low-grade ore (LGO), topsoil, and overburden stockpiles. Ore from the open pit will be mined for nine years and will be stockpiled and processed at the process plant. The process plant will operate for another three years by processing ore from the LGO stockpiles of the Leprechaun and Marathon deposits. Tailings will be deposited in the TMF for the first nine years of operation, and into the exhausted Leprechaun pit for the last three years of operation.

The model incorporates the relevant water management infrastructure designs to simulate watershed areas, volume capacities, flow diversions and flow paths for major mine components of the Marathon Complex. Main concepts of the water management included in the model are:

- Perimeter ditches around the stockpiles will flow into water management ponds and discharge to local Final Discharge Points (FDPs). Progressive rehabilitation and closure activities will include adding a soil cover and vegetating the waste rock pile. Water management ponds and perimeter seepage collection ditches will be maintained until water quality meets objectives and are assumed to be functional during closure in the model.
- Mine water from dewatering the open pit will be collected in sumps and pumped to a water management pond prior to discharge to the environment until year 10. Accelerated filling of the pit will start in year 10.
- Water withdrawal from Valentine Lake is proposed to accelerate filling of the Marathon pit. Accelerated pit filling is considered to be the base case scenario because it allows submergence of Potentially Acid Generating (PAG) materials exposed on pit walls limiting ARD/ML. This scenario also increases the safety of the Leprechaun mine in post-closure.

The model predicts that filling of the Marathon pit will take around 36 years after pit closure. Additionally, an acceleration of pit filling was modelled in the 8 years after mining of the pit ceases (mine years 10 to end 17), using water from Valentine Lake. In this scenario, the total water intake rate from Valentine lake is 17,000 m^3/day, during closure, under average climate conditions of pit filling. Accelerated pit filling is considered to be the base case scenario because it allows submergence of PAG materials exposed on pit walls limiting acid rock drainage (ARD)/metal leaching (ML). This scenario also increases the safety of the Marathon mine in post-closure.

Generally, the simulation flow results on the water management ponds and the FDPs, from 5th to 95th percentile results, range from approximately -25% to +25% of the mean results within each mine phase. This is consistent with the range of precipitation and approximately represents the 1:25 return period wet year to the 1:5 dry year.

The major objective of the water quality model is to predict concentrations of potential contaminants in mine water collection facilities and at FDPs. The contaminant transport module of GoldSim is used to build a water quality model directly linked to the water quantity model, which provides direct inputs to volume and inflow/outflow rates to/from facilities. The inputs to the model are associated with the concentration or mass-rate (loading) addition to the mine facilities. Scaled mass-rates from laboratory kinetic tests and production tonnages are used as inputs for waste rock lithologies, ores and tailings exposed to weathering in mine facilities. Loadings of nitrogen species leached from undetonated explosives were estimated from empirical data from other open pit mines. Chemistry of process water and tailings pond seepage were evaluated from laboratory ageing tests and subaqueous columns, respectively. Unimpacted groundwater, runoff from undisturbed areas, covers and overburden and soil stockpiles were represented by respective concentration inputs. To address variability and uncertainty of the inputs, probabilistic distributions were assigned to most inputs including scaleup factors. The parameters included in the model have criteria listed in *Canadian Water Quality Guidelines* (CWQG) for the Protection of Freshwater Aquatic Life (FAL) and limits in *Metal and Diamond Mining Effluent Regulations of the Fisheries Act* (MDMER). Only the MDMER limits are directly applicable to the discharges. The CWQG-FAL guidelines are not applicable to discharges, as these guidelines are developed for the receiving environment and are used for screening and providing inputs to assimilative capacity assessments.

The water quality model shows that there are no MDMER exceedances predicted at facilities (stockpiles, open pit, ponds) and discharge points (MA-FDP-01 to MA-FDP-04) in the Marathon mine complex during all Project phases at 95th percentile confidence level.

The long-term CWQG-FAL are not applicable to discharges, however, were used to screen parameters of concerns for the receivers. At baseline conditions, P, Cr, and Zn exceed the respective long-term CWQG-FAL in streams near the Marathon open pit. During construction and operation, the highest number of long-term CWQG-FAL exceedances were predicted for MA-FDP-02 and associated with seepage from waste rock. During operation, Cu (over 10 times), Hg (over 10 times), F (over 10 times), N-NO_2 (over 10 times), Ag, N-$NH_{3\,UN}$, Cd, Mn, Al, As, N-$NH_{3\,T}$, Se, U, Pb, Fe, and N-NO_3 are predicted to be above the respective long-term CWQG-FAL in addition to the parameters exceeding at baseline conditions. These parameters decline during closure and stabilize in post-closure with Cu, Hg, F, Ag, Cd, Mn, and Al remaining above CWQG-FAL. Exceedance for F could be a modelling artifact related to high detection limits scaled up to full size waste rock pile. Zn and Cr stabilize above the background levels in post-closure. The levels and trends for the parameters exceeding CWQG-FAL in MA-FDP-02 and MA-FDP-03 are similar.

Discharge point MA-FDP-01 has better water quality compared to MA-FDP-02 and MA-FDP-03 due to dilution of seepage from waste rock and LGO by runoff from overburden stockpile. In addition to the parameters exceeding at baseline conditions (P, Cr, and Zn), Cu, As, F, Hg, Al, N-NO_2,Cd, Se, Ag, Mn, N-$NH_{3\,UN}$, Fe, and N-$NH_{3\,T}$ are predicted to be above the respective long-term CWQG-FAL during operation. These parameters are predicted to decline during closure and stabilize in post-closure with Cu, F, and Hg remaining above CWQG-FAL. Zn and Cr concentrations stabilize above the above background levels in post-closure.

MA-FDP-04 receives water from waste rock, open pit dewatering and overflow from the pit lake. At baseline conditions, parameters predicted to exceed the long-term CWQG-FAL are P, Cr, and Zn. During construction and operation, Cu, Hg, F, Al, Ag, As, Mn, Cd, N-NO_2, N-$NH_{3\ UN}$, Fe, N-$NH_{3\ T}$, Se, Pb, and U are predicted to exceed the respective long-term CWQG-FAL, in addition to the parameters elevated at baseline conditions. These parameters generally decline in post-closure when overflow from pit lake dominates over seepage from waste rock in this discharge point. In post-closure Cu, F, Al, N-NO_2, and Fe remain above the respective long-term CWQG-FAL. Zn stabilizes above the above the background levels in post-closure, while Cr declines to background concentrations.

Abbreviations

AEP	Annual Exceedance Probability
ARD	Acid Rock Drainage
AET	Actual Evapotranspiration
CaCO3	calcium carbonate
CCME	Canadian Council of Ministers of the Environment
CEAA	Canadian Environmental Assessment Act
CT	Contaminant Transport
CWQG-FAL	Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life
ECCC	Environment and Climate Change Canada
EIS	Environmental Impact Statement
ET	Evapotranspiration
FDP	Final Discharge Point
HGO	High-Grade Ore
km	Kilometers
LGO	Low-Grade Ore
LAA	Local Assessment Area
m	Meter
MAF	mean annual flow
masl	Meters above de sea level
Marathon	Marathon Gold Corporation
MDMER	*Metal and Diamond Mining Effluent Regulations*
ML	Metal Leaching
Mt/a	Million tons per annum
Mm3	Million cubic meters
NL	Newfoundland and Labrador
NLDMAE	NL Department of Municipal Affairs and Environment
NLEPA	Newfoundland and Labrador Environmental Protection Act
NTU	Nephelometric Turbidity Units
PAG	Potentially Acid Generating
PoPC	Parameters of Potential Concern

Project	Valentine Gold Project
RDL	Reportable Detection Limit
SF	Scaling Factors
Stantec	Stantec Consulting Ltd.
TMF	Tailings Management Facility
TSS	Total Suspended Solids
WMP	Water Management Plan
WS	Watershed (areas)
WSC	Water Survey of Canada
°C	Degrees Celsius
µS	microsiemens
µg	micrograms

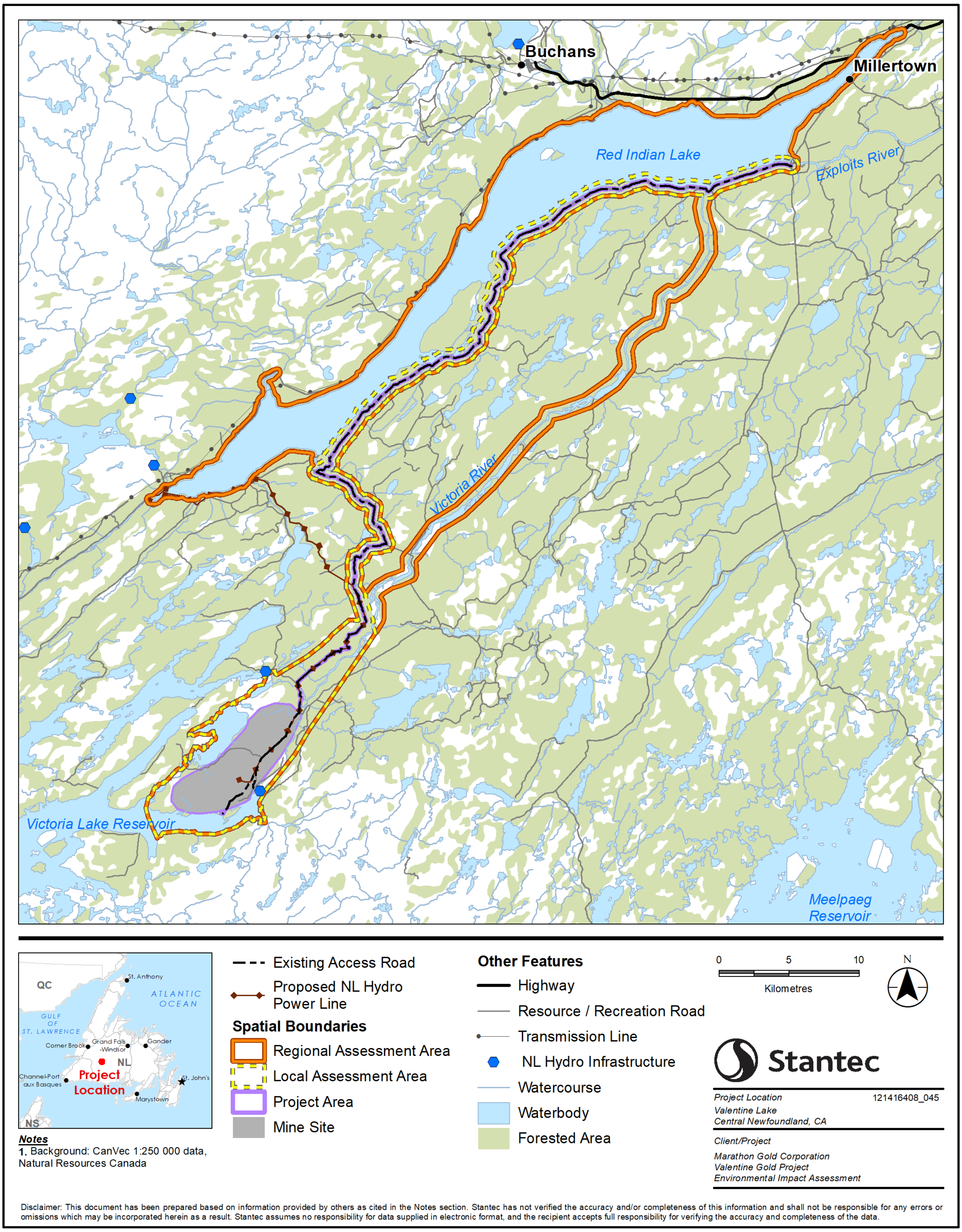
1.0 INTRODUCTION

Marathon Gold Corporation (Marathon) is planning to develop an open pit gold mine south of Valentine Lake, located in the central region of the Island of Newfoundland, approximately 60 kilometres (km) southwest of the Town of Millertown, Newfoundland and Labrador (NL) (Figure 1-1). The Valentine Gold Project (the Project) includes the construction, operation and decommissioning, rehabilitation and closure of an open pit gold mine and associated ancillary activities. Two open pits are proposed at the mine site: the Marathon and Leprechaun pits. As part of the environmental assessment for the Project, Marathon is preparing an environmental impact statement (EIS) and has commissioned Stantec Consulting Ltd. (Stantec) to develop a water quantity and water quality model to predict potential changes in flow and water quality as a result of the Project.

As presented in Figure 1-2, the Project is geographically divided in three complexes, from northeast to southwest including the Marathon Complex, the Processing Plant and Tailing Management Facility (TMF) Complex, and the Leprechaun Complex. This report describes the inputs and assumptions used to develop water quantity and water quality predictions prepared in support of the EIS for the Marathon Complex. As operation of the Leprechaun Complex and Processing Plant and TMF Complex will include interaction between these two complexes, these were combined into one model and described under a separate cover (Stantec 2020a).

1.1 SITE LOCATION

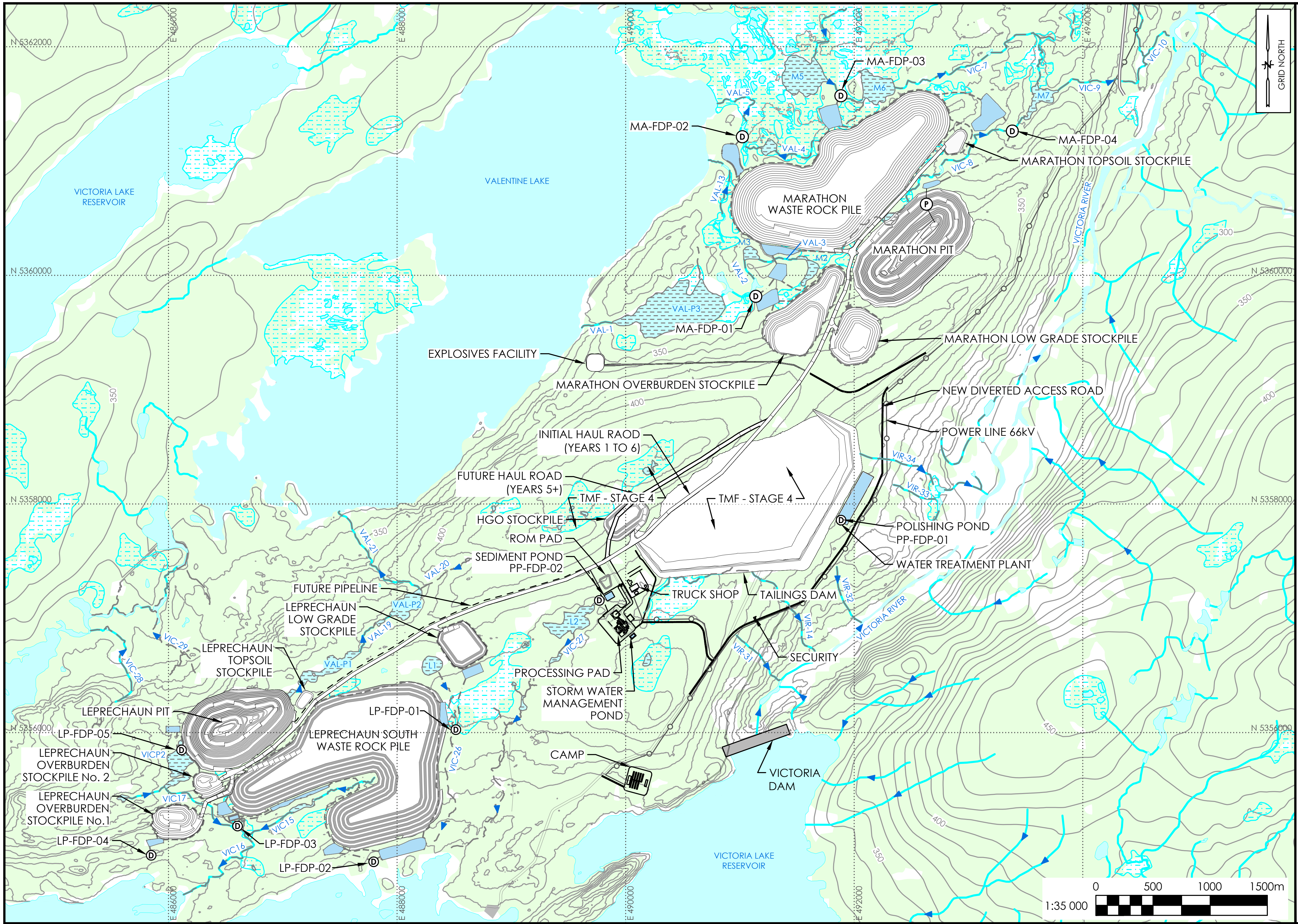
The Project is situated amidst gentle to moderately steep, hilly terrain and the ground surface elevation ranges from approximately 320 m to 480 metres above sea level (masl) relative to the Canadian Geodetic Vertical Datum of 1928. Victoria Lake Reservoir, a hydroelectric reservoir forming part of the Bay d’Espoir Hydroelectric Development, is adjacent to the Project on the west. The Victoria Dam diverts flow that would otherwise flow to the Victoria River to the White Bear drainage basin to the south. Valentine Lake lies north of the Project and drains to the Victoria River. An overview of the mine complexes and the Project facilities is presented in Figure 1-2.



Notes
1. Background: CanVec 1:250 000 data, Natural Resources Canada

Disclaimer: This document has been prepared based on information provided by others as cited in the Notes section. Stantec has not verified the accuracy and/or completeness of this information and shall not be responsible for any errors or omissions which may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format, and the recipient accepts full responsibility for verifying the accuracy and completeness of the data.

Figure 1-1 Project Location and Spatial Boundaries for Surface Water Resources VC



LEGEND

—	EXISTING CONTOURS, m
═	PROPOSED MINE PIT / STOCKPILE
—	WATERCOURSE
– –	FISH BEARING WATERCOURSE
🟩	WOODED AREA
▨	WETLAND
▭	WATERBODY
▨	FISH BEARING WATERBODY
▭	PROPOSED POND
–·–	PROPOSED DRAINAGE CHANNEL
----	PROPOSED DITCH
–··–	FUTURE PIPELINE
–o–	POWER LINE
Ⓓ	FINAL DISCHARGE POINT

NOTE:
COORDINATES ARE NAD83(CSRS) UTM ZONE 21.

V:\1214\active\121416408\03_data\gis_cad\1_CAD\4_Sheet_Files\03_WQQ\121416408C_WQQ_Fig1-2.dwg

THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC CONSULTING LTD. REPORT AND MUST NOT BE USED FOR OTHER PURPOSES.

Reference:

1. EXISTING CONTOURS AND PROPOSED INFRASTRUCTURE: AUSENCO; PROJECT No. 104878-01; DRAWING No. 104878-0000-G-001; 2020-05-11; PRELIMINARY.
2. WATERCOURSES, WATERBODIES & WETLANDS: CANVEC DATABASE FROM NATURAL RESOURCES CANADA.
3. FISH BEARING WATERCOURSES AND WATERBODIES: SURVEYED FISH BEARING OR HAS CONNECTIVITY TO FISH BEARING WATER (STANTEC 2012, 2019, 2020).

SITE LAYOUT
WATER QUANTITY AND QUALITY MODELLING REPORT
VALENTINE GOLD PROJECT, NL

Client: MARATHON GOLD CORP

Job No.:	121416408
Scale:	1 : 35 000
Date:	28-SEP-2020
Dwn. By:	JL
App'd By:	NS

Fig. No.: 1-2

Stantec

1.2 STUDY OBJECTIVES

The model considers both the quantity and quality of water under management by the Project and is used to support the prediction of potential environmental effects in the EIS.

The objectives of the Marathon model are to:

- Estimate the quantity and quality of surface water runoff associated with the Project facilities including the open pit, ore stockpile, overburden stockpile, topsoil stockpile, and waste rock pile.
- Predict the quantity and quality of effluent discharge to each final discharge points (FDP) during all phases of development
- Aid in the development of the conceptual closure plan for the Project

Effects of the Project on surface water quantity of the receiving environment are not simulated in this model. A separate assessment of the assimilative capacity of the receiving waters (Stantec 2020b) provides the surface water quality of the effluent discharge once mixed with the receiving waters. The model uses process plant water balance inputs and outputs provided in the Pre-Feasibility Study (Ausenco 2020).

1.3 PROJECT SPATIAL BOUNDARIES

The spatial boundaries for the Project include the Project Area, the Local Assessment Area (LAA), and the Regional Assessment Area (RAA) (Figure 1-1). Interactions between the Project and surface water may occur in all three of these defined areas.

Project Area: The Project Area encompasses the immediate area in which Project activities and facilities occur and is comprised of two distinct areas: the mine site and the access road. The mine site includes the area within which Project infrastructure will be located. The access road is the existing road to the site plus a 20 m buffer on either side. The Project Area is the anticipated area of direct physical disturbance associated with the construction and operation of the Project.

Local Assessment Area: The LAA for the Surface Water Resources Valued Component (VC) incorporates the Project Area and watersheds that intersect with the Project Area, as shown in Figure 1-1. The LAA also includes portions of Victoria Lake Reservoir in the expected effluent mixing zones, which are typically considered to be up to several hundred meters from points of discharge in the lake. The LAA includes all of Valentine Lake and the Victoria River to the point downstream where all Project-affected tributaries converge with the main branch of the river.

Regional Assessment Area: The RAA for surface water resources incorporates the Project Area and LAA and extends to include areas where potential Project interactions may be observed, as shown in Figure 1-1. This includes all of the LAA, the Victoria River and Red Indian Lake, including its discharge at the head of the Exploits River. This area encompasses the potential downstream receivers of surface water that may flow from the Project Area. The model is limited to the Project Area, but receives inputs from Victoria Lake Reservoir, which is within the LAA.

1.4 PROJECT OVERVIEW

1.4.1 Project Facilities

The Marathon Complex consists of an open pit, waste rock pile, stockpiles (i.e., topsoil, overburden and low-grade ore (LGO) stockpiles), and water management ponds. A description of the individual Project facilities at the Marathon Complex are presented below and in the Water Management Plan (Stantec 2020b). The location of the facilities is shown on Figure 1-2.

Marathon Open Pit: The open pit will be progressively expanded over the first nine years of mining. The Marathon and Leprechaun pits will be mined simultaneously with plans for the ore stream to be blended and processed together. Ore extracted from the open pits will be hauled to stockpiles or the processing plant. Ore grading between 0.33 and 0.50 grams per tonne (g/t) of gold (Au) will be stockpiled in the associated LGO stockpiles. Cut-off grade optimization in the mine production schedule will also send ore above 0.50 g/t Au to a high-grade ore (HGO) stockpile in certain planned periods.

The Marathon Pit will be dewatered throughout operation by pumping from sump pits at the base of the pit. The collected contact water will be stored in a sump pit prior to being pumped to a pond at the surface. Water from the water management ponds will be discharged to the environment following treatment in the water management ponds as needed to meet discharge quality criteria.

The anticipated depth under the projected spillway of the Marathon open pit is approximately 266 metres (m), with a maximum area of 0.5 square kilometers (km^2). After completion of mining, the Marathon pit will be filled with water to an elevation of 330 m at the crest of the spillway and an associated maximum storage volume of 62.2 million cubic metres (Mm^3). Once full, the pit lake will be spilled through a discharge channel toward the existing FDP.

Active mining extraction of ore and waste rock will cease in Mine Year 9, however ore processing is anticipated to continue from Years 10 to 12. Pit water filling will commence in Year 10.

Low-Grade Ore Stockpile, Overburden Stockpile, Topsoil Stockpile and Waste Rock Pile: The Marathon waste rock pile area is located northwest of the pit limits and built up to a crest elevation of 415 m. Topsoil from the pit will be stored in a topsoil stockpile north of the pit limits and overburden will be stored in a overburden stockpile southwest of the pit limits. The LGO stockpile will be located south of the pit. These piles are separated to avoid local natural watercourses.

The waste rock will be constructed from the existing ground surface and will be sloped and benched as it is developed, creating overall safe slopes for final closure of three horizontal to one vertical (3H:1V). In addition, the pile will be progressively rehabilitated during operation and closure by covering slopes and benches with a vegetated soil cover to reduce infiltration and increase evapotranspiration.

Final Discharge Points: The FDPs receive outflows from the water management ponds. Watershed areas upstream of each FDP associated with Project water management infrastructure were developed using available public topographic information and LiDAR data collected for the Project.

1.4.2 Water Management Infrastructure

Water management infrastructure includes the water management ponds and ditching constructed upstream of each FDP. At the Marathon Complex, collection ditches will be installed around the perimeter of Project facilities to intercept surface water and toe seepage and convey to the water management ponds. Further details regarding water management infrastructure is described in Section 3.3.

The water management ponds at the Marathon Complex are intended to control the sediment contained in contact water discharges from mine facilities. Each water management pond collects runoff, toe seepage, and groundwater infiltration through a series of ditches. The ditches may capture flow from waste rock piles, LGO, topsoil, or overburden stockpiles, or water from pit dewatering. These water management features (ditches and water management ponds) were designed under a decentralized water treatment framework, operating under gravity drainage to reduce the need for pumping when managing flows.

Table 1-1 shows a list of the ditches and water management ponds in the Marathon Complex that capture runoff and toe seepage from each mine facility, as well as watershed area and volume of the water management ponds. Figure 1-2 provides location of the water management ponds and ditches. The water management ponds discharge to the FDPs. The footprint of the topsoil stockpile was changed between the water management design prepared for the Pre-Feasibility Study and the EIS. This has resulted in slight overlaps of proposed water management infrastructure with some of the Project components at the Marathon Complex. This is not anticipated to result in substantive changes to the water quantity or water quality predictions presented in this report. The water management design will be updated to reflect the layout of the Marathon Complex during the feasibility-level design.

Table 1-1 Water Management Ponds and Approximate Ultimate Surface Areas

Mine Facility	Ditch Name	Water Management Pond Name	Water Management Pond Watershed Area (m^2)	Pond Volume (m^3)	Pond Area (m^2)
LGO Stockpile	MA-DR-01	MA-SP-01A	107,555	16,989	8,915
	MA-DR-02		57,385		
Overburden Stockpile	MA-DR-03	MA-SP-01B	104,553	29,810	29,625
	MA-DR-04		184,865		
Waste Rock Pile	MA-DR-05	MA-SP-01C	220,350	22,696	8,915
	MA-DR-06				
	MA-DR-07	MA-SP-02	388,120	39,976	30,848
	MA-DR-08				
	MA-DR-09	MA-SP-03	302,385	31,146	32,460
	MA-DR-10				
	MA-DR-11	MA-SP-04	81,510	53,383	51,975
	MA-DR-12		436,770		

Table 1-1 Water Management Ponds and Approximate Ultimate Surface Areas

Mine Facility	Ditch Name	Water Management Pond Name	Water Management Pond Watershed Area (m^2)	Pond Volume (m^3)	Pond Area (m^2)
	MA-DR-13				
	MA-DR-15				
Topsoil Stockpile	MA-DR-14		40,100		
Marathon Pit	MA-BR-01	MA-SP-05	695000*	5,454	6,670

Notes:
* Ultimate watershed area (final year of mine of development)

1.4.3 Project Phases

The overall Project development schedule will consist of three primary phases: construction, operation, and decommissioning, rehabilitation and closure. Project activities within these phases are further subdivided for the purposes of this report as shown in Table 1-2. For convenience, “closure” in this document refers to the first five years of the decommissioning, rehabilitation and closure phase, while “post-closure” refers to the remainder of this phase.

The time frame for the Project phases in years, and the corresponding model year (at the beginning of the model year), are presented on Figure 1-3. The model assumes that construction starts in model Year 0 and operation commences in model Year 1.

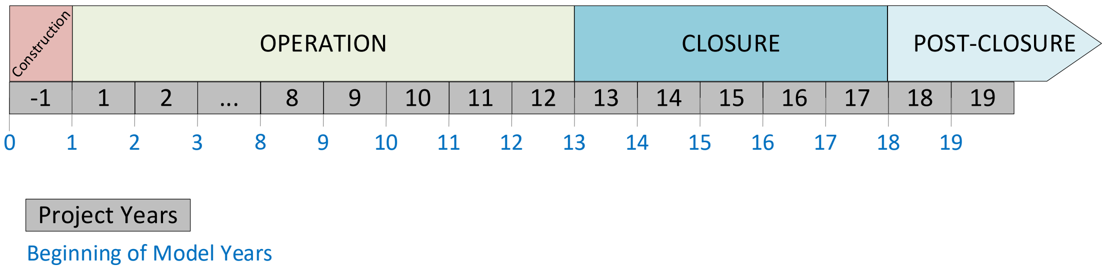


Figure 1-3 Project Phases of Development (Project Year versus Model Year)

Table 1-2 Description of Project Phases of Development

Project Phase	Time Frames Incorporated into the Model	Description
Construction	Year -1 *	Construction activities will occur over 16 -20 months, for simplicity associated to mine Year -1. Mining activity has commenced during construction to provide material for TMF and road construction. Topsoil and overburden stockpiles will be developed during construction, as well as the ground preparation for the waste rock pile footprint for the first year of operation.
Operations	Year 1 – Year 9 (9 years)	During Years 1 - 9, the open pits will be mined, waste rock piles will be extended to their full footprint and constructed vertically, ore will be processed, and the mill plant and TMF will be operational. Mining activities cease at the end of Year 9.
	Year 10 – Year 12 (3 years)	Waste rock piles are designed for closure and the slopes and benches will be progressively rehabilitated. The model does not account for progressive rehabilitation vegetated soil covering activities that begun during operation, representing a conservative estimate of environmental effects during operations. The Marathon pit will commence filling with water during Years 10-12, as dewatering activities will cease.
Decommissioning, Rehabilitation and Closure	Closure: Year 13 – Year 17 (5 years)	During the first 18 month of closure, the overburden topsoil, and LGO stockpiles will be used up and the footprint areas stabilized with vegetation, the waste rock piles will be rehabilitated with vegetated soil covers. Existing Project buildings and associated infrastructure will be dismantled, removed for disposal, and/or demolished. The open pits will be filled naturally from incidental precipitation and groundwater inflows as well as accelerated by pumping from Valentine Lake (Marathon pit). The pit lakes will be filled to allow development of stratified pit lakes and eventual discharge to the Victoria River. Unless otherwise stated in this report, water management infrastructure will remain in place at closure until the water quality is such that removal of such infrastructure is acceptable.
	Post-Closure: from Year 18 onward	During this phase, the open pit will continue to fill and eventually discharge to the environment. Other discharges to the environment include groundwater and surface water runoff from the waste rock pile. At this point all water management features should be removed, and ‘natural’ drainage re-established.

Note:

* For simplicity, modelling considered a one-year construction period rather than 16 – 20 months, as the majority of construction activities are schedule to occur in 2022.

1.4.4 Post-Development Watershed Areas

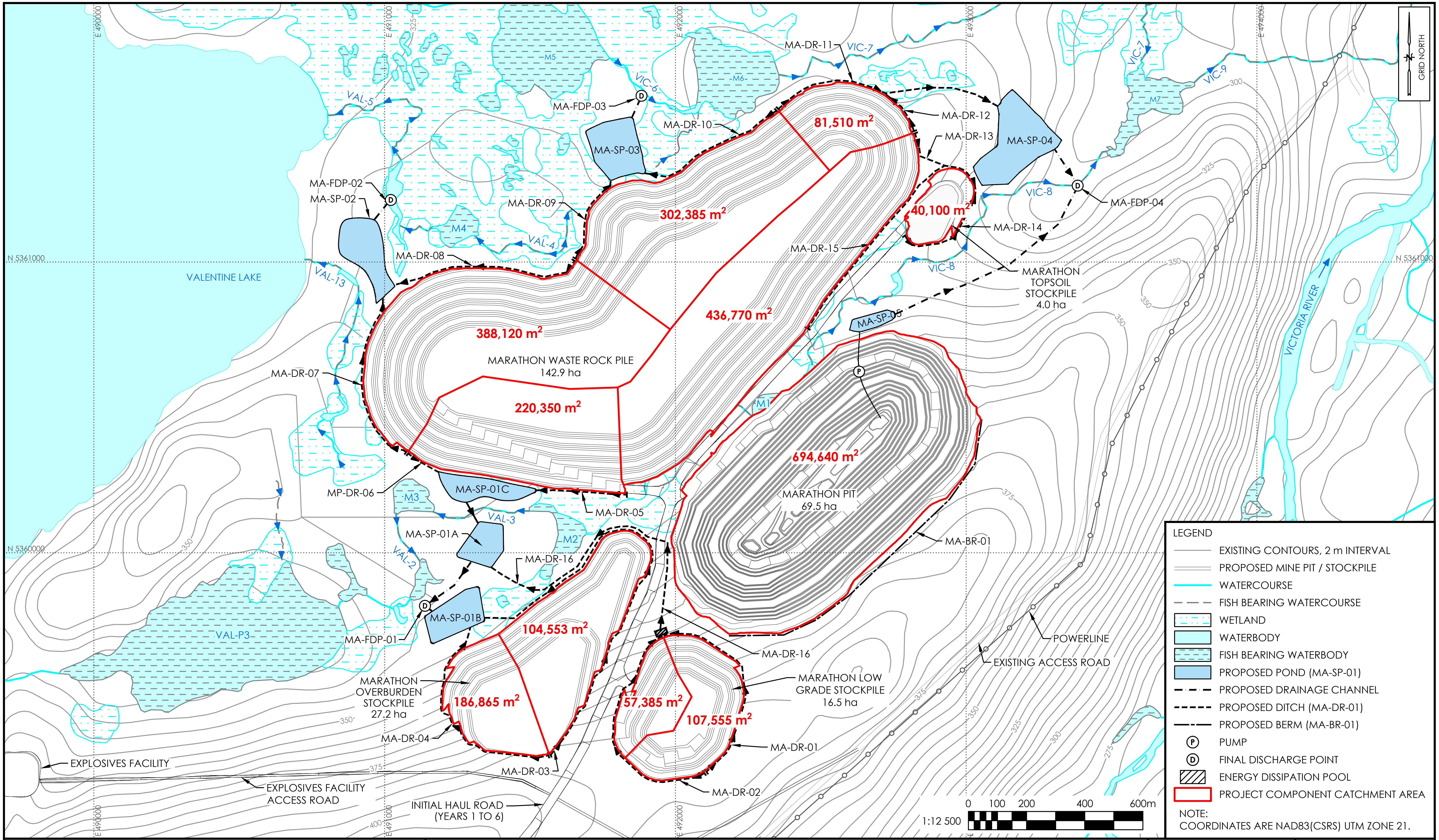
The water management design diverts non-contact water from the natural water drainage areas associated with the mine facilities, where possible. Diversion of surface flows using channels and berms constructed around the crest of open pits or up-gradient of waste rock piles, stockpiles and other developed areas will reduce the contact water inventory. Figure 1-4 presents the post-development watershed areas, flow directions, locations of FDPs, historical surface water hydrology and quality monitoring stations details on the mine facilities.

As presented in Table 1-3, the Marathon Complex will have 5 FDPs that ultimately drain to the Victoria River by way of Valentine Lake or tributaries to the river. MDMER limits will be met at FDPs prior to release.

During operation, the Marathon waste rock pile will be graded to maintain pre-development watershed areas, where possible. The waste rock pile drains to four different water management ponds. During operation, perimeter berms will be installed where required around the Marathon pit to prevent surface water runoff from flowing into the pit. During closure, these berms will be removed allowing surface water runoff to flow into the pit in an effort to accelerate pit filling and reestablish pre-development drainage conditions.

Table 1-3 Post-development Watershed Areas

Final Discharge Point	Watershed ID	Watershed Area (km^2) Water Management Pond	Watershed Area (km^2) During Operation	Watershed Area (km^2) During Closure/Post-Closure
MA-FDP-01A	WS-16	0.384	0.687	1.347/1.966
MA-FDP-01B	WS-17	0.220	0.638	0.377/0.377
MA-FDP-02	WS-19/20	0.388	0.633	0.633
MA-FDP-03	WS-22	0.302	1.156	1.156
MA-FDP-04	WS-18	2.09	2.154	2.772/2.154



V:\1214\active\121416408\03_data\gis_cad\1_CAD\4_Sheet_Files\03_WQQ\121416408C_WQQ_MAR_Fig1-4.dwg

THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC CONSULTING LTD. REPORT AND MUST NOT BE USED FOR OTHER PURPOSES.

Reference:

1. EXISTING CONTOURS AND PROPOSED INFRASTRUCTURE: AUSENCO; PROJECT No. 104878-01; DRAWING No. 104878-0000-G-001; 2020-05-11; PRELIMINARY.
2. WATERCOURSES, WATERBODIES & WETLANDS: CANVEC DATABASE FROM NATURAL RESOURCES CANADA.
3. FISH BEARING WATERCOURSES AND WATERBODIES: SURVEYED FISH BEARING OR HAS CONNECTIVITY TO FISH BEARING WATER (STANTEC 2012, 2019, 2020).

WATER MANAGEMENT DESIGN AT MARATHON COMPLEX

WATER QUANTITY AND QUALITY MODELLING REPORT

VALENTINE GOLD PROJECT, NL

Client: MARATHON GOLD CORP

Job No.:	121416408
Scale:	1 : 12 500
Date:	28-SEP-2020
Dwn. By:	JL
App'd By:	RJ

Fig. No.: 1-4

Stantec

2.0 MODELLING APPROACH

The water quantity and water quality model for the Marathon Complex was constructed using GoldSim simulation software (GoldSim) with the contaminant transport (CT) module extension. GoldSim is commonly used in the mining industry to develop water balance models and predict water quality at user-defined modelling nodes by combining system dynamics with discrete event simulations. The model was run dynamically on a monthly time step for the construction, operation, and decommissioning, rehabilitation and closure phases.

The model includes a water quantity component (Section 3) and a water quality component (Section 4). Water quantity is calculated incorporating defined inputs, such as inflow rates and outflow rates. These inflows and outflows are based on precipitation, evapotranspiration, infiltration and runoff rates, catchment and facility areas and volumes, groundwater inflow rates, operational water management strategies and the movement of materials within the site. The water quality predictions are calculated at the model nodes by integrating source terms developed for mass loading sources into the water quantity component.

An average climate condition (i.e., based on climate normals) was considered to evaluate the potential effects of the Project on surface water as a base case. Building from this base case, a probabilistic Monte Carlo analysis was conducted to extend the analysis to include extreme wet and dry climatic conditions. This allows for the prediction of runoff, seepage and water quality behaviour and characteristics over this range of climatic conditions.

The Monte Carlo analysis consisted of series runs of randomly generated yearly precipitation totals using a probabilistic precipitation distribution throughout the year based on a monthly time step. A single run in this model consisted of 100 years with different annual precipitation values for each year. This approach enabled the analysis of a range of climate scenarios and the development of statistical frequencies and confidence intervals for the flow rates and water quality predicted by the model. The Monte Carlo analysis was set for 100 runs, i.e., running the model 100 times, for different annual precipitation each year. Results of the Monte Carlo analysis are presented as percentiles from the whole range of model results, from the 5th percentile (equivalent to a 1:5 dry year) to the 95th percentile (equivalent to 1:25 wet year).

The water quantity model and climate scenarios are discussed in more detail in Section 3.3.1. Results are provided for the average scenario and for the probabilistic analysis. Considering that the model simulates the Project Area without long term climate and flow monitoring stations, and a highly adapted and manipulated Project Area, the model was adjusted to predict mean and standard deviation baseline conditions based on observed mean and standard deviation (from historical data) and assumptions of a log-normal distribution based on the frequency analysis of the data.

3.0 WATER QUANTITY MODEL

3.1 CONCEPTUAL WATER QUANTITY MODEL

The water quantity model relies on climate and hydrological inputs, drainage areas, and characteristics of mine facilities during different phases of the Project. The water quantity model is developed to predict outflow rates of the mine site, including the water management pond discharges to the FDPs, within the LAA. The LAA for the Surface Water Resources VC is shown in Figure 1-1. The Marathon Complex drains and discharges ultimately to the Victoria River by way of direct river tributaries and Valentine Lake through direct lake tributaries.

Figure 3-1 to Figure 3-4 present the schematic structure of the water quantity model, the Marathon FDPs and receivers, and identifies the Project facilities, contact water (i.e., water that is in contact with the Project facilities) and non-contact water (i.e., water not affected by the Project) flow pathways. The modelled Project facilities identified in Section 1.4 (i.e., open pit, waste rock pile, and stockpiles) will have drainage and diversion controls that prevent external natural drainage from coming into contact with Project facilities and becoming contact water.

Watershed areas for the Project facilities were delineated based on the site layout (Figure 1-2) and existing ground surface topography. The watershed areas were delineated where seepage from the bases of the waste rock pile, ore stockpile and overburden stockpile are expected to report to the collection ditches and then to the water management pond. It is assumed that these watershed areas are at the ultimate footprint stage of mine development at the beginning of the Project phase of development. For example, the model assumes that contact water from stockpiles starts flowing to the collection ponds at the beginning of operation with the exception of the pit, which has been set as a gradually expanding area over Years 1-9.

Conceptual models showing the interactions of the Project facilities during construction, operation, decommissioning, rehabilitation and closure (sub-divided into closure and post-closure periods) are presented in Figure 3-1 to Figure 3-4. The flow arrows show the direction of flow accounted for in the water quantity model to or away from the Project facility. To simulate post-closure, the water quantity model was extended to run until the end of Year 100. Natural and accelerated pit filling scenarios were considered. The natural pit filling scenario included seepage, direct precipitation on the pit, and runoff from upgradient catchments that were temporarily diverted from draining to the pit during operation. The accelerated pit filling scenario pumps water from Valentine Lake, with a withdrawal rate based on filling the pit during the eight years from Year 10 to Year 18 (Year 5 of Closure) to form final pit lake by the end of closure. The base case of the model simulated the accelerated eight year filling scenario for the Marathon pit.

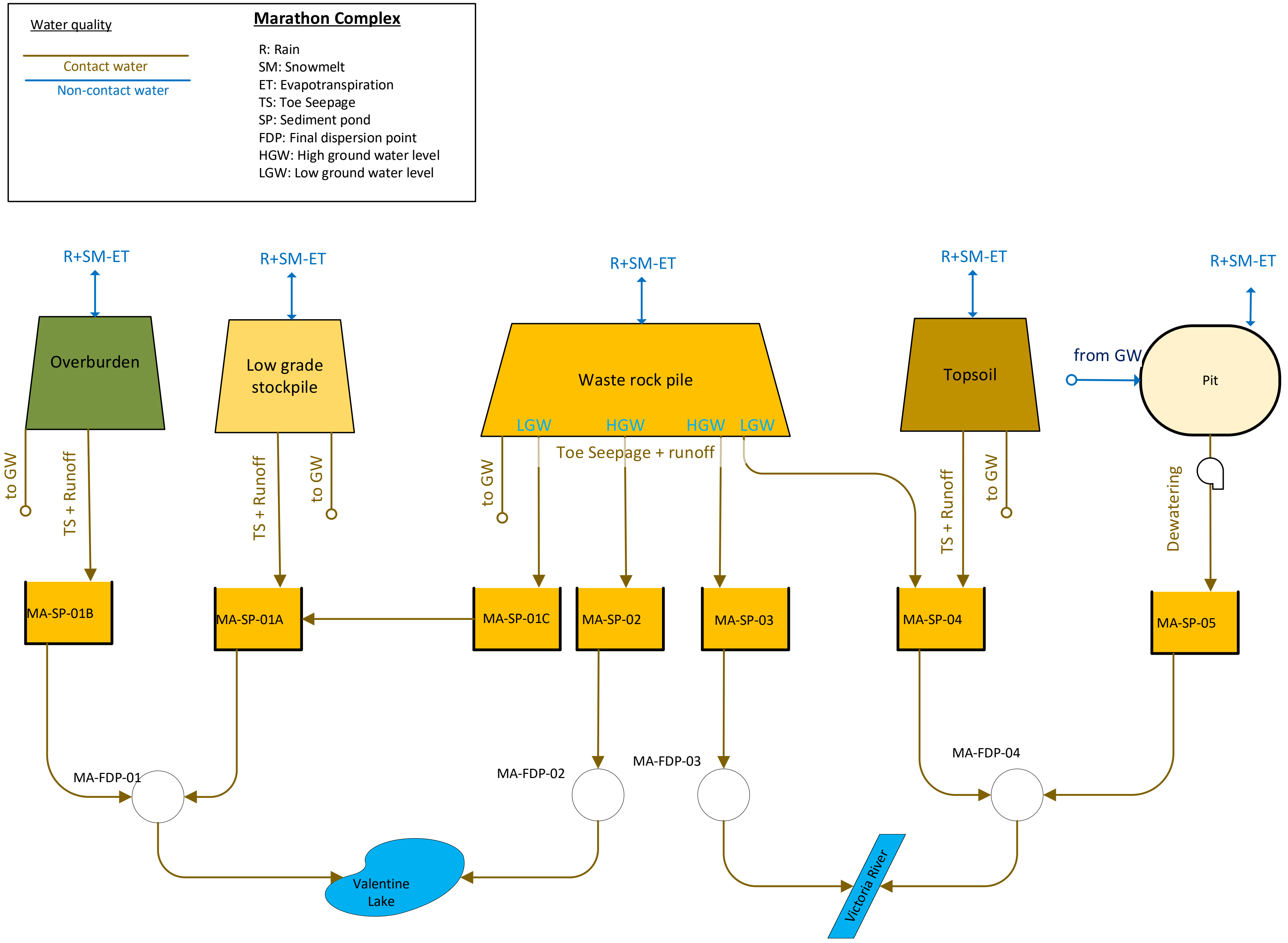


Figure 3-1 Conceptual Model of Mine Water Management – Construction/Operation (Year -1 to 9)

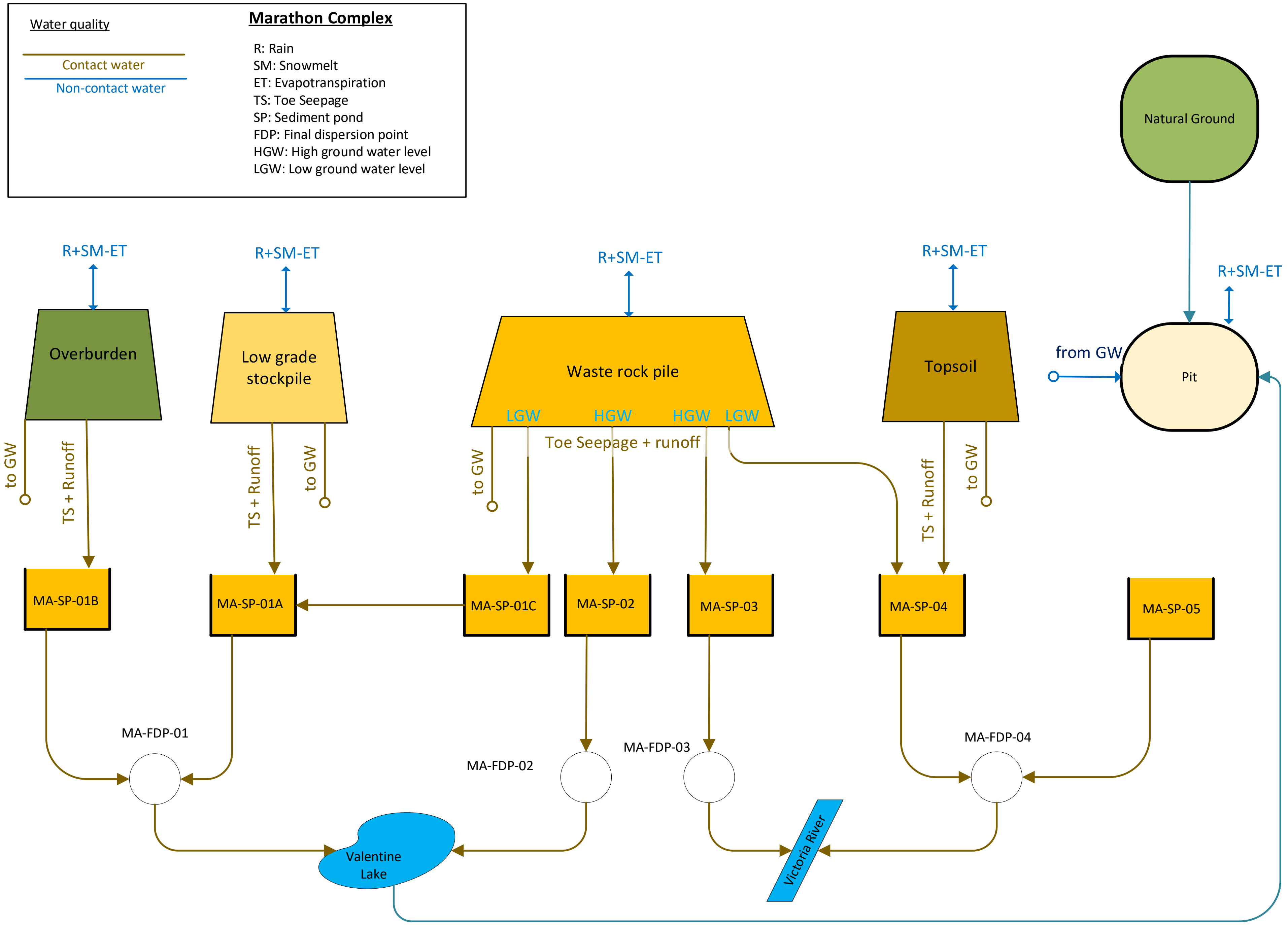


Figure 3-2 **Conceptual Model of Mine Water Management – Operation (Year 10 to 12)**

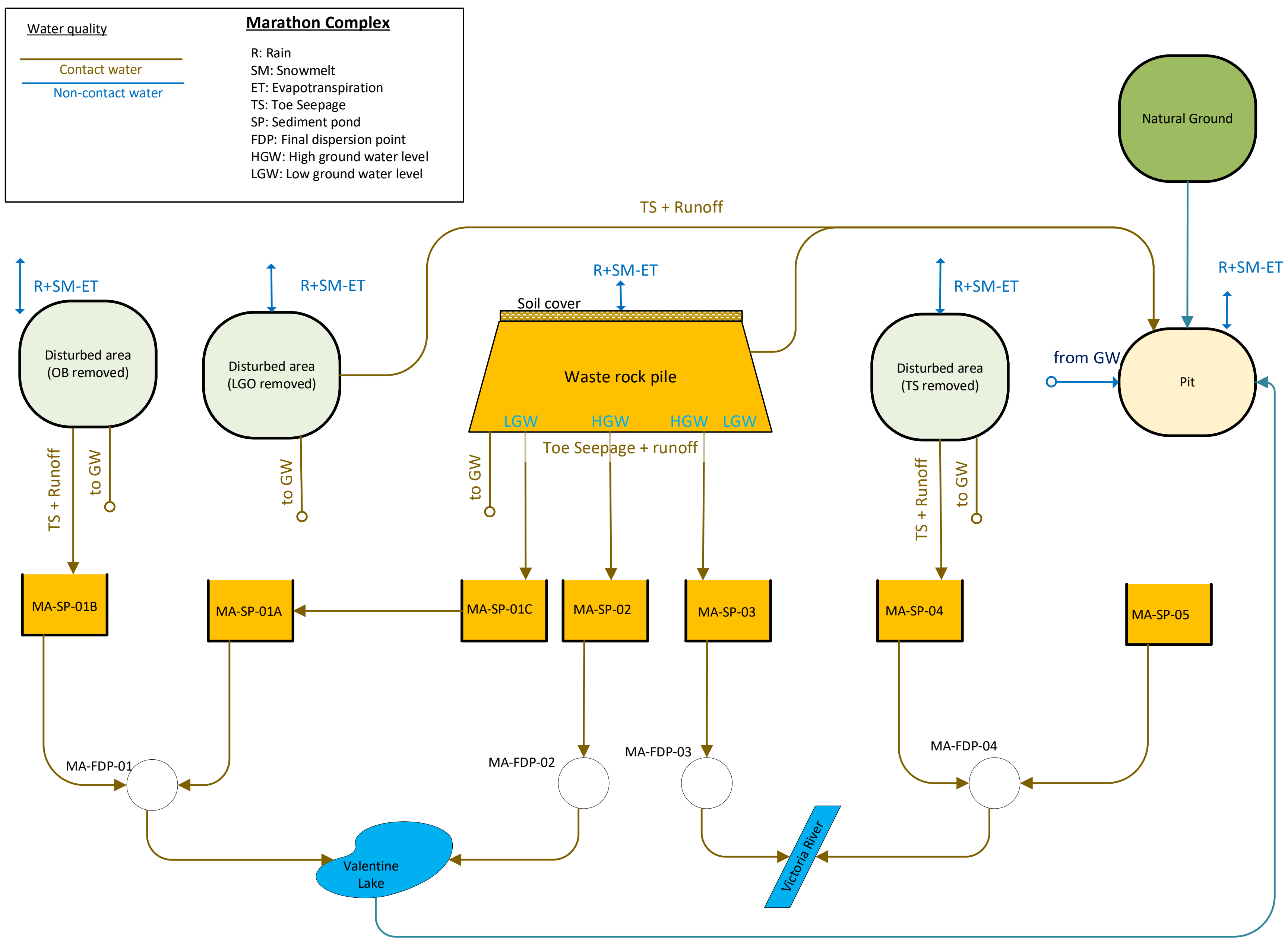


Figure 3-3 Conceptual Model of Mine Water Management – Closure (Year 13 until Pit is full)

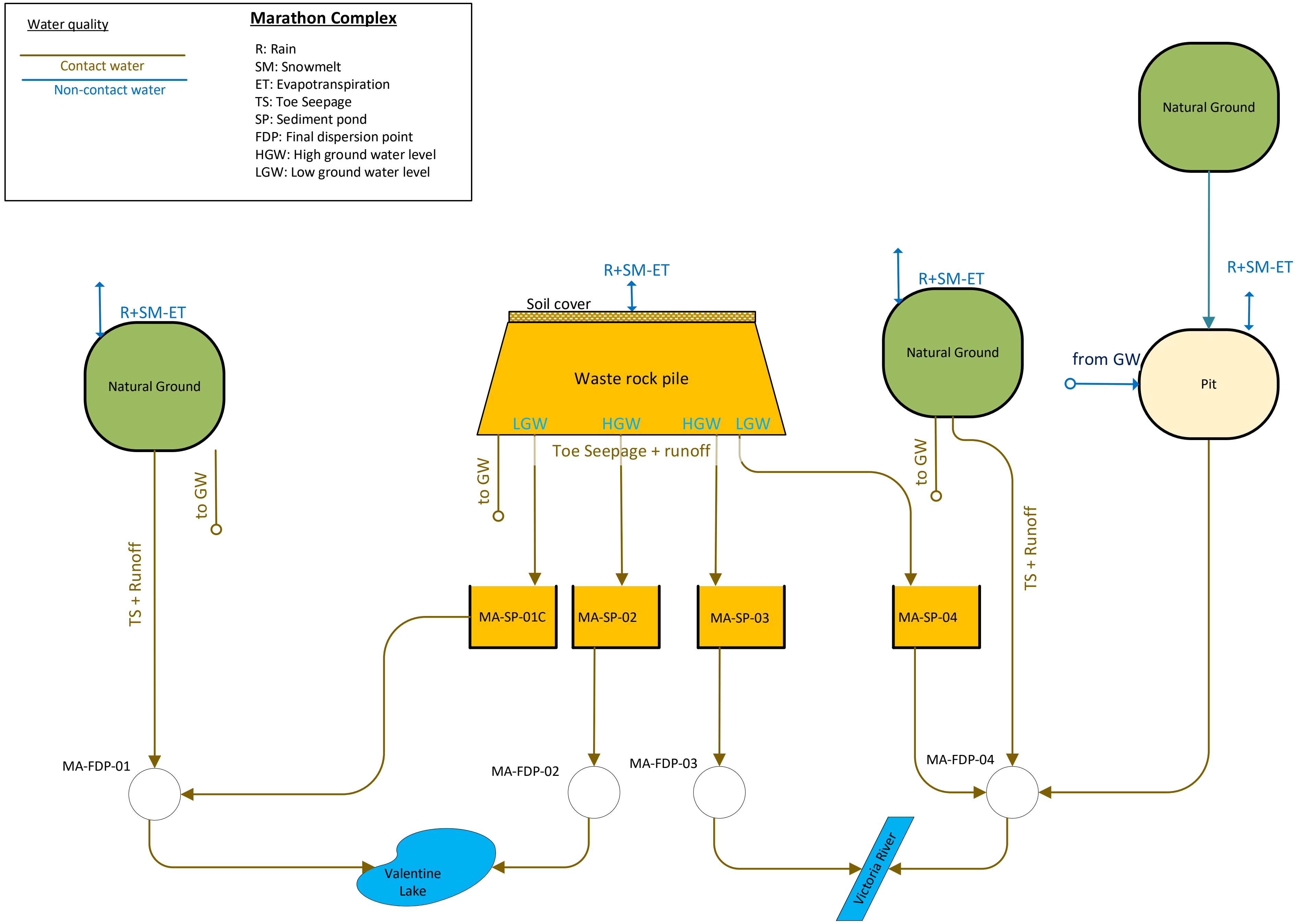


Figure 3-4 Conceptual Model of Mine Water Management – Post-Closure (Pit is full)

3.2 WATER QUANTITY APPROACH

The water quantity model was developed using the GoldSim CT module. The water quantity model accounted for the precipitation, evapotranspiration, infiltration and groundwater gains and runoff at each identified Project facility.

The conceptual flow paths for precipitation on a stockpile or waste rock pile are presented in Figure 3-5. The percentage of precipitation that results in runoff from the pile areas was accounted for in the water quantity model by a water balance approach. These inputs to the model are summarized in Table 3-1, showing the monthly totals in mm and the percent monthly distribution. For the purposes of the model, it was assumed that the pore space in the waste rock pile was fully saturated during operation, and therefore did not require accounting for the initial saturation of the pile. Equation 3-1 presents the accounting of runoff from stockpiles and the waste rock pile collected in the seepage collection ditches and water management ponds based on the hydrological inputs:

Equation 3-1

Runoff to water management ponds = Precipitation
– ET (%F)
- Snow Storage
+ Snow Melt and Runoff (%F)
– Net infiltration
+ Toe Seepage
+ Shallow Groundwater Infiltration (%F)

Where:
%F = Adjustment factor applies as % of precipitation
Net Infiltration = Toe Seepage + Shallow Groundwater + Deep Groundwater

Runoff from the tailings and polishing pond was estimated in the model based on the proportion of total precipitation (rainfall plus snow melt runoff) on the catchment multiplied by a runoff coefficient. This method is consistent with the prefeasibility level water balance model conducted by Golder for design (Golder 2019).

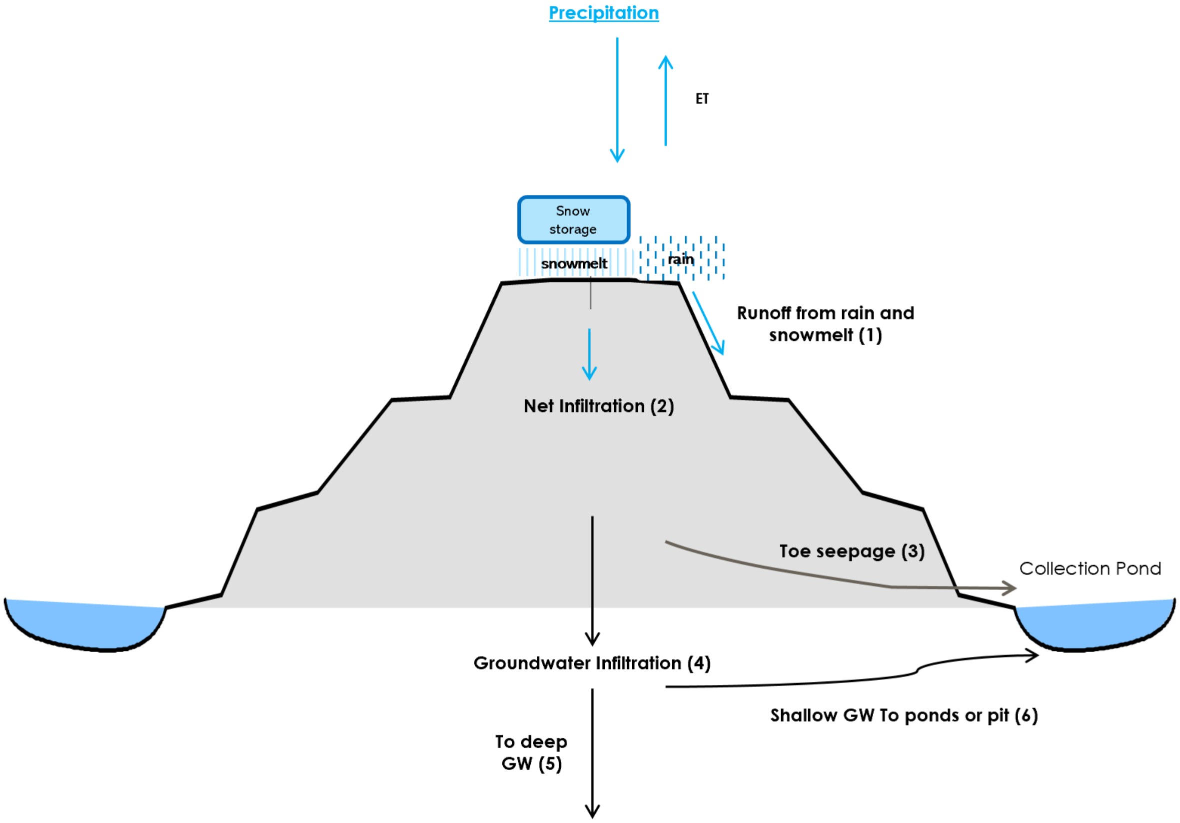


Figure 3-5 Conceptual Stockpile or Waste Rock Pile Flow Pathways

The proportion of net infiltration that integrates with basal seepage and becomes part of deeper regional groundwater flow (flow 5 in Figure 3-5) will not report to seepage collection ditches and is not carried through in the water quantity or water quality models to the water management ponds and FDPs. The proportion of net infiltration that reports as seepage to perimeter ditching and is collected in the seepage collection system is carried through the model to the water management ponds (flows 3 and 6 in Figure 3-5). The net infiltration reporting as seepage to the collection ditches, water management ponds, and FDPs is the primary groundwater seepage included in the model. The percentage of net infiltration reporting to the ditches as toe seepage is included in Section 3.3.1.1.

3.4 WATER BALANCE INPUTS

3.4.1 Climate and Hydrology

An evaluation of climate hydrologic data for the Project was presented in the Baseline Hydrology report (Stantec 2020c). Climate and hydrology inputs to the model are summarized in Table 3-1. Monthly distributions and totals for climate and hydrology inputs at the mine site were represented by precipitation from the climate normals (1981-2010) at the Environment and Climate Change Canada (ECCC) Buchans climate station (Station ID 8400698, ECCC 2020a).

Average precipitation at the mine site was input to allow for both probabilistic and stochastic model extractions. The probability distribution function that best fits the annual precipitation data at the Buchans station is a Log-Normal distribution with mean and standard deviation values of 1236.6 mm and 187 mm, respectively. This probability distribution function was used in GoldSim for the Monte Carlo simulation. The results of the entire set of 100 runs are presented as percentiles, from 5th to 95th. The 95th and 5th percentile annual precipitation totals are approximately equivalent to the 1:25 year wet and 1:5 year dry years, respectively.

Under average climate conditions, the coldest month is February with an average monthly temperature of -8.4°C and the warmest month is July with an average monthly temperature of 16.3°C. The average annual temperature is 3.8°C. Average monthly temperatures typically drop below freezing in December and remains below freezing until April.

The average annual snowfall recorded at Buchans is 359.3 cm with month end snow depths typically highest in February. The average climate snow depth on ground in February was recorded at 67 cm. No snow on ground was reported for the months of May to October, inclusive. The extreme snow depth recorded was in March 1982 at 210 cm. The estimate of snow storage and snow melt was designed to replicate the average climate conditions at the Buchans Climate Station. The total snow storage was based on the March storage of 60 cm (average climate conditions) converted to snow-water-equivalent. A snow density of 0.35 was used, based on the reported snow density in the Maritimes increasing from 0.1 to 0.35 over the winter to account for ice and melt in snow (Sturm et al. 1995). The proportion of precipitation in the cold months was assumed to be stored as snow for the months of November through March and the majority of melt occurring in the months of April through June. A proportion of the snow melt was assumed to runoff into the collection ditches, and the remainder was assumed to infiltrate into the pile. The percentage of snow melt as snow melt runoff is summarized in Table 3-1. Although the mine site is inland, the Project Area is influenced by the Island of Newfoundland's maritime climate, which produces melting conditions throughout the winter and rainfall in all months of the year. Thus, snowmelt can and is expected to occur in all winter months.

Mean annual potential evapotranspiration for the Island of Newfoundland has been mapped. The potential mean annual evapotranspiration for the Project Area ranges from 450 to 474 mm (NLDOEC 1992). The evaporation from ponds at the site was represented by the average lake evaporation rate (mm/month) reported at the Stephenville and Gander climate stations (ECCC 2020b, Station IDs 8401700 and 8403800). Actual evapotranspiration (AET) at the site was based on a USGS Thornthwaite model (Thornthwaite 1948). Inputs to the USGS Thornthwaite model included average climate precipitation and temperature data at Buchans, local soil conditions, and recommended values provided by the USGS (McCabe and Markstrom 2007).

The amount of AET was adjusted in the model based on Project facility and Project phase. These adjustments were applied to account for the characteristics of stockpile slope, soil storage, and infiltration of each Project facility. During operation, 90% of evapotranspiration (ET) was represented as the AET loss in the water quantity model, as the stockpiles are un-vegetated, and the uptake and transpiration of precipitation will not occur, hereafter referred to as ET for un-vegetated piles.

As shown in Table 3-1, in the months of November to February (inclusive), snow storage is greater than snow melt resulting in snow accumulation on ground. In March, the snow storage is less than the snow melt, meaning that the snow on the ground begins to decrease at the start of spring runoff.

Table 3-1 Water Balance Elements (mm) and Monthly Distribution

Parameter Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Precipitation mm	122.0	98.1	95.0	85.7	86.6	87.8	95.3	123.0	110.4	97.5	111.8	123.1	1236.3
Distribution	9.9%	7.9%	7.7%	6.9%	7.0%	7.1%	7.7%	9.9%	8.9%	7.9%	9.0%	10.0%	0.0%
AET mm	8.8	9.2	15.3	25.6	44.0	62.6	81.3	71.6	44.6	26.5	15.2	10.5	415.2
Distribution	0.7%	0.7%	1.2%	2.1%	3.6%	5.1%	6.6%	5.8%	3.6%	2.1%	1.2%	0.8%	33.6%
Lake Evaporation mm	0.0	0.0	0.0	0.0	46.5	100.5	110.1	96.1	63.0	20.2	0.0	0.0	436.3
Distribution	0.0%	0.0%	0.0%	0.0%	3.8%	8.1%	8.9%	7.8%	5.1%	1.6%	0.0%	0.0%	35.3%
Snow Storage mm	83.3	67.0	66.6	26.2	4.4	0.1	0.0	0.0	0.1	5.0	30.4	76.9	360.0
Distribution	6.7%	5.4%	5.4%	2.1%	0.4%	0.0%	0.0%	0.0%	0.0%	0.4%	2.5%	6.2%	29.1%
Snow Melt runoff mm	25.1	40.9	67.2	151.0	14.9	0.1	0.0	0.0	0.1	5.0	20.4	35.3	360.0
Distribution	2.0%	3.3%	5.4%	12.2%	1.2%	0.0%	0.0%	0.0%	0.0%	0.4%	1.7%	2.9%	29.1%

3.4.1.1 Pile Runoff and Net Infiltration

The saturated-unsaturated hydrologic model Hydrologic Evaluation for Landfill Performance (HELP, US Environmental Protection Agency 1994) was run for the waste rock piles to simulate infiltration through piles and the proportion of toe seepage collected in the perimeter ditching. The HELP model input included precipitation, temperature, solar radiation, ET, and characteristics of the pile itself, such as pile height, bench slope, ground slope and ground soil conditions. Based on results of the HELP model, 50% of AET during operation was applied in the water quantity model for the waste rock pile, as the voids spacing in the rock is not conducive to soil storage and water wetting the pile surfaces will evaporate over the month.

To represent vegetated covers during the closure and post-closure sub-phases on the waste rock pile stabilized with vegetation, the water quantity model assumed 100% of AET and 90% of snowmelt runoff from the pile, resulting in a decrease of the net infiltration, and therefore a reduction on the seepage. The percent of total AET applied in the model is summarized in Table 3-2.

The LGO, topsoil and overburden stockpiles are assumed to be removed at closure. LGO will be processed at the mill, and the topsoil and overburden stockpiles will be used for progressive rehabilitation of rock slopes. Respective areas of these pile are modelled as “prepared ground” during closure and “natural ground” during post-closure, using runoff coefficients presented in Table 3-3 .

It was assumed that during the first year (modelled during Year -1), net infiltration will be consumed in wetting the pile. Therefore, there is no seepage during that period.

Table 3-2 Adjustment Factor (%) in the Water Quantity Model by Project Facility

Project Facility	Adjustment Factors			
	Percent of Total ET	Percent of Snow Melt as Runoff	Percent of Rain as Runoff	Percent of NI as Toe Seepage
Operation Project Phase				
Low grade stockpile	50%	50%	0%	18%
Topsoil	90%	90%	90%	0%
Overburden	90%	90%	90%	0%
Waste rock pile – low GW level	50%	50%	0%	18%
Waste rock pile – high GW level	50%	50%	0%	100%
Open Pit	0%	100%	100%	0%
Rehabilitation & Closure/ Closure Project Phase				
Waste rock pile (i.e. Vegetated Cover)	100%	90%	40%	18%[1]
Open Pit	95%	100%	100%	0%

[1] Net infiltration within the stockpile reduces with the application of the vegetated soil cover. The proportion of net infiltration reporting as toe seepage remains the same.

Table 3-3 Runoff coefficients by Land Use Type

Land Use Type	Runoff Coefficient
Natural ground	63%
Prepared Ground	85%*

The net infiltration that percolates through the waste rock pile and LGO stockpile reports to the perimeter collection ditches as toe seepage and shallow groundwater infiltration or will be lost to deeper regional groundwater flow not affected by the seepage collection system. Based on the HELP model, the percent of net infiltration reporting to the ditch as toe seepage is included in Table 3-2. The proportion of groundwater intercepted by the collection ditches/ponds (i.e., shallow groundwater infiltration or groundwater recharge to the ditches) was simulated in a groundwater model for the site (Stantec 2020d).

The proportion of total groundwater infiltration that could intercept this recharge is summarized in Table 3-4 for the water management pond infrastructure and the pit.

Different from the waste rock and LGO piles, the topsoil and overburden stockpiles are fine-grained which limits infiltration and increases runoff. As a result of the soil material combined with the steep pile slopes, the net infiltration through the piles was assumed to be negligible.

3.4.1.2 Groundwater Infiltration

The proportion of groundwater infiltration at the bottom of the piles that is intercepted by the collection ditches/ponds, i.e., shallow groundwater infiltration or groundwater recharge to the ditches (flow 6 in Figure 3-5) – not through toe seepage, was simulated in a groundwater model for the Project Area (Stantec 2020d). The percent of net infiltration recharging to deeper regional groundwater (flow 5 in Figure 3-5), perimeter ditches, and the pit is summarized in Table 3-4. It is assumed that during the first year of the model, net infiltration will be consumed in wetting the pile, therefore there is no seepage during that period. Figure 3-6 presents a schematic of the groundwater infiltration intercepted by water management infrastructure receptors represented by the percentages in Table 3-4.

Table 3-4 Groundwater Recharge by Water Management Receptor During Operation (as percentage of total infiltration to pile)

Receptor	Waste Rock Pile	Low-grade Ore Stockpile*	Overburden Stockpile*	Topsoil Stockpile*
Marathon Pit	10.9%	52.6%	4.4%	0.0%
MA-SP-01A	0.0%	3.7%	18.9%	0.0%
MA-SP-01B	0.0%	2.8%	64.9%	0.0%
MA-SP-01C	2.3%	0.0%	0.0%	0.0%
MA-SP-02	27.6%	0.0%	0.0%	0.0%
MA-SP-03	15.2%	0.0%	0.0%	0.0%
MA-SP-04	6.8%	0.0%	0.0%	0.0%
Other	19.2%	22.9%	11.8%	100.0%
Total Marathon Pile Groundwater Recharge (% of Net Infiltration) **	**82.0%**	**82.0%**	**100.0%**	**100.0%**

Notes:

*These values become 0% at closure, since stockpiles are removed. Source: Stantec 2020d.

** Total % of net infiltration does not account for toe seepage, which is the difference to 100% (18% for waste rock pile and LGO).

The groundwater recharge to receptors increases after the pit is full during the post-closure and monitoring project phase as groundwater flow paths and gradients will stabilize locally and the pit filling will no longer exercise influence on local groundwater flows. Table 3-5 summarizes the simulated groundwater recharge from the waste rock pile to receptors post-closure (Stantec 2020d). The other piles were not modelled as these Project facilities no longer remain during the post-closure period.

Table 3-5 Groundwater Recharge to Water Management Receptors after the Pit is Full (as % of Total Groundwater Infiltration)

Water Management Receptor	Percentage of Recharge from waste Waste rock Rock Pile
Marathon Pit	7.2%
MA-SP-01A	0.0%
MA-SP-01B	0.0%
MA-SP-01C	1.5%
MA-SP-02	26.5%
MA-SP-03	15.4%
MA-SP-04	23.0%
Other	8.3%
Total Groundwater Recharge (% of Net Infiltration)	82.0%

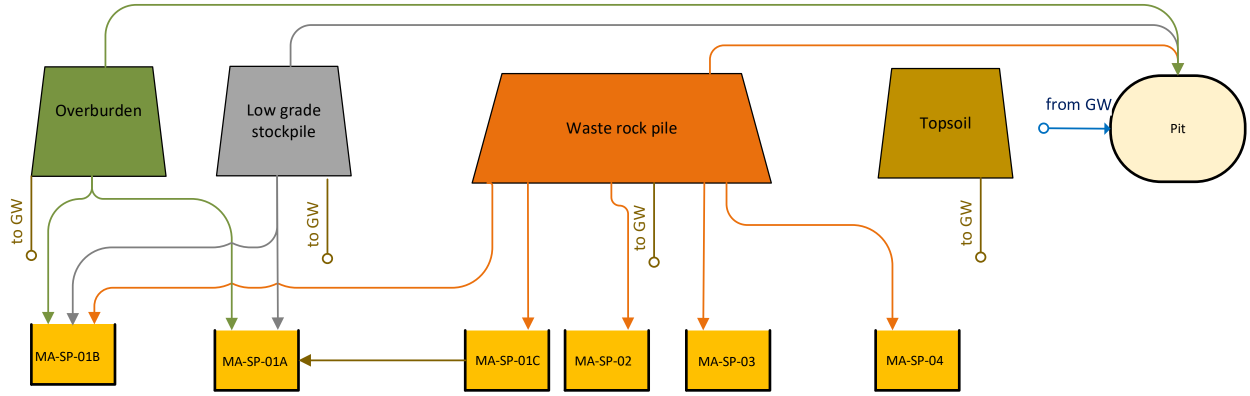


Figure 3-6 Shallow Groundwater Infiltration from Stockpiles to Receptors

3.4.2 Open Pit Runoff

3.4.2.1 Area and Volume

The Marathon pit will be developed over time throughout the nine years of active mining. The surface area of the pit by Project year is summarized in Table 3-6.

Table 3-6 Surface Area of the Pit during Mining

Project Year	-1	1	2	3	4	5	6	7	8	9	10
Area (ha)	28.1	40	45.4	69.5	69.5	69.5	69.5	69.5	69.5	69.5	69.5

Based on the ultimate pit footprint at the end of Year 9, and the topographic information in the area surrounding the pit, a pit overflow elevation of 330 m has been assigned. The relationship between pit stage (i.e., water elevation inside the pit as it is filled), the surface area of the pit at that stage, and the volume in the pit below that stage are presented on Table 3-7.

Table 3-7 Water Elevation – Area – Volume Table (at end of Project Year 9)

Stage (masl)	Projected Surface Area (m²)	Pit Volume Below Stage (m³)	Stage (masl)	Projected Surface Area (m²)	Pit Volume Below Stage (m³)
330	558,660 *	62,230,143	200	217,548	12,885,834
325	540,496	59,483,713	195	207,362	11,823,753
320	526,315	56,817,075	190	197,568	10,811,474
315	510,892	54,223,991	185	186,128	9,853,587
310	494,903	51,711,498	180	177,340	8,944,819
305	480,418	49,273,286	175	169,197	8,078,157
300	464,765	46,909,869	170	159,196	7,256,905
295	447,175	44,631,109	165	149,016	6,488,369
290	434,398	42,427,796	160	140,622	5,764,490
285	423,670	40,282,903	155	132,231	5,082,130
280	411,540	38,194,112	150	122,045	4,445,380
275	397,894	36,171,616	145	113,836	3,856,354
270	386,873	34,209,432	140	106,740	3,304,975
265	375,449	32,303,954	135	97,591	2,793,487
260	363,758	30,454,285	130	88,648	2,329,156
255	350,876	28,669,682	125	79,207	1,909,393
250	340,286	26,942,425	120	70,610	1,534,524
245	329,488	25,268,459	115	61,651	1,202,405
240	316,830	23,651,002	110	53,707	914,526
235	305,653	22,094,935	105	45,842	666,360
230	295,303	20,592,960	100	38,245	455,536
225	283,436	19,145,896	95	29,383	286,106
220	270,344	17,762,434	90	20,903	160,785
215	258,564	16,440,385	85	13,294	75,459
210	244,623	15,179,356	80	7,831	22,218
205	228,248	14,000,322	75	1,385	1,067

3.4.2.2 Net Runoff

Model inputs and outputs to the open pit include groundwater inflow, precipitation and runoff that will flow into the open pit, and dewatering and evaporation losses from the open pit. Schematics of flows to and from the open pit are presented in Figure 3-1 to Figure 3-4.

Storage and surface area of the pit for various pit stages are presented in Table 3-7.

Natural and accelerated pit filling scenarios were considered. The natural pit filling scenario includes runoff from upgradient catchments that were temporarily diverted from draining to the pit during operation (total area 0.991 km^2).

3.4.2.3 Groundwater Infiltration

Groundwater inflow rates to the open pit were predicted using the numerical groundwater flow model developed for the Project (Stantec 2020d). The volume of groundwater inflow to the pit is dependent upon the pit stage, which represents the elevation of the bottom of the pit during pit development, and the water elevation in the pit during subsequent pit filling. Table 3-8 presents the groundwater inflow rate depending on the water level of the pit. The minimum stage (75.4 masl) applies to the pit floor when there is no water accumulated at the bottom of the fully excavated open pit.

Table 3-8 Groundwater Inflow to Marathon Pit

Pit Stage (masl)	GW inflow (m^3/d)
75.4	1846
100	1846
109.4	1846
125	1846
150	1846
175	1846
200	1846
225	1846
250	1789
275	1662
300	1479
325	1186
330	991

Source: Stantec 2020d

3.4.2.4 Open Pit Inflows and Outflows

Operation (until Year 9)

Groundwater inflow, precipitation and runoff that accumulates in the open pit will be pumped to water management pond 5 (MA-SP-05).

Operation (From Year 10), Closure, and Post-Closure

Water is accumulated in the pit, with the same inflows explained above, and the addition of:

- Fresh water from Valentine Lake. The model was run iteratively with different flow rates, and model runs where the pit can be filled to the design elevation of 330 masl. An accelerated pill filling scenario covering eight years, commencing in Year 10, was selected. The selected flow rate from Valentine Lake is presented in Section 4.4.
- Water from ditch MA-DR-13. This is water from the waste rock pile that is directed to the water management pond MA-SP-04 until Year 9, and can flow to the pit by gravity.
- Water from ditches MA-DR-01 and MA-DR-02. This is water from the LGO stockpile that is directed to the water management pond MA-SP-01b until Year 9, and can flow to the pit by gravity drainage.
- The area west of the pit is diverted by MA-BR-01. This diversion can be removed in rehabilitation and closure and the additional 296,500 m^2 can flow into the pit.

Once the water level within the pit lake reaches the elevation of 330 m, water from the pit will overflow and discharge towards MA-FDP-04.

Natural and accelerated pit filling scenarios were considered where the model was run iteratively with different flow rates, and model runs where the pit can be filled to the design elevation of 330 masl. Accelerated pit filling was simulated by the addition of water pumped from Valentine Lake. The preferred scenario required eight years to fill the pit, commencing in Project Year 10. The selected pumping rate from Valentine Lake is presented in Section 4.4

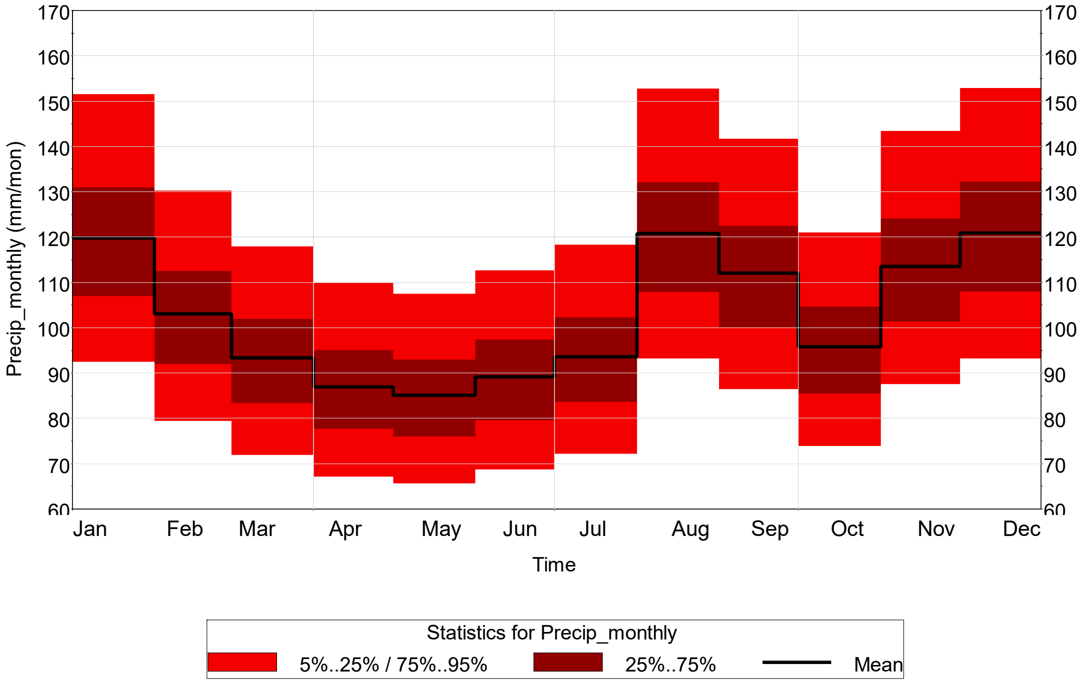
4.0 PROJECT WATER BALANCE RESULTS

4.1 OVERVIEW

The water quantity model provides estimates of flows and storage volumes for mine facilities during the construction, operation, closure, and post-closure phases and sub-phases of the Project, and incorporates the mine plan and water management features of the mine. The water quantity model also incorporates results from groundwater modelling (Stantec 2020d), and runoff and seepage from key Project facilities as described in Chapter 3.0.

The results are presented for the average climate conditions, which includes the probabilistic distribution of climate inputs that on average match the average precipitation. As such, probabilistic results are generated based on the full range of the 100 Monte Carlo simulations for the probabilistic precipitation distribution. Each model was run for 100 years, and the precipitation was varied independently for each year of each of the simulations. Although the models were run for 100 years, the summary plots in this section are presented with a time range relevant to the results discussed.

As an illustrative example, Figure 4-1 presents the results of the Monte Carlo simulation for two years of precipitation using a colored scale. Probabilistic results are shown for three ranges from bottom to top for each month: the 5th to 25th percentile range at the bottom, the 25th to 75th percentile range in the middle, and the 75th to 95th percentile range at the top. Generally, results of the 5th to 95th percentile Monte Carlo realizations range from -25% to +25% of the mean values.



Note: The mean value presented in the probabilistic plots is the mean of all the Monte Carlo Runs, and not the average Climate condition.

Figure 4-1 Probabilistic Precipitation Results for a Generic Year

4.2 WATER MANAGEMENT PONDS

The water management ponds are influenced by climate inputs, and collect runoff, toe seepage, and shallow groundwater flow from the waste rock pile and LGO, overburden, and topsoil stockpiles through seepage collection ditches around these facilities. The water quantity model simulated the function of the water management ponds, and the results indicate that the ponds tend to become full during the spring freshet of the first modelled year, and overflow to the FDPs there after. This is illustrated on Figure 4-2, which presents the timing of the flows and volume of the water storage in water management pond MA-SP-02, which collects runoff from the waste rock pile.

The other water management ponds exhibit the same behaviour as water management pond MA-SP-02, with the exception of MA-SP-05, which captures flows from the pit dewatering. Flows to MA-SP-05 correlate to the timing of pit dewatering rates, which are less variable due to the relatively steady groundwater inflow to the pit. Water management pond MA-SP-05 becomes full after only a few days of commencement of the pit dewatering, as presented in Figure 4-3.

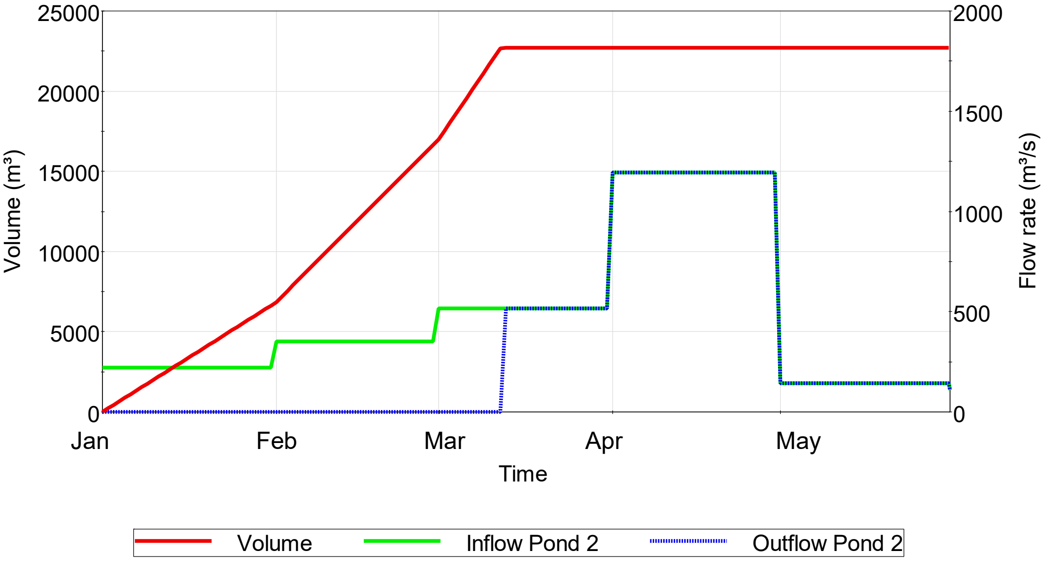


Figure 4-2 Volume, Inflow and Outflow of Water Management Pond MA-SP-02

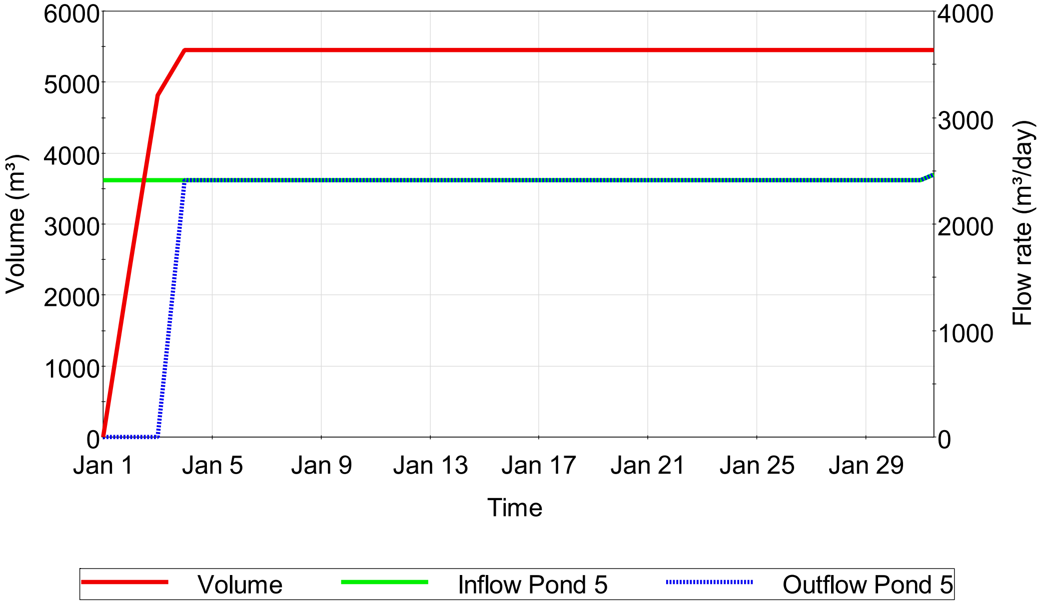


Figure 4-3 Volume, Inflow and Outflow of Water Management Pond MA-SP-5

The magnitude of the flow to a water management pond depends on the watershed area and characteristics draining to the pond, and the groundwater infiltration reporting to the pond. In general, the water management ponds will discharge to the FDPs when the pond water level rises above the low-level outlet.

Figure 4-4 presents the average annual inflow collected in water management pond MA-SP-02 from ditches (runoff + toe seepage), the groundwater discharge to the pond, and the total sum of inflows. Direct precipitation represents only a small proportion of the total inflow to the pond.

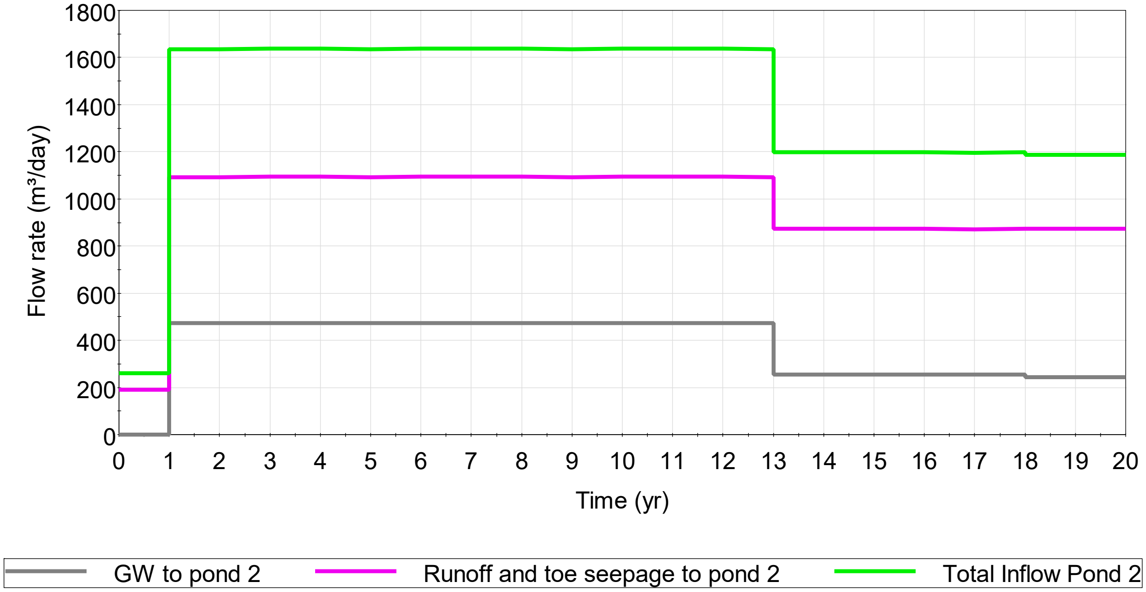


Figure 4-4 Annual Average Flows to Water Management Pond MA-SP-02

Table 4-1 presents average inflows to the water management ponds for each phase and subphase of the Project. Average outflows mimic the average inflows from the ponds. Tables presenting inflows at the water management ponds for the range of probabilities using the Monte Carlo analysis are presented in Appendix A.

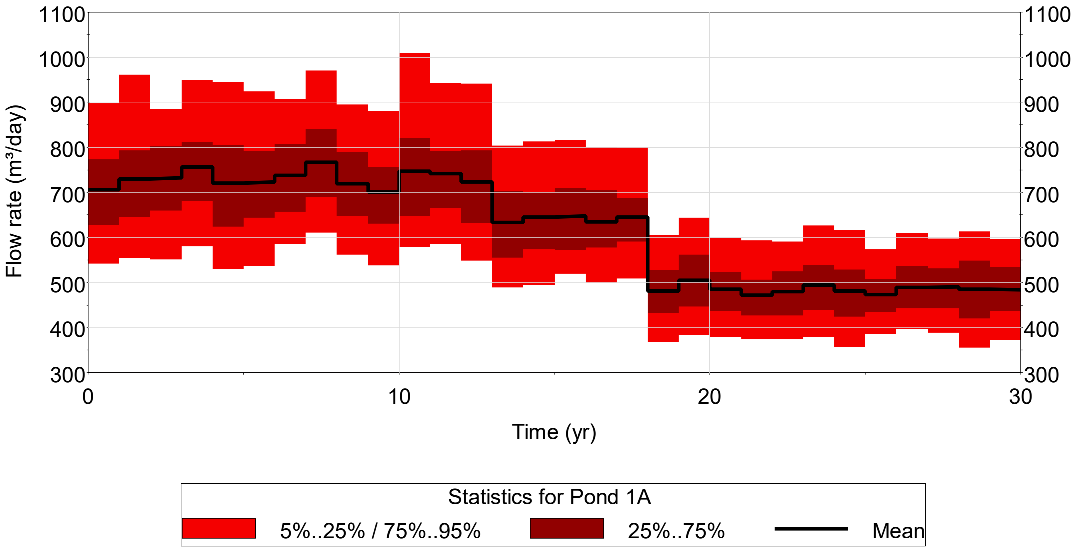
Figure 4-5 to Figure 4-11 present the probabilistic results for all the ponds from operation to post-closure sub-phases.

Generally, the minimum and maximum simulation results (i.e., 5th to 95th percentile results) range from approximately -25% to +25% of the mean results. This is consistent with the range for precipitation explained in section 4.1 and approximately represents the 1: 25 return period wet year to the 1:5 dry year.

Table 4-1 Monthly Average Inflows/Outflows to/from Water Management Ponds (m^3/day)

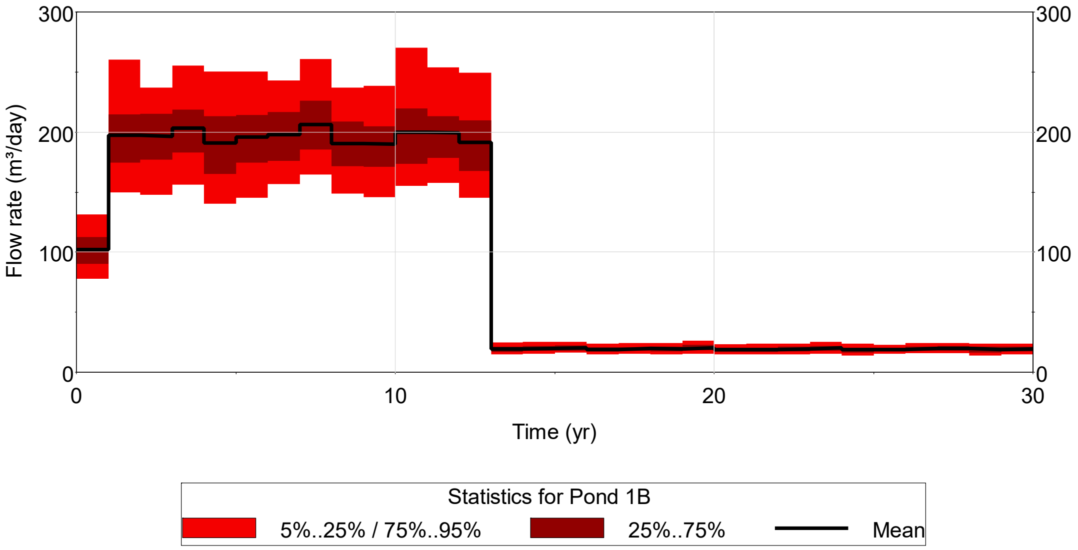
Pond	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
MA-SP-1A	Operations (Year 1 to 9)	536	669	785	1849	539	280	192	527	667	702	875	690	690
	Operations (Year 10 to 12)	573	713	838	1976	579	303	209	569	717	752	937	738	740
	Closure (Year 13 to 17)	504	632	741	1745	505	258	176	490	623	658	823	650	648
	Post-Closure (from Year 18)	390	487	573	1347	387	191	130	370	474	507	636	502	498
MA-SP-1B	Operations (Year 1 to 9)	151	216	286	663	145	76	69	123	136	146	206	200	201
	Operations (Year 10 to 12)	151	216	286	663	145	76	69	123	136	146	206	200	201
	Closure (Year 13 to 17)	18	23	27	63	15	0	0	8	14	22	30	23	20
	Post-Closure (from Year 18)	18	23	27	63	15	0	0	8	14	22	30	23	20
MA-SP-1C	Operations (Year 1 to 9)	193	277	366	848	191	107	100	167	181	189	264	256	260
	Operations (Year 10 to 12)	193	276	366	848	191	107	100	167	181	189	264	256	260
	Closure (Year 13 to 17)	248	319	379	898	232	103	55	210	282	305	394	321	311
	Post-Closure (from Year 18)	243	312	373	882	227	100	54	205	276	298	386	316	305
MA-SP-2	Operations (Year 1 to 9)	1115	1345	1554	3605	1435	1115	1044	1692	1787	1669	1894	1421	1637
	Operations (Year 10 to 12)	1115	1340	1554	3605	1435	1115	1044	1692	1787	1669	1894	1421	1636
	Closure (Year 13 to 17)	953	1186	1373	3260	915	429	231	873	1168	1243	1564	1225	1197
	Post-Closure (from Year 18)	943	1172	1360	3228	905	424	228	863	1155	1229	1548	1214	1185
MA-SP-3	Operations (Year 1 to 9)	816	992	1155	2678	1031	781	731	1195	1269	1199	1374	1041	1186
	Operations (Year 10 to 12)	816	988	1155	2678	1031	781	731	1195	1269	1199	1374	1041	1186
	Closure (Year 13 to 17)	714	890	1034	2450	681	311	167	641	862	926	1170	920	894
	Post-Closure (from Year 18)	716	892	1037	2459	684	312	168	644	866	930	1175	923	897
MA-SP-4	Operations (Year 1 to 9)	599	829	1069	2479	590	309	279	517	589	636	860	787	792
	Operations (Year 10 to 12)	599	825	1069	2479	590	309	279	517	589	636	860	787	792
	Closure (Year 13 to 17)	441	558	661	1554	407	159	91	353	485	550	711	588	544
	Post-Closure (from Year 18)	542	679	798	1880	507	210	117	456	621	691	883	699	671
MA-SP-5	Operations (Year 1 to 9)	3102	3402	3728	6128	3747	3612	3701	4247	4078	3761	3917	3450	3904
	Operations (Year 10 to 12)	14	17	21	47	11	0	0	6	11	17	23	18	15
	Closure (Year 13 to 17)	14	17	21	47	11	0	0	6	11	17	23	531	59
	Post-Closure (from Year 18)	3287	3834	4401	8724	3345	1903	1825	3138	3583	3967	4704	3912	3876

Note: inflows are approximately equal to outflows



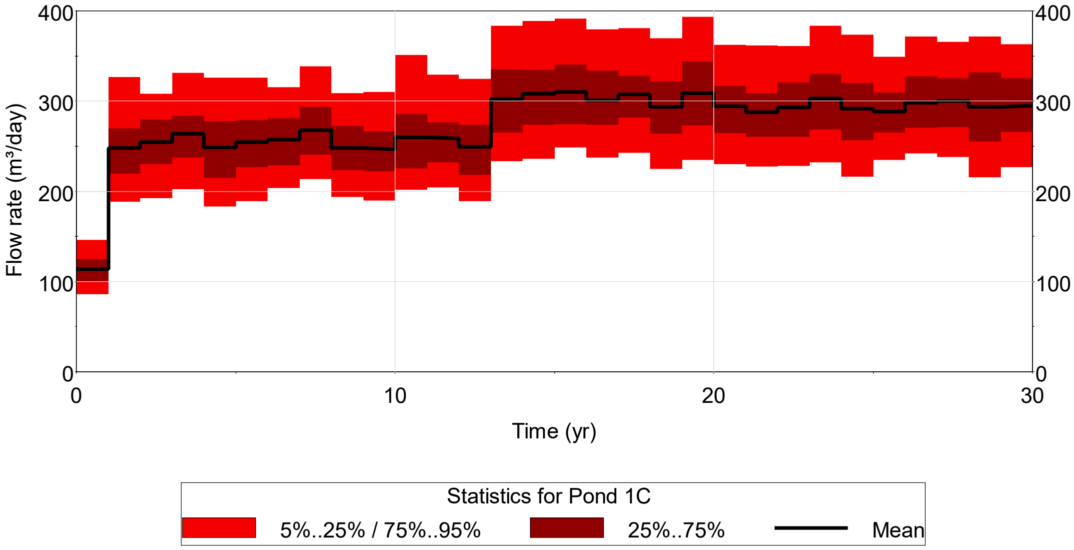
Note: Water management pond MA-SP-01A collects runoff from the LGO stockpile and also captures groundwater from the overburden stockpile. The LGO stockpile is removed at closure (end of Year 12). Prepared ground is assumed during closure (from Year 13) and natural ground during post-closure (from Year 18).

Figure 4-5 Water Management Pond MA-SP-1A Annual Average Inflow/Outflows - Probabilistic Analysis



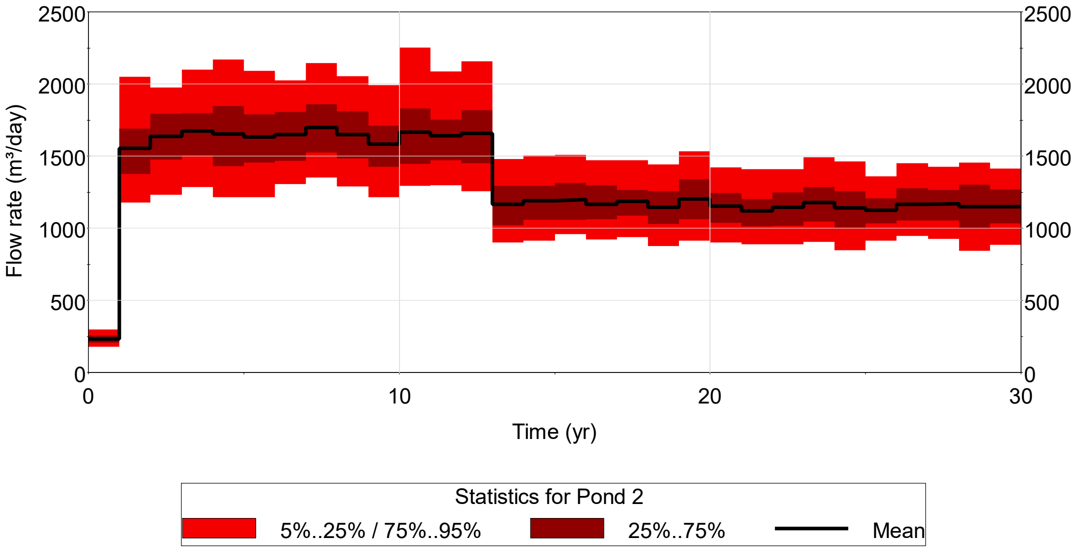
Note: Water management pond 1B collects water from the overburden stockpile and also captures shallow groundwater from the LGO stockpile. The LGO stockpile is removed at closure (end of Year 12). Prepared ground is assumed during closure (from Year 13) and natural ground during post-closure (from Year 18). At closure runoff from its catchment area is diverted to the pit, receiving only runoff from the pond.

Figure 4-6 Water Management Pond MA-SP-1B Annual Average Flows - Probabilistic Analysis



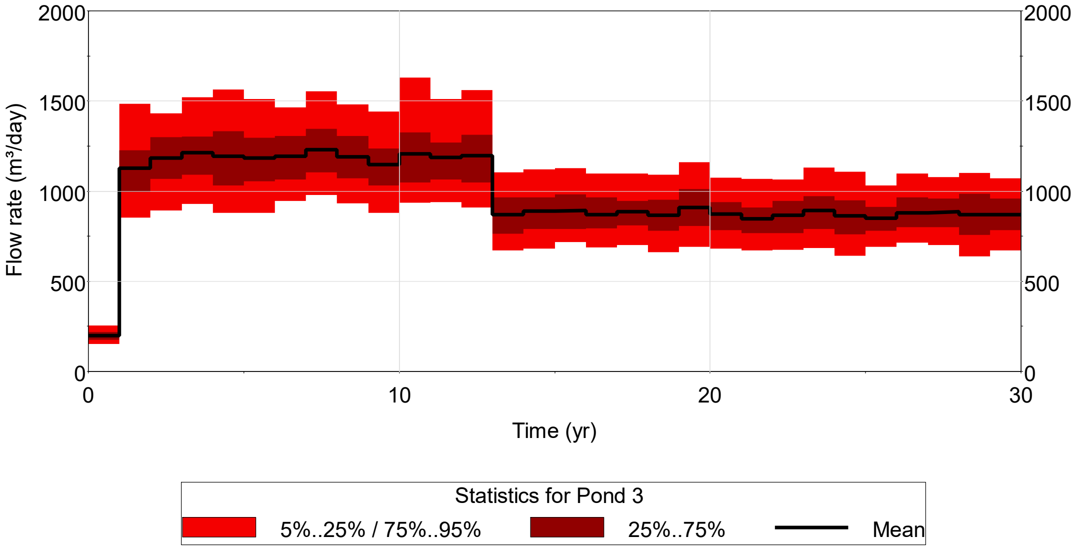
Note: Water management pond 1C collects water from the waste rock pile. At closure, the waste rock pile is covered by a vegetated soil cover, increasing surface runoff.

Figure 4-7 Water Management Pond MA-SP-1C Annual Average Flows - Probabilistic Analysis



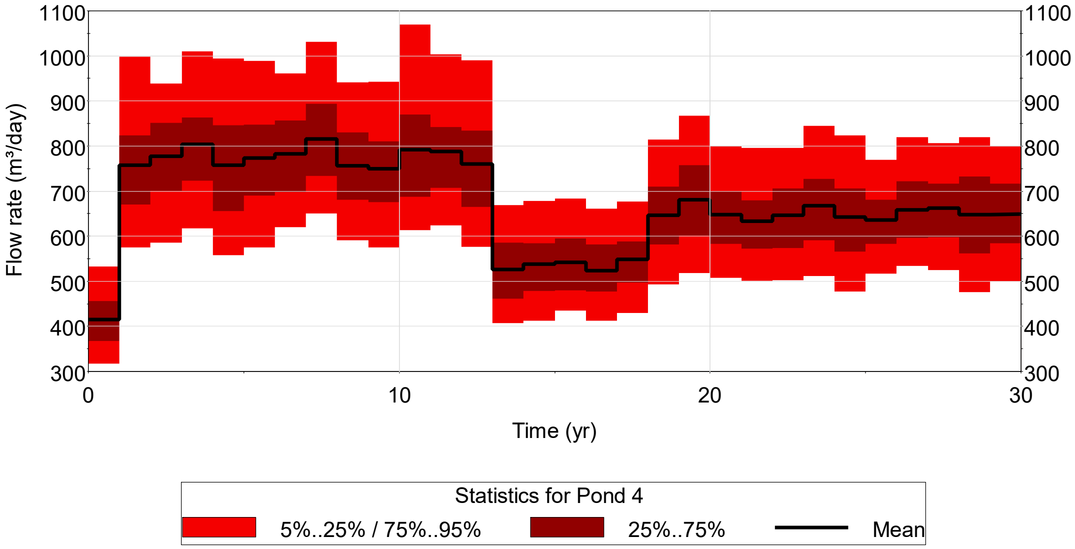
Note: Water management pond 2 collects water from the waste rock pile, located in a high groundwater level. At closure, the waste rock pile is covered by a vegetated soil cover, increasing runoff, but also increasing the evapotranspiration, and therefore reducing the sum of runoff plus toe seepage.

Figure 4-8 Water Management Pond MA-SP-2 Annual Average Flows - Probabilistic Analysis



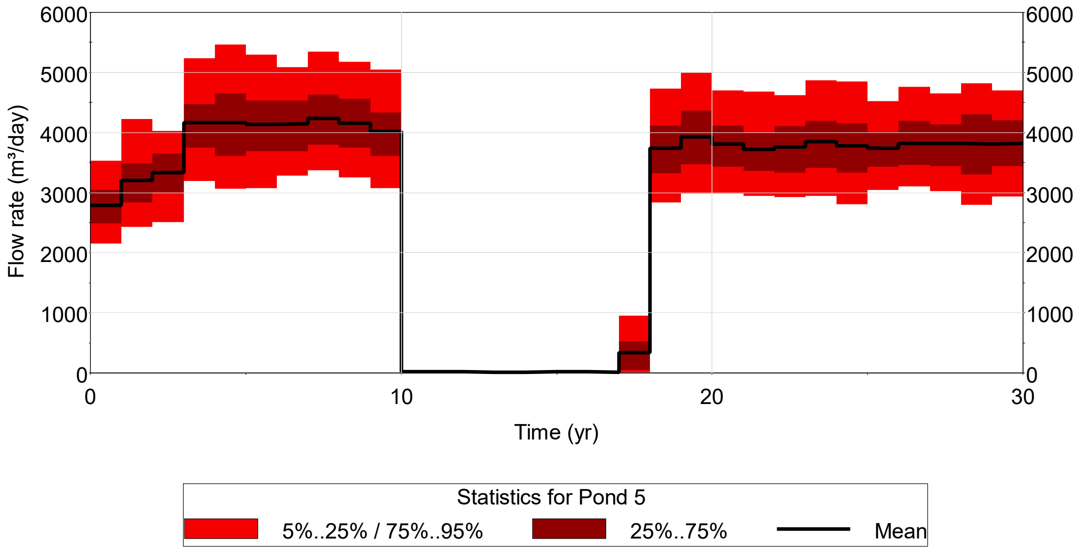
Note: Water management pond 3 collects water from the waste rock pile, located in a high groundwater level. At closure, the waste rock pile is covered by a vegetated soil cover, increasing runoff, but also increasing the evapotranspiration, and therefore reducing the sum of runoff plus toe seepage.

Figure 4-9 Water Management Pond MA-SP-3 Annual Average Flows - Probabilistic Analysis



Note: Water management pond 4 collects water from the waste rock pile and the topsoil stockpile. At closure, the ditch collecting water from the waste rock pile is diverted to the pit, decreasing the total inflow to the pond. At post-closure, there is an increase in shallow groundwater to pond 4.

Figure 4-10 Water Management Pond MA-SP-4 Annual Average Flows - Probabilistic Analysis



Note: Water management pond 5 collects dewatering from the pit. At Year 10, the pit starts to be filled until the end of Year 17. In the plot, there is a range of results around Year 17 related the variability of the climate scenarios, and the constant flow rate from Valentine Lake. From Year 18, the pond receives overflow from the pit.

Figure 4-11 Water Management Pond MA-SP-5 Annual Average Flows - Probabilistic Analysis

4.3 FINAL DISCHARGE POINTS (FDP)

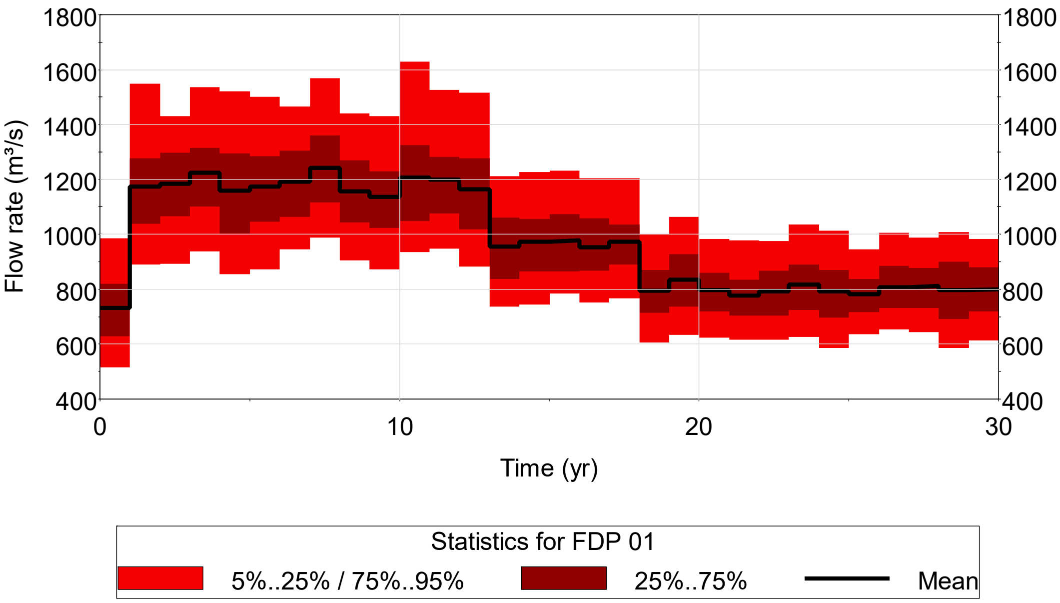
FDPs receive flow from undisturbed watershed area and the water management ponds, which in turn are driven by event meteorology and seasonal climatic patterns, and therefore present similar seasonal behavior noted in Section 4.2.

Table 4-2 presents average monthly flows at the FDPs for each phase and subphase of the Project, including the discharges from the water management ponds. Tables presenting flow rates at the FDPs for the range of probabilities using the Monte Carlo analysis are presented in Appendix B.

Figure 4-12 to Figure 4-15 presents the probabilistic annual flows results for all the FDPs from operations to post-closure. Generally, the minimum and maximum simulation results (i.e., 5th to 95th percentile results) range from approximately -25% to +25% of the mean monthly results.

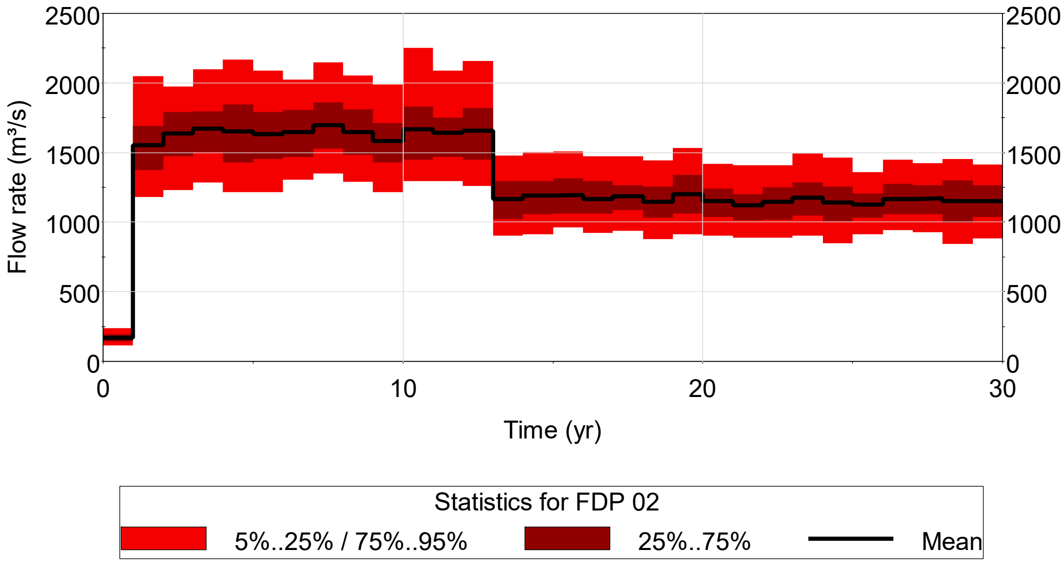
Table 4-2 Mean Monthly Flow Rates at FDPs (m^3/day)

FDP	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
MA-FDP-01	Operations (Year 1 to 9)	917	1209	1490	3487	915	486	379	859	1034	1088	1407	1194	1205
	Operations (Year 10 to 12)	917	1204	1490	3487	915	486	379	859	1034	1088	1407	1194	1205
	Closure (Year 13 to 17)	771	973	1148	2705	751	361	231	708	919	985	1247	994	983
	Post-Closure (from Year 18)	651	822	973	2292	628	291	184	583	764	827	1052	841	826
MA-FDP-02	Operations (Year 1 to 9)	1115	1345	1554	3605	1435	1115	1044	1692	1787	1669	1894	1421	1640
	Operations (Year 10 to 12)	1115	1340	1554	3605	1435	1115	1044	1692	1787	1669	1894	1421	1639
	Closure (Year 13 to 17)	953	1186	1373	3260	915	429	231	873	1168	1243	1564	1225	1202
	Post-Closure (from Year 18)	943	1172	1360	3228	905	424	228	863	1155	1229	1548	1214	1189
MA-FDP-03	Operations (Year 1 to 9)	4516	5222	5951	11285	5367	4702	4711	5958	5935	5595	6151	5278	5889
	Operations (Year 10 to 12)	1428	1830	2244	5204	1631	1090	1010	1717	1868	1851	2257	1846	1998
	Closure (Year 13 to 17)	1168	1465	1715	4051	1099	470	258	1000	1357	1493	1903	2060	1503
	Post-Closure (from Year 18)	4545	5405	6236	13063	4536	2426	2109	4237	5070	5588	6762	5533	5459
MA-FDP-04	Operations (Year 1 to 9)	599	829	1069	2479	590	309	279	517	589	636	860	787	795
	Operations (Year 10 to 12)	599	825	1069	2479	590	309	279	517	589	636	860	787	795
	Closure (Year 13 to 17)	441	558	661	1554	407	159	91	353	485	550	711	589	546
	Post-Closure (from Year 18)	542	679	798	1880	507	210	117	456	621	691	883	699	674



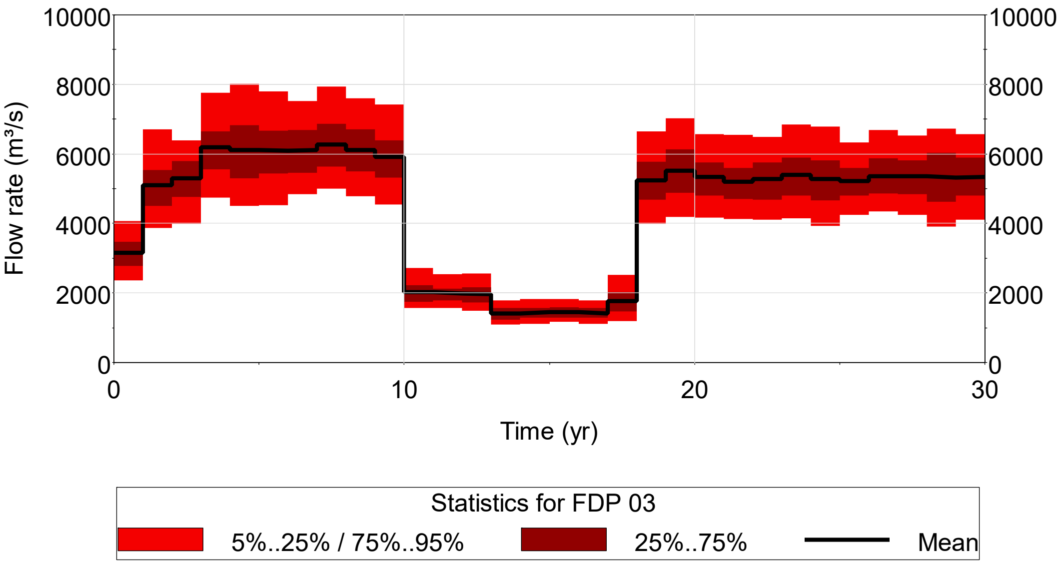
Note: MA-FDP-01 receives water from the water management ponds MA-SP-01A, MA-SP-01B and MA-SP-01C (LGO and overburden stockpile and waste rock pile).

Figure 4-12 MA-FDP-01 Average Annual Flows - Probabilistic Analysis



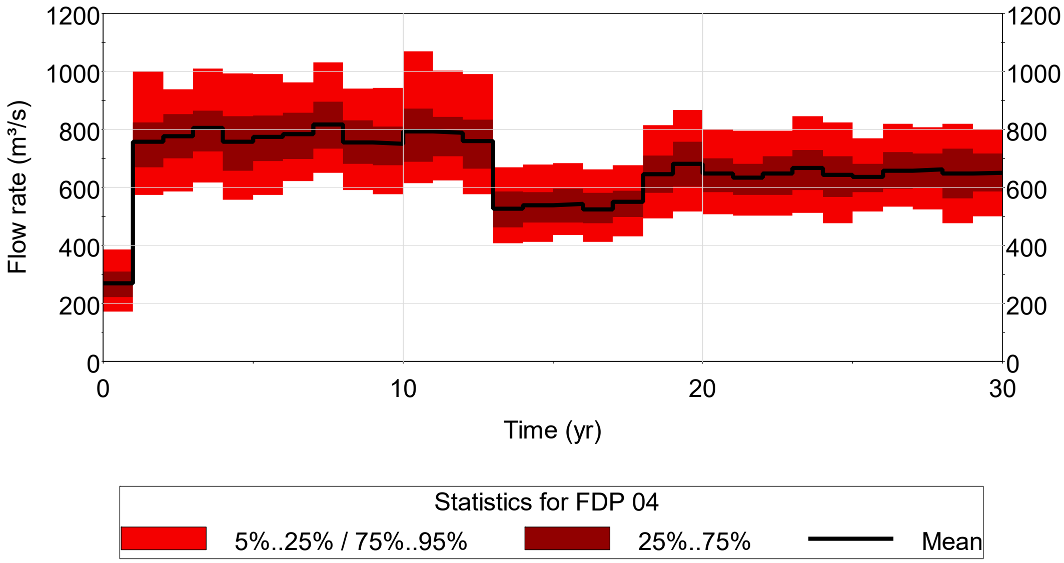
Note: MA-FDP-02 receive water from the water management ponds 2 (waste rock pile).

Figure 4-13 MA-FDP-02 Average Annual Flows - Probabilistic Analysis



Note: MA-FDP-03 receive water from the water management pond 3 (waste rock pile).

Figure 4-14 MA-FDP-03 Average Annual Flows - Probabilistic Analysis



Note: MA-FDP-04 receive water from the water management ponds 4 and 5 (topsoil stockpile and pit).

Figure 4-15 MA-FDP-04 Average Annual Flows - Probabilistic Analysis

4.4 OPEN PIT

During the operation phase (until end of Year 9), flows into (and from) the open pit include groundwater seepage, precipitation, surface runoff from natural areas, evaporation, and dewatering. From Year 10 to 17, water from Valentine Lake is added to the pit with the objective to accelerate filling the pit. The flow rate intake from Valentine Lake was set to 6.2 Mm^3/year (17,000 m^3/day) to fill the pit in eight years based on iterative simulations using the water quantity model. Additional earthworks may be considered to direct additional natural runoff toward the pit. Based on the existing topography, the total natural watershed that could flow via gravity toward the pit without limited earthworks is approximately 1.605 km^2.

Figure 4-16 presents the average monthly groundwater inflow rate and runoff flows from incident precipitation and natural ground for the climate normal scenario. The total dewatering rate includes groundwater inflows and net precipitation. The total flow rates from Valentine Lake are also presented. Table 4-3 presents average, maximum and minimum monthly-average dewatering flows.

Figure 4-17 presents the probabilistic dewatering results. Monthly dewatering rates from the open pit ranges from 1,360 m^3/day (5th percentile of the minimum monthly value) to 8,155 m^3/day (95th percentile of the maximum monthly value). Probabilistic pit filling results are shown in Figure 4-17.

Model predicts, that filling of Marathon pit will take between 34 and 38 years (for the 95th and 5th percentiles, respectively) after the pit closure. Accelerated pit filling was modelled to require eight years after end of pit mining (Year 10 to end of Year 17) by using water from Valentine Lake. Figure 4-18 and Figure 4-19 present the probabilistic results for the water level in the pit for the natural case (i.e., without pumping water from Valentine Lake), and the accelerated case, respectively.

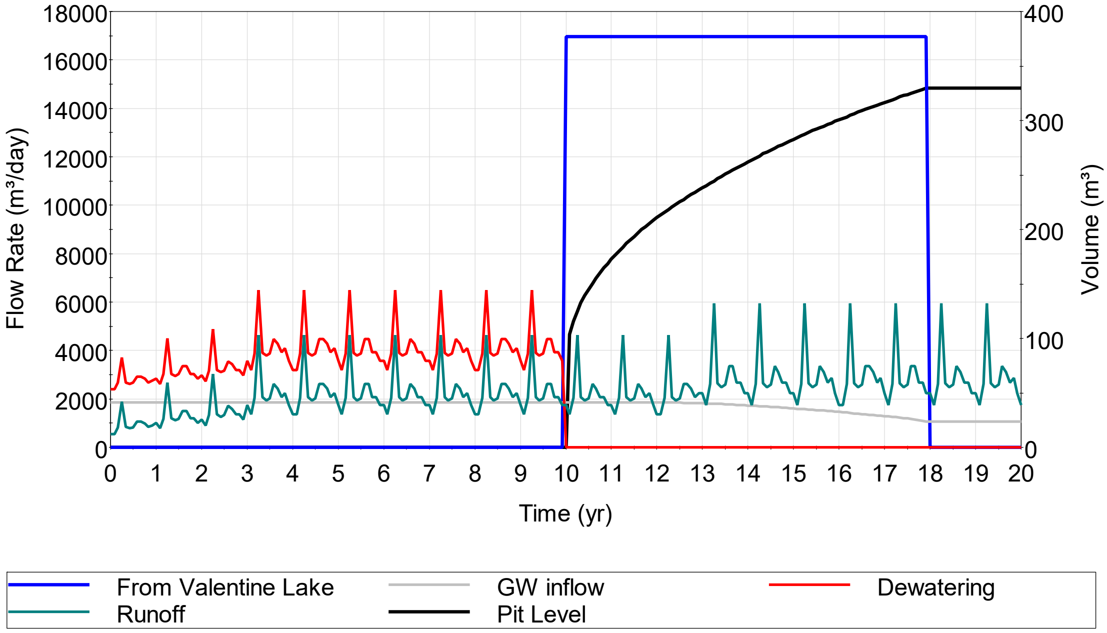
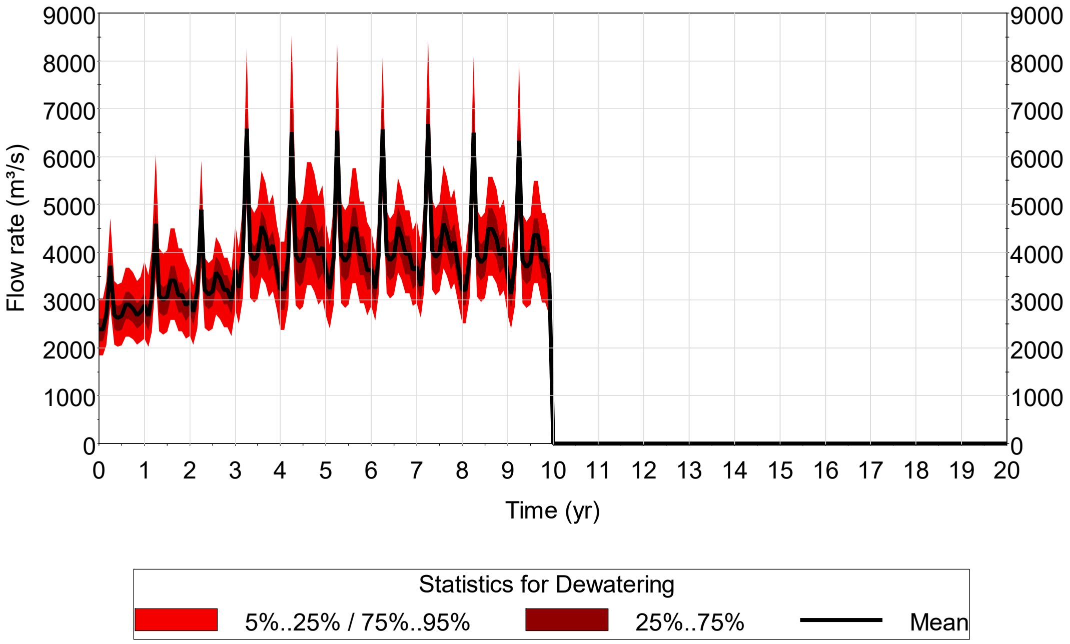


Figure 4-16 Pit Water Level, Inflows and Dewatering (Average scenario)

Table 4-3 Monthly Mean, Minimum (percentile 5th) and Maximum (percentile 95th) Pit Dewatering Flows During Pit Operations (m³/day)

Value	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Average	3,019	3,297	3,603	5,845	3,631	3,514	3,598	4,107	3,943	3,638	3,780	3,344
Min	2,395	2,508	2,669	3,719	2,682	2,627	2,666	2,905	2,828	2,685	2,751	2,547
Max	3,204	3,543	3,882	6,478	3,914	3,778	3,875	4,465	4,275	3,922	4,086	3,581



Note: The 95th and 5th percentile annual precipitation totals are approximately equivalent to the 1:25 year wet and 1:5 year dry years, respectively.

Figure 4-17 Pit Dewatering Rate (Probabilistic Analysis)

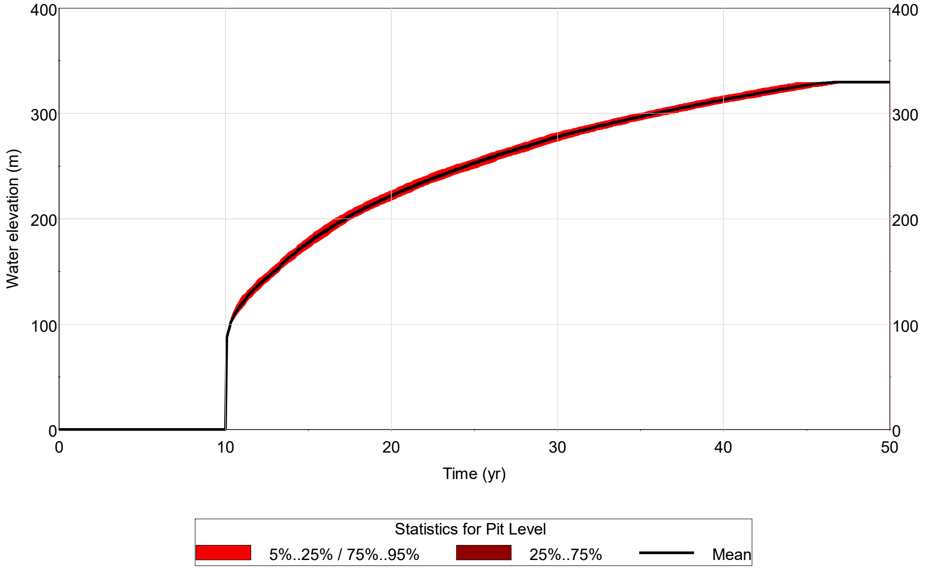


Figure 4-18 **Natural Filling of the Open Pit (i.e., without adding water from Valentine Lake) - Probabilistic Analysis**

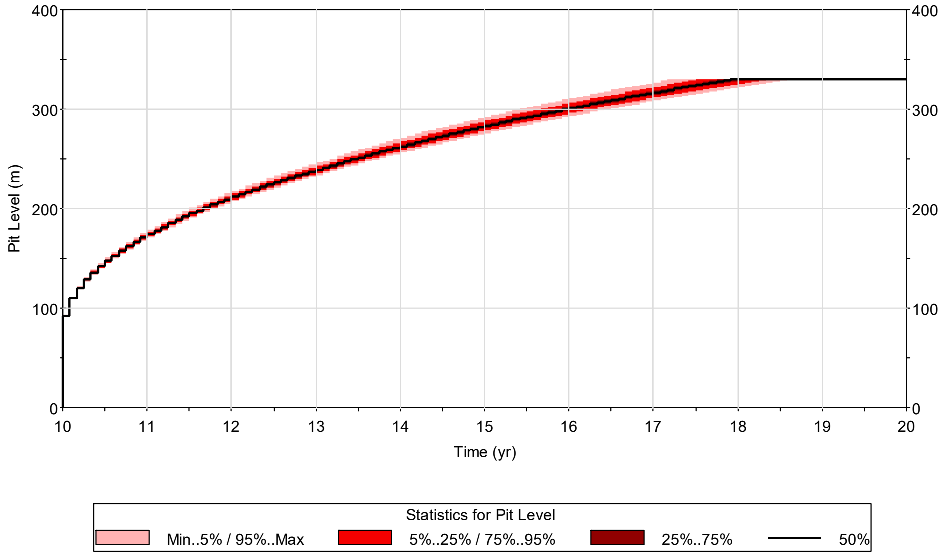


Figure 4-19 Pit level - Probabilistic Analysis

5.0 WATER QUALITY MODEL

5.1 CONCEPTUAL MODEL

The major objective of a water quality model is to predict concentrations of potential contaminants in mine facilities and final discharge points. The contaminant transport module of GoldSim is used to build the water quality model directly linked to the water quantity model. The water quality model consists of the network of individual cells representing pore water of the waste rock pile and LGO stockpiles, ponds and pit lakes (undeveloped areas and Project facilities) connected by links representing ditches and channels. The water quantity model provides direct inputs to storage volumes and water inflow/outflow rates at the cells. All the annual infiltration during the first year of the model (mine Year -1) was arbitrarily assigned to pore water in the waste rock pile and LGO stockpile to facilitate wetting of the piles. Therefore, a volume equal to infiltration during the first year was stored. In subsequent years, the wetting (and stored volume) is maintained for the period that the stockpile remains in place. Based on this assumption of simulating wetting of solids, no seepage drains from these sources to the water management ponds during the first year. The water quality inputs to the cells are associated with the concentration or mass-rate (loading) addition to the cell. The concentration in a cell is calculated by GoldSim as the mass retained in a cell divided by the volume of the cell at the end of each time step.

The selection of parameters for inclusion in the model is based on criteria listed in the following federal and provincial regulatory documents:

- *Canadian Water Quality Guidelines* (CWQG) *for the Protection of Freshwater Aquatic Life* (FAL) by Canadian Council of Ministers of the Environment (CCME 2020, 2010)
- *Metal and Diamond Mining Effluent Regulations of the Fisheries Act* (MDMER), Table 1 of Schedule 4 (SOR/2002-222, 2020)

The selection of parameters for inclusion in the model is based on criteria listed in CWQG-FAL and MDMER. In addition to the parameters listed in these guidelines and regulations, the supporting parameters, such as general water chemistry are added. The full list of parameters, their symbols and applicable reference values are provided in Table C-1 (Appendix C). Trace element concentrations are modelled as total. Temperature and pH are not modelled, but are required to calculate the CWQG-FAL values for aluminum (Al), manganese (Mn), un-ionized ammonia ($N\text{-}NH_{3\ UN}$), and zinc (Zn). Although pH and alkalinity are not modelled, they are tracked by the model for potential future geochemical modelling outside of GoldSim, if needed. It should be noted that pH values below 7.0 are not expected as discussed in Stantec (2020e).

Conservative inputs are used to calculate CWQG-FAL that are dependent on hardness, pH or/and temperature observed in the baseline dataset Table C-1 (Appendix C). For example, to calculate guidelines for cadmium (Cd), copper (Cu), lead (Pb), and nickel (Ni), the lowest hardness observed in baseline surface water (6.5 mg $CaCO_3$/L) is used. Dissolved zinc and dissolved manganese guidelines (CCME 2019) are conservatively applied to total concentrations of these metals predicted by the model.

Phosphorus (P) CWQG-FAL guideline is narrative and is related to change of receptor's tropic status. In this report, Stantec conservatively applied the lowest threshold of 4 µg/L appropriate for screening purposes. This threshold corresponds to ultraoligotrophic water bodies, while current drainage from at the site likely has mesotrophic or eutrophic status.

5.2 BASELINE WATER QUALITY INPUTS

Data from surface water quality monitoring station VAL01 are assumed to represent the baseline source. The monitoring location and the original data are shown in Stantec 2020c. The baseline data were prepared using the following steps to calculate input statistics:

Step 1: Concentrations of some elements are reported below detection limits with some detection limits being above the respective CWQG-FAL (e.g., Zn and P, etc.). For concentrations below the detection limits, half detection limits are used for model inputs.

Step 2: Concentrations of some parameters (e.g., fluoride (F), total cyanide (CN_T) and weak-acid dissociable cyanide (CN_{WAD})) are not analyzed at some stations. These missing inputs are conservatively replaced with full detection limits observed in other station/water types. Un-ionized ammonia values are calculated from total ammonia ($N\text{-}NH_{3\ T}$) using maximum temperature and pH (19 °C and 7.8, respectively) values observed in surface water, where temperature and/or pH are not present in the input data set.

Step 3: Outliers are evaluated using 1.5 of the upper quartile rule (Tukey 1977). These included:

- Cd: 5/15/2012, 2.25 µg/L
- Chromium (Cr): 1/13/2013, 19.7 µg/L

Step 4: Calculation of statistics for each parameter for probabilistic modelling.

The resulting statistics are presented in Table C-2 (Appendix C). Normal distribution is assumed using means and standard deviations as inputs. The distribution is truncated to minimum and maximum values.

Groundwater water quality in bedrock around the Marathon open pit is represented by monitoring wells MA-17-158-2017, MA-17-218-2017, and MA-17-250-2017, while overburden water quality is based on samples from wells MW7 and MW8. Well locations and water chemistry are shown in Gemtec (2019). The groundwater quality data is processed using the same steps as for surface water. However, due to limited data, a triangular distribution for probabilistic model runs is conservatively assumed (Table C-3, Appendix C). This distribution requires minimum, the most probable (mean), and maximum values as inputs.

5.3 PROJECT INPUTS

5.3.1 Waste Rock Pile, Ore Stockpiles, and Rubble in the Open Pit

Water infiltrating into the waste rock pile, the LGO stockpile and precipitating in the open pit is conservatively assumed to have the quality of undisturbed runoff (i.e., baseline chemistry). In addition, waste rock source terms include leaching rates from the rock rubble from the pit and pit walls as a result of weathering and nitrogen species leached from undetonated explosives.

5.3.1.1 Weathering (Metal) Leaching Rates

Weathering (metal) leaching rates are calculated from humidity cell tests containing representative samples of different rock lithologies and ores Stantec (2020d). The leaching rates are assumed to have triangular distributions requiring inputs for minimum, most probable (mean), and maximum values. These statistics are calculated for the first month of the tests to represent construction, operation, while the last month of testing reflects conditions during closure and post-closure when rates have stabilized (Table C-4, Appendix C). The leaching rates (R_{HC}) are proportioned by the volume or area of lithology exposed in a stockpile or open pit, respectively. The percentages of lithologies and showed in Table 5.1.

Table 5-1 Percentages and Inputs for Different Lithologies/Materials

Lithology	% of Lithology	% PAG Samples in Lithology	Humidity Cell ID in Table C-4
Waste Rock Pile			
Qzt Porphyry/Aphanitic Qzt Porphyry	58	13	M QE-POR
Vein zones	15	33	
Sediments	21	0	M CG
Gabbro	6	25	M MD
LGO Stockpile			
Low-grade ore	100	50	MLGO Met
Open Pit Rubble and Walls			
Qzt Porphyry/Aphanitic Qzt Porphyry	39	13	M QE-POR
Vein zones	10	33	M QZ-QE-POR-QTP-MIN
Sediments	29	0	M CG
Gabbro	12	25	M MD
Low-grade ore	5	50	MLGO Met
High-grade ore	5	67	

The leaching rates are multiplied by the mass of the lithology or material present in a mine component and by applying scaling factors (SF) to convert the laboratory rates to full size field components. The scale up factors have stochastic inputs assuming a triangular distribution. Leaching rates are calculated using Equation 5-1:

$$R = M \times R_{HC} \times SF_{TEMPERATURE} \times SF_{GRAIN\ SIZE} \times SF_{CONTACT} \times SF_{CLOSURE}$$

Equation 5-1

where:

- M = rock/ore mass of rock exposed. Stockpile mass balances from the mine schedule (Table C-5, Appendix C). For the rubble mass, assumed that the pit area is covered, fractured down to 1 m of rubble with the grain size the same as in the stockpile;
- R_{HC} = leaching rate of a humidity cell (Table C-4, Appendix C);
- $SF_{TEMPERATURE}$ = scaling factor for the rock surface area;
- $SF_{GRAIN\ SIZE}$ = scaling factor for a grain size distribution;
- $SF_{CONTACT}$ = contact factor accounting for reduction in solute leaching (flushing) due to hydraulic isolation, which is limited in laboratory tests; and
- $SF_{CLOSURE}$ = reduction of an element leaching rates starting in closure due to placement of covers.

A summary of all scaling factors applied to each mine component, for which the mined material is a source, is provided in Table 5-2.

Table 5-2 Range and Source of Scale Up Factors

Factor	Range	Source
$SF_{TEMPERATURE}$	0.2 - 0.4	Arrhenius's equation assuming temperature range 6-7.4 ℃ (bedrock groundwater temperatures) and activation energies 47 to 58 kJ/mol for pyrite
$SF_{GRAIN\ SIZE}$	0.062 - 0.07	Fragmentation analysis. Percent of minus 10 mm mass fraction in blasted rock
$SF_{CONTACT}$	0.34 - 0.65	Kempton, 2012
$SF_{CLOSURE}$	0.53	During closure and post-closure only, Steinepreis (2018)

All leaching rates are obtained from neutral drainage because none of the geochemical tests have developed acidic leachate. However, samples of some lithologies are expected to generate acidic drainage resulting in increase in metal leaching in localized zones of PAG materials. In order to account for this increase, neutral leaching rates are inflated by factors of 11.9 for Zn, 7.5 for Ni, 3.5 for Fe, 1.8 for Cd, 1.6 for Pb 1.2 for Cu, 1.1 for SO_4 in PAG rock mass at ARD onset time. These inflation factors were estimated as a ratio of first-month leaching from carbonate depleted humidity cell containing Marathon LGO to the same rates from the initial (non-depleted) sample for LGO. The inflation factors were applied only to parameters with ratios above 1, otherwise the factor was set to zero (no leaching increase after ARD onset). Fraction of PAG rock in each lithology is shown in Table 5-1. ARD onset time inputs for triangular distribution were set as follows minimum 6.2 mine years, median 11.3 mine years, maximum 16.3 mine years based on conservative values discussed in the ARD/ML assessment report (Stantec 2020d). The inflated rates are calculated using Equation 5-1 for the mass of PAG rock in each lithology of waste rock, LGO, and rubble.

5.3.1.2 Nitrogen Rates

The blasting of waste rock will release nitrite, nitrate, and ammonia, which subsequently will be rinsed from the rock and contribute loads to contact water. The mass rate of lost (non-exploded) nitrogen (R_N, g/yr) is calculated using *Equation 5-2*:

$$R_N = MR \times PF \times F_N \times L_N \times FR_N \qquad \textit{Equation 5-2}$$

where:

- MR = total mining rate of ore + waste rock for pits or just mine rock, or ore for stockpiles t/yr (Table C-5, Appendix C)
- PF = 300 g/t, powder factor based on Ausenco (2020)
- F_N = 0.333, based on 1/3 of nitrogen in the explosive (Bailey et al. 2012) dimensionless
- L_N = fraction of lost nitrogen 0.001 to 0.043 with the likely values of 0.002 for the expected and upper cases, respectively, is based on 0.2% nitrogen of total nitrogen from Ferguson and Leask (1988) and 4.3% as maximum observed in dry open pit mines from Golder (2008)
- FR_N = 0.1 (10%), fraction of nitrogen released from rock and ore while in the open pit, prior to material transfer to storage areas and 0.9 for the rock and ore stockpile assuming that another 90% will be leached later based on Golder (2007)

The release of nitrogen species is assumed to be instant and the leached nitrogen is speciated as follows based on recommendations from Ferguson and Leask (1988): $N\text{-}NH_3$ - 11%, $N\text{-}NO_3$ - 87%, $N\text{-}NO_2$ - 2%.

Weathering and nitrogen leaching rates are released to pore water cells of rock and ore stockpiles. Pore water from these cells becomes seepage collected in ditches and ponds.

Runoff Quality from Piles

Runoff from the waste rock pile, and the ore and overburden stockpiles during operation is assumed to have quality obtained from shake flask tests of the respective materials (Table C-6, Appendix C). In post-closure, runoff quality from covered and rehabilitated areas is assumed to be similar to baseline chemistry. The runoff is mixed with seepage in the nodes representing water management ponds, which are connected to a specific FDP to the environment. An additional load in equivalent of 15 mg/L of total suspended solids (TSS) of waste rock or ore is added to the respective water management ponds, conservatively assuming MDMER limit for TSS in the discharges. Input concentrations in these solids are presented in Table C-7 (Appendix C).

5.3.2 Open Pit

In the Marathon pit, the leaching (input) rates from Equations 5-1 and 5-2 are applied to monthly dewatering volumes during mining or volumes of pit lake after mining ceases. During pit development, 99% of groundwater is originated from bedrock based on the groundwater modeling and the rest from overburden for that period. During pit filling, approximately 22.6% of groundwater inflow are originated from overburden and the rest from bedrock. Therefore, groundwater quality from overburden wells was assigned to 22.6% of total flow and reminder was assumed to have bedrock groundwater quality. No removal of elements due to chemical reactions (precipitation, degradation) was conservatively assumed in the Leprechaun pit lake. The model conservatively assumes a fully mixed pit lake.

5.3.3 Solubility Controls

The model conservatively passes a mass through the cells (nodes) with the exception of parameters having solubility limits (caps). These caps are included in the model and applied to all model nodes, because concentrations of some elements are often limited by mineral saturation. The derivation of solubility caps is presented in Stantec (2020d). The solubility caps set in the model for the following elements are Al (600 µg/L), F (1600 µg/L), Fe (900 µg/L), Mn (1300 µg/L), and P (50 µg/L).

6.0 WATER QUALITY PREDICTIONS

6.1 MODEL RUNS AND OUTPUTS

The water quality model is run in a probabilistic mode with 100 realizations. Each realization is run for 100 years in a monthly timestep. Probabilistic water quality inputs are sampled monthly using the Latin Hypercube method (GoldSim 2018). Monthly mean and monthly 95th percentile concentrations are calculated in GoldSim for baseline water, selected Project components (waste rock, LGO, and the open pit) and all FDPs. The average and elevated values of monthly mean and monthly 95th percentile concentrations are calculated for each mine period (construction, operation, closure, and post-closure). The highest of monthly statistic in (Project results or baseline) for each mine phase are conservatively selected and presented in the summary of outputs (Appendix D). The Project results are compared to the respective statistics for probabilistically simulated baseline surface water. The results of the model are also compared to the MDMER limits and CWQG-FAL guidelines shown in Table C-1 (Appendix C). Only the MDMER limits are directly applicable to the discharges. The CWQG-FAL guidelines are not applicable to discharges, as these guidelines are developed for the receiving environment and are used for screening to update the parameters of potential concern (POPC) identified in the ARD/ML report (Stantec 2020e) and provide inputs to assimilative capacity assessment (Stantec 2020f). The time series for monthly mean and monthly 95th percentile concentrations of select parameters for mine components and specific discharges are presented in Appendix E.

6.2 PROJECT COMPONENTS

6.2.1 Waste Rock

Seepage from waste rock is an important source of contact water collected in water management ponds MA-SP-01c, MA-SP-02, MA-SP-03, MA-SP-04, and in the open pit. No exceedances of the MDMER limits are predicted in the seepage/waste rock pore water when considering the 95% percentile levels. Concentrations of Zn, Cu, mercury (Hg), F, P, and N-NO_2 may exceed the long-term CWQG-FAL over an order of magnitude (Appendix D). The elevated concentrations of F and P are modelling artifacts related to high detection limits in humidity cells and in baseline water. Half of the value of the detection limits from humidity cells are used in calculations of leaching rates, which are scaled up to a full-size waste rock pile. Also, half of the value of highest detection limits for these elements were also used as inputs to baseline conditions in case of non-detects or if a parameter was not measured. Concentrations of Zn, Cu and Hg increase during operations peaking at the end of operation when the mass of waste rock is the greatest and acidic terms for Zn and Cu engage after Year 6 (Figure 6-1).

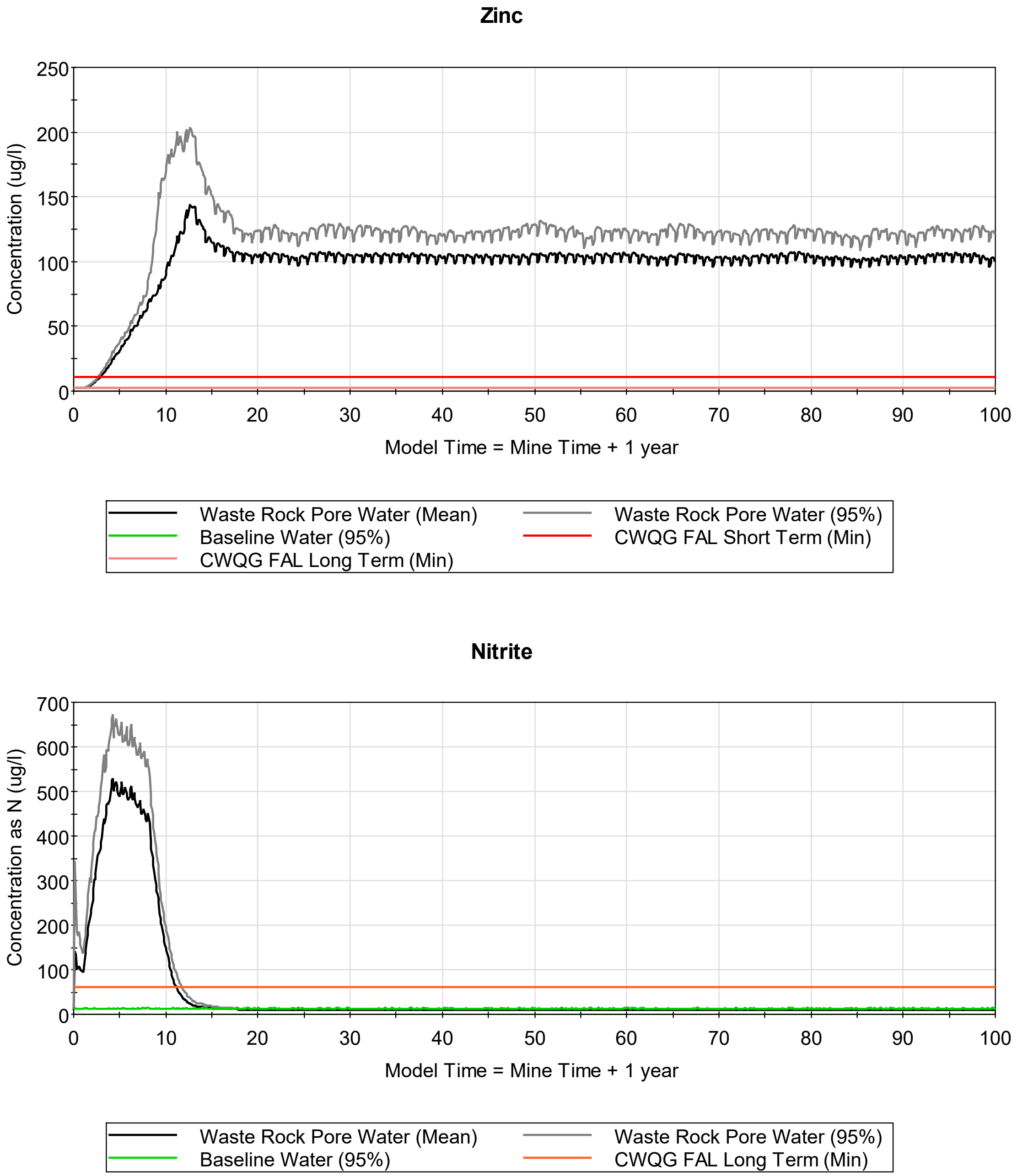


Figure 6-1 Concentration Trends of Zn and N-NO_2 in Waste Rock

Metal concentrations decline during closure, because metal leaching is partially reduced due to soil cover, and stabilize during post-closure. Concentrations of $N\text{-}NO_2$, as well as other nitrogen species, peak in mine Year 3 when the rate of waste rock blasting and disposal are the highest. During closure, $N\text{-}NO_2$ is flushed from the pile decreasing below the CWQG-FAL and stabilizing at background levels. Other parameters exceeding their long-term CWQG-FAL are Cr, Ag, $N\text{-}NH_{3\ UN}$, Cd, Mn, Al, As, $N\text{-}NH_{3\ T}$, Se, U, Pb, Fe, $N\text{-}NO_3$. Exceedance of Ag is also modelling artifact related to high detection limits in humidity cells. Most of the parameters exceeding CWQG-FAL generally follow a trend similar to Zn and Cu, except for Al, which may remain at the solubility limit until end of model runs (Appendix E). Nitrogen species leaching from blasting residues have patterns similar to $N\text{-}NO_2$. The long-term CWQG-FAL could be exceeded for P (over an order of magnitude), Cr, and Zn at baseline conditions (Appendix D). In the baseline dataset, P exceedances are related to detection limit (100 µg/L).

6.2.2 Low-Grade Ore

Seepage from the LGO stockpile will be collected in MA-SP-01a, MA-SP-01b, and the open pit during operation. Water collected in MA-SP-01a and MA-SP-01b will be discharged to the environment through MA-FDP-01. Similar to the waste rock pile, no exceedances of MDMER guidelines are predicted in the seepage from LGO considering 95th percentile concentrations. Zn may exceed the short-term CWQG-FAL value by two orders of magnitude. Concentrations of Zn and other trace elements peak around mine Year 9 when the mass of LGO in the stockpile is high and acidic terms are engaged (Appendix E). Afterwards, concentrations sharply decline as ore from the stockpile is transferred to the processing plant and then returned to background levels as the pile is mined out at the end of operation. Other parameters exceeding their long-term CWQG-FAL are Cu, Se, Hg, Al, $N\text{-}NO_2$, Cd, Cr, $N\text{-}NH_{3\ UN}$, Mn, Ag, As, U, $N\text{-}NH_{3\ T}$, Mo, $N\text{-}NO_3$, and Pb, with P and F being model artifacts. Exceedances of P, F and Ag are modelling artifacts as discussed in Section 6.2.1. Most of the trace elements from this list generally follow a trend similar to Zn (Appendix E). Concentrations of nitrogen species peak in mine Year 3, following the highest rate of LGO deposition and then decline down to background levels by start of the closure.

6.2.3 Open Pit

Overflow from the open pit will be collected in MA-SP-04 water management pond and discharged to the environment through MA-FDP-04. No exceedances of MDMER guidelines are predicted in mine water or pit lake overflow at 95th percentile concentrations. Concentrations of Zn and P may exceed the long-term CWQG-FAL by 10 times (Appendix D). Exceedances of P are modelling artifacts as discussed in Section 6.2.1. Elevated concentrations of Zn are predicted in mine water during operation and decline during closure (Figure 6-2). Additional parameters exceeding long-term CWQG-FAL are Mn, $N\text{-}NO_2$, Cu, Al, Fe, $N\text{-}NH_{3\ UN}$, Cr, F, $N\text{-}NH_{3\ T}$, and Hg. These parameters are elevated during operation and decline during the closure as a result of rehabilitation activities (Appendix E).

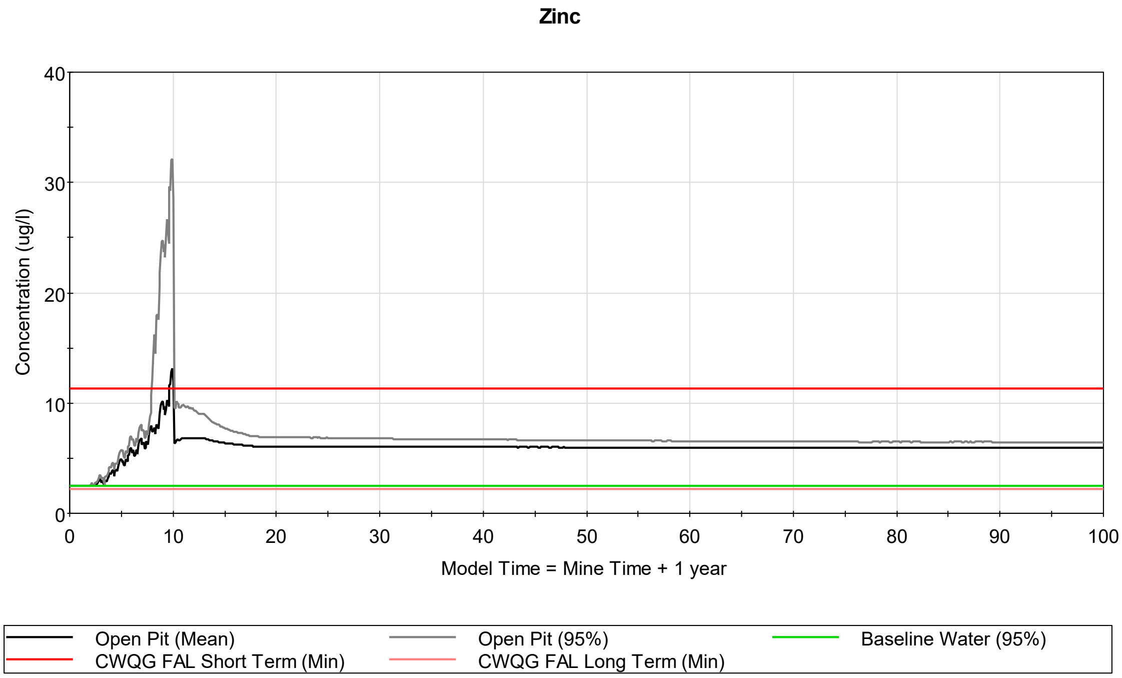


Figure 6-2 Concentration of Zn in Mine Water and the Pit Lake

6.3 FINAL DISCHARGE POINTS

6.3.1 MA-FDP-01

MA-FDP-01 receives water from water management pond MA-SP-01a, which collects runoff and seepage from LGO and waste rock piles, and from MA-SP-01b water management pond, which collects runoff from overburden. No MDMER exceedances are predicted in the discharge considering 95% level of confidence. The long-term CWQG-FAL could be exceeded for P (over 10 times), Cr, and Zn at baseline conditions represented by undisturbed runoff (Appendix D). Water quality during construction is similar to the baseline conditions when there is no discharge from the piles due to wetting of waste rock and LGO. During operation, Cu, As, F, Hg, Al, N-NO_2,Cd, Se, Ag, Mn, N-$NH_{3\ UN}$, Fe, and N-$NH_{3\ T}$ are predicted to be above the respective long-term CWQG-FAL, in addition to the parameters exceeding at the baseline conditions. These parameters are predicted to decline during closure and stabilize in post-closure with Cu, F, and Hg remaining above CWQG-FAL (Appendix E). Zn and Cr stabilize above the above background levels in post-closure.

6.3.2 MA-FDP-02

MA-FDP-02 receives water from the MA-SP-02 water management pond, which collects runoff and seepage from the waste rock pile. No MDMER exceedances are predicted in the discharge considering 95% level of confidence. At baseline conditions and during construction, parameters predicted to exceed the respective CWQG-FAL are the same as for MA-FDP-01 (P (over 10 times), Cr, and Zn) and other discharge points located near the Marathon pit. During operation, Cu (over 10 times), Hg (over 10 times), F (over 10 times), $N\text{-}NO_2$ (over 10 times), Ag, $N\text{-}NH_{3\ UN}$, Cd, Mn, Al, As, $N\text{-}NH_{3\ T}$, Se, U, Pb, Fe, and $N\text{-}NO_3$ are predicted to be above the respective long-term CWQG-FAL in addition to the parameters exceeding at baseline conditions (Appendix D). These parameters decline during closure and stabilize in post-closure with Cu, Hg, F, Ag, Cd, Mn, and Al remaining above CWQG-FAL (Appendix E). Zn and Cr stabilize above the above background levels in post-closure.

6.3.3 MA-FDP-03

MA-FDP-03 receives water from MA-SP-03 water management pond, which collects runoff and seepage generally from the waste rock pile. No MDMER exceedances are predicted in the discharge considering 95th percentile level of confidence. At baseline conditions and during construction, parameters predicted to exceed the long-term CWQG-FAL are P (over 10 times), Cr, and Zn. During operation, Cu (over 10 times), Hg (over 10 times), F (over 10 times), $N\text{-}NO_2$ (over 10 times), Ag, $N\text{-}NH_{3\ UN}$, Cd, Mn, Al, As, $N\text{-}NH_{3\ T}$, Se, U, Pb, Fe, and $N\text{-}NO_3$ are predicted to be above the respective long-term CWQG-FAL in addition to the parameters exceeding at baseline conditions (Appendix D). These parameters decline during closure and stabilize in post-closure with Cu, Hg, F, Ag, Cd, Mn, and Al remaining above CWQG-FAL (Appendix D). Zn and Cr stabilize above the background levels in post-closure.

6.3.4 MA-FDP-04

MA-FDP-04 receives water from MA-SP-04, which represents seepage and runoff from the waste rock pile, and MA-SP-05 which receives open pit dewatering and overflow from the pit lake. No MDMER exceedances are predicted at this discharge point considering 95th % level of confidence. At baseline conditions and construction, parameters predicted to exceed the long-term CWQG-FAL are P (over 10 times), Cr, and Zn. During operation, Cu (over 10 times), Hg (over 10 times), F, Al, Ag, As, Mn, Cd, $N\text{-}NO_2$, $N\text{-}NH_{3\ UN}$, Fe, $N\text{-}NH_{3\ T}$, Se, Pb, and U are predicted to exceed the respective long-term CWQG-FAL in addition to the parameters elevated at baseline conditions (Appendix D). These parameters are elevated in the last 2 years of operation and during the first years of closure, when MA-FDP-04 receives water only from the waste rock stockpile during pit filling. Most trace elements and nitrogen species decline in post-closure when the discharge quality is dominated by overflow from the pit lake. In post-closure, Cu, F, Al, $N\text{-}NO_2$, and Fe remain above the respective long-term CWQG-FAL. Zn stabilizes above the background levels in post-closure, while Cr declines to the baseline conditions.

7.0 CONCLUSIONS

Model probabilistic analysis predicts that filling of the Marathon open pit will take between 34 and 36 years (for the 95th and 5th percentiles, respectively) after the end of mining. Additionally, an acceleration of open pit filling was modelled for the eight years after mining of the open pit ceases (mine Years 10 to end of Year 17), using water from Valentine Lake. In this scenario, the total water intake rate from Valentine Lake is 17,000 m^3/day for average climate conditions during open pit filling.

The magnitude of the flow to the water management ponds depends on the watershed area, changes in drainage characteristics from sources (e.g., waste rock pile, undisturbed runoff) and the addition of groundwater seepage reporting to the pond, which also varies through the mine phases. Generally, the simulation flow results on the water management ponds and the FDPs, from 5th to 95th percentile results, range from approximately -25% to +25% of the mean results within each mine phase. This is consistent with the range of precipitation and approximately represents the 1:25 return period wet year to the 1:5 dry year.

The water quality model shows that there are no MDMER exceedances predicted at facilities (stockpiles, open pit, ponds) and discharge points (MA-FDP-01 to MA-FDP-04) in the Marathon mine complex during all mine phases at 95th percentile confidence level.

The long-term CWQG-FAL are not applicable to discharges but were used to screen POPCs for the receivers. At baseline conditions, P, Cr, and Zn exceed the respective long-term CWQG-FAL in streams near the Marathon open pit. During construction and operations, the highest number of long-term CWQG-FAL exceedances were predicted for MA-FDP-02 and associated with seepage from waste rock. During operation, Cu (over 10 times), Hg (over 10 times), F (over 10 times), N-NO_2 (over 10 times), Ag, N-$NH_{3\,UN}$, Cd, Mn, Al, As, N-$NH_{3\,T}$, Se, U, Pb, Fe, and N-NO_3 are predicted to be above the respective long-term CWQG-FAL in addition to the parameters exceeding at baseline conditions. These parameters decline during closure and stabilize in post-closure with Cu, Hg, F, Ag, Cd, Mn, and Al remaining above CWQG-FAL. Exceedance for F could be a modelling artifact related to high detection limits scaled up to a full size waste rock pile. Zn and Cr stabilize above the background levels in post-closure. The levels and trends for the parameters exceeding CWQG-FAL in MA-FDP-02 and MA-FDP-03 are similar.

Discharge point MA-FDP-01 has better water quality compared to MA-FDP-02 and MA-FDP-03 due to dilution of seepage from waste rock and LGO by runoff from the overburden stockpile. In addition to the parameters exceeding at baseline conditions (P, Cr, and Zn), Cu, As, F, Hg, Al, N-NO_2,Cd, Se, Ag, Mn, N-$NH_{3\,UN}$, Fe, and N-$NH_{3\,T}$ are predicted to be above the respective long-term CWQG-FAL during operation. These parameters are predicted to decline during closure and stabilize in post-closure with Cu, F, and Hg remaining above CWQG-FAL. Zn and Cr concentrations stabilize above the above background levels in post-closure.

MA-FDP-04 receives water from waste rock, open pit dewatering and overflow from the pit lake. At baseline conditions, parameters predicted to exceed the long-term CWQG-FAL are P, Cr, and Zn. During construction and operation, Cu, Hg, F, Al, Ag, As, Mn, Cd, $N\text{-}NO_2$, $N\text{-}NH_{3\ UN}$, Fe, $N\text{-}NH_{3\ T}$, Se, Pb, and U are predicted to exceed the respective long-term CWQG-FAL, in addition to the parameters elevated at baseline conditions. These parameters generally decline in post-closure when overflow from pit lake dominates over seepage from waste rock in this discharge point. In post-closure, Cu, F, Al, $N\text{-}NO_2$, and Fe remain above the respective long-term CWQG-FAL. Zn stabilizes above the background levels in post-closure, while Cr declines to background concentrations.

8.0 REFERENCES

Ausenco Engineering Canada. (Ausenco). 2020. N.I. 43-101 Technical Report & Pre-Feasibility Study On The Valentine Gold Project. Newfoundland and Labrador, Canada. April 2020.

Canadian Council of Ministers of the Environment (CCME). 2010. Canadian water quality guidelines for the protection of aquatic life: Ammonia. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

Canadian Council of Ministers of the Environment (CCME). 2019. Canadian water quality guidelines for the protection of aquatic life: Manganese (Dissolved) 2019. In: Canadian environmental quality guidelines, Canadian Council of Ministers of the Environment, Winnipeg.

Canadian Council of Ministers of the Environment (CCME). 2020. Canadian water quality guidelines for the protection of aquatic life: Summary Table. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg, MB. Accessed from http://st-ts.ccme.ca/en/index.html in January 2020.

Environment Canada and Climate Change (ECCC). 2020a. Climate Normals (1981-2010) at the Environment and Climate Change Canada (ECCC) Buchans climate station (Station ID 8400698).

Environment Canada and Climate Change (ECCC). 2020b. Stephenville and Gander ECCC climate stations (Station IDs 8401700 and 8403800).

Environment Canada and Climate Change (ECCC). 2020c. National Long-term Water Quality Monitoring Data. Retrieved from Environment and Climate Change Canada: https://open.canada.ca/data/en/fgpv_vpgf/67b44816-9764-4609-ace1-68dc1764e9ea

Ferguson, K.D. and S.M. Leask. 1988. *The Export of Nutrients from Surface Coal Mines*. Environment Canada Regional Program Report 87-12, dated March, 1988, p. 127.

Gemtec. 2019. Limited Geotechnical Investigation, Draft Proposed Site Development Valentine Gold Project. Draft factual report prepared for Marathon Gold Corporation, 2 December 2019.

Government of Alberta. 2018. Environmental Quality Guidelines for Alberta Surface Waters. Water Policy Branch, Alberta Environment and Parks. Edmonton, Alberta.

Golder Associates. (Golder). 2007. Water Quality Predictions. Meadowbank Gold Project. Nunavut. Prepared for Agnico Eagle Mines Ltd. August, 2007.

Golder Associates. (Golder). 2008. Blasting practices at Ekati mine and sources of nitrate available for dissolution of mine drainage water. Prepared for Ekati Diamond Mine, BHP Billiton Diamond Mines Ltd. December, 2008.

Golder Associates. (Golder). 2020. Marathon Gold, Prefeasibility Study for Tailings Disposal at the Valentine Gold Project, Newfoundland. March, 2020.

GoldSim 2018. GoldSim User’s Manual. Can be found at the following address: https://www.goldsim.com/Web/Customers/Education/Documentation/

McCabe, G. & and Markstrom, S. A Monthly Water-Balance Model Driven by a Graphical User Interface. U.S. Department of the Interior. U.S. Geological Survey. 2007.

Stantec Consulting Ltd. (Stantec) 2020a. Valentine Gold Project (VGP) Water Quantity and Water Quality Modelling Report: Polishing Plant & TMF Complex, and Leprechaun Complex. September 2020.

Stantec Consulting Ltd. (Stantec). 2020b. Water Management Plan, Marathon Valentine Gold Project. September 2020.

Stantec Consulting Ltd. (Stantec) 2020c. Valentine Gold Project Hydrology and Surface Water Quality Monitoring Baseline Report. September 2020.

Stantec Consulting Ltd. (Stantec). 2020d. Hydrogeology Modelling, Valentine Gold Project. September 2020.

Stantec Consulting Ltd. (Stantec) 2020e. Valentine Gold Project (VGP): Valentine Gold Project: Acid Rock Drainage/Metal Leaching (ARD/ML) assessment report. September 2020.

Stantec Consulting Ltd. (Stantec) 2020f. Valentine Gold Project (VGP) Assimilative Capacity Report:. September 2020.

Sturm, M & Holmgren, J & Liston, G. E. 1995. A Seasonal Snow Cover Classification System for Local to Global applications. US Army Cold Regions Research and Engineering Laboratory Ft. Wainwright, Alaska. Department of Atmospheric Science, Colorado State University, Fort Collins, Colorado.

SOR/2002-222. 2020. Metal and Diamond Mining Effluent Regulations. Published by the Minister of Justice at the following address: http://laws-lois.justice.gc.ca Last amended on June 25, 2019.

Thornthwaite, C.W. 1948. An approach toward a rational classification of climate. Geographical Review v. 38, p. 55-94.

Tukey, J. W. 1977. Exploratory Data Analysis. Addison-Wesley. ISBN 978-0-201-07616-5. OCLC 3058187.

US Environmental Protection Agency, 1994. The Hydrologic Evaluation of Landfill Performance (HELP) Model. September, 1994.

APPENDICES

Appendix A WATER MANAGEMENT PONDS FLOW RESULTS

Montlhy Average Flow from Sediment Ponds (m^3/s) - Average Climate Scenario

	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Pond 1A	Operations (Year 1 to 9)	573	716	838	1976	579	303	209	569	717	752	937	738	742
	Operations (Year 10 to 12)	573	713	838	1976	579	303	209	569	717	752	937	738	742
	Closure (Year 13 to 17)	504	632	741	1745	505	258	176	490	623	658	823	650	650
	Post Closure (from year 18)	390	487	573	1347	387	191	130	370	474	507	636	502	499
Pond 1B	Operations (Year 1 to 9)	151	216	286	663	145	76	69	123	136	146	206	200	202
	Operations (Year 10 to 12)	151	216	286	663	145	76	69	123	136	146	206	200	201
	Closure (Year 13 to 17)	18	23	27	63	15	0	0	8	14	22	30	23	20
	Post Closure (from year 18)	18	23	27	63	15	0	0	8	14	22	30	23	20
Pond 1C	Operations (Year 1 to 9)	193	277	366	848	191	107	100	167	181	189	264	256	262
	Operations (Year 10 to 12)	193	276	366	848	191	107	100	167	181	189	264	256	261
	Closure (Year 13 to 17)	248	319	379	898	232	103	55	210	282	305	394	321	312
	Post Closure (from year 18)	243	312	373	882	227	100	54	205	276	298	386	316	306
Pond 2	Operations (Year 1 to 9)	1115	1345	1554	3605	1435	1115	1044	1692	1787	1669	1894	1421	1640
	Operations (Year 10 to 12)	1115	1340	1554	3605	1435	1115	1044	1692	1787	1669	1894	1421	1639
	Closure (Year 13 to 17)	953	1186	1373	3260	915	429	231	873	1168	1243	1564	1225	1202
	Post Closure (from year 18)	943	1172	1360	3228	905	424	228	863	1155	1229	1548	1214	1189
Pond 3	Operations (Year 1 to 9)	816	992	1155	2678	1031	781	731	1195	1269	1199	1374	1041	1188
	Operations (Year 10 to 12)	816	988	1155	2678	1031	781	731	1195	1269	1199	1374	1041	1188
	Closure (Year 13 to 17)	714	890	1034	2450	681	311	167	641	862	926	1170	920	897
	Post Closure (from year 18)	716	892	1037	2459	684	312	168	644	866	930	1175	923	900
Pond 4	Operations (Year 1 to 9)	599	829	1069	2479	590	309	279	517	589	636	860	787	795
	Operations (Year 10 to 12)	599	825	1069	2479	590	309	279	517	589	636	860	787	795
	Closure (Year 13 to 17)	441	558	661	1554	407	159	91	353	485	550	711	589	547
	Post Closure (from year 18)	542	679	798	1880	507	210	117	456	621	691	883	699	674
Pond 5	Operations (Year 1 to 9)	3102	3402	3728	6128	3747	3612	3701	4247	4078	3761	3917	3450	3906
	Operations (Year 10 to 12)	14	17	21	47	11	0	0	6	11	17	23	18	15
	Closure (Year 13 to 17)	14	17	21	47	11	0	0	6	11	17	23	568	61
	Post Closure (from year 18)	3287	3834	4401	8724	3345	1903	1825	3138	3583	3967	4704	3912	3885

Montlhy Average Flow from Sediment Ponds (m^3/s) - Probabilistic Result Percentile 5%

	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Pond 1A	Operations (Year 1 to 9)	443	553	648	1528	447	235	162	440	555	582	724	570	574
	Operations (Year 10 to 12)	448	558	656	1546	453	237	164	445	561	589	733	577	581
	Closure (Year 13 to 17)	399	500	587	1382	400	204	139	388	493	521	652	514	515
	Post Closure (from year 18)	301	376	442	1039	298	147	100	286	365	391	491	387	385
Pond 1B	Operations (Year 1 to 9)	117	167	221	513	112	59	54	95	105	113	160	155	156
	Operations (Year 10 to 12)	118	169	224	519	114	59	54	96	107	115	161	157	158
	Closure (Year 13 to 17)	15	18	22	50	12	0	0	6	11	18	24	19	16
	Post Closure (from year 18)	14	18	21	48	11	0	0	6	11	17	23	18	16
Pond 1C	Operations (Year 1 to 9)	149	214	283	656	148	83	77	129	140	146	204	198	202
	Operations (Year 10 to 12)	151	216	286	663	150	84	78	131	141	148	206	200	205
	Closure (Year 13 to 17)	197	252	300	711	183	81	44	166	223	241	312	254	247
	Post Closure (from year 18)	188	241	288	680	175	77	42	158	213	230	298	243	236
Pond 2	Operations (Year 1 to 9)	862	1040	1201	2787	1110	862	807	1308	1382	1291	1465	1099	1268
	Operations (Year 10 to 12)	873	1049	1216	2821	1123	872	817	1324	1398	1306	1482	1112	1283
	Closure (Year 13 to 17)	754	939	1087	2581	724	339	183	691	925	984	1238	970	951
	Post Closure (from year 18)	727	904	1049	2490	698	327	176	666	891	948	1194	937	917
Pond 3	Operations (Year 1 to 9)	631	767	893	2070	797	604	565	924	981	927	1062	805	919
	Operations (Year 10 to 12)	638	773	904	2095	806	611	572	935	993	938	1075	815	930
	Closure (Year 13 to 17)	565	705	818	1940	539	246	132	508	683	733	926	728	710
	Post Closure (from year 18)	553	688	800	1897	527	241	129	497	668	717	906	712	695
Pond 4	Operations (Year 1 to 9)	463	641	826	1917	456	239	216	400	455	491	665	608	615
	Operations (Year 10 to 12)	469	646	836	1940	461	242	218	405	461	497	673	616	622
	Closure (Year 13 to 17)	349	441	524	1231	322	126	72	280	384	435	567	455	432
	Post Closure (from year 18)	417	524	615	1450	391	162	90	351	479	533	681	539	519
Pond 5	Operations (Year 1 to 9)	2399	2631	2883	4741	2899	2794	2863	3285	3154	2909	3030	2669	3021
	Operations (Year 10 to 12)	11	13	16	37	9	0	0	5	8	13	18	14	12
	Closure (Year 13 to 17)	11	13	16	37	9	0	0	5	8	13	18	14	12
	Post Closure (from year 18)	2440	2958	3395	6729	2580	1468	1408	2420	2763	3060	3629	3017	2989

Montlhy Average Flow from Sediment Ponds (m^3/s) - Probabilistic Result Percentile 25%

	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Pond 1A	Operations (Year 1 to 9)	516	644	755	1779	521	273	188	512	646	677	843	664	668
	Operations (Year 10 to 12)	509	633	745	1755	514	270	186	506	637	668	832	655	659
	Closure (Year 13 to 17)	457	572	671	1580	457	234	159	444	564	596	745	588	589
	Post Closure (from year 18)	347	434	510	1200	344	170	116	330	422	452	566	447	445
Pond 1B	Operations (Year 1 to 9)	136	195	257	597	131	68	62	110	123	132	186	180	182
	Operations (Year 10 to 12)	134	192	254	589	129	67	62	109	121	130	183	178	179
	Closure (Year 13 to 17)	17	21	25	57	13	0	0	7	13	20	27	21	18
	Post Closure (from year 18)	16	20	24	56	13	0	0	7	13	20	27	21	18
Pond 1C	Operations (Year 1 to 9)	174	249	329	763	172	96	90	150	163	171	238	231	236
	Operations (Year 10 to 12)	172	245	325	753	170	95	89	148	161	168	234	227	232
	Closure (Year 13 to 17)	225	288	343	813	210	93	50	190	255	276	357	291	283
	Post Closure (from year 18)	217	278	332	785	202	89	48	183	245	265	344	281	272
Pond 2	Operations (Year 1 to 9)	1004	1211	1399	3246	1293	1004	940	1524	1609	1503	1706	1280	1476
	Operations (Year 10 to 12)	991	1190	1380	3202	1275	990	927	1503	1587	1483	1683	1262	1456
	Closure (Year 13 to 17)	862	1074	1243	2951	828	388	209	790	1058	1125	1416	1109	1088
	Post Closure (from year 18)	839	1044	1211	2874	806	377	203	769	1028	1094	1378	1081	1059
Pond 3	Operations (Year 1 to 9)	735	893	1040	2411	928	703	658	1076	1143	1080	1237	938	1070
	Operations (Year 10 to 12)	725	878	1026	2379	915	694	649	1061	1127	1065	1221	925	1055
	Closure (Year 13 to 17)	646	806	936	2218	616	281	151	581	781	838	1059	833	812
	Post Closure (from year 18)	638	794	924	2190	609	278	149	573	771	828	1046	822	802
Pond 4	Operations (Year 1 to 9)	539	746	963	2232	531	278	251	466	530	572	775	709	716
	Operations (Year 10 to 12)	532	733	950	2202	524	274	248	459	523	565	764	699	706
	Closure (Year 13 to 17)	399	505	599	1407	368	144	82	320	439	498	645	527	494
	Post Closure (from year 18)	482	604	710	1674	452	187	104	406	553	615	786	622	600
Pond 5	Operations (Year 1 to 9)	2793	3063	3356	5517	3374	3252	3332	3823	3671	3386	3526	3106	3517
	Operations (Year 10 to 12)	12	15	18	42	10	0	0	5	9	15	20	16	13
	Closure (Year 13 to 17)	12	15	19	42	10	0	0	5	10	15	21	165	26
	Post Closure (from year 18)	2904	3414	3919	7768	2978	1695	1625	2794	3190	3532	4189	3483	3457

Montlhy Average Flow from Sediment Ponds (m^3/s) - Probabilistic Result Percentile 75%

	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Pond 1A	Operations (Year 1 to 9)	632	789	925	2179	638	335	231	628	791	830	1033	813	819
	Operations (Year 10 to 12)	630	783	922	2172	636	334	230	626	789	827	1029	811	816
	Closure (Year 13 to 17)	558	698	819	1929	558	285	194	542	689	728	910	718	719
	Post Closure (from year 18)	424	530	623	1465	420	208	142	403	515	552	692	546	543
Pond 1B	Operations (Year 1 to 9)	167	239	315	731	160	84	76	135	150	162	228	221	222
	Operations (Year 10 to 12)	166	237	314	729	160	83	76	135	150	161	227	220	221
	Closure (Year 13 to 17)	20	25	30	69	16	0	0	9	16	25	33	26	22
	Post Closure (from year 18)	20	25	30	68	16	0	0	8	15	24	33	25	22
Pond 1C	Operations (Year 1 to 9)	213	305	403	935	211	118	110	184	199	209	291	282	288
	Operations (Year 10 to 12)	212	303	402	932	210	118	110	184	199	208	290	281	287
	Closure (Year 13 to 17)	275	352	419	992	256	113	61	232	312	337	435	355	345
	Post Closure (from year 18)	265	340	406	960	247	109	59	223	300	324	420	343	333
Pond 2	Operations (Year 1 to 9)	1230	1483	1713	3975	1583	1229	1151	1866	1971	1841	2089	1567	1808
	Operations (Year 10 to 12)	1226	1473	1708	3962	1578	1225	1147	1860	1964	1835	2082	1562	1802
	Closure (Year 13 to 17)	1053	1311	1518	3604	1011	474	255	965	1292	1374	1728	1355	1328
	Post Closure (from year 18)	1025	1275	1479	3511	984	461	248	939	1256	1337	1683	1321	1293
Pond 3	Operations (Year 1 to 9)	900	1094	1274	2953	1136	861	806	1317	1399	1322	1515	1148	1311
	Operations (Year 10 to 12)	897	1086	1269	2943	1133	858	803	1313	1395	1318	1510	1145	1306
	Closure (Year 13 to 17)	789	984	1143	2709	753	343	185	709	953	1024	1294	1017	992
	Post Closure (from year 18)	779	970	1128	2675	744	339	182	701	942	1011	1278	1004	979
Pond 4	Operations (Year 1 to 9)	660	914	1179	2734	650	340	307	570	649	701	949	868	877
	Operations (Year 10 to 12)	658	907	1175	2725	648	339	306	568	647	699	946	865	874
	Closure (Year 13 to 17)	487	616	731	1718	450	176	100	391	536	614	805	653	607
	Post Closure (from year 18)	590	738	868	2045	552	229	127	495	676	752	961	760	733
Pond 5	Operations (Year 1 to 9)	3420	3751	4111	6757	4132	3983	4081	4683	4496	4147	4319	3804	4307
	Operations (Year 10 to 12)	15	19	23	51	12	0	0	6	12	18	25	19	17
	Closure (Year 13 to 17)	15	19	23	52	12	0	0	6	12	19	461	826	120
	Post Closure (from year 18)	3573	4170	4787	9490	3638	2070	1985	3413	3897	4315	5117	4255	4226

Montlhy Average Flow from Sediment Ponds (m^3/s) - Probabilistic Result Percentile 95%

	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Pond 1A	Operations (Year 1 to 9)	730	912	1068	2517	737	387	267	725	914	958	1193	940	946
	Operations (Year 10 to 12)	757	942	1108	2612	765	401	277	752	948	994	1238	975	981
	Closure (Year 13 to 17)	642	804	943	2221	642	328	223	624	793	838	1048	827	828
	Post Closure (from year 18)	483	604	710	1671	480	237	161	459	588	629	789	622	620
Pond 1B	Operations (Year 1 to 9)	193	276	364	845	185	97	88	156	173	187	263	255	257
	Operations (Year 10 to 12)	200	285	378	877	192	100	92	162	180	194	273	265	266
	Closure (Year 13 to 17)	23	29	35	80	19	0	0	10	18	28	38	30	26
	Post Closure (from year 18)	23	28	34	78	18	0	0	10	17	28	38	29	25
Pond 1C	Operations (Year 1 to 9)	246	353	466	1080	244	136	127	213	230	241	336	326	333
	Operations (Year 10 to 12)	255	364	483	1121	253	141	132	221	239	250	349	338	346
	Closure (Year 13 to 17)	316	405	483	1142	295	131	70	268	359	388	501	409	397
	Post Closure (from year 18)	302	387	463	1094	281	124	67	255	342	370	479	392	380
Pond 2	Operations (Year 1 to 9)	1421	1714	1980	4593	1829	1420	1330	2156	2277	2127	2413	1811	2089
	Operations (Year 10 to 12)	1474	1771	2054	4765	1898	1473	1380	2237	2362	2207	2504	1879	2167
	Closure (Year 13 to 17)	1212	1509	1747	4148	1164	546	293	1111	1487	1582	1991	1560	1529
	Post Closure (from year 18)	1170	1454	1687	4004	1123	526	283	1071	1433	1525	1920	1506	1475
Pond 3	Operations (Year 1 to 9)	1040	1264	1471	3412	1313	995	931	1522	1617	1528	1751	1327	1514
	Operations (Year 10 to 12)	1079	1306	1527	3540	1362	1032	966	1579	1677	1585	1816	1377	1570
	Closure (Year 13 to 17)	908	1133	1315	3118	867	395	213	816	1097	1178	1489	1170	1142
	Post Closure (from year 18)	889	1106	1287	3051	848	387	208	799	1074	1154	1457	1145	1117
Pond 4	Operations (Year 1 to 9)	763	1056	1362	3159	751	393	355	659	750	810	1096	1003	1013
	Operations (Year 10 to 12)	791	1091	1413	3277	779	408	369	683	778	840	1137	1040	1051
	Closure (Year 13 to 17)	561	710	842	1978	518	203	116	450	617	704	922	755	698
	Post Closure (from year 18)	673	842	990	2333	629	261	145	565	770	857	1096	867	836
Pond 5	Operations (Year 1 to 9)	3951	4333	4748	7804	4773	4601	4714	5408	5193	4790	4988	4394	4975
	Operations (Year 10 to 12)	18	22	27	62	14	0	0	8	14	22	30	23	20
	Closure (Year 13 to 17)	17	22	26	60	14	0	0	7	14	623	1050	998	236
	Post Closure (from year 18)	4076	4756	5460	10823	4149	2361	2264	3892	4445	4922	5836	4853	4820

Appendix B FDP FLOW RESULTS

Montlhy Average FDPs flows (m^3/day) - Average Climate Scenario

FDP	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1	Operations (Year 1 to 9)	917	1209	1490	3487	915	486	379	859	1034	1088	1407	1194	1205
	Operations (Year 10 to 12)	917	1204	1490	3487	915	486	379	859	1034	1088	1407	1194	1205
	Closure (Year 13 to 17)	771	973	1148	2705	751	361	231	708	919	985	1247	994	983
	Post Closure (from year 18)	651	822	973	2292	628	291	184	583	764	827	1052	841	826
2	Operations (Year 1 to 9)	1115	1345	1554	3605	1435	1115	1044	1692	1787	1669	1894	1421	1640
	Operations (Year 10 to 12)	1115	1340	1554	3605	1435	1115	1044	1692	1787	1669	1894	1421	1639
	Closure (Year 13 to 17)	953	1186	1373	3260	915	429	231	873	1168	1243	1564	1225	1202
	Post Closure (from year 18)	943	1172	1360	3228	905	424	228	863	1155	1229	1548	1214	1189
3	Operations (Year 1 to 9)	4516	5222	5951	11285	5367	4702	4711	5958	5935	5595	6151	5278	5889
	Operations (Year 10 to 12)	1428	1830	2244	5204	1631	1090	1010	1717	1868	1851	2257	1846	1998
	Closure (Year 13 to 17)	1168	1465	1715	4051	1099	470	258	1000	1357	1493	1903	2060	1503
	Post Closure (from year 18)	4545	5405	6236	13063	4536	2426	2109	4237	5070	5588	6762	5533	5459
4	Operations (Year 1 to 9)	599	829	1069	2479	590	309	279	517	589	636	860	787	795
	Operations (Year 10 to 12)	599	825	1069	2479	590	309	279	517	589	636	860	787	795
	Closure (Year 13 to 17)	441	558	661	1554	407	159	91	353	485	550	711	589	546
	Post Closure (from year 18)	542	679	798	1880	507	210	117	456	621	691	883	699	674

Montlhy Average FDPs flows (m^3/day) - Probabilistic Result Percentile 5%

FDP	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1	Operations (Year 1 to 9)	709	935	1152	2696	708	376	293	664	800	841	1088	923	932
	Operations (Year 10 to 12)	718	942	1166	2728	716	381	296	672	809	851	1101	934	943
	Closure (Year 13 to 17)	611	770	909	2142	594	286	183	561	728	780	987	787	778
	Post Closure (from year 18)	503	634	750	1768	484	225	142	450	589	638	812	649	637
2	Operations (Year 1 to 9)	862	1040	1201	2787	1110	862	807	1308	1382	1291	1465	1099	1268
	Operations (Year 10 to 12)	873	1049	1216	2821	1123	872	817	1324	1398	1306	1482	1112	1283
	Closure (Year 13 to 17)	754	939	1087	2581	724	339	183	691	925	984	1238	970	951
	Post Closure (from year 18)	727	904	1049	2490	698	327	176	666	891	948	1194	937	917
3	Operations (Year 1 to 9)	3493	4039	4603	8728	4151	3636	3644	4608	4590	4327	4757	4082	4555
	Operations (Year 10 to 12)	1118	1433	1756	4072	1276	853	790	1344	1462	1449	1766	1444	1563
	Closure (Year 13 to 17)	925	1160	1358	3208	870	372	204	792	1075	1182	1519	1204	1156
	Post Closure (from year 18)	3413	4169	4810	10076	3499	1871	1627	3268	3910	4310	5216	4268	4203
4	Operations (Year 1 to 9)	463	641	826	1917	456	239	216	400	455	491	665	608	615
	Operations (Year 10 to 12)	469	646	836	1940	461	242	218	405	461	497	673	616	622
	Closure (Year 13 to 17)	349	441	524	1231	322	126	72	280	384	435	567	455	432
	Post Closure (from year 18)	417	524	615	1450	391	162	90	351	479	533	681	539	519

Montlhy Average FDPs flows (m3/s) - Probabilistic Result Percentile 25%

FDP	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1	Operations (Year 1 to 9)	826	1089	1342	3140	824	438	341	773	931	980	1267	1075	1085
	Operations (Year 10 to 12)	815	1070	1323	3097	813	432	336	763	919	967	1250	1060	1070
	Closure (Year 13 to 17)	698	881	1039	2449	680	326	209	641	832	892	1129	900	890
	Post Closure (from year 18)	580	732	866	2041	559	259	164	519	680	737	937	749	735
2	Operations (Year 1 to 9)	1004	1211	1399	3246	1293	1004	940	1524	1609	1503	1706	1280	1476
	Operations (Year 10 to 12)	991	1190	1380	3202	1275	990	927	1503	1587	1483	1683	1262	1456
	Closure (Year 13 to 17)	862	1074	1243	2951	828	388	209	790	1058	1125	1416	1109	1088
	Post Closure (from year 18)	839	1044	1211	2874	806	377	203	769	1028	1094	1378	1081	1059
3	Operations (Year 1 to 9)	4066	4703	5359	10161	4833	4233	4242	5364	5344	5038	5538	4753	5303
	Operations (Year 10 to 12)	1269	1626	1994	4622	1449	968	897	1525	1659	1644	2005	1640	1775
	Closure (Year 13 to 17)	1058	1326	1553	3668	995	425	233	906	1229	1353	1736	1509	1332
	Post Closure (from year 18)	4017	4812	5553	11632	4038	2160	1878	3773	4514	4976	6021	4927	4858
4	Operations (Year 1 to 9)	539	746	963	2232	531	278	251	466	530	572	775	709	716
	Operations (Year 10 to 12)	532	733	950	2202	524	274	248	459	523	565	764	699	706
	Closure (Year 13 to 17)	399	505	599	1407	368	144	82	320	439	498	645	527	494
	Post Closure (from year 18)	482	604	710	1674	452	187	104	406	553	615	786	622	600

Montlhy Average FDPs flows (m3/s) - Probabilistic Result Percentile 75%

FDP	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1	Operations (Year 1 to 9)	1011	1333	1643	3845	1009	536	417	947	1141	1200	1551	1317	1329
	Operations (Year 10 to 12)	1008	1323	1638	3833	1006	535	416	944	1137	1196	1546	1312	1324
	Closure (Year 13 to 17)	852	1076	1269	2991	830	399	255	783	1016	1089	1378	1099	1086
	Post Closure (from year 18)	709	894	1058	2493	683	317	200	634	831	900	1145	915	898
2	Operations (Year 1 to 9)	1230	1483	1713	3975	1583	1229	1151	1866	1971	1841	2089	1567	1808
	Operations (Year 10 to 12)	1226	1473	1708	3962	1578	1225	1147	1860	1964	1835	2082	1562	1802
	Closure (Year 13 to 17)	1053	1311	1518	3604	1011	474	255	965	1292	1374	1728	1355	1328
	Post Closure (from year 18)	1025	1275	1479	3511	984	461	248	939	1256	1337	1683	1321	1293
3	Operations (Year 1 to 9)	4980	5759	6563	12444	5919	5185	5195	6570	6545	6170	6783	5821	6494
	Operations (Year 10 to 12)	1570	2012	2467	5720	1793	1198	1110	1888	2053	2035	2481	2029	2196
	Closure (Year 13 to 17)	1291	1619	1897	4479	1215	520	285	1106	1502	1674	2540	2497	1719
	Post Closure (from year 18)	4943	5878	6783	14210	4934	2638	2295	4609	5515	6079	7356	6019	5938
4	Operations (Year 1 to 9)	660	914	1179	2734	650	340	307	570	649	701	949	868	877
	Operations (Year 10 to 12)	658	907	1175	2725	648	339	306	568	647	699	946	865	874
	Closure (Year 13 to 17)	487	616	731	1718	450	176	100	391	536	613	804	653	606
	Post Closure (from year 18)	590	738	868	2045	552	229	127	495	676	752	961	760	733

Montlhy Average FDPs flows (m3/s) - Probabilistic Result Percentile 95%

FDP	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1	Operations (Year 1 to 9)	1169	1540	1898	4443	1166	620	482	1094	1318	1386	1792	1521	1536
	Operations (Year 10 to 12)	1212	1592	1969	4609	1210	643	500	1135	1367	1438	1860	1578	1593
	Closure (Year 13 to 17)	981	1238	1460	3443	955	459	294	901	1170	1254	1587	1265	1251
	Post Closure (from year 18)	808	1019	1207	2843	779	361	228	724	947	1026	1305	1043	1024
2	Operations (Year 1 to 9)	1421	1714	1980	4593	1829	1420	1330	2156	2277	2127	2413	1811	2089
	Operations (Year 10 to 12)	1474	1771	2054	4765	1898	1473	1380	2237	2362	2207	2504	1879	2167
	Closure (Year 13 to 17)	1212	1509	1747	4148	1164	546	293	1111	1487	1582	1991	1560	1529
	Post Closure (from year 18)	1170	1454	1687	4004	1123	526	283	1071	1433	1525	1920	1506	1475
3	Operations (Year 1 to 9)	5753	6652	7581	14375	6837	5989	6001	7589	7560	7128	7835	6724	7502
	Operations (Year 10 to 12)	1888	2420	2967	6879	2156	1440	1335	2270	2469	2447	2984	2440	2641
	Closure (Year 13 to 17)	1487	1864	2183	5155	1398	598	328	1273	1731	2424	3408	2915	2064
	Post Closure (from year 18)	5637	6704	7736	16206	5627	3009	2617	5256	6289	6932	8389	6864	6772
4	Operations (Year 1 to 9)	763	1056	1362	3159	751	393	355	659	750	810	1096	1003	1013
	Operations (Year 10 to 12)	791	1091	1413	3277	779	408	369	683	778	840	1137	1040	1051
	Closure (Year 13 to 17)	561	710	842	1978	518	203	116	450	617	704	922	755	698
	Post Closure (from year 18)	673	842	990	2333	629	261	145	565	770	857	1096	867	836

Appendix C WATER QUALITY MODEL INPUTS

Table C-1: List of input parameters and water quality guidelines

Parameter name	Parameter Symbol	Name in model	Parameter group	Units	Highest RDL	CWQG FAL Guidelines		MDMER Limits
						Short-term	Long-term	
Aluminum	Al	Aluminum	Trace elements	µg/L	5.0	n/v	5 or 100*	n/v
Antimony	Sb	Antimony	Trace elements	µg/L	1.0	n/v	n/v	n/v
Arsenic	As	Arsenic	Trace elements	µg/L	1.0	n/v	5	100
Barium	Ba	Barium	Trace elements	µg/L	1.0	n/v	n/v	n/v
Boron	B	Boron	Trace elements	µg/L	50	29000	1500	n/v
Cadmium	Cd	Cadmium	Trace elements	µg/L	0.017	0.13	0.04	n/v
Calcium	Ca	Calcium	Trace elements	µg/L	100	n/v	n/v	n/v
Chromium	Cr	Chromium	Trace elements	µg/L	1.0	n/v	1	n/v
Copper	Cu	Copper	Trace elements	µg/L	2.0	n/v	2	100
Iron	Fe	Iron	Trace elements	µg/L	50	n/v	300	n/v
Lead	Pb	Lead	Trace elements	µg/L	0.50	n/v	1	80
Magnesium	Mg	Magnesium	Trace elements	µg/L	100	n/v	n/v	n/v
Manganese	Mn	Manganese	Trace elements	µg/L	2.0	596	210	n/v
Mercury	Hg	Mercury	Trace elements	µg/L	0.013	n/v	0.026	n/v
Molybdenum	Mo	Molybdenum	Trace elements	µg/L	2.0	n/v	73	n/v
Nickel	Ni	Nickel	Trace elements	µg/L	2.0	n/v	25	250
Phosphorus	P	Phosphorus	Trace elements	µg/L	100	n/v	4	n/v
Potassium	K	Potassium	Trace elements	µg/L	100	n/v	n/v	n/v
Selenium	Se	Selenium	Trace elements	µg/L	1.0	n/v	1	n/v
Silver	Ag	Silver	Trace elements	µg/L	0.10	n/v	0.25	n/v
Sodium	Na	Sodium	Trace elements	µg/L	100	n/v	n/v	n/v
Thallium	Tl	Thallium	Trace elements	µg/L	0.10	n/v	0.8	n/v
Uranium	U	Uranium	Trace elements	µg/L	0.10	33	15	n/v
Zinc	Zn	Zinc	Trace elements	µg/L	5.0	11.3	2.2	400
Chloride	Cl	Chloride	General chemistry	µg/L	1000	640000	120000	n/v
Nitrate + Nitrite (as Nitrogen)	$N\text{-}NO_3{+}NO_2$	N_Nitrate_Nitrite	General chemistry	µg/L	50	n/v	n/v	n/v
Nitrite (as Nitrogen)	$N\text{-}NO_2$	N_Nitrite	General chemistry	µg/L	10	n/v	60	n/v
Nitrate (as Nitrogen)	$N\text{-}NO_3$	N_Nitrate	General chemistry	µg/L	50	550000	13000	n/v
Total Ammonia (as Nitrogen)	$N\text{-}NH_{3\ T}$	N_Ammonia_t	General chemistry	µg/L	50	n/v	689	n/v
Un-ionized Ammonia (as Nitrogen)	$N\text{-}NH_3$ un	N_Ammonia_un	General chemistry	µg/L	N/A	16	16	500
Cyanide, Total**	CN_T	Cyanide_t	General chemistry	µg/L	10	n/v	n/v	500
Cyanide, WAD**	CN_{WAD}	Cyanide_WAD	General chemistry	µg/L	1	n/v	5	n/v
Sulphate	SO_4	Sulphate	General chemistry	µg/L	2000	n/v	n/v	n/v
Fluoride**	F	Fluoride	General chemistry	µg/L	60.0	n/v	120	n/v
Radium-226**	Ra-226	Radium_226	Radioactivity	Bq/L	0.005	n/v	n/v	0.37
Temperature***	Temp	Temperature	General chemistry	°C	na	n/v	Narrative	n/v
Total Alkalinity (as $CaCO_3$)	Alk tot	Alkalinity	General chemistry	mg/L	5	n/v	n/v	n/v
pH	pH	pH	General chemistry	pH Unit	N/A	n/v	6.5-9.0	6.0-9.5
Hardness (as $CaCO_3$)	Hard	Hardness	General chemistry	mg/L	1	n/v	n/v	n/v
Dissolved Organic Carbon**	DOC	DOC	General chemistry	mg/L	1	n/v	n/v	n/v

See notes on next page

Table C-1: List of input parameters and water quality guidelines

Notes:
All concentrations are total (unfiltered) fraction.
The most stringent guideline is selected when two or more guidelines are established for the same parameter under the same jurisdiction.
CWQG FAL - Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life by Canadian Council of Ministers of the Environment (CCME 2020).
MDMER - Metal and Diamond Mining Effluent Regulations (Canada), Schedule 4 Table 1 (amendment not yet in force) - Authorized Limits of Deleterious Substances, Maximum Authorized Monthly Mean Concentrations (SOR/2002-222 2020).
n/v = no value.
*Equations are used to calculate hardness-, pH-, temperature-, and DOC-dependent guidelines for these parameters as per CCME (2020) or as otherwise noted:

Aluminium: guideline is 5 µg/L if pH < 6.5 or 100 µg/L if pH ≥ 6.5. 100 µg/L is used since pH ≥ 6.5 for surface water.

Cadmium (long-term): at hardness < 17 mg/L the guideline is 0.04 µg/L; at hardness between 17 and 280 mg/L the guideline is 10^{0.83(log[hardness]) – 2.46} µg/L; at hardness > 280 mg/L the guideline is 0.37 µg/L. For the most stringent guideline, minimum hardness (6.5 mg CaCO3/L for surface water) is used.

Cadmium (short-term): at hardness < 5.4 mg/L the guideline is 0.11 µg/L; at hardness between 5.3 and 360 the guideline is 10^{1.016(log[hardness]) – 1.71 } µg/L; at hardness > 360 the guideline is 7.7 µg/L. For the most stringent guideline, minimum hardness (6.5 mg CaCO3/L for surface water) is used.

Copper: at hardness < 82 mg/L the guideline is 2 µg/L; at hardness between 82 and 180 mg/L the guideline is 0.2 * e^{0.8545[ln(hardness)]-1.465} µg/L; at hardness > 180 mg/L the hardness is 4 µg/L; at an unknown hardness the guideline is 2 µg/L. For the most stringent guideline, minimum hardness (6.5 mg CaCO3/L for surface water) is used.

Lead: at hardness < 60 mg/L the guideline is 1 µg/L; at hardness between 60 and 180 mg/L the guideline is e^{1.273[ln(hardness)]-4.705} µg/L; at hardness > 180 mg/L the hardness is 7 µg/L; at an unknown hardness the guideline is 1 µg/L. For the most stringent guideline, minimum hardness (6.5 mg CaCO3/L for surface water) is used.

Manganese (long-term): dissolved manganese guideline is pH- and hardness-dependent and found using the CWQG FAL calculator in Appendix B of the Scientific Criteria Document for the Development of the Canadian Water Quality Guidelines for the Protection of Aquatic Life: Manganese (CCME 2019). For the most stringent guideline, minimum hardness (6.5 mg CaCO3/L for surface water) is used. Values within pH range are tested (minimum of 6.5 and maximum of 7.8 for surface water) both giving most conservative guideline.

Manganese (short-term): dissolved managanese benchmark is found using the benchmark calculator in Appendix B (see Manganese (long-term)) or e^{0.878[ln(hardness)] + 4.76} µg/L.

Nickel: at hardness < 60 mg/L the guideline is 25 µg/L; at hardness between 60 and 180 mg/L the guideline is e^{0.76[ln(hardness)]+1.06} µg/L; at hardness > 180 mg/L the hardness is 150 µg/L; at an unknown hardness the guideline is 25 µg/L. For the most stringent guideline, minimum hardness (6.5 mg CaCO3/L for surface water) is used.

Phosphorus: trigger ranges for phosphorus are provided by Guidance Framework and depend upon trophic index of a water body. Phosphorus trigger range for freshwater nutrients in an ultra-oligotrophic environment is used.

Zinc (long-term): guideline for dissolved zinc is e^{0.947[ln(hardness)] - 0.815[pH] + 0.398[ln(DOC)] + 4.625} µg/L. The equation is valid between hardness 23.4 and 399 mg CaCO3/L, pH 6.5 and 8.13, and DOC 0.3 to 22.9 mg/L. DOC = dissolved organic carbon. The lowest hardness (23.4 mg CaCO3/L) and DOC (0.3 mg/L), for which equation is valid, and maximum pH (7.8 for surface water) is used.

Zinc (short-term): guideline for dissolved zinc is e^(0.833[ln(hardness mg·L-1)] + 0.240[ln(DOC)] + 0.526) µg/L. The benchmark equation is valid between hardness 13.8 and 250.5 mg CaCO3/L and DOC 0.3 and 17.3 mg/L. 'The lowest hardness (13.8 mg CaCO3/L) and DOC (0.3 mg/L), for which equation is valid is used.

Ammonia guideline is pH- and temperature-dependent and is taken from the Environmental Quality Guidelines for Alberta Surface Water (Government of Alberta 2018), which is similar to CCME (2010), but is calculated for smaller teperature (1 °C) and pH (0.1 pH unit) intervals. Maximum pH (7.8 for surface water) and maximum temperature (19 °C for surface water) is used.

Chromium long-term assumes Cr(VI).
Unionized ammonia values are calculated where temperature and/or pH are not present in the data set using maximum temperature and pH (19 °C and 7.8 for surface water).
Cyanide WAD is compared to the long-term for free cyanide.
**The highest Reportable Detection Limit (RDL) is used for modeling.
***Surface water temperature values are the mean daily air temperature, or 0 °C if air temperature is negative, on the day of sampling or the closest day with data available, taken from the Government of Canada Daily Data Reports (2011-2019) for Burnt Pond, NL, with values ranging from 0 to 18.5 °C. Groundwater temperature values are from field records where available, or are assumed to be 6.0 °C otherwise (average groundwater temperature (Stantec 2017)).

Table C-2: Inputs for background surface water quality

Parameter	**Units**	MDMER	CWQG	**CWQG**	Statistics for VAL01				Statistics for VL01 (Valentine lake)			
Statistics			Short-term	Long-term	Min	Mean	Max	St. Dev	Min	Mean	Max	St. Dev
Aluminum	µg/L	-	-	100	11	14	22	3.9	13	78	**282**	54
Antimony	µg/L	-	-	-	0.50	0.50	0.50	0.00083	0.50	0.50	0.50	0.00083
Arsenic	µg/L	100	-	5	0.50	0.50	0.50	0.00083	0.50	2.1	5.0	0.93
Barium	µg/L	-	-	-	1.6	2.1	3.0	0.51	1.20	2.0	4.1	0.74
Boron	µg/L	-	29000	1500	25	25	25	0.042	25	25	25	0.042
Cadmium	µg/L	-	0.13	0.04	0.0050	0.0050	0.0050	0.0000083	0.0050	0.0093	**0.064**	0.011
Calcium	µg/L	-	-	-	2700	2800	2900	82	2010	3976	7500	1176
Chromium	µg/L	-	-	1.0	0.50	0.75	**2.0**	0.56	0.50	0.78	**5.1**	**1.0**
Copper	µg/L	100	-	2.0	0.25	0.52	0.92	0.28	0.52	1.0	1.3	0.10
Iron	µg/L	-	-	300	25	25	25	0.042	25	135	**560**	116
Lead	µg/L	80	-	1	0.25	0.25	0.25	0.00042	0.25	0.25	0.25	0.00042
Magnesium	µg/L	-	-	-	320	333	350	9.4	366	613	1510	205
Manganese	µg/L	-	596	210	3.5	5.5	6.9	1.4	8.9	81	**365**	81
Mercury	µg/L	-	-	0.026	0.0064	0.0065	0.0065	0.000011	0.0065	0.0070	0.014	0.0018
Molybdenum	µg/L	-	-	73	1.0	1.0	1.0	0.0017	1.0	1.0	2.1	0.20
Nickel	µg/L	250	-	25	0.99	1.0	1.0	0.0017	0.99	1.0	1.0	0.0017
Phosphorus	µg/L	-	-	4	**50**	**50**	**50**	0.083	**50**	**54**	**160**	**20**
Potassium	µg/L	-	-	-	50	83	130	34	50	135	290	53
Selenium	µg/L	-	-	1	0.25	0.25	0.25	0.00042	0.25	0.48	0.50	0.062
Silver	µg/L	-	-	0.25	0.050	0.050	0.050	7E-18	0.050	0.050	0.050	2E-17
Sodium	µg/L	-	-	-	1300	1383	1500	69	1290	1716	2210	285
Thallium	µg/L	-	-	0.8	0.050	0.050	0.050	7E-18	0.050	0.050	0.050	2E-17
Uranium	µg/L	-	33	15	0.050	0.050	0.050	7E-18	0.050	0.050	0.050	2E-17
Zinc	µg/L	400	11.3	2.2	**2.5**	**2.5**	**2.5**	0.0042	**2.5**	**3.7**	12	**2.7**
Chloride	µg/L	-	640000	120000	2100	2317	2600	167	1000	2550	5000	857
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	25	30	55	11	25	61	300	60
Nitrite (as Nitrogen)	µg/L	-	-	60	5.0	8.7	14	3.8	5.0	38	**500**	**123**
Nitrate (as Nitrogen)	µg/L	-	550000	13000	25	25	25	0.042	25	61	300	60
Total Ammonia (as Nitrogen)	µg/L	-	-	689	25	25	25	0.042	25	62	500	119
Un-ionized Ammonia (as Nitrogen)	µg/L	500	16	16	0.022	0.053	0.10	0.030	0.0064	0.072	0.30	0.076
Cyanide, Total	µg/L	500	-	-	9.9	10	10	0.017	9.9	10	10	0.017
Cyanide, WAD	µg/L	-	-	5	0.99	1.0	1.0	0.0017	0.99	1.0	1.0	0.0017
Sulphate	µg/L	-	-	-	990	1000	1000	1.7	500	1083	2800	463
Fluoride	µg/L	-	-	120	59	60	60	0.10	59	60	60	0.10
Radium-226	Bg/L	0.37	-	-	0.0050	0.0050	0.0050	0.0000083	0.0050	0.0050	0.0050	2E-18
Temperature	°C	-	-	-	3.5	11	18	7.0	0	7.7	19	6.8
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	7.6	8.6	9.8	0.69	2.5	11	21	3.8
pH	pH Unit	6.0-9.5	-	6.5-9.0	6.9	7.0	7.1	0.058	**6.5**	6.9	7.3	0.23
Hardness (as $CaCO_3$)	mg/L	-	-	-	8.0	8.4	8.7	0.25	6.5	12	22	3.6
Dissolved Organic Carbon	mg/L	-	-	-	0.99	1.0	1.0	0.0017	0.99	1.0	1.0	0.0017

Notes: See Table C-1 notes for details on the parameters and guidelines.

Table C-3: Inputs for groundwater quality

Parameter	**Units**	MDMER	CWQG	**CWQG**	**Marathon bedrock**			**Marathon overburden**		
Statistics			Short-term	Long-term	Min	Median	Max	Min	Median	Max
Aluminum	µg/L	-	-	100	12	12	42	13	**273**	**533**
Antimony	µg/L	-	-	-	0.50	0.50	0.51	0.99	1.0	1.0
Arsenic	µg/L	100	-	5	0.50	1.5	2.9	3.0	**24**	**44**
Barium	µg/L	-	-	-	1.6	6.7	11	24	31	38
Boron	µg/L	-	29000	1500	25	25	25	6.0	6.5	7.0
Cadmium	µg/L	-	0.13	0.04	0.0084	0.0085	0.022	0.0085	0.025	**0.042**
Calcium	µg/L	-	-	-	37000	82000	150000	22400	29850	37300
Chromium	µg/L	-	-	1	0.50	0.50	0.51	**2.0**	**2.5**	**3.0**
Copper	µg/L	100	-	2	0.99	1.0	2.0	1.0	1.5	2.0
Iron	µg/L	-	-	300	120	190	**1400**	25	**3813**	**7600**
Lead	µg/L	80	-	1	0.25	0.25	0.25	0.25	0.43	0.60
Magnesium	µg/L	-	-	-	2200	8500	15000	2200	4600	7000
Manganese	µg/L	-	596	210	**250**	**500**	**1700**	42	**345**	**647**
Mercury	µg/L	-	-	0.026	0.0064	0.0065	0.0066	0.013	0.013	0.013
Molybdenum	µg/L	-	-	73	2.7	7.4	12	1.0	13	25
Nickel	µg/L	250	-	25	0.99	1.0	1.0	2.0	4.0	6.0
Phosphorus	µg/L	-	-	4	**50**	**50**	**51**	**50**	**625**	**1200**
Potassium	µg/L	-	-	-	340	720	1300	792	800	808
Selenium	µg/L	-	-	1	0.50	0.50	0.51	0.50	0.50	0.51
Silver	µg/L	-	-	0.25	0.050	0.050	0.051	0.050	0.050	0.051
Sodium	µg/L	-	-	-	3800	54000	110000	8400	11500	14600
Thallium	µg/L	-	-	0.8	0.050	0.050	0.051	0.050	0.050	0.051
Uranium	µg/L	-	33	15	0.86	0.92	1.3	0.40	0.85	1.3
Zinc	µg/L	400	11.3	2.2	**2.5**	**2.5**	**2.5**	**2.5**	**40**	**77**
Chloride	µg/L	-	640000	120000	4500	48000	92000	1980	2000	4000
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	25	25	25	25	25	25
Nitrite (as Nitrogen)	µg/L	-	-	60	5.0	5.0	5.1	25	25	25
Nitrate (as Nitrogen)	µg/L	-	550000	13000	25	25	25	25	25	25
Total Ammonia (as Nitrogen)	µg/L	-	-	689	25	330	**820**	40	315	620
Un-ionized Ammonia (as Nitrogen)	µg/L	500	16	16	0.15	2.6	5.3	0.18	0.40	2.0
Cyanide, Total	µg/L	500	-	-	9.9	10	10	9.9	10	10
Cyanide, WAD	µg/L	-	-	5	1.5	1.5	1.5	1.0	1.0	1.0
Sulphate	µg/L	-	-	-	3300	220000	460000	1000	5500	12000
Fluoride	µg/L	-	-	120	59	60	61	59	60	61
Radium-226	Bq/L	0.37	-	-	0.0050	0.0050	0.0051	0.0025	0.081	0.18
Temperature	°C	-	-	-	5.9	6.0	6.1	6.0	6.4	7.4
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	72	100	101	58	87	116
pH	pH Unit	6.0-9.5	-	6.5-9.0	7.7	7.7	7.8	**6.4**	7.2	8.1
Hardness (as $CaCO_3$)	mg/L	-	-	-	100	240	450	27	83	122
Dissolved Organic Carbon	mg/L	-	-	-	0.99	1.0	1.0	0.99	1.0	1.0

Notes: See Table C-1 notes for details on the parameters and guidelines.

Table C-4: Input leaching rates and pH values from humidity cells

Sample	**Units**	**M QE-POR**	**M QE-POR**	**M QE-POR**	**M QE-POR**	**M QE-POR**	**M QE-POR**	**M CG**	**M CG**	**M CG**	**M CG**	**M CG**
Period		1st Month	1st Month	1st Month	Last Month	Last Month	Last Month	1st Month	1st Month	1st Month	Last Month	Last Month
Statictics		Min	Median	Max	Min	Median	Max	Min	Median	Max	Min	Median
Aluminum	mg/kg/week	0.072	0.076	0.092	0.035	0.055	0.070	0.061	0.072	0.11	0.034	0.035
Antimony	mg/kg/week	0.00041	0.00042	0.00043	0.00042	0.00043	0.00043	0.00039	0.00040	0.00046	0.00042	0.00042
Arsenic	mg/kg/week	0.00019	0.00028	0.00036	0.000093	0.000095	0.00010	0.00045	0.00051	0.00061	0.000093	0.00028
Barium	mg/kg/week	0.0012	0.0013	0.0014	0.00024	0.0011	0.0012	0.00057	0.00071	0.0011	0.00024	0.00027
Boron	mg/kg/week	0.00093	0.00095	0.0027	0.00093	0.00095	0.00095	0.00089	0.0010	0.0018	0.00092	0.00093
Cadmium	mg/kg/week	0.0000014	0.0000014	0.0000014	0.0000014	0.0000028	0.0000047	0.0000013	0.0000013	0.0000015	0.0000014	0.0000014
Calcium	mg/kg/week	3.4	3.4	3.5	1.4	2.4	2.9	1.7	1.9	3.3	1.3	1.4
Chromium	mg/kg/week	0.000036	0.000037	0.000038	0.000038	0.00010	0.00015	0.000036	0.000041	0.000079	0.000037	0.00014
Copper	mg/kg/week	0.00072	0.0010	0.0010	0.00010	0.00085	0.00093	0.00098	0.0012	0.0015	0.00074	0.00093
Iron	mg/kg/week	0.0033	0.0081	0.0095	0.0032	0.0033	0.0033	0.0031	0.0092	0.013	0.0032	0.0032
Lead	mg/kg/week	0.0000047	0.000018	0.000028	0.0000046	0.0000048	0.000076	0.0000045	0.000026	0.000031	0.0000046	0.0000046
Magnesium	mg/kg/week	0.22	0.27	0.32	0.14	0.16	0.33	0.34	0.40	0.65	0.28	0.33
Manganese	mg/kg/week	0.015	0.017	0.020	0.0082	0.013	0.016	0.0092	0.010	0.022	0.0081	0.0082
Mercury	mg/kg/week	0.0000045	0.0000047	0.0000047	0.0000046	0.0000047	0.0000095	0.0000044	0.0000045	0.0000051	0.0000046	0.0000046
Molybdenum	mg/kg/week	0.00042	0.00046	0.00051	0.000057	0.00028	0.00086	0.00038	0.00053	0.00077	0.000019	0.00010
Nickel	mg/kg/week	0.000045	0.000047	0.000047	0.000046	0.000047	0.000048	0.000044	0.000051	0.00018	0.000046	0.000046
Phosphorus	mg/kg/week	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0013	0.0015	0.0035	0.0014	0.0014
Potassium	mg/kg/week	0.42	0.67	0.70	0.10	0.12	0.16	0.94	1.3	2.0	0.16	0.16
Selenium	mg/kg/week	0.000019	0.000045	0.000057	0.000019	0.000019	0.000019	0.000018	0.000061	0.000079	0.000018	0.000019
Silver	mg/kg/week	0.000023	0.000023	0.000024	0.000023	0.000024	0.000024	0.000022	0.000022	0.000025	0.000023	0.000023
Sodium	mg/kg/week	0.43	2.0	2.3	0.057	0.065	0.076	0.72	2.7	3.4	0.055	0.065
Thallium	mg/kg/week	0.0000023	0.0000023	0.0000024	0.0000024	0.0000024	0.0000046	0.0000022	0.0000022	0.0000025	0.0000023	0.0000023
Uranium	mg/kg/week	0.00011	0.00044	0.00058	0.000063	0.000075	0.00036	0.00093	0.0015	0.0016	0.00018	0.00023
Zinc	mg/kg/week	0.00090	0.00093	0.00095	0.00093	0.00095	0.00095	0.00088	0.00089	0.0010	0.00092	0.00093
Chloride	mg/kg/week	*0.000045*	*0.000050*	*0.000055*	*0.000045*	*0.000050*	*0.000055*	*0.000045*	*0.000050*	*0.000055*	*0.000045*	*0.000050*
Nitrate + Nitrite (as Nitrogen)	mg/kg/week	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*
Nitrite (as Nitrogen)	mg/kg/week	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000050*	*0.0000055*
Nitrate (as Nitrogen)	mg/kg/week	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*
Total Ammonia (as Nitrogen)	mg/kg/week	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*
Un-ionized Ammonia (as Nitrogen)	mg/kg/week	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*
Cyanide, Total	mg/kg/week	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000050*	*0.0000055*
Cyanide, WAD	mg/kg/week	*0.00000050*	*0.00000055*	*0.00000061*	*0.00000050*	*0.00000055*	*0.00000061*	*0.00000050*	*0.00000055*	*0.00000061*	*0.00000050*	*0.00000055*
Sulphate	mg/kg/week	0.47	1.7	1.8	0.093	0.19	0.28	0.089	0.35	0.51	0.092	0.093
Fluoride	mg/kg/week	0.027	0.028	0.028	0.028	0.028	0.029	0.026	0.027	0.031	0.028	0.028
Radium-226	Bq/kg/week	*0.0000023*	*0.0000025*	*0.0000028*	*0.0000023*	*0.0000025*	*0.0000028*	*0.0000023*	*0.0000025*	*0.0000028*	*0.0000023*	*0.0000025*
Temperature	°C	*18*	*20*	*22*	*18*	*20*	*22*	*18*	*20*	*22*	*18*	*20*
Total Alkalinity (as $CaCO_3$)	mg/kg/week	10	12	13	6.5	6.6	8.6	8.9	11	20	6.5	7.4
pH	pH Unit	7.4	8.2	8.3	7.1	7.3	7.6	7.6	8.0	8.3	7.1	7.3
Hardness (as $CaCO_3$)	mg/kg/week	*0.00045*	*0.00050*	*0.00055*	*0.00045*	*0.00050*	*0.00055*	*0.00045*	*0.00050*	*0.00055*	*0.00045*	*0.00050*
Dissolved Organic Carbon	mg/kg/week	*0.00045*	*0.00050*	*0.00055*	*0.00045*	*0.00050*	*0.00055*	*0.00045*	*0.00050*	*0.00055*	*0.00045*	*0.00050*

Notes:

Values of the parameters shown in Italics and shaded are the respective detection limits conservatively used for modeling when laboratory measured values were not available.

Temperature and pH are shown for information; no calculations are applied for these parameters.

MLGO Met/ M-LGO CNP DPL ratio values below 1 are shown as zeros.

Table C-4: Input leaching rates and pH values from humidity cells

Sample	**Units**	**M CG**	**M MD**	**M MD**	**M MD**	**M MD**	**M MD**	**M MD**	**M QZ-QE-POR-QTP-MIN**	**M QZ-QE-POR-QTP-MIN**	**M QZ-QE-POR-QTP-MIN**	**M QZ-QE-POR-QTP-MIN**
Period		Last Month	1st Month	1st Month	1st Month	Last Month	Last Month	Last Month	1st Month	1st Month	1st Month	Last Month
Statictics		Max	Min	Median	Max	Min	Median	Max	Min	Median	Max	Min
Aluminum	mg/kg/week	0.042	0.062	0.062	0.066	0.062	0.062	0.066	0.061	0.072	0.079	0.041
Antimony	mg/kg/week	0.00042	0.00041	0.00042	0.00043	0.00041	0.00042	0.00043	0.00040	0.00041	0.00043	0.00042
Arsenic	mg/kg/week	0.00037	0.000090	0.000093	0.00010	0.00009	0.000093	0.00010	0.00029	0.00036	0.00037	0.000094
Barium	mg/kg/week	0.00030	0.0051	0.0051	0.0098	0.0051	0.0051	0.0098	0.00073	0.00089	0.0011	0.00054
Boron	mg/kg/week	0.00093	0.00090	0.00093	0.00095	0.00090	0.00093	0.00095	0.00092	0.00096	0.0036	0.00094
Cadmium	mg/kg/week	0.0000028	0.0000014	0.0000014	0.0000014	0.0000014	0.0000014	0.0000014	0.0000013	0.0000014	0.0000014	0.0000014
Calcium	mg/kg/week	1.8	7.8	13	22	7.8	13	22	2.8	2.8	3.9	2.0
Chromium	mg/kg/week	0.00015	0.000036	0.000037	0.000038	0.000036	0.000037	0.000038	0.000036	0.000037	0.000038	0.000038
Copper	mg/kg/week	0.0010	0.00028	0.00045	0.00067	0.00028	0.00045	0.00067	0.00062	0.00096	0.0010	0.00067
Iron	mg/kg/week	0.0032	0.0032	0.0033	0.0033	0.0032	0.0033	0.0033	0.0032	0.0071	0.0096	0.0033
Lead	mg/kg/week	0.0000092	0.0000047	0.0000090	0.000038	0.000005	0.0000090	0.000038	0.0000046	0.000018	0.000019	0.0000047
Magnesium	mg/kg/week	0.35	0.57	1.4	1.6	0.57	1.4	1.6	0.15	0.18	0.19	0.092
Manganese	mg/kg/week	0.011	0.019	0.022	0.025	0.019	0.022	0.025	0.015	0.016	0.020	0.011
Mercury	mg/kg/week	0.0000092	0.0000045	0.0000047	0.0000048	0.0000045	0.0000047	0.0000048	0.0000045	0.0000046	0.0000048	0.0000047
Molybdenum	mg/kg/week	0.00086	0.00026	0.00048	0.00068	0.00026	0.00048	0.00068	0.00023	0.00037	0.00073	0.00011
Nickel	mg/kg/week	0.000046	0.000045	0.000047	0.000048	0.000045	0.000047	0.000048	0.000045	0.000048	0.000092	0.000047
Phosphorus	mg/kg/week	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0013	0.0014	0.0014	0.0014
Potassium	mg/kg/week	0.21	0.23	0.46	0.59	0.23	0.46	0.59	0.35	0.49	0.55	0.10
Selenium	mg/kg/week	0.000019	0.000018	0.000047	0.000076	0.000018	0.000047	0.000076	0.000018	0.000018	0.000058	0.000019
Silver	mg/kg/week	0.000023	0.000023	0.000023	0.000024	0.000023	0.000023	0.000024	0.000022	0.000023	0.000024	0.000024
Sodium	mg/kg/week	0.065	0.29	1.5	1.7	0.29	1.5	1.7	0.53	2.1	2.4	0.075
Thallium	mg/kg/week	0.0000046	0.0000023	0.0000023	0.0000024	0.0000023	0.0000023	0.0000024	0.0000022	0.0000023	0.0000024	0.0000024
Uranium	mg/kg/week	0.00033	0.000090	0.00011	0.00013	0.00009	0.00011	0.00013	0.00018	0.00022	0.00027	0.000053
Zinc	mg/kg/week	0.00093	0.00090	0.00093	0.00095	0.00090	0.00093	0.00095	0.00089	0.00092	0.00096	0.00094
Chloride	mg/kg/week	*0.000055*	*0.000045*	*0.000050*	*0.000055*	*0.000045*	*0.000050*	*0.000055*	*0.000045*	*0.000050*	*0.000055*	*0.000045*
Nitrate + Nitrite (as Nitrogen)	mg/kg/week	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*
Nitrite (as Nitrogen)	mg/kg/week	*0.0000061*	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000050*
Nitrate (as Nitrogen)	mg/kg/week	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*
Total Ammonia (as Nitrogen)	mg/kg/week	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*
Un-ionized Ammonia (as Nitrogen)	mg/kg/week	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*
Cyanide, Total	mg/kg/week	*0.0000061*	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000050*
Cyanide, WAD	mg/kg/week	*0.00000061*	*0.00000050*	*0.00000055*	*0.00000061*	*0.00000050*	*0.00000055*	*0.00000061*	*0.00000050*	*0.00000055*	*0.00000061*	*0.00000050*
Sulphate	mg/kg/week	0.093	10	27	47	10.24	27	47	0.37	1.1	1.2	0.19
Fluoride	mg/kg/week	0.028	0.027	0.028	0.029	0.027	0.028	0.029	0.027	0.028	0.029	0.028
Radium-226	Bq/kg/week	*0.0000028*	*0.0000023*	*0.0000025*	*0.0000028*	*0.0000023*	*0.0000025*	*0.0000028*	*0.0000023*	*0.0000025*	*0.0000028*	*0.0000023*
Temperature	°C	*22*	*18*	*20*	*22*	*18*	*20*	*22*	*18*	*20*	*22*	*18*
Total Alkalinity (as CaCO$_3$)	mg/kg/week	8.3	9.3	10	11	9	10	11	8.3	11	12	6.6
pH	pH Unit	7.5	7.1	7.3	7.7	7.1	7.3	7.7	7.3	8.0	8.4	7.2
Hardness (as CaCO$_3$)	mg/kg/week	*0.00055*	*0.00045*	*0.00050*	*0.00055*	*0.00045*	*0.00050*	*0.00055*	*0.00045*	*0.00050*	*0.00055*	*0.00045*
Dissolved Organic Carbon	mg/kg/week	*0.00055*	*0.00045*	*0.00050*	*0.00055*	*0.00045*	*0.00050*	*0.00055*	*0.00045*	*0.00050*	*0.00055*	*0.00045*

Notes:

Values of the parameters shown in Italics and shaded are the respective detection limits conservatively used for modeling when laboratory measured values were not available.

Temperature and pH are shown for information; no calculations are applied for these parameters.

MLGO Met/ M-LGO CNP DPL ratio values below 1 are shown as zeros.

Table C-4: Input leaching rates and pH values from humidity cells

Sample	**Units**	**M QZ-QE-POR-QTP-MIN**	**M QZ-QE-POR-QTP-MIN**	**MLGO Met**	**MLGO Met**	**MLGO Met**	**MLGO Met**	**MLGO Met**	**MLGO Met**	**M-LGO CNP DPL**	**MLGO Met/ M-LGO CNP DPL**
Period		Last Month	Last Month	1st Month	1st Month	1st Month	Last Month	Last Month	Last Month	1st Month	PAG multiplier
Statictics		Median	Max	Min	Median	Max	Min	Median	Max	Median	
Aluminum	mg/kg/week	0.043	0.043	0.099	0.10	0.11	0.061	0.065	0.070	0.021	0
Antimony	mg/kg/week	0.00043	0.00043	0.00041	0.00042	0.0012	0.00042	0.00042	0.00043	0.00040	0
Arsenic	mg/kg/week	0.00010	0.00010	0.00036	0.00037	0.00057	0.00019	0.00019	0.00019	0.000089	0
Barium	mg/kg/week	0.00056	0.00056	0.0012	0.0022	0.0031	0.0014	0.0015	0.0015	0.00022	0
Boron	mg/kg/week	0.00095	0.00095	0.0028	0.0073	0.011	0.0019	0.0024	0.0028	0.0021	0
Cadmium	mg/kg/week	0.0000038	0.0000038	0.0000014	0.0000075	0.0000096	0.0000014	0.0000014	0.0000014	0.000014	1.8
Calcium	mg/kg/week	2.2	2.4	4.0	4.6	6.8	2.9	3.1	3.3	1.0	0
Chromium	mg/kg/week	0.000094	0.00010	0.000037	0.000082	0.00014	0.000037	0.000038	0.000038	0.000036	0
Copper	mg/kg/week	0.0012	0.0016	0.00027	0.00038	0.00065	0.000094	0.000094	0.000095	0.00045	1.2
Iron	mg/kg/week	0.0033	0.0033	0.0032	0.0033	0.0077	0.0033	0.0033	0.0033	0.012	3.6
Lead	mg/kg/week	0.0000048	0.0000048	0.0000045	0.0000093	0.000057	0.0000047	0.000017	0.000028	0.000015	1.6
Magnesium	mg/kg/week	0.10	0.11	0.35	0.45	0.88	0.18	0.20	0.22	0.12	0
Manganese	mg/kg/week	0.011	0.013	0.012	0.022	0.026	0.024	0.025	0.026	0.022	1.0
Mercury	mg/kg/week	0.0000048	0.0000048	0.0000045	0.0000047	0.0000048	0.0000046	0.0000047	0.0000047	0.0000065	1.4
Molybdenum	mg/kg/week	0.00012	0.00025	0.0021	0.0021	0.0077	0.00072	0.00076	0.00080	0.00013	0
Nickel	mg/kg/week	0.000048	0.000048	0.000045	0.000047	0.00057	0.000047	0.000047	0.000047	0.00035	7.5
Phosphorus	mg/kg/week	0.0014	0.0014	0.0014	0.0064	0.015	0.0014	0.0035	0.0057	0.0013	0
Potassium	mg/kg/week	0.11	0.13	0.37	0.70	1.0	0.12	0.13	0.14	0.071	0
Selenium	mg/kg/week	0.000019	0.000019	0.000075	0.00021	0.00034	0.000019	0.000019	0.000019	0.000030	0
Silver	mg/kg/week	0.000024	0.000024	0.000023	0.000023	0.000024	0.000023	0.000024	0.000024	0.000022	0
Sodium	mg/kg/week	0.076	0.086	0.81	3.5	5.2	0.13	0.16	0.20	1.2	0
Thallium	mg/kg/week	0.0000024	0.0000057	0.0000023	0.0000023	0.000024	0.0000023	0.0000024	0.0000024	0.0000022	0
Uranium	mg/kg/week	0.00012	0.00049	0.00011	0.00054	0.0028	0.000078	0.00011	0.00015	0.000012	0
Zinc	mg/kg/week	0.00095	0.00095	0.00091	0.00093	0.00096	0.00094	0.0014	0.0019	0.011	11.9
Chloride	mg/kg/week	*0.000050*	*0.000055*	*0.000045*	*0.000050*	*0.000055*	*0.000045*	*0.000050*	*0.000055*	*0.000050*	0
Nitrate + Nitrite (as Nitrogen)	mg/kg/week	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000028*	0
Nitrite (as Nitrogen)	mg/kg/week	*0.0000055*	*0.0000061*	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000055*	0
Nitrate (as Nitrogen)	mg/kg/week	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000028*	0
Total Ammonia (as Nitrogen)	mg/kg/week	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000028*	0
Un-ionized Ammonia (as Nitrogen)	mg/kg/week	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000025*	*0.000028*	*0.000030*	*0.000028*	0
Cyanide, Total	mg/kg/week	*0.0000055*	*0.0000061*	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000050*	*0.0000055*	*0.0000061*	*0.0000055*	0
Cyanide, WAD	mg/kg/week	*0.00000055*	*0.00000061*	*0.00000050*	*0.00000055*	*0.00000061*	*0.00000050*	*0.00000055*	*0.00000061*	*0.00000055*	0
Sulphate	mg/kg/week	0.29	0.29	3.2	5.5	11	0.66	0.71	0.75	6.1	1.1
Fluoride	mg/kg/week	0.029	0.029	0.027	0.028	0.057	0.028	0.028	0.028	0.027	0
Radium-226	Bq/kg/week	*0.0000025*	*0.0000028*	*0.0000023*	*0.0000025*	*0.0000028*	*0.0000023*	*0.0000025*	*0.0000028*	*0.0000025*	0
Temperature	°C	*20*	*22*	*18*	*20*	*22*	*18*	*20*	*22*	*20*	0
Total Alkalinity (as $CaCO_3$)	mg/kg/week	6.7	12	14	19	21	8.4	10	10	0.89	0
pH	pH Unit	7.2	7.5	7.9	8.1	8.1	7.6	7.7	7.7	4.4	0
Hardness (as $CaCO_3$*)*	mg/kg/week	*0.00050*	*0.00055*	*0.00045*	*0.00050*	*0.00055*	*0.00045*	*0.00050*	*0.00055*	*0.00045*	0
Dissolved Organic Carbon	mg/kg/week	*0.00050*	*0.00055*	*0.00045*	*0.00050*	*0.00055*	*0.00045*	*0.00050*	*0.00055*	*0.00045*	0

Notes:

Values of the parameters shown in Italics and shaded are the respective detection limits conservatively used for modeling when laboratory measured values were not available.

Temperature and pH are shown for information; no calculations are applied for these parameters.

MLGO Met/ M-LGO CNP DPL ratio values below 1 are shown as zeros.

Table C-5: Marathon mine mass inputs

Mine Year End	Model year End	HGO mine rate	LGO mine rate	Waste rock mine rate	LGO stockpile balance	Waste rock storage balance
Unit	Year	ktonnes/yr	ktonnes/yr	ktonnes/yr	ktonnes	ktonnes
Y-1	1	362	342	3697	342	235
Y1	2	1950	1717	15305	2060	15481
Y2	3	1870	1240	21156	3300	36706
Y3	4	1833	1732	26395	5032	61395
Y4	5	1798	1337	22551	6369	82062
Y5	6	1457	251	21806	6621	101946
Y6	7	909	186	19777	6059	120192
Y7	8	2224	736	18189	6795	137545
Y8	9	2571	614	6558	7409	142758
Y9	10	2321	0	1829	6874	144737
Y10	11	0	0	0	4374	144737
Y11	12	0	0	0	1874	144737
Y12	13	0	0	0	0	144737
Y13	14	0	0	0	0	144737
Y14	15	0	0	0	0	144737
Y15	500	0	0	0	0	144737

Notes:

HGO - High-Grade Ore

LGO - Low-Grade Ore

TMF - Tailings Management Facility

Table C-6: SFE as input of runoff from waste rock, ore and overburden piles.

Parameter	**Units**	MDMER	CWQG	**CWQG**	M AQPOR	M CG	M MD	M QE-POR	M QZ-QE-POR-QTP-MIN	**MLGO Comp**	**Marathon OB**			
Statistics			Short-term	Long-term	11-Mar-20	11-Mar-20	11-Mar-20	11-Mar-20	11-Mar-20	07-May-20	Min	Mean	Max	St. Dev.
Aluminum	µg/L	-	-	100	**912**	**807**	**624**	**1140**	**1160**	**1300**	55	**150**	**274**	75
Antimony	µg/L	-	-	-	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.84	2.5	0.62
Arsenic	µg/L	100	-	5	0.60	2.4	0.40	0.70	0.50	1.5	2.9	**11**	**33**	10
Barium	µg/L	-	-	-	2.2	1.1	68	2.1	1.1	2.3	2.1	5.0	8.3	1.9
Boron	µg/L	-	29000	1500	8.0	8.0	2.0	7.0	12	19	3.0	4.4	7.0	1.3
Cadmium	µg/L	-	0.13	0.04	0.0030	0.0015	0.0030	0.0015	0.0015	0.0015	0.0015	0.027	**0.12**	0.035
Calcium	µg/L	-	-	-	8640	6250	8860	6050	5760	8410	110	7267	16800	6713
Chromium	µg/L	-	-	1	0.040	0.040	0.040	0.15	0.10	0.040	0.040	0.25	0.59	0.15
Copper	µg/L	100	-	2	0.30	0.30	0.20	0.10	0.30	1.8	1.3	**3.7**	**15**	4.1
Iron	µg/L	-	-	300	3.5	3.5	3.5	3.5	3.5	3.5	43	272	**598**	175
Lead	µg/L	80	-	1	0.030	0.020	0.010	0.010	0.060	0.11	0.040	0.30	**1.1**	0.30
Magnesium	µg/L	-	-	-	504	1320	1650	471	291	717	57	686	1650	606
Manganese	µg/L	-	596	210	1.8	2.0	5.9	1.1	1.4	2.9	4.7	68	**223**	75
Mercury	µg/L	-	-	0.026	0.0050	0.0050	0.0050	0.0050	0.0050	0.010	0.0050	0.0055	0.010	0.0015
Molybdenum	µg/L	-	-	73	0.90	0.12	0.14	0.19	0.22	1.2	0.21	2.9	7.5	2.6
Nickel	µg/L	250	-	25	0.20	0.20	0.20	0.20	0.30	0.050	0.20	0.59	0.90	0.20
Phosphorus	µg/L	-	-	4	**100**	**100**	**100**	**100**	**100**	**100**	**99**	**100**	**100**	0.17
Potassium	µg/L	-	-	-	1120	3440	173	1150	664	2340	347	1766	3600	1192
Selenium	µg/L	-	-	1	0.20	0.070	0.050	0.070	0.060	0.11	0.020	0.50	**1.4**	0.46
Silver	µg/L	-	-	0.25	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	3E-18
Sodium	µg/L	-	-	-	8780	6310	4140	6970	7550	6220	1400	2055	3320	532
Thallium	µg/L	-	-	0.8	0.0025	0.0025	0.0025	0.0025	0.0025	0.032	0.006	0.022	0.025	0.0067
Uranium	µg/L	-	33	15	0.23	0.56	0.43	1.9	0.19	0.36	0.023	0.44	1.8	0.65
Zinc	µg/L	400	11.3	2.2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.8	**6.0**	1.5
Chloride	µg/L	-	640000	120000	1000	1000	1000	1000	1000	1000	990	1000	1000	1.7
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	50	50	50	50	50	50	50	50	50	0.083
Nitrite (as Nitrogen)	µg/L	-	-	60	10	10	10	10	10	10	9.9	10	10	0.017
Nitrate (as Nitrogen)	µg/L	-	550000	13000	50	50	50	50	50	50	50	50	50	0.083
Total Ammonia (as Nitrogen)	µg/L	-	-	689	50	50	50	50	50	50	50	50	50	0.083
Un-ionized Ammonia (as Nitrogen)	µg/L	500	16	16	**19**	**23**	**17**	**26**	**27**	**19**	0.31	3.8	12	4.3
Cyanide, Total	µg/L	500	-	-	10	10	10	10	10	10	9.9	10	10	0.017
Cyanide, WAD	µg/L	-	-	5	1.0	1.0	1.0	1.0	1.0	1.0	0.99	1.0	1.0	0.0017
Sulphate	µg/L	-	-	-	2000	1000	3000	1000	1000	1000	1000	3600	14000	3800
Fluoride	µg/L	-	-	120	80	80	80	60	30	70	60	**128**	**190**	37
Radium-226	Bg/L	0.37	-	-	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	7E-18
Temperature	°C	-	-	-	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	1E-17
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	37	42	36	32	32	32	4000	22900	51000	18892
pH	pH Unit	6.0-9.5	-	6.5-9.0	**9.2**	**9.4**	**9.2**	9.5	**9.5**	**9.2**	7.2	8.0	9.0	0.64
Hardness (as $CaCO_3$)	mg/L	-	-	-	1.0	1.0	1.0	1.0	1.0	1.0	0.99	1.0	1.0	0.0017
Dissolved Organic Carbon	mg/L	-	-	-	1.0	1.0	1.0	1.0	1.0	1.0	0.99	1.0	1.0	0.0017

Notes: See Table C-1 notes for details on the parameters and guidelines.

Table C-7: Total element concentrations in waste rock and ore (ppm).

Parameter	M QE-POR and M QE-POR-BX	M CG	M GB	M LGO	M Ore
Statistics	Mean	Mean	Mean	Mean	Max
Aluminum	9000	7119	9358	6533	5308
Antimony	0.39	0.51	1.60	0.29	0.32
Arsenic	0.87	2.0	44	1.1	1.1
Barium	143	260	27	85	35
Boron	0.010	0.010	0.010	0.010	0.010
Cadmium	0.027	0.069	0.13	0.15	0.024
Calcium	7.0	14	82	3.1	2.5
Chromium	75	53	130	83	92
Copper	11	31	506	27	14
Iron	16551	15193	5693	11976	12877
Lead	1.5	4.9	1.1	2.6	6.0
Magnesium	4628	6750	4635	2428	1679
Manganese	537	962	997	401	297
Mercury	0.025	0.025	0.010	0.025	0.025
Molybdenum	1.4	0.43	0.21	3.7	11
Nickel	6.0	20	99	2.5	3.0
Phosphorus	28	59	3.4	7.7	6.3
Potassium	393	1123	36	599	311
Selenium	0.42	0.42	1.9	0.41	0.40
Silver	0.029	0.058	0.11	0.12	0.21
Sodium	2692	2023	918	3783	3840
Thallium	0.10	0.12	0.25	0.10	0.090
Uranium	0.21	0.75	0.050	0.22	0.13
Zinc	21	49	37	12	10
Chloride	0.010	0.010	0.010	0.010	0.010
Nitrate + Nitrite (as Nitrogen)	0.010	0.010	0.010	0.010	0.010
Nitrite (as Nitrogen)	0.010	0.010	0.010	0.010	0.010
Nitrate (as Nitrogen)	0.010	0.010	0.010	0.010	0.010
Total Ammonia (as Nitrogen)	0.010	0.010	0.010	0.010	0.010
Un-ionized Ammonia (as Nitrogen)	0.010	0.010	0.010	0.010	0.010
Cyanide, Total	0.010	0.010	0.010	0.010	0.010
Cyanide, WAD	0.010	0.010	0.010	0.010	0.010
Sulphate	0.010	0.010	0.010	0.010	0.010
Fluoride	0.010	0.010	0.010	0.010	0.010
Radium-226	0.010	0.010	0.010	0.010	0.010
Temperature	0.010	0.010	0.010	0.010	0.010
Total Alkalinity (as $CaCO_3$)	0.010	0.010	0.010	0.010	0.010
pH	0.010	0.010	0.010	0.010	0.010
Hardness (as $CaCO_3$)	0.010	0.010	0.010	0.010	0.010
Dissolved Organic Carbon	0.010	0.010	0.010	0.010	0.010

Appendix D SUMMARIES OF WATER QUALITY PREDICTIONS

Table D-1: Baseline water quality in the area of the open pit and waste rock

Parameter	Units	MDMER	CWQG	**CWQG**	Baseline		
Statistics			Short-term	Long-term	mean	75 %ile	95 %ile (5 %ile for pH)
Aluminum	µg/L	-	-	100	16	19	22
Antimony	µg/L	-	-	-	0.50	0.50	0.50
Arsenic	µg/L	100	-	5	0.5	0.5	0.5
Barium	µg/L	-	-	-	2.3	2.6	3.0
Boron	µg/L	-	29000	1500	25	25	25
Cadmium	µg/L	-	0.13	0.04	0.0050	0.005	0.005
Calcium	µg/L	-	-	-	2800	2900	2900
Chromium	µg/L	-	-	1	**1.1**	**1.5**	**1.9**
Copper	µg/L	100	-	2	0.61	0.77	0.9
Iron	µg/L	-	-	300	25	25	25
Lead	µg/L	80	-	1	0.25	0.25	0.25
Magnesium	µg/L	-	-	-	340	340	350
Manganese	µg/L	-	596	210	5.5	6.4	6.8
Mercury	µg/L	-	-	0.026	0.007	0.007	0.007
Molybdenum	µg/L	-	-	73	1.0	1.0	1.0
Nickel	µg/L	250	-	25	1.0	1.0	1.0
Phosphorus	µg/L	-	-	4	**50**	**50**	**50**
Potassium	µg/L	-	-	-	95	110	130
Selenium	µg/L	-	-	1	0.25	0.25	0.25
Silver	µg/L	-	-	0.25	0.050	0.050	0.050
Sodium	µg/L	-	-	-	1400	1400	1500
Thallium	µg/L	-	-	0.8	0.050	0.050	0.050
Uranium	µg/L	-	33	15	0.050	0.05	0.05
Zinc	µg/L	400	11.3	2.2	**2.5**	**2.5**	**2.5**
Chloride	µg/L	-	640000	120000	2400	2500	2600
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	38	44	53
Nitrite (as Nitrogen)	µg/L	-	-	60	9.9	12.0	14
Nitrate (as Nitrogen)	µg/L	-	550000	13000	25	25	25
Total Ammonia (as Nitrogen)	µg/L	-	-	689	25	25	25
Un-ionized Ammonia (as Nitrogen)	µg/L	500	16	16	0.06	0.08	0.10
Cyanide, Total	µg/L	500	-	-	10	10	10
Cyanide, WAD	µg/L	-	-	5	1.0	1.0	1.0
Sulphate	µg/L	-	-	-	1000	1000	1000
Fluoride	µg/L	-	-	120	60	60	60
Radium-226	Bg/L	0.37	-	-	0.0050	0.0050	0.0050
Temperature	°C	-	-	-	12	15	17
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	8.8	9.3	9.7
pH	pH Unit	6.0-9.5	-	6.5-9.0	7.0	7.0	6.9
Hardness (as $CaCO_3$)	mg/L	-	-	-	8.4	8.6	8.7
Dissolved Organic Carbon	mg/L	-	-	-	1.0	1.0	1.0

Notes: See Table C-1 notes for details on the parameters and guidelines.

Table D-2: The highest value of the monthly mean and 95th %-ile for each project phase in waste rock seepage

Parameter	Units	MDMER	CWQG	**CWQG**	Baseline		Construction		Operation		Closure		Post-closure	
Statistics			Short-term	Long-term	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile
Aluminum	µg/L	-	-	100	16	22	20	21	**600**	**600**	**600**	**600**	**600**	**600**
Antimony	µg/L	-	-	-	0.50	0.50	0.52	0.53	34	39	30	35	17	20
Arsenic	µg/L	100	-	5	0.50	0.50	0.52	0.52	**24**	**28**	**10**	**12**	**5.6**	**6.6**
Barium	µg/L	-	-	-	2.3	3.0	2.4	2.9	120	140	80	93	46	54
Boron	µg/L	-	29000	1500	25	25	25	25	130	150	93	100	63	70
Cadmium	µg/L	-	0.13	0.04	0.0050	0.0050	0.0051	0.0051	**0.23**	**0.27**	**0.22**	**0.26**	**0.14**	**0.17**
Calcium	µg/L	-	-	-	2800	2900	3000	3100	290000	340000	200000	240000	110000	140000
Chromium	µg/L	-	-	1	**1.1**	**1.9**	**1.2**	**1.8**	**7.8**	**9.2**	**7.4**	**8.6**	**4.8**	**5.5**
Copper	µg/L	100	-	2	0.61	0.90	0.66	0.89	**74**	**88**	**54**	**60**	**32**	**38**
Iron	µg/L	-	-	300	25	25	25	25	**570**	**680**	**350**	**420**	230	270
Lead	µg/L	80	-	1	0.25	0.25	0.25	0.25	**2.2**	**2.8**	**2.1**	**2.7**	**1.4**	**1.8**
Magnesium	µg/L	-	-	-	340	350	350	360	28000	33000	21000	24000	12000	14000
Manganese	µg/L	-	596	210	5.5	6.8	6.3	6.9	**1300**	**1300**	**980**	**1100**	**580**	**690**
Mercury	µg/L	-	-	0.026	0.0065	0.0065	0.0067	0.0068	**0.52**	**0.61**	**0.48**	**0.55**	**0.30**	**0.36**
Molybdenum	µg/L	-	-	73	1.0	1.0	1.0	1.0	38	44	28	34	17	20
Nickel	µg/L	250	-	25	1.0	1.0	1.0	1.0	6.8	8.8	6.7	8.5	5.0	5.9
Phosphorus	µg/L	-	-	4	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**
Potassium	µg/L	-	-	-	95	130	130	140	56000	67000	14000	17000	6600	7800
Selenium	µg/L	-	-	1	0.25	0.25	0.25	0.25	**3.5**	**4.1**	**1.8**	**2.0**	**1.1**	**1.2**
Silver	µg/L	-	-	0.25	0.050	0.050	0.051	0.052	**1.9**	**2.2**	**1.7**	**1.9**	**1.0**	**1.2**
Sodium	µg/L	-	-	-	1400	1500	1500	1500	130000	160000	19000	24000	7400	9200
Thallium	µg/L	-	-	0.8	0.050	0.050	0.050	0.050	0.28	0.32	0.26	0.30	0.17	0.20
Uranium	µg/L	-	33	15	0.050	0.050	0.081	0.089	**42**	**52**	14	**17**	7.5	8.8
Zinc	µg/L	400	11.3	2.2	**2.5**	**2.5**	**2.5**	**2.6**	**140**	**200**	**140**	**200**	**110**	**130**
Chloride	µg/L	-	640000	120000	2400	2600	2400	2600	2400	2600	2400	2600	2400	2600
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	38	53	5900	15000	23000	30000	470	910	83	160
Nitrite (as Nitrogen)	µg/L	-	-	60	9.9	14	**140**	**340**	**530**	**670**	19	29	11	14
Nitrate (as Nitrogen)	µg/L	-	550000	13000	25	25	5800	**15000**	**23000**	**29000**	450	880	71	150
Total Ammonia (as Nitrogen)	µg/L	-	-	689	25	25	**750**	**1900**	**2900**	**3700**	80	130	32	41
Un-ionized Ammonia (as Nitrogen)	µg/L	500	16	16	0.064	0.10	**29**	**72**	**110**	**140**	3.0	4.9	1.2	1.6
Cyanide, Total	µg/L	500	-	-	10	10	10	10	10	10	10	10	10	10
Cyanide, WAD	µg/L	-	-	5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Sulphate	µg/L	-	-	-	1000	1000	1100	1200	210000	260000	160000	190000	96000	120000
Fluoride	µg/L	-	-	120	60	60	61	62	**1600**	**1600**	**1600**	**1600**	**1600**	**1600**
Radium-226	Bg/L	0.37	-	-	0.0050	0.0050	0.0051	0.0052	0.2000	0.23	0.18	0.21	0.10	0.12
Temperature	°C	-	-	-	12	17	11	17	12	17	11	17	12	17
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	8.8	9.7	660	820	900000	1100000	540000	620000	300000	350000
pH (mean or 5 %ile)	pH Unit	6.0-9.5	-	6.5-9.0	7.0	6.9	7.9	7.7	8.0	7.7	7.3	7.2	7.3	7.2
Hardness (as $CaCO_3$)	mg/L	-	-	-	8.4	8.7	8.9	9.2	840	980	590	700	320	410
Dissolved Organic Carbon	mg/L	-	-	-	1.0	1.0	1.0	1.0	40	47	36	42	21	25

Notes: See Table C-1 notes for details on the parameters and guidelines.

Table D-3: The highest value of the monthly mean and 95th %-ile for each project phase in seepage from the low-grade ore stockpile

Parameter	Units	MDMER	CWQG	**CWQG**	Baseline		Construction		Operation		Closure		Post-closure	
Statistics			Short-term	Long-term	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile
Aluminum	µg/L	-	-	100	16	22	86	100	**600**	**600**	**600**	**600**	16	22
Antimony	µg/L	-	-	-	0.50	0.50	0.97	1.1	20	25	4.0	6.1	0.50	0.50
Arsenic	µg/L	100	-	5	0.50	0.50	0.80	0.87	**13**	**15**	2.7	4.0	0.50	0.50
Barium	µg/L	-	-	-	2.3	3.0	3.7	4.1	62	73	13	20	2.3	3.0
Boron	µg/L	-	29000	1500	25	25	30	31	220	270	58	81	25	25
Cadmium	µg/L	-	0.13	0.04	0.0050	0.0050	0.0093	0.011	**0.18**	**0.21**	**0.041**	**0.055**	0.0050	0.0050
Calcium	µg/L	-	-	-	2800	2900	6300	7200	150000	180000	29000	44000	2800	2900
Chromium	µg/L	-	-	1	**1.1**	**1.9**	**1.2**	**1.8**	**3.3**	**4.0**	**1.4**	**1.9**	**1.1**	**1.9**
Copper	µg/L	100	-	2	0.61	0.90	0.86	0.97	**13**	**15**	**2.9**	**4.1**	0.61	0.90
Iron	µg/L	-	-	300	25	25	28	29	180	270	68	92	25	25
Lead	µg/L	80	-	1	0.25	0.25	0.27	0.27	0.92	**1.1**	0.38	0.44	0.25	0.25
Magnesium	µg/L	-	-	-	340	350	720	800	16000	19000	3200	5000	340	350
Manganese	µg/L	-	596	210	5.5	6.8	19	23	**610**	**740**	160	210	5.5	6.8
Mercury	µg/L	-	-	0.026	0.0065	0.0065	0.010	0.010	**0.15**	**0.19**	**0.042**	**0.055**	0.0065	0.0065
Molybdenum	µg/L	-	-	73	1.0	1.0	3.7	4.5	**110**	**140**	21	33	1.0	1.0
Nickel	µg/L	250	-	25	1.0	1.0	1.2	1.2	7.9	10	2.7	3.4	1.0	1.0
Phosphorus	µg/L	-	-	4	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**
Potassium	µg/L	-	-	-	95	130	570	700	20000	24000	3700	5700	95	130
Selenium	µg/L	-	-	1	0.25	0.25	0.39	0.44	**6.1**	**7.4**	**1.3**	**1.9**	0.25	0.25
Silver	µg/L	-	-	0.25	0.050	0.050	0.066	0.070	**0.69**	**0.83**	0.16	0.24	0.050	0.050
Sodium	µg/L	-	-	-	1400	1500	3600	4300	91000	110000	18000	27000	1400	1500
Thallium	µg/L	-	-	0.8	0.050	0.050	0.056	0.059	0.310	0.40	0.092	0.12	0.050	0.050
Uranium	µg/L	-	33	15	0.050	0.050	0.86	1.2	**31**	**42**	6.1	10	0.050	0.050
Zinc	µg/L	400	11.3	2.2	**2.5**	**2.5**	**3.1**	**3.3**	**88**	**250**	**38**	**77**	**2.5**	**2.5**
Chloride	µg/L	-	640000	120000	2400	2600	2400	2600	2400	2600	2400	2600	2400	2600
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	38	53	4800	12000	12000	15000	89	160	38	53
Nitrite (as Nitrogen)	µg/L	-	-	60	9.9	14	**120**	**280**	**270**	**350**	10	14	9.9	14
Nitrate (as Nitrogen)	µg/L	-	550000	13000	25	25	4600	12000	11000	**15000**	78	150	25	25
Total Ammonia (as Nitrogen)	µg/L	-	-	689	25	25	610	**1500**	**1500**	**1900**	29	38	25	25
Un-ionized Ammonia (as Nitrogen)	µg/L	500	16	16	0.064	0.10	**23**	**57**	**57**	**72**	1.1	1.4	0.064	0.097
Cyanide, Total	µg/L	500	-	-	10	10	10	10	10	10	10	10	10	10
Cyanide, WAD	µg/L	-	-	5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Sulphate	µg/L	-	-	-	1000	1000	5400	6800	180000	220000	36000	56000	1000	1000
Fluoride	µg/L	-	-	120	60	60	85	93	**1100**	**1300**	**250**	**360**	60	60
Radium-226	Bg/L	0.37	-	-	0.0050	0.0050	0.0067	0.0071	0.074	0.088	0.017	0.025	0.0050	0.0050
Temperature	°C	-	-	-	12	17	9.2	17	9.3	18	9.1	18	12	17
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	8.8	9.7	12000	15000	510000	610000	94000	150000	8.8	9.7
pH (mean or 5 %ile)	pH Unit	6.0-9.5	-	6.5-9.0	7.0	6.9	8.0	8.0	8.0	8.0	7.7	7.6	7.0	6.9
Hardness (as $CaCO_3$)	mg/L	-	-	-	8.4	8.7	19	21	440	530	86	130	8.4	8.7
Dissolved Organic Carbon	mg/L	-	-	-	1.0	1.0	1.3	1.4	15	18	3.4	5.0	1.0	1.0

Notes: See Table C-1 notes for details on the parameters and guidelines.

Table D-4: The highest value of the monthly mean and 95th %-ile for each project phase in open pit discharge

Parameter	Units	MDMER	CWQG	**CWQG**	Baseline		Construction		Operation		Closure		Post-closure	
Statistics			Short-term	Long-term	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile
Aluminum	µg/L	-	-	100	16	22	20	29	**210**	**300**	100	**110**	**120**	**120**
Antimony	µg/L	-	-	-	0.50	0.50	0.50	0.50	3.8	4.7	1.0	1.1	0.71	0.77
Arsenic	µg/L	100	-	5	0.50	0.50	1.4	2.1	3.2	3.7	2.2	2.4	2.2	2.3
Barium	µg/L	-	-	-	2.3	3.0	5.2	7.6	17	22	4.0	4.5	4.4	4.7
Boron	µg/L	-	29000	1500	25	25	25	25	32	38	25	25	25	25
Cadmium	µg/L	-	0.13	0.04	0.0050	0.0050	0.010	0.015	0.025	0.030	0.017	0.019	0.015	0.016
Calcium	µg/L	-	-	-	2800	2900	68000	98000	75000	96000	14000	15000	22000	22000
Chromium	µg/L	-	-	1	**1.1**	**1.9**	**1.1**	**1.8**	**1.5**	**2.4**	**1.4**	**1.9**	**1.3**	**1.9**
Copper	µg/L	100	-	2	0.61	0.90	1.0	1.3	**6.5**	**7.8**	1.7	1.8	1.3	1.4
Iron	µg/L	-	-	300	25	25	**480**	**880**	**440**	**800**	210	230	**320**	**330**
Lead	µg/L	80	-	1	0.25	0.25	0.25	0.25	0.27	0.31	0.25	0.25	0.25	0.25
Magnesium	µg/L	-	-	-	340	350	6500	9800	6900	9500	1500	1700	2200	2300
Manganese	µg/L	-	596	210	5.5	6.8	**620**	**1100**	**510**	**840**	160	170	190	200
Mercury	µg/L	-	-	0.026	0.0065	0.0065	0.0065	0.0065	**0.040**	**0.049**	0.014	0.015	0.011	0.012
Molybdenum	µg/L	-	-	73	1.0	1.0	5.6	8.0	13	16	2.6	2.9	2.5	2.6
Nickel	µg/L	250	-	25	1.0	1.0	1.0	1.0	1.3	1.7	1.0	1.1	1.0	1.0
Phosphorus	µg/L	-	-	4	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**
Potassium	µg/L	-	-	-	95	130	600	860	5500	6700	600	690	400	430
Selenium	µg/L	-	-	1	0.25	0.25	0.38	0.39	0.82	1.0	0.46	0.48	0.41	0.42
Silver	µg/L	-	-	0.25	0.050	0.050	0.050	0.050	0.19	0.23	0.069	0.075	0.058	0.060
Sodium	µg/L	-	-	-	1400	1500	42000	70000	40000	64000	6300	7000	12000	12000
Thallium	µg/L	-	-	0.8	0.050	0.050	0.050	0.050	0.054	0.062	0.050	0.050	0.050	0.050
Uranium	µg/L	-	33	15	0.050	0.050	0.78	0.92	5.3	6.6	0.58	0.70	0.41	0.43
Zinc	µg/L	400	11.3	2.2	**2.5**	**2.5**	**2.5**	**2.5**	**13**	**32**	**6.8**	**9.0**	**6.1**	**7.0**
Chloride	µg/L	-	640000	120000	2400	2600	36000	59000	33000	48000	5300	5900	9200	9400
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	38	53	720	1800	4900	9400	100	120	83	91
Nitrite (as Nitrogen)	µg/L	-	-	60	9.9	14	20	43	**110**	**250**	**93**	**110**	**91**	**100**
Nitrate (as Nitrogen)	µg/L	-	550000	13000	25	25	700	1700	4800	9200	100	120	83	92
Total Ammonia (as Nitrogen)	µg/L	-	-	689	25	25	380	610	**790**	**1400**	140	160	130	150
Un-ionized Ammonia (as Nitrogen)	µg/L	500	16	16	0.064	0.10	14	**23**	**30**	**53**	5.3	6.1	4.9	5.7
Cyanide, Total	µg/L	500	-	-	10	10	10	10	10	10	10	10	10	10
Cyanide, WAD	µg/L	-	-	5	1.0	1.0	1.1	1.2	1.0	1.0	1.0	1.0	1.0	1.0
Sulphate	µg/L	-	-	-	1000	1000	170000	290000	160000	260000	21000	24000	46000	47000
Fluoride	µg/L	-	-	120	60	60	60	60	**220**	**260**	80	85	68	70
Radium-226	Bg/L	0.37	-	-	0.0050	0.0050	0.0050	0.0050	0.021	0.025	0.0073	0.0078	0.0110	0.011
Temperature	°C	-	-	-	12	17	9.2	17	9.3	18	9.1	18	10	18
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	8.8	9.7	300	480	99000	120000	11000	14000	6800	7800
pH (mean or 5 %ile)	pH Unit	6.0-9.5	-	6.5-9.0	7.0	6.9	7.8	7.6	7.8	7.6	7.3	7.2	7.4	7.3
Hardness (as $CaCO_3$)	mg/L	-	-	-	8.4	8.7	200	290	220	280	41	44	64	64
Dissolved Organic Carbon	mg/L	-	-	-	1.0	1.0	1.0	1.0	4.1	4.9	1.4	1.5	1.2	1.2

Notes: See Table C-1 notes for details on the parameters and guidelines.

Table D-5: The highest value of the monthly mean and 95th %-ile for each project phase in MA-FDP-01

Parameter	Units	MDMER	CWQG	**CWQG**	Baseline		Construction		Operation		Closure		Post-closure	
Statistics			Short-term	Long-term	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile
Aluminum	µg/L	-	-	100	16	22	**180**	**230**	**260**	**300**	**240**	**260**	**160**	**200**
Antimony	µg/L	-	-	-	0.50	0.50	1.1	1.4	8.4	10	5.9	6.9	4.1	4.5
Arsenic	µg/L	100	-	5	0.50	0.50	**12**	**18**	**16**	**21**	**17**	**23**	**18**	**23**
Barium	µg/L	-	-	-	2.3	3.0	4.7	5.5	31	35	19	22	13	15
Boron	µg/L	-	29000	1500	25	25	25	25	54	61	29	34	45	46
Cadmium	µg/L	-	0.13	0.04	0.0050	0.0050	0.0350	**0.055**	**0.074**	**0.092**	**0.067**	**0.087**	**0.069**	**0.090**
Calcium	µg/L	-	-	-	2800	2900	7600	10000	71000	81000	42000	49000	28000	32000
Chromium	µg/L	-	-	1	**1.1**	**1.9**	**1.1**	**1.8**	**1.8**	**2.1**	**1.6**	**1.9**	**2.2**	**2.5**
Copper	µg/L	100	-	2	0.61	0.90	**4.700**	**6.7**	**18**	**20**	**13**	**15**	**11**	**13**
Iron	µg/L	-	-	300	25	25	270	**340**	**350**	**440**	300	**390**	280	**370**
Lead	µg/L	80	-	1	0.25	0.25	0.37	0.52	0.73	0.88	0.68	0.86	0.71	0.86
Magnesium	µg/L	-	-	-	340	350	740	1000	7000	8000	4300	5100	2800	3300
Manganese	µg/L	-	596	210	5.5	6.8	81	120	**340**	**380**	**240**	**270**	120	150
Mercury	µg/L	-	-	0.026	0.0065	0.0065	0.0066	0.0072	**0.10**	**0.11**	**0.080**	**0.093**	**0.057**	**0.064**
Molybdenum	µg/L	-	-	73	1.0	1.0	3.0	4.6	21	26	11	14	6.7	8.0
Nickel	µg/L	250	-	25	1.0	1.0	1.0	1.0	2.4	3.0	1.9	2.3	2.2	2.2
Phosphorus	µg/L	-	-	4	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**
Potassium	µg/L	-	-	-	95	130	1700	2200	13000	15000	4700	5300	3300	3900
Selenium	µg/L	-	-	1	0.25	0.25	0.53	0.75	**1.7**	**2.0**	1.0	**1.2**	0.90	**1.1**
Silver	µg/L	-	-	0.25	0.050	0.050	0.050	0.050	**0.40**	**0.46**	**0.29**	**0.35**	0.22	0.24
Sodium	µg/L	-	-	-	1400	1500	2600	3300	34000	39000	9500	12000	4300	4700
Thallium	µg/L	-	-	0.8	0.050	0.050	0.050	0.050	0.091	0.10	0.068	0.078	0.097	0.10
Uranium	µg/L	-	33	15	0.050	0.050	0.64	0.89	11	13	4.1	5.0	2.1	2.4
Zinc	µg/L	400	11.3	2.2	**2.5**	**2.5**	**2.6**	**3.1**	**31**	**59**	**27**	**41**	**19**	**23**
Chloride	µg/L	-	640000	120000	2400	2600	2300	2600	2400	2600	2400	2600	3800	3900
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	38	53	49	51	5100	6400	180	280	90	120
Nitrite (as Nitrogen)	µg/L	-	-	60	9.9	14	11	14	**130**	**150**	15	17	15	17
Nitrate (as Nitrogen)	µg/L	-	550000	13000	25	25	48	49	5000	6200	180	270	86	110
Total Ammonia (as Nitrogen)	µg/L	-	-	689	25	25	48	49	680	**830**	68	80	69	72
Un-ionized Ammonia (as Nitrogen)	µg/L	500	16	16	0.064	0.10	1.8	1.9	**26**	**32**	2.6	3.0	2.6	2.7
Cyanide, Total	µg/L	500	-	-	10	10	10	10	13	13	14	14	16	16
Cyanide, WAD	µg/L	-	-	5	1.0	1.0	1.0	1.0	1.3	1.3	1.4	1.4	1.6	1.6
Sulphate	µg/L	-	-	-	1000	1000	4600	6600	59000	68000	33000	37000	21000	23000
Fluoride	µg/L	-	-	120	60	60	120	**140**	**490**	**510**	**370**	**400**	**170**	**190**
Radium-226	Bg/L	0.37	-	-	0.0050	0.0050	0.047	0.048	0.085	0.091	0.075	0.078	0.076	0.079
Temperature	°C	-	-	-	12	17	9.2	17	9.3	18	9.1	18	10	18
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	8.8	9.7	22000	30000	220000	260000	120000	140000	76000	85000
pH (mean or 5 %ile)	pH Unit	6.0-9.5	-	6.5-9.0	7.0	6.9	7.9	7.7	8.0	7.7	7.3	7.2	7.3	7.2
Hardness (as $CaCO_3$)	mg/L	-	-	-	8.4	8.7	22	29	210	240	120	140	81	93
Dissolved Organic Carbon	mg/L	-	-	-	1.0	1.0	1.0	1.0	9.0	10	6.7	7.8	4.8	5.3

Notes: See Table C-1 notes for details on the parameters and guidelines.

Table D-6: The highest value of the monthly mean and 95th %-ile for each project phase in MA-FDP-02

Parameter	Units	MDMER	CWQG	**CWQG**	Baseline		Construction		Operation		Closure		Post-closure	
Statistics			Short-term	Long-term	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile
Aluminum	µg/L	-	-	100	16	22	**600**	**600**	**600**	**600**	**600**	**600**	**420**	**450**
Antimony	µg/L	-	-	-	0.50	0.50	0.50	0.50	32	37	27	31	11	14
Arsenic	µg/L	100	-	5	0.50	0.50	0.88	0.89	**24**	**27**	**11**	**15**	**7.8**	**11**
Barium	µg/L	-	-	-	2.3	3.0	6.7	6.7	110	130	72	83	30	36
Boron	µg/L	-	29000	1500	25	25	25	25	130	150	83	92	49	53
Cadmium	µg/L	-	0.13	0.04	0.0050	0.0050	0.0050	0.0050	**0.22**	**0.26**	**0.19**	**0.23**	**0.099**	**0.12**
Calcium	µg/L	-	-	-	2800	2900	5100	5100	280000	320000	180000	210000	76000	89000
Chromium	µg/L	-	-	1	**1.1**	**1.9**	**1.1**	**1.8**	**7.6**	**8.8**	**6.6**	**7.6**	**3.5**	**4.0**
Copper	µg/L	100	-	2	0.61	0.90	0.70	0.89	**71**	**81**	**48**	**54**	**21**	**25**
Iron	µg/L	-	-	300	25	25	190	190	**550**	**640**	**330**	**390**	230	**310**
Lead	µg/L	80	-	1	0.25	0.25	0.25	0.25	**2.2**	**2.7**	**1.9**	**2.3**	1.0	**1.2**
Magnesium	µg/L	-	-	-	340	350	640	650	27000	30000	19000	22000	7900	9300
Manganese	µg/L	-	596	210	5.5	6.8	9.2	9.3	**1200**	**1300**	**870**	**990**	**390**	**460**
Mercury	µg/L	-	-	0.026	0.0065	0.0065	0.0065	0.0065	**0.50**	**0.58**	**0.43**	**0.49**	**0.20**	**0.24**
Molybdenum	µg/L	-	-	73	1.0	1.0	1.0	1.0	36	41	25	31	11	13
Nickel	µg/L	250	-	25	1.0	1.0	1.0	1.0	6.7	8.7	5.9	7.5	3.6	4.2
Phosphorus	µg/L	-	-	4	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**
Potassium	µg/L	-	-	-	95	130	1300	1300	55000	63000	13000	15000	4600	5500
Selenium	µg/L	-	-	1	0.25	0.25	0.25	0.25	**3.4**	**3.9**	**1.6**	**1.8**	0.86	**1.1**
Silver	µg/L	-	-	0.25	0.050	0.050	0.050	0.050	**1.8**	**2.1**	**1.5**	**1.7**	**0.66**	**0.77**
Sodium	µg/L	-	-	-	1400	1500	5400	5400	120000	150000	17000	22000	5300	6500
Thallium	µg/L	-	-	0.8	0.050	0.050	0.050	0.050	0.27	0.31	0.23	0.26	0.13	0.14
Uranium	µg/L	-	33	15	0.050	0.050	1.2	1.2	**41**	**48**	13	**16**	4.8	5.8
Zinc	µg/L	400	11.3	2.2	**2.5**	**2.5**	**2.5**	**2.5**	**140**	**200**	**130**	**170**	**72**	**87**
Chloride	µg/L	-	640000	120000	2400	2600	2300	2600	2400	2600	2400	2600	2400	2600
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	38	53	42	51	22000	28000	440	840	68	120
Nitrite (as Nitrogen)	µg/L	-	-	60	9.9	14	9.8	14	**510**	**640**	18	27	11	14
Nitrate (as Nitrogen)	µg/L	-	550000	13000	25	25	40	41	**22000**	**27000**	420	810	60	110
Total Ammonia (as Nitrogen)	µg/L	-	-	689	25	25	40	41	**2800**	**3500**	76	130	36	42
Un-ionized Ammonia (as Nitrogen)	µg/L	500	16	16	0.064	0.10	1.5	1.6	**110**	**130**	2.9	4.9	1.4	1.6
Cyanide, Total	µg/L	500	-	-	10	10	10	10	10	10	10	10	10	10
Cyanide, WAD	µg/L	-	-	5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Sulphate	µg/L	-	-	-	1000	1000	1000	1000	200000	240000	140000	170000	63000	76000
Fluoride	µg/L	-	-	120	60	60	60	60	**1600**	**1600**	**1400**	**1400**	**1100**	**1100**
Radium-226	Bg/L	0.37	-	-	0.0050	0.0050	0.041	0.041	0.19	0.22	0.16	0.19	0.081	0.091
Temperature	°C	-	-	-	12	17	9.2	17	9.3	18	9.1	18	10	18
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	8.8	9.7	28	28	870000	1000000	480000	560000	200000	230000
pH (mean or 5 %ile)	pH Unit	6.0-9.5	-	6.5-9.0	7.0	6.9	7.9	7.7	8.0	7.7	7.3	7.2	7.3	7.2
Hardness (as $CaCO_3$)	mg/L	-	-	-	8.4	8.7	15	15	810	920	530	610	220	260
Dissolved Organic Carbon	mg/L	-	-	-	1.0	1.0	1.0	1.0	39	45	32	37	14	16

Notes: See Table C-1 notes for details on the parameters and guidelines.

Table D-7: The highest value of the monthly mean and 95th %-ile for each project phase in MR-FDP-03

Parameter	Units	MDMER	CWQG	**CWQG**	Baseline		Construction		Operation		Closure		Post-closure	
Statistics			Short-term	Long-term	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile
Aluminum	µg/L	-	-	100	16	22	**600**	**600**	**600**	**600**	**600**	**600**	**400**	**430**
Antimony	µg/L	-	-	-	0.50	0.50	0.50	0.50	31	36	26	30	11	13
Arsenic	µg/L	100	-	5	0.50	0.50	0.82	0.82	**23**	**26**	**10**	**15**	**7.8**	**10**
Barium	µg/L	-	-	-	2.3	3.0	6.2	6.2	110	130	71	82	29	34
Boron	µg/L	-	29000	1500	25	25	25	25	130	140	82	91	47	51
Cadmium	µg/L	-	0.13	0.04	0.0050	0.0050	0.0050	0.0050	**0.22**	**0.25**	**0.19**	**0.22**	**0.096**	**0.11**
Calcium	µg/L	-	-	-	2800	2900	4700	4700	270000	310000	180000	210000	72000	84000
Chromium	µg/L	-	-	1	**1.1**	**1.9**	**1.1**	**1.8**	**7.4**	**8.6**	**6.5**	**7.5**	**3.3**	**3.8**
Copper	µg/L	100	-	2	0.61	0.90	0.67	0.89	**70**	**80**	**47**	**53**	**20**	**24**
Iron	µg/L	-	-	300	25	25	180	180	**540**	**630**	**320**	**380**	230	290
Lead	µg/L	80	-	1	0.25	0.25	0.25	0.25	**2.1**	**2.7**	**1.8**	**2.3**	0.96	**1.2**
Magnesium	µg/L	-	-	-	340	350	600	600	26000	30000	18000	21000	7500	8800
Manganese	µg/L	-	596	210	5.5	6.8	8.5	8.6	**1200**	**1300**	**860**	**980**	**370**	**430**
Mercury	µg/L	-	-	0.026	0.0065	0.0065	0.0065	0.0065	**0.49**	**0.57**	**0.42**	**0.49**	**0.19**	**0.22**
Molybdenum	µg/L	-	-	73	1.0	1.0	1.0	1.0	35	41	25	30	11	13
Nickel	µg/L	250	-	25	1.0	1.0	1.0	1.0	6.6	8.5	5.8	7.4	3.4	4.0
Phosphorus	µg/L	-	-	4	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**
Potassium	µg/L	-	-	-	95	130	1200	1200	54000	62000	13000	15000	4500	5300
Selenium	µg/L	-	-	1	0.25	0.25	0.25	0.25	**3.3**	**3.8**	**1.6**	**1.8**	0.83	1.0
Silver	µg/L	-	-	0.25	0.050	0.050	0.050	0.050	**1.8**	**2.0**	**1.5**	**1.7**	**0.62**	**0.73**
Sodium	µg/L	-	-	-	1400	1500	5000	5000	120000	140000	17000	22000	5100	6300
Thallium	µg/L	-	-	0.8	0.050	0.050	0.050	0.050	0.26	0.30	0.23	0.26	0.12	0.14
Uranium	µg/L	-	33	15	0.050	0.050	1.1	1.2	**40**	**47**	13	15	4.7	5.5
Zinc	µg/L	400	11.3	2.2	**2.5**	**2.5**	**2.5**	**2.5**	**140**	**200**	**120**	**170**	**68**	**82**
Chloride	µg/L	-	640000	120000	2400	2600	2300	2600	2400	2600	2400	2600	2400	2600
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	38	53	40	51	22000	27000	440	850	66	110
Nitrite (as Nitrogen)	µg/L	-	-	60	9.9	14	9.7	14	**490**	**620**	18	27	11	14
Nitrate (as Nitrogen)	µg/L	-	550000	13000	25	25	37	38	**21000**	**27000**	430	820	59	110
Total Ammonia (as Nitrogen)	µg/L	-	-	689	25	25	37	38	**2700**	**3400**	77	130	35	41
Un-ionized Ammonia (as Nitrogen)	µg/L	500	16	16	0.064	0.10	1.4	1.4	**100**	**130**	2.9	4.9	1.3	1.6
Cyanide, Total	µg/L	500	-	-	10	10	10	10	10	10	10	10	10	10
Cyanide, WAD	µg/L	-	-	5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Sulphate	µg/L	-	-	-	1000	1000	1000	1000	200000	230000	140000	170000	60000	72000
Fluoride	µg/L	-	-	120	60	60	60	60	**1600**	**1600**	**1400**	**1400**	**1000**	**1000**
Radium-226	Bg/L	0.37	-	-	0.0050	0.0050	0.038	0.038	0.19	0.22	0.16	0.19	0.078	0.088
Temperature	°C	-	-	-	12	17	9.2	17	9.3	18	9.1	18	10	18
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	8.8	9.7	26	26	850000	990000	480000	550000	190000	220000
pH (mean or 5 %ile)	pH Unit	6.0-9.5	-	6.5-9.0	7.0	6.9	7.9	7.7	8.0	7.7	7.3	7.2	7.3	7.2
Hardness (as $CaCO_3$)	mg/L	-	-	-	8.4	8.7	14	14	780	900	520	610	210	250
Dissolved Organic Carbon	mg/L	-	-	-	1.0	1.0	1.0	1.0	38	44	32	36	13	16

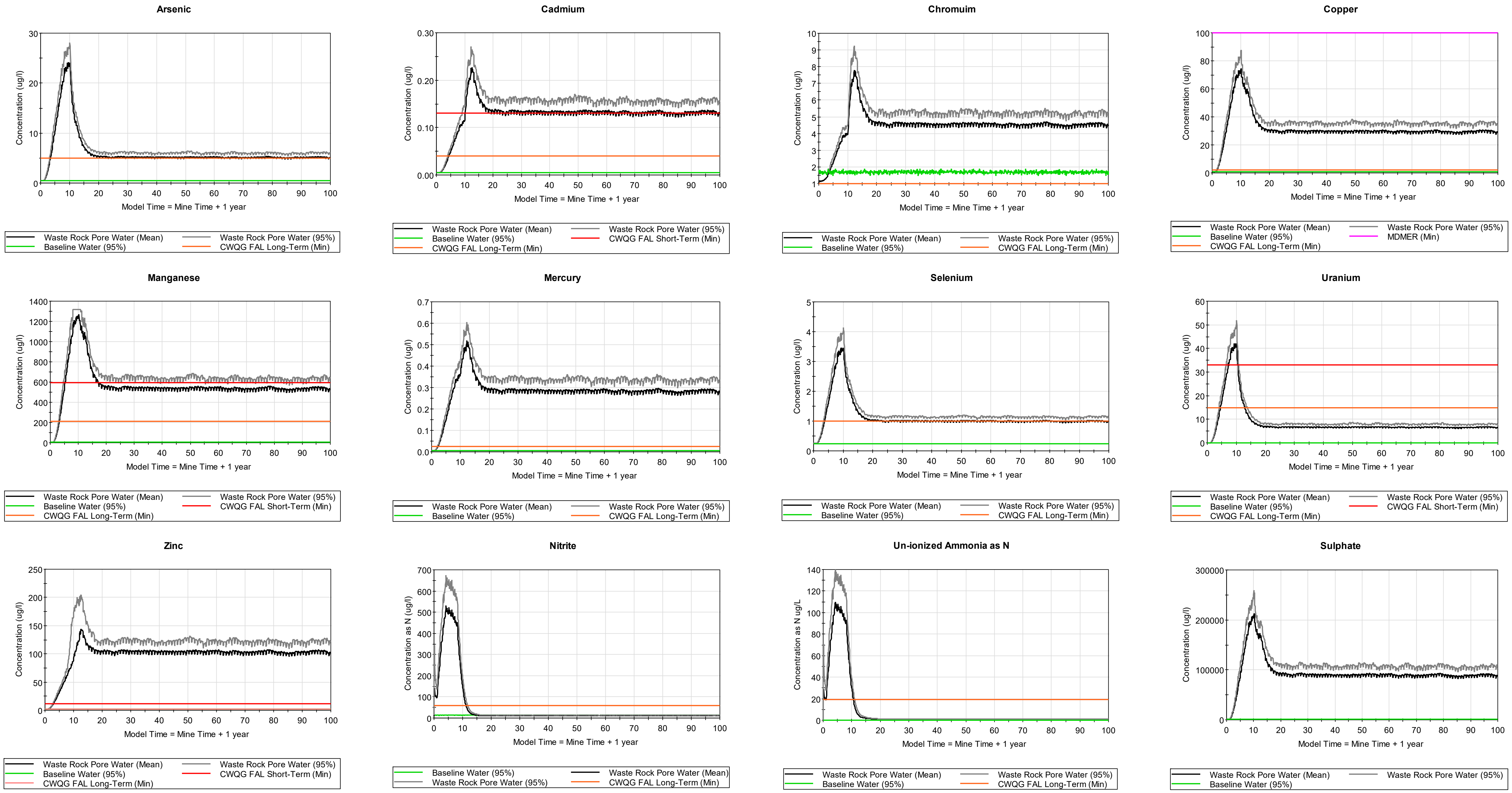
Notes: See Table C-1 notes for details on the parameters and guidelines.

Table D-8: The highest value of the monthly mean and 95th %-ile for each project phase in MA-FDP-04

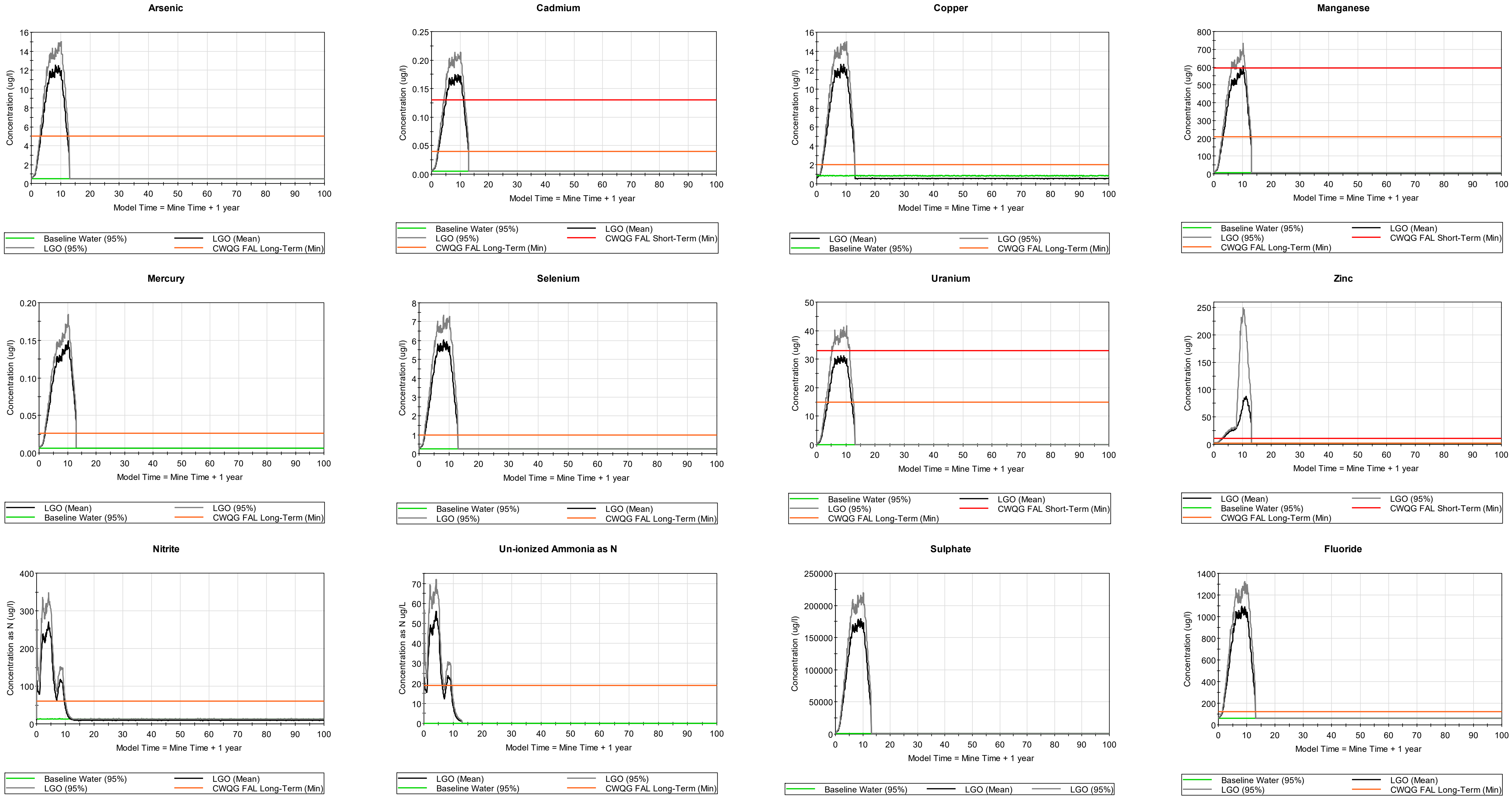
Parameter	Units	MDMER	CWQG	**CWQG**	Baseline		Construction		Operation		Closure		Post-closure	
Statistics			Short-term	Long-term	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile	mean	95 %ile
Aluminum	µg/L	-	-	100	16	22	**190**	**200**	**590**	**590**	**590**	**590**	**220**	**360**
Antimony	µg/L	-	-	-	0.50	0.50	0.50	0.50	17	20	17	20	3.9	7.4
Arsenic	µg/L	100	-	5	0.50	0.50	1.3	1.7	**10**	**12**	**16**	**20**	**8.3**	**16**
Barium	µg/L	-	-	-	2.3	3.0	4.7	6.2	55	63	47	57	12	21
Boron	µg/L	-	29000	1500	25	25	25	25	63	71	54	62	27	27
Cadmium	µg/L	-	0.13	0.04	0.0050	0.0050	0.0089	0.012	**0.12**	**0.14**	**0.12**	**0.14**	**0.049**	**0.090**
Calcium	µg/L	-	-	-	2800	2900	60000	78000	140000	160000	120000	140000	29000	51000
Chromium	µg/L	-	-	1	**1.1**	**1.9**	**1.1**	**1.8**	**4.2**	**5.1**	**4.3**	**5.1**	**1.6**	**2.0**
Copper	µg/L	100	-	2	0.61	0.90	0.92	1.1	**35**	**40**	**31**	**35**	**8.6**	**16**
Iron	µg/L	-	-	300	25	25	**420**	**710**	**380**	**600**	**370**	**450**	**310**	**370**
Lead	µg/L	80	-	1	0.25	0.25	0.25	0.25	**1.1**	**1.4**	**1.2**	**1.5**	0.55	0.93
Magnesium	µg/L	-	-	-	340	350	5900	7800	13000	15000	12000	15000	3100	5000
Manganese	µg/L	-	596	210	5.5	6.8	**550**	**840**	**620**	**700**	**560**	**630**	210	**300**
Mercury	µg/L	-	-	0.026	0.0065	0.0065	0.0065	0.0065	**0.26**	**0.32**	**0.27**	**0.31**	**0.060**	**0.11**
Molybdenum	µg/L	-	-	73	1.0	1.0	5.0	6.6	18	21	16	19	5.4	9.2
Nickel	µg/L	250	-	25	1.0	1.0	1.0	1.0	3.6	4.6	3.7	4.7	1.6	2.3
Phosphorus	µg/L	-	-	4	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**
Potassium	µg/L	-	-	-	95	130	580	720	22000	25000	9100	11000	2200	4400
Selenium	µg/L	-	-	1	0.25	0.25	0.34	0.34	**1.5**	**1.8**	**1.1**	**1.3**	0.66	1.0
Silver	µg/L	-	-	0.25	0.050	0.050	0.050	0.050	**0.94**	**1.1**	**0.96**	**1.1**	0.21	**0.38**
Sodium	µg/L	-	-	-	1400	1500	36000	53000	50000	59000	14000	18000	11000	11000
Thallium	µg/L	-	-	0.8	0.050	0.050	0.050	0.050	0.14	0.17	0.15	0.17	0.061	0.080
Uranium	µg/L	-	33	15	0.050	0.050	0.71	0.80	**17**	**20**	9.0	11	1.8	3.5
Zinc	µg/L	400	11.3	2.2	**2.5**	**2.5**	**2.5**	**2.5**	**73**	**110**	**76**	**110**	**22**	**40**
Chloride	µg/L	-	640000	120000	2400	2600	32000	45000	29000	39000	2800	4400	8600	8900
Nitrate + Nitrite (as Nitrogen)	µg/L	-	-	-	38	53	640	1400	5800	8800	390	680	81	100
Nitrite (as Nitrogen)	µg/L	-	-	60	9.9	14	18	34	**130**	**200**	30	**77**	**84**	**95**
Nitrate (as Nitrogen)	µg/L	-	550000	13000	25	25	620	1400	5700	8600	380	660	80	96
Total Ammonia (as Nitrogen)	µg/L	-	-	689	25	25	340	500	**840**	**1300**	75	120	130	140
Un-ionized Ammonia (as Nitrogen)	µg/L	500	16	16	0.064	0.10	13	**19**	**32**	**49**	2.9	4.6	4.9	5.3
Cyanide, Total	µg/L	500	-	-	10	10	10	10	10	10	13	13	11	13
Cyanide, WAD	µg/L	-	-	5	1.0	1.0	1.0	1.0	1.0	1.0	1.3	1.3	1.1	1.3
Sulphate	µg/L	-	-	-	1000	1000	160000	240000	130000	200000	89000	100000	46000	48000
Fluoride	µg/L	-	-	120	60	60	60	60	**860**	**940**	**880**	**940**	**360**	**660**
Radium-226	Bg/L	0.37	-	-	0.0050	0.0050	0.012	0.013	0.11	0.13	0.11	0.13	0.044	0.084
Temperature	°C	-	-	-	12	17	9.2	17	9.3	18	9.1	18	10	18
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	8.8	9.7	250	400	400000	460000	310000	370000	66000	140000
pH (mean or 5 %ile)	pH Unit	6.0-9.5	-	6.5-9.0	7.0	6.9	7.8	7.6	7.8	7.6	7.3	7.2	7.4	7.3
Hardness (as $CaCO_3$)	mg/L	-	-	-	8.4	8.7	170	230	400	460	350	410	85	150
Dissolved Organic Carbon	mg/L	-	-	-	1.0	1.0	1.0	1.0	20	24	21	25	4.7	8.5

Notes: See Table C-1 notes for details on the parameters and guidelines.

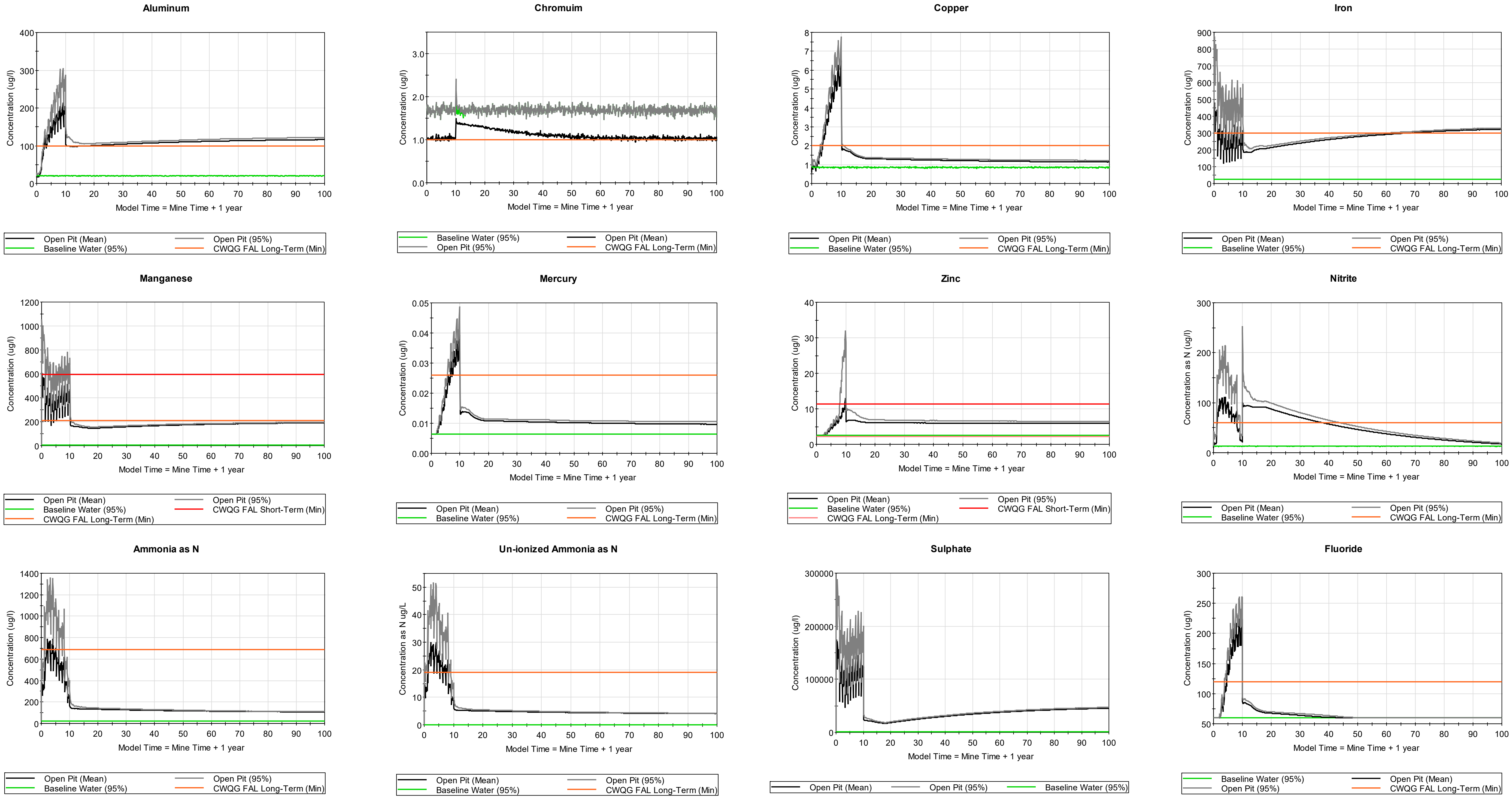
Appendix E TIME SERIES FOR SELECTED PARAMETERS



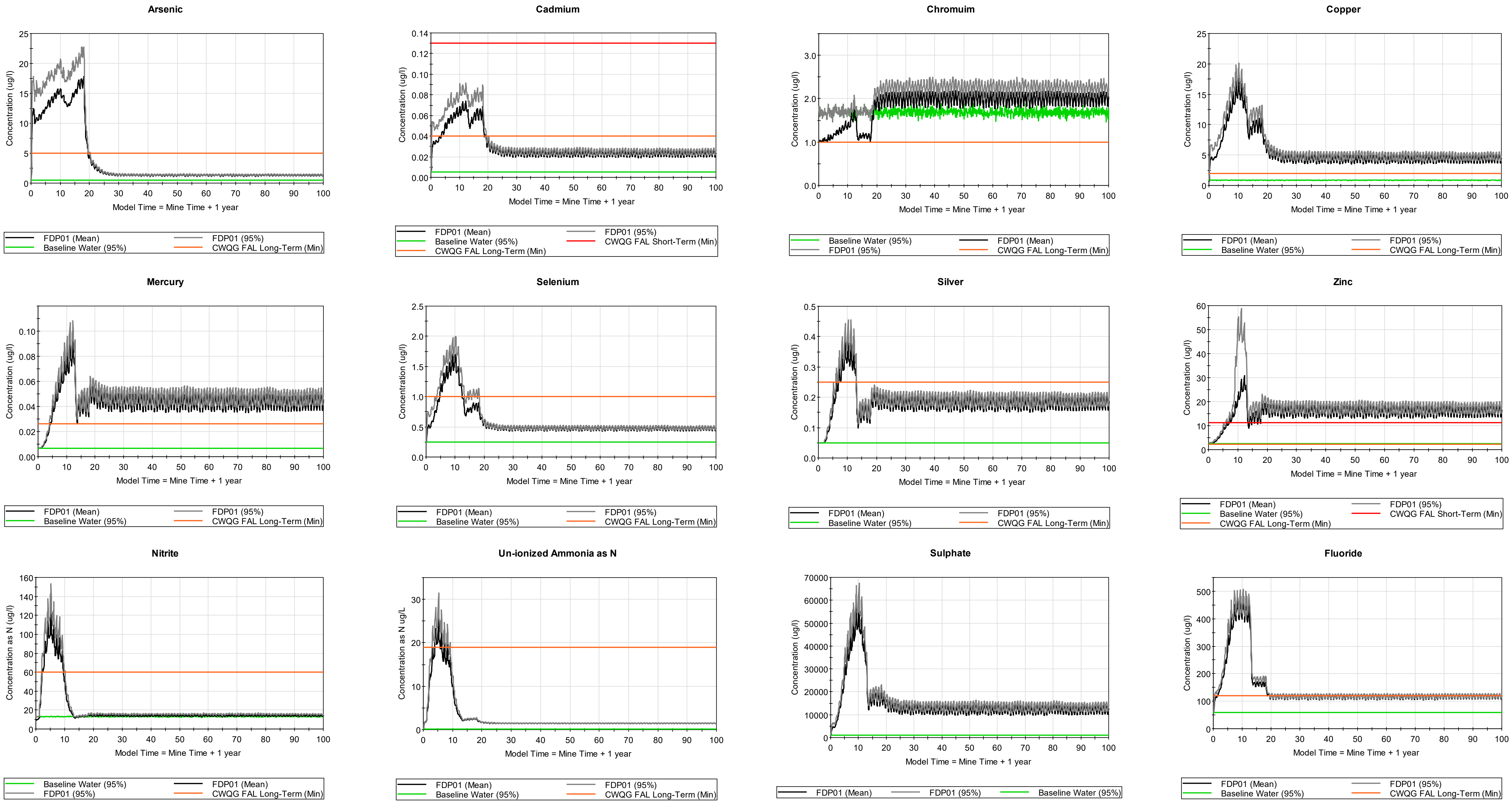
Waste Rock Pore Water Plots.



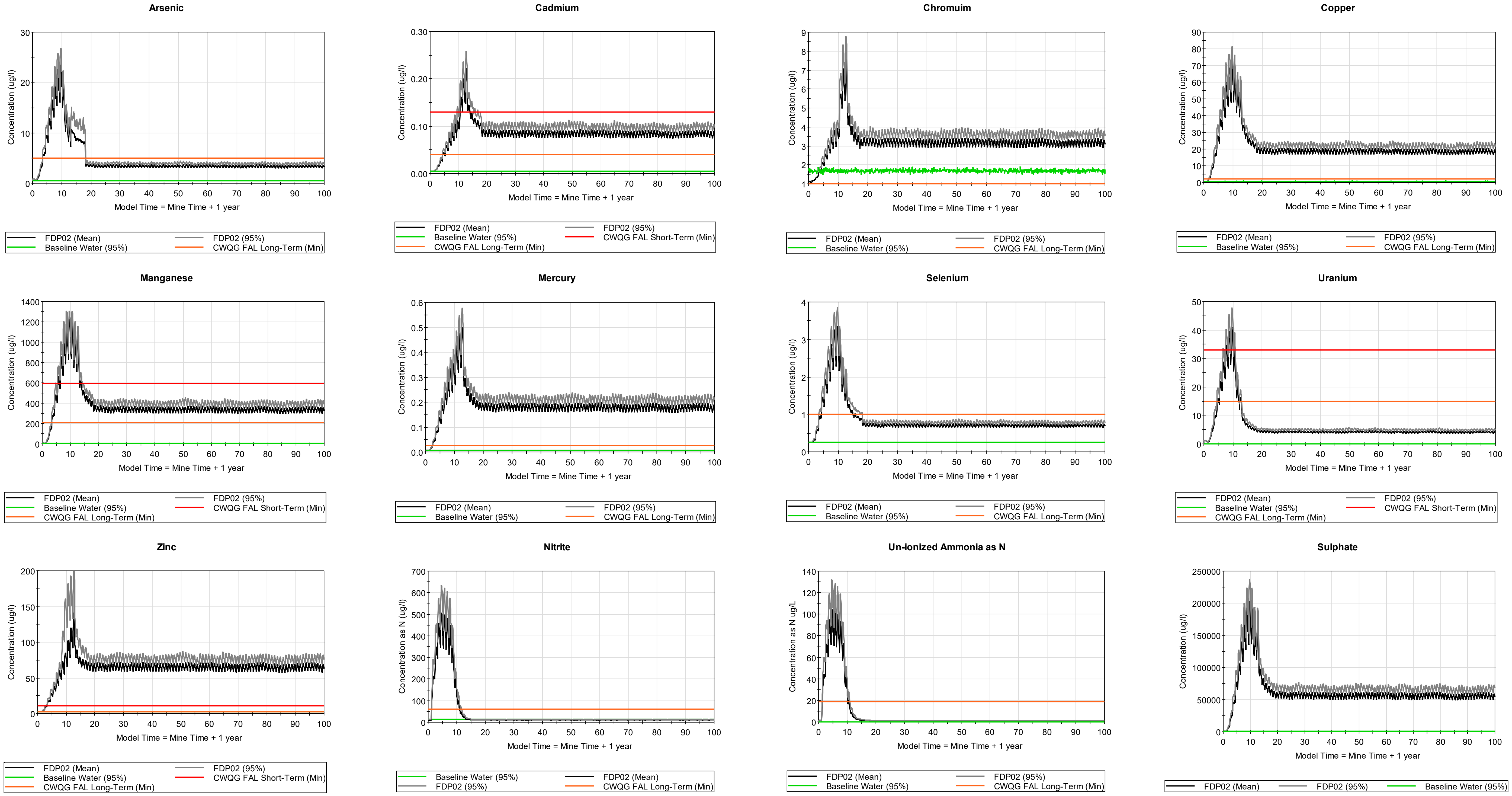
Low-Grade Ore Plots.



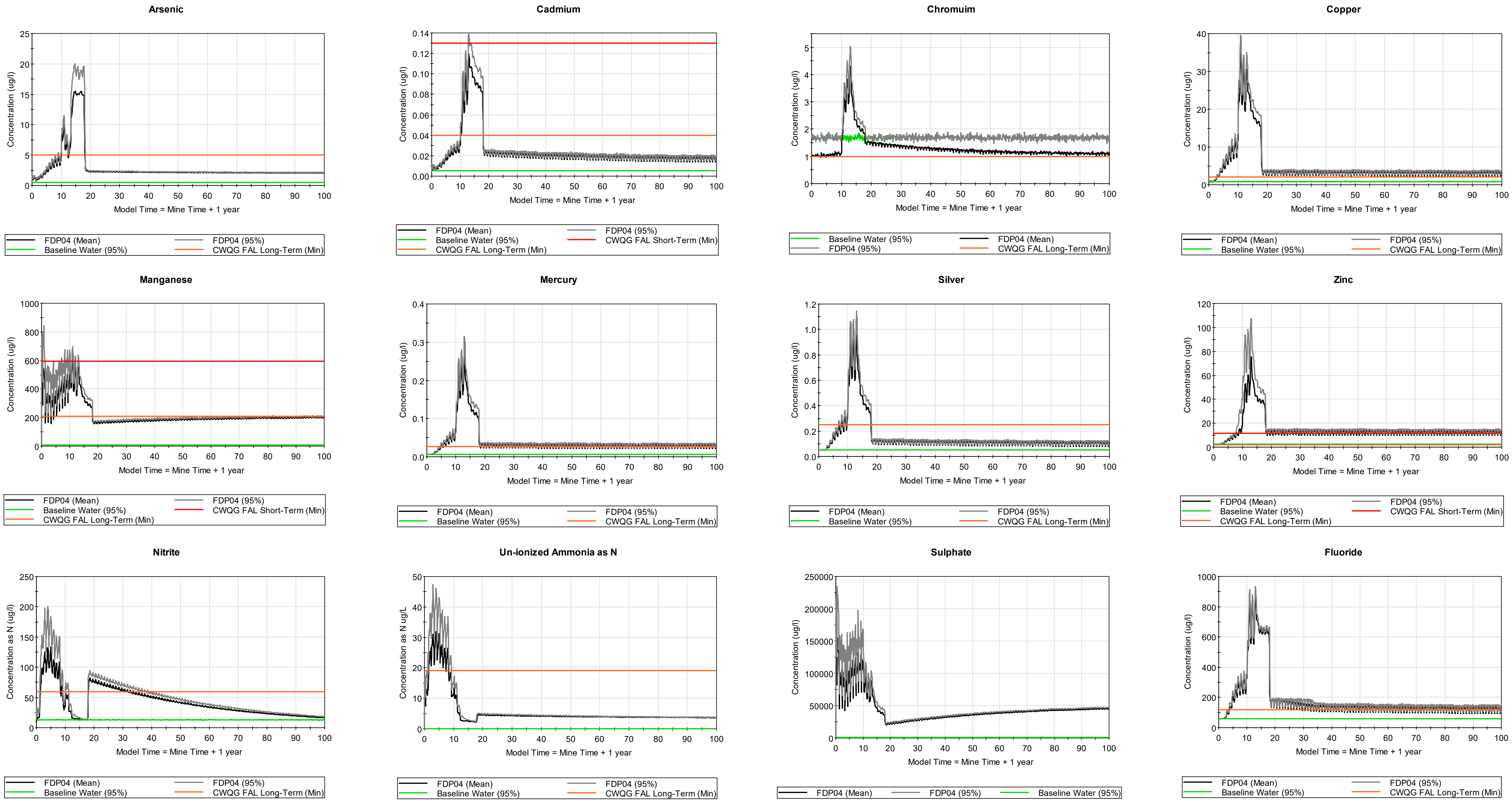
Open Pit Plots.



MA-FDP-01 Plots.



MA-FDP-02 Plots.



MA-FDP-04 Plots.

APPENDIX 7C

Assimilative Capacity Assessment Report

Valentine Gold Project: Assimilative Capacity Assessment

Final Report

Prepared for:

Marathon Gold Corporation
36 Lombard Street, Suite 600
Toronto, ON M5C 2X3

Prepared by:

Stantec Consulting Ltd.
141 Kelsey Drive
St. John's, NL A1B 0L2
Tel: (709) 576-1458
Fax: (709) 576-2126

File No: 121416408

September 25, 2020

Sign-off Sheet

This document entitled Valentine Gold Project: Assimilative Capacity Assessment was prepared by Stantec Consulting Ltd. (“Stantec”) for the account of Marathon Gold Corporation (the “Client”). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Stantec’s professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. In preparing the document, Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

Prepared by ______________________________
(signature)

Igor Iskra, Ph.D., P.Eng.
Senior Water Resources Engineer

Reviewed by ______________________________
(signature)

Jonathan Keizer, M.Sc.E., P.Eng.
Senior Associate, Environmental Services

Approved by ______________________________
(signature)

Sheldon, MES, P.Geo.
Principal, Senior Hydrologist

pk \\cd1151-f01\work_group\1214\active\121416408\05_report_deliv\assimilative_capacity_assessment\rpt_121416408_assimilative_capacity_20200925_fin.docx

Table of Contents

LIST OF TABLES

LIST OF FIGURES

Abbreviations

AC	Assimilative Capacity
CCME	Canadian Council of Ministers of the Environment
CWQG-FAL	Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life
EIS	Environmental Impact Statement
FDP	Final Discharge Point
MAF	Mean annual flow
MDMER	*Metal and Diamond Mining Effluent Regulations*
mg/L	milligrams per litre
POPC	Parameters of Potential Concern
Project	Valentine Gold Project
TMF	Tailings Management Facility
µg/L	micrograms per litre

1.0 INTRODUCTION

Stantec Consulting Ltd. (Stantec) was retained by Marathon Gold Corporation (Marathon) to complete an Assimilative Capacity (AC) Assessment of the surface water effluent discharge during the operation phase and post-closure period of the decommissioning, rehabilitation and closure phase for the Valentine Gold Project (the Project). This AC Assessment is prepared in support of the Surface Water Resources VC Chapter (Chapter 7) of the Environmental Impact Statement (EIS).

The AC was assessed during the operation phase and post-closure period of the Project, as these phases are anticipated to represent the worst-case conditions with respect to effluent quality. The AC Assessment was completed at the Project's effluent Final Discharge Points (FDPs), at 100 m and 250 m downstream of the FDPs, and at the three ultimate receivers of Victoria Lake Reservoir, Valentine Lake, and the Victoria River. Water quality was assessed using a mass balance approach under two discharge conditions: regulatory and normal. The regulatory operating conditions are considered worst case and conservative, while normal operating conditions are considered representative of the expected average discharge conditions. Input parameters for these two operating conditions were:

- Regulatory Operating Conditions:
  - MDMER limits for Parameters of Potential Concern (POPC) listed in the *Metal and Diamond Mining Effluent Regulations* (MDMER) for effluent
  - 95th percentile water quality for POPC not listed in MDMER
  - 75th percentile baseline water quality in the receiving watercourses
  - 7Q10 flow conditions (7-day low flow, 10-year return period) in the receiving watercourses based on regression analysis
  - Seepage flow out of the ponds to represent effluent discharge during a dry condition
- Normal Operating Conditions:
  - Maximum mean monthly water quality concentrations for POPC predicted in modelling
  - Mean concentrations for baseline water quality in the receiving watercourses
  - Mean annual flow (MAF) conditions in the receiving watercourses based on a regression analysis (Stantec 2020d)
  - Predicted effluent flow modelled using regional equations and contact areas

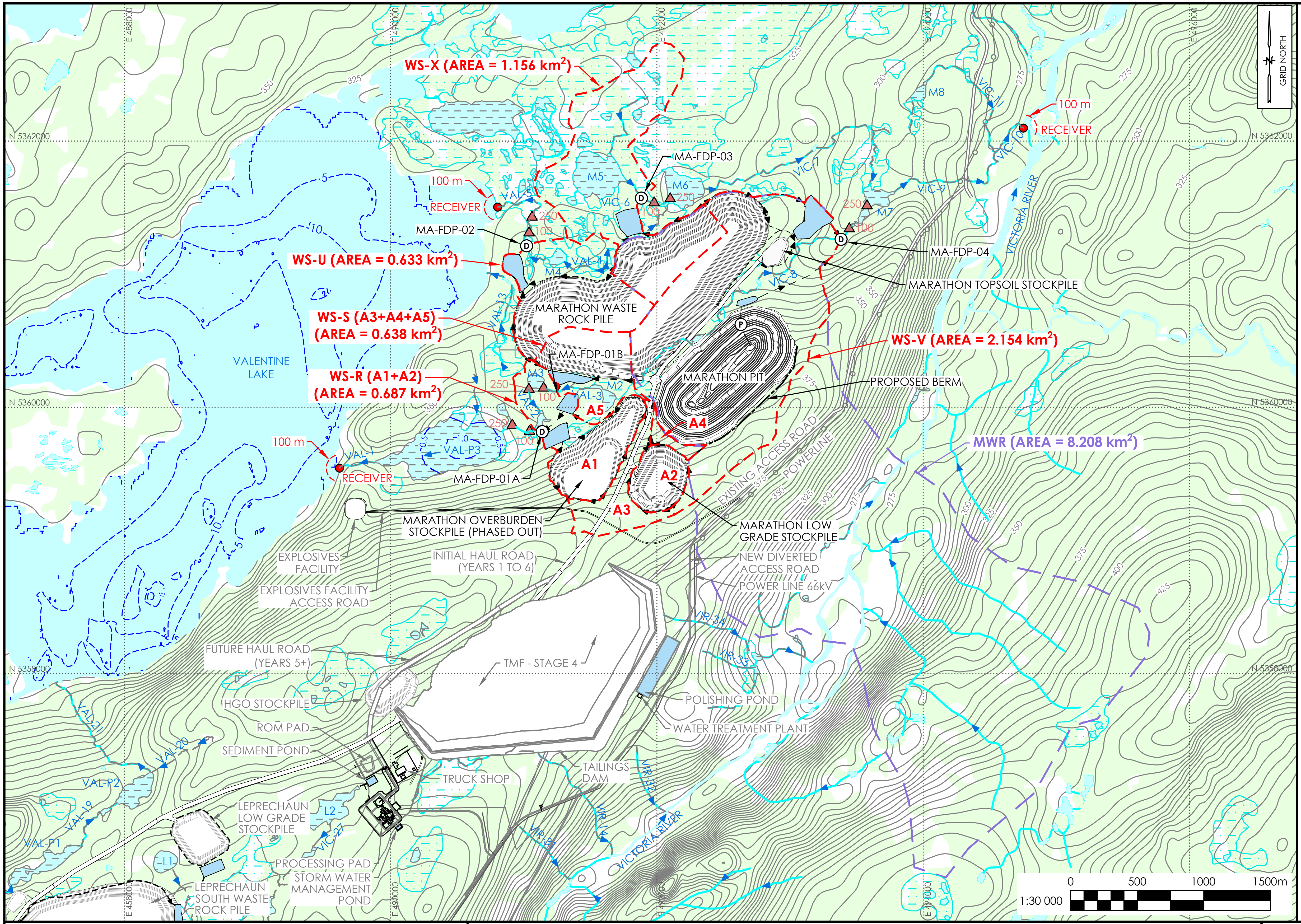
The assimilative capacity assessment for the three ultimate receivers of Valentine Lake, Victoria Lake Reservoir, and the Victoria River was completed using the near-field mixing model Cornell Mixing Zone Expert System, CORMIX, Version 11.0 (Doneker and Jirka 2017). The CORMIX model was used to model mixing zones at the three ultimate receivers (Victoria Lake Reservoir, Valentine Lake and Victoria River) under both the regulatory and normal operating conditions.

The Canadian Council of Ministers of the Environment (CCME) defines the mixing zone as, “an area contiguous with a point source (effluent) where the effluent mixes with ambient water and where concentrations of some substances may not comply with water quality guidelines or objectives” (CCME 2003). The purpose of this study is to define the extent of the mixing zone and model concentrations of POPC at the end of the mixing zone. Conditions within the mixing zone should not result in bioconcentration of POPC to levels that are harmful to organisms, aquatic-dependent wildlife, or human health. Also, accumulation of toxic substances in water or sediment to toxic levels should not occur in the mixing zone (CCME 2003).

1.1 BACKGROUND

The Project is located in the central region of the Island of Newfoundland. The Project is centered on a topographic ridge that divides the Valentine Lake watershed to the north and west, and the Victoria Lake Reservoir and Victoria River watersheds to the south and east, respectively. Valentine Lake drains to the Victoria River and subsequently to Red Indian Lake. Victoria Lake Reservoir, which formerly drained to the Victoria River, was diverted to the southeast to flow through the Bay D’Espoir hydroelectric watershed.

The Project can be broadly divided into three complexes from north to south, the Marathon Complex, the Process Plant and Tailings Management Facility (TMF) Complex, and the Leprechaun Complex. As outlined in the Water Management Plan (Stantec 2020a), a design objective for water management infrastructure is to keep non-contact water and contact water separate. Contact water is directed to water management ponds to allow for flow attenuation and water quality treatment prior to discharge to the environment at the FDP locations shown in Figure 1-1 through Figure 1-3. Non-contact water has been assumed to be represented by baseline water quality. Contact water quality was predicted using GoldSim software and is further discussed in the Water Quality Modelling Reports (Stantec 2020b,c). The Project has a total of 11 FDPs. There are four FDPs at the Marathon Complex that drain to Valentine Lake and the Victoria River either directly or through tributaries (Figure 1-1). There are five FDPs at the Leprechaun Complex that drain to Victoria Lake Reservoir, either directly to the lake or through tributaries (Figure 1-2). The Processing Plant and TMF Complex has two FDPs that flow to Victoria Lake Reservoir, this includes the TMF effluent pipeline (Figure 1-3). The figures present the FDP locations, ultimate receivers, mine infrastructure, and mixing zone points 100 m and 250 m downstream of each FDP. A description of the mixing zones and ultimate receivers is provided in Section 4.0.



LEGEND

EXISTING CONTOURS, 5 m INTERVAL

PROPOSED MINE PIT / STOCKPILE

WATERCOURSE

FISH BEARING WATERCOURSE

WOODED AREA

WETLAND

WATERBODY

FISH BEARING WATERBODY

PROPOSED POND

PROPOSED DRAINAGE CHANNEL

PROPOSED DITCH

PROPOSED BERM

POWERLINE

Ⓟ PUMP

Ⓓ DISPERSION OUTLET (MA-FDP-01)

BATHYMETRY DEPTH CONTOUR, m

MARATHON COMPLEX SEEPAGE FLOW AT RECEIVER DURING POST-CLOSURE

POST DEVELOPMENT SUB-WATERSHED

▲ DISTANCE DOWNSTREAM OF FDP, m

● FDP RECEIVER LOCATION

NOTE:
COORDINATES ARE NAD83(CSRS) UTM ZONE 21.

THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC CONSULTING LTD. REPORT AND MUST NOT BE USED FOR OTHER PURPOSES.

Reference:
1. EXISTING CONTOURS AND PROPOSED INFRASTRUCTURE: AUSENCO; PROJECT No. 104878-01; DRAWING No. 104878-0000-G-001; 2020-05-11; PRELIMINARY.
2. WATERCOURSES, WATERBODIES & WETLANDS: CANVEC DATABASE FROM NATURAL RESOURCES CANADA.
3. FISH BEARING WATERCOURSES AND WATERBODIES: SURVEYED FISH BEARING OR HAS CONNECTIVITY TO FISH BEARING WATER (STANTEC 2012, 2019, 2020).

MARATHON COMPLEX POST DEVELOPMENT WATERSHEDS
ASSIMILATIVE CAPACITY STUDY
VALENTINE GOLD PROJECT, NL

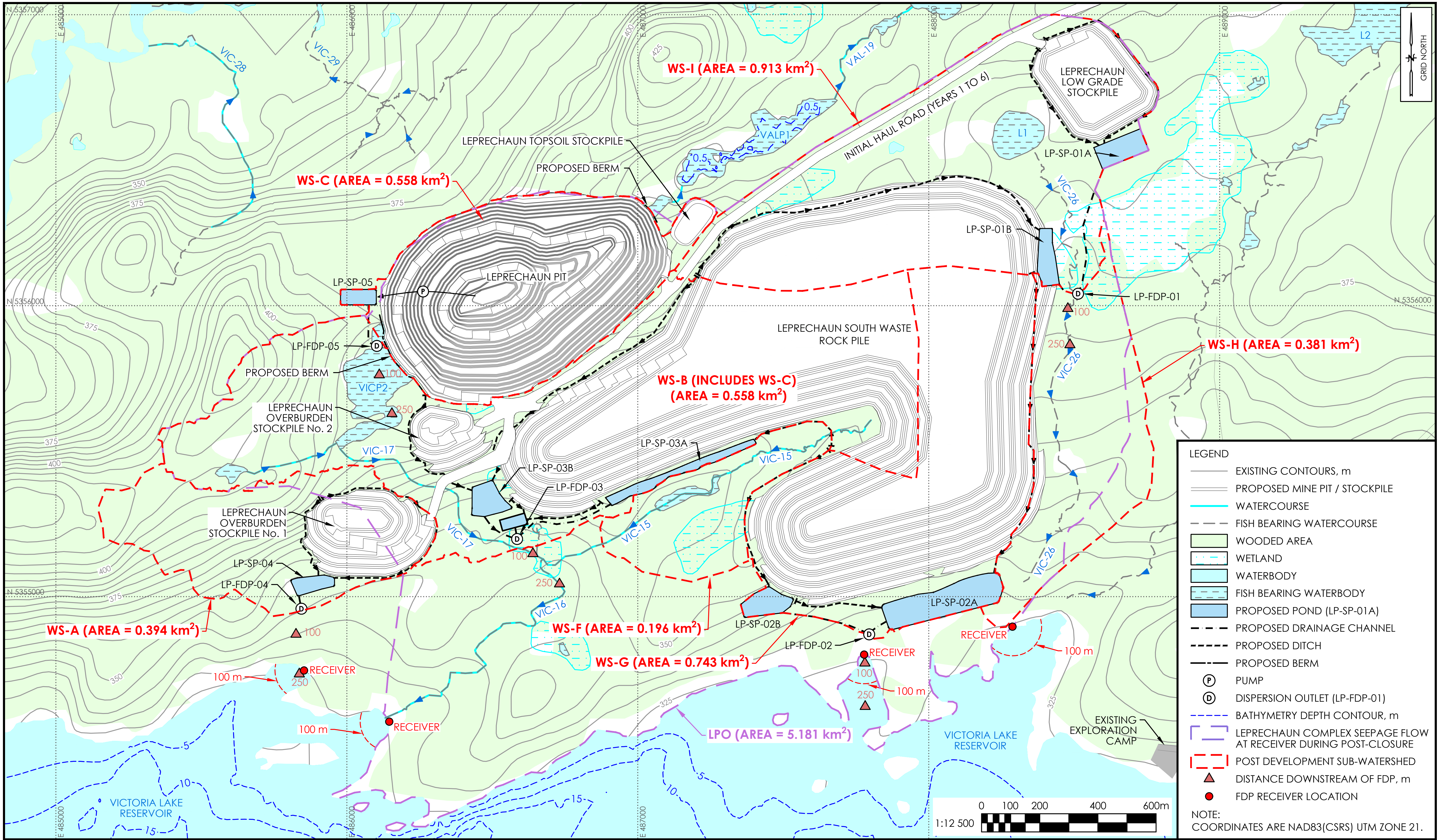
Client: MARATHON GOLD CORP

Job No.:	121416408
Scale:	1 : 30 000
Date:	28-SEP-2020
Dwn. By:	JL
App'd By:	IA

Fig. No.: 1-1

Stantec

V:\1214\active\121416408\03_data\gis_cad\1_CAD\4_Sheet_Files\01_ACS\121416408C_ACS_F1-1.dwg



LEGEND

―	EXISTING CONTOURS, m
═	PROPOSED MINE PIT / STOCKPILE
―	WATERCOURSE
– –	FISH BEARING WATERCOURSE
🟩	WOODED AREA
▨	WETLAND
🟦	WATERBODY
▨	FISH BEARING WATERBODY
🟦	PROPOSED POND (LP-SP-01A)
–·–	PROPOSED DRAINAGE CHANNEL
– –	PROPOSED DITCH
–·–	PROPOSED BERM
Ⓟ	PUMP
Ⓓ	DISPERSION OUTLET (LP-FDP-01)
– –	BATHYMETRY DEPTH CONTOUR, m
– –	LEPRECHAUN COMPLEX SEEPAGE FLOW AT RECEIVER DURING POST-CLOSURE
– –	POST DEVELOPMENT SUB-WATERSHED
▲	DISTANCE DOWNSTREAM OF FDP, m
●	FDP RECEIVER LOCATION

NOTE:
COORDINATES ARE NAD83(CSRS) UTM ZONE 21.

THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC CONSULTING LTD. REPORT AND MUST NOT BE USED FOR OTHER PURPOSES.

Reference:
1. EXISTING CONTOURS AND PROPOSED INFRASTRUCTURE: AUSENCO; PROJECT No. 104878-01; DRAWING No. 104878-0000-G-001; 2020-05-11; PRELIMINARY.
2. WATERCOURSES, WATERBODIES & WETLANDS: CANVEC DATABASE FROM NATURAL RESOURCES CANADA.
3. FISH BEARING WATERCOURSES AND WATERBODIES: SURVEYED FISH BEARING OR HAS CONNECTIVITY TO FISH BEARING WATER (STANTEC 2012, 2019, 2020).

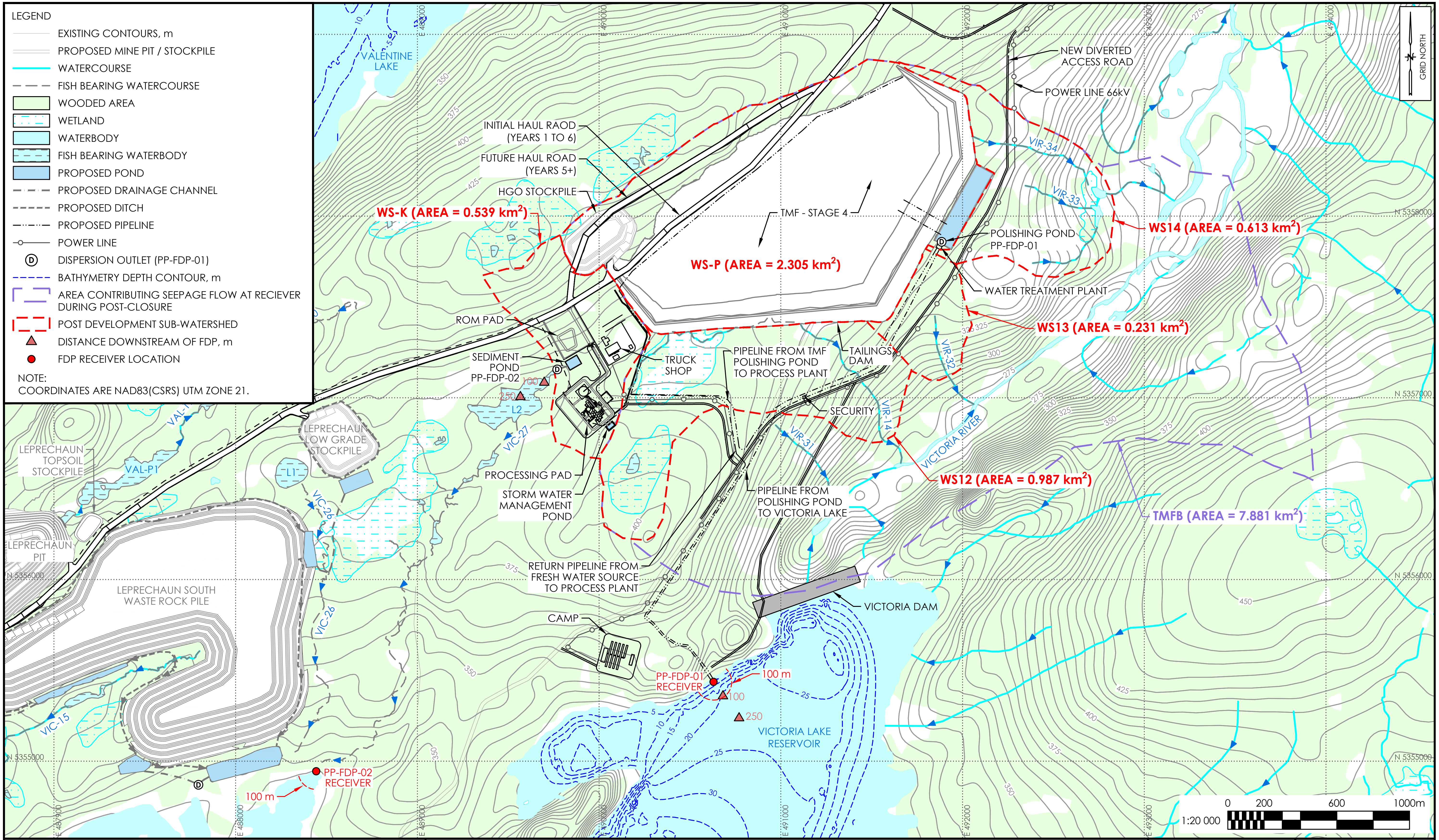
LEPRECHAUN COMPLEX POST DEVELOPMENT WATERSHEDS
ASSIMILATIVE CAPACITY STUDY
VALENTINE GOLD PROJECT, NL

Client: MARATHON GOLD CORP

Job No.:	121416408
Scale:	1 : 12 500
Date:	28-SEP-2020
Dwn. By:	JL
App'd By:	IA
Fig. No.:	1-2

Stantec

V:\1214\active\121416408\03_data\gis_cad\1_CAD\4_Sheet_Files\01_ACS\121416408C_ACS_F1-2.dwg



THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC CONSULTING LTD. REPORT AND MUST NOT BE USED FOR OTHER PURPOSES.

Reference:

1. EXISTING CONTOURS AND PROPOSED INFRASTRUCTURE: AUSENCO; PROJECT No. 104878-01; DRAWING No. 104878-0000-G-001; 2020-05-11; PRELIMINARY.
2. WATERCOURSES, WATERBODIES & WETLANDS: CANVEC DATABASE FROM NATURAL RESOURCES CANADA.
3. FISH BEARING WATERCOURSES AND WATERBODIES: SURVEYED FISH BEARING OR HAS CONNECTIVITY TO FISH BEARING WATER (STANTEC 2012, 2019, 2020).

PROCESSING PLANT AND TMF COMPLEX POST DEVELOPMENT WATERSHEDS

ASSIMILATIVE CAPACITY STUDY
VALENTINE GOLD PROJECT, NL

Client:	MARATHON GOLD CORP
Job No.:	121416408
Scale:	1 : 20 000
Date:	28-SEP-2020
Dwn. By:	JL
App'd By:	IA
Fig. No.:	1-3

Stantec

V:\1214\active\121416408\03_data\gis_cad\1_CAD\4_Sheet_Files\01_ACS\121416408C_ACS_F1-3.dwg

1.2 REGULATORY CRITERIA

The following regulatory criteria were considered in the completion of this AC assessment:

- Effluent limits will be below the MDMER. As per the MDMER, the daily concentrations limits are set at two (2) times the monthly average concentration limits. Effluent limits, which are legally enforceable requirements, will represent the monthly average concentration limits and daily effluent limits.
- Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life (CWQG-FAL; CCME 2003) in the receivers.
- Environmental effects of mine effluent in relation to receiving watercourses or waterbodies baseline water quality to satisfy requirements of the EIS.

2.0 RECEIVING ENVIRONMENT

2.1 HYDROLOGY

A complete description of local hydrological conditions has been provided in the Surface Water Resources VC Chapter 7 of the EIS. For this AC assessment, the hydrology of watercourses and waterbodies receiving discharges at the FDPs, as well as at the ultimate receivers (i.e., Valentine Lake, Victoria Lake Reservoir, and the Victoria River) was considered. The hydrology of the receiving environment was assessed under climate normal and dry discharge conditions. Regional regression relationships, presented in the Surface Water VC, between watershed area and flow were used to estimate the natural flow contribution at each FDP location, as well as at 100 m downstream, 250 m downstream and at the ultimate receivers. The expected average condition was based on the MAF regression relationship. The low flow statistic selected to represent conservative dry conditions was the 7Q10 (i.e., the minimum 7-day average low flow with a recurrence period of 10 years).

Seepage flow out of stockpiles (ore, overburden, and topsoil) and waste rock piles to and from the water management ponds was modelled using GoldSim (Stantec 2020b,c) and was used to represent effluent discharge during a dry condition. Effluent flow during the average discharge conditions was calculated based on the contact areas and regional regressions.

Table 2-1 provides the watershed area, MAF and 7Q10 for the watercourse mixing point of each FDP, 100 m downstream, 250 m downstream, as well as for the ultimate receivers.

Table 2-1: Flow Statistics for Non-Contact Areas During Operation

FDPs	Watershed Area, km^2				MAF, m^3/day				7Q10, m^3/day			
	Mixing Point	100 m D/S	250 m D/S	Receiver	Mixing Point	100m D/S	250 m D/S	Receiver	Mixing Point	100 m D/S	250 m D/S	Receiver
LP-FDP-01	0.51	0.51	0.54	0.89	1,090	1,100	1,159	1,900	49.4	50.3	52.6	85.7
LP-FDP-02	0.13	-	-	0.14	265	-	-	289	11.2	-	-	12
LP-FDP-03	1.12	1.13	1.38	1.98	2,449	2,465	2,990	4,329	117	118	141	209
LP-FDP-04	0.29	0.30	-	0.43	614	626	-	917	27.1	27.6	-	39.9
LP-FDP-05	0.04	0.09	0.25	1.98	77.4	180	514	4,329	3	7.1	21.3	209
MP-FDP-01A	0.65	0.65	0.85	3.38	1,399	1,403	1,814	7,478	64.9	65.1	82.8	373
MP-FDP-01B	0.42	0.44	0.48	3.38	893	932	1,017	7,478	40.4	41.8	45.2	373
MP-FDP-02	0.27	0.30	0.34	0.41	635	318	719	853	27.6	13.2	30.9	36.3
MP-FDP-03	0.85	0.89	0.93	6.79	1,853	1,920	1,997	15,231	87.4	90	93	794
MP-FDP-04	0.90	0.91	1.2	6.79	1,957	1,977	2,590	15,231	92.6	93.3	120	794
PP-FDP-02	0.27	0.56	0.64	4.77	571	1,195	1,362	10,602	25.2	52.7	59.6	539

2.2 BASELINE WATER QUALITY

A complete description of local water quality has been characterized in the Surface Water Resources VC (Chapter 7) of the EIS. For this AC assessment, the water quality of waterbodies receiving discharges directly from FDPs, as well as the ultimate receivers were considered. POPCs have been identified for the Project and include parameters with MDMER discharge limits, common parameters to the processing of the ore rock, and other locally elevated parameters that have a listed CWQG-FAL guideline. Receiving water quality (i.e., background conditions) for the POPCs are summarized in Table 2-2 and Table 2-3 and are considered to be representative of the identified FDPs.

Background concentrations of zinc and phosphorus in Valentine Lake, Victoria River and Victoria Lake Reservoir are above the CWQG-FAL guidelines due to high detection limits of these parameters. Their laboratory analytical results returned a “non-detect” value, but a half detection limit was used for calculations. Therefore, the CWQG-FAL exceedances for zinc and phosphorus are not representative of true concentrations of these parameters. Additionally, fluoride had a detection limit at the CWQG-FAL, that skewed the mixing zone results for fluoride as well. It is recommended to use analytical methods with lower detection limits for these three parameters for future sampling.

The only recorded exceedance of the CWQG-FAL is for arsenic in the Victoria River. The 75th percentile of arsenic concentration in the river water is 103 micrograms per litre (µg/L) while the CWQG-FAL is 100 µg/L.

The CWQG-FAL for zinc is a function of water hardness, pH and DOC. Based on available water quality samples, a limit of 4 µg/L was used for Valentine Lake and Victoria Lake Reservoir and a limit of 10.2 µg/L was used for the Victoria River.

Table 2-2: Baseline Water Quality Data (Ultimate Receivers)

Parameter	**Units**	**MDMER, Max Monthly Mean**	**CWQG-FAL Long-term**	**Detection Limit**[e]	**Valentine Lake**		**Victoria River**		**Victoria Lake Reservoir**	
					Mean	**75th Percentile**	**Mean**	**75th Percentile**	**Mean**	**75th Percentile**
Aluminum (Total)	µg/L	-	100[b]	5.0	14.2	15.0	76.5	**103.3**	47	48
Arsenic (Total)	µg/L	100	5	1.0	0.5	0.5	0.5	0.5	0.5	0.5
Cadmium (Total)	µg/L	-	0.04[b]	0.01	0.005	0.005	0.005	0.005	0.005	0.005
Copper (Total)	µg/L	100	2[b]	0.5	0.52	0.75	0.67	0.70	0.57	0.81
Iron (Total)	µg/L	-	300	50	25	25	167.5	238.8	59.3	70.5
Lead (Total)	µg/L	80	1[b]	0.5	0.25	0.25	0.25	0.25	0.39	0.25
Manganese (Total)	µg/L	-	210	2.0	5.5	6.7	56.5	78.3	9.7	12
Phosphorus (Total)	µg/L	-	4	**100**	**50**	**50**	**50**	**50**	**50**	**50**
Zinc (Total)	µg/L	400	4 &10.2[d]	5.0	2.5	2.5	2.5	2.5	2.5	2.5
Nitrite	µg/L	-	60	0.01	9	12	9	10	14	16
Ammonia (N), total	µg/L	-	689	0.05	25	25	25	25	25	25
Ammonia (N), Unionized	µg/L	500	19	0.01	0.95	0.95	0.95	0.95	0.95	0.95
Cyanide (total)[a]	µg/L	500		20	10	10	10	10	10	10
Cyanide (WAD)[a]	µg/L	-	5 (as free CN)	2.0	1.0	1.0	1.0	1.0	1.0	1.0
Sulfate	µg/L	128,000[c]	-	2,000	1,000	1,000	1,000	1,000	1,000	1,000
Fluoride[a]	µg/L	-	120	120	60	60	60	60	60	60

Notes:

[a] Indicates parameters that do not have baseline water quality data. Mean and 95th percentile concentrations for these parameters outlined in the Water Quantity and Water Quality Modelling reports (Stantec 2020b, c).

[b] Calculated for receiver specific conditions

[c] Sulfate Guideline is for British Columbia Ministry of Environment and Climate Change Strategy (2017) for the protection of aquatic life

[d] 4 µg/L for Valentine Lake and Victoria Lake Reservoir and 10.2 µg/L for the Victoria River (based on hardness, pH and DOC)

[e] Half Detection Limit was used for “non detect” samples

Bold indicates exceedance of CWQG-FAL

Table 2-3: Baseline Water Quality Data (Tributaries)

Parameter	Units	MDMER, Max Monthly Mean	CWQG-FAL Long-term	Valentine Lake Tributaries (MA-FDP-01, 02)		Victoria River Tributaries (MA-FDP-03, 04)		Victoria Lake Reservoir Tributaries (LP-FDP-01 to 04)		Victoria Lake Reservoir Tributaries (LP-FDP-05, PP-FDP-02)	
				Mean	75th Percentile	Mean	75th Percentile	Mean	75th Percentile	Mean	75th Percentile
Aluminum (Total)	µg/L	-	100 [b]	16	19	56	64	**130**	**170**	79	**110**
Arsenic (Total)	µg/L	100	5	0.5	0.5	3.6	4.4	1.1	1.4	3.8	**5.5**
Cadmium (Total)	µg/L	-	0.04 [b]	0.01	0.01	0.01	0.01	0.010	0.012	0.011	0.014
Copper (Total)	µg/L	100	2 [b]	0.61	0.77	0.95	1.00	1.10	1.40	1.20	1.50
Iron (Total)	µg/L	-	300	25	25	173.7	202	290	**390**	210	270
Lead (Total)	µg/L	80	1 [b]	0.25	0.25	0.25	0.25	0.30	0.32	0.25	0.25
Manganese (Total)	µg/L	-	210	5.5	6.4	53	28	200	**300**	150	**220**
Phosphorus (Total)	µg/L	-	4	**50**	**50**	**53**	**50**	**50**	**50**	**62**	**68**
Zinc (Total)	µg/L	400	4 &10.2 [d]	2.5	2.5	3.0	2.5	**4.9**	**6.0**	**4.8**	**6.1**
Nitrite	µg/L	-	60	9.9	12.0	5	5	8	9	5.0	5.0
Ammonia (N), total	µg/L	-	689	25	25	28	25	63	88	53	69
Ammonia (N), Unionized	µg/L	500	19	0.06	0.08	0.1	0.1	0.2	0.2	0.17	0.25
Cyanide (total) [a]	µg/L	500		10	10	10	10	10	10	10	10
Cyanide (WAD) [a]	µg/L	-	5 (as free CN)	1	1	1	1	1	1	1	1
Sulfate	µg/L	128,000 [c]	-	1,000	1,000	1,110	1,000	1,800	2,200	1,400	1,600
Fluoride [a]	µg/L	-	120	60	60	60	60	60	60	60	60

Notes:

a Indicates parameters that do not have baseline water quality data. Mean and 95th percentile concentrations for these parameters outlined in the Water Quantity and Water Quality Modelling reports (Stantec 2020b, c)

b Calculated for receiver specific conditions

c Sulfate Guideline is for British Columbia Ministry of Environment and Climate Change Strategy (2017) for the protection of aquatic life

d 4 µg/L for Valentine Lake and Victoria Lake Reservoir and 10.2 µg/L for the Victoria River (based on hardness, pH and DOC)

Bold indicates exceedance of CWQG-FAL

3.0 EFFLUENT DISCHARGE DURING OPERATION

3.1 EFFLUENT FLOWS

The expected effluent flow rate from each FDP was calculated for both climate normal and dry condition at the FDP mixing point and are shown in Table 3-1. Outflows from the water management ponds were simulated using a GoldSim model as described in the Water Quantity and Water Quality Modelling reports (Stantec 2020b, c).

The climate normal discharge from the water management ponds was used to simulate the average condition. The seepage flow from source stockpiles flowing into and out of the ponds was used to represent discharge during a dry condition, as it was assumed that there was no precipitation during dry conditions.

Table 3-1: FDP Effluent Discharge Flow Rates (Operation)

FDP	Climate Normal Flow Rate (m^3/day)	7Q10 Flow Rate (m^3/day)
LP-FDP-01	712.1	134.5
LP-FDP-02	868.2	85.3
LP-FDP-03	2,259	778.8
LP-FDP-04	257.2	0.8
LP-FDP-05	2,900	1,350
PP-FDP-01	2,753	987.6
PP-FDP-02	571.4	134.5
MP-FDP-01A	1,151	41.8
MP-FDP-01B	200.7	17.8
MP-FDP-02	1,637	213.5
MP-FDP-03	1,186	117.6
MP-FDP-04	4,696	1,898

3.2 EFFLUENT QUALITY

The effluent water quality at each FDP during operation was simulated using a GoldSim model, as described in the Water Quantity and Quality Modelling reports (Stantec 2020b,c). Simulated water quality statistics (mean and 95th percentile) for the POPCs at each FDP are summarized in Table 3-2.

For modeling purposes, the regulatory operating condition for POPC with MDMER limits assumed that predicted water quality of effluent would require treatment prior to discharge. Treated discharge was assumed to have concentrations at the MDMER maximum authorized monthly mean limit. The monthly limit was used for three reasons, including:

- Water management pond water quality design and GoldSim water quality predictions indicated MDMER effluent parameters would not exceed the monthly limit
- The monthly limit is a more conservative lower effluent threshold than the daily limits
- The monthly limit is also better aligned with GoldSim modelled water quality predictions which are based on a monthly model timestep

The effluent water quality for the POPCs without MDMER limits was assumed at the predicted 95th percentile of the GoldSim predicted concentrations. For a normal operating condition, the mean effluent water quality values were assumed for the POPCs as predicted by GoldSim.

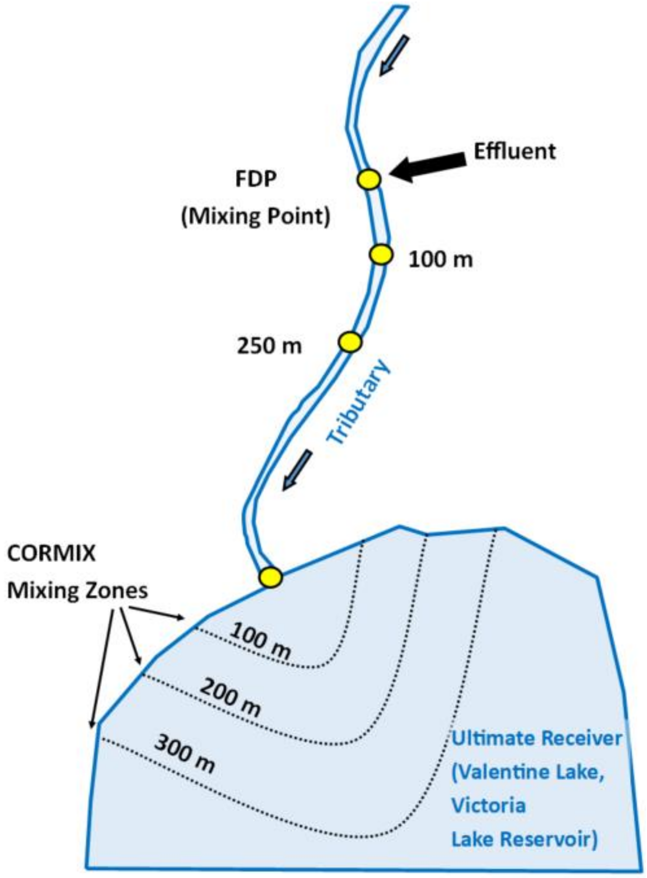
Table 3-2: Predicted FDP Effluent Water Quality - Operation

Parameter	Units	MDMER	LP-FDP-01		LP-FDP-02		LP-FDP-03		LP-FDP-04		LP-FDP-05		PP-FDP-01		PP-FDP-02		MP-FDP-01		MP-FDP-01B		MP-FDP-02		MP-FDP-03		MP-FDP-04	
			Mean	95%	Mean	95%	Mean	95%	Mean	95%	Mean	95%	Mean	95%	Mean	95%	Mean	95%	Mean	95%	Mean	95%	Mean	95%	Mean	95%
Aluminum (Total)	µg/L		600	600	600	600	600	600	190	280	190	260	150	280	150	280	260	300	260	300	600	600	600	600	590	590
Arsenic (Total)	µg/L	100	11.0	13.0	23.0	27.0	22.0	25.0	1.2	2.0	4.3	5.1	6.3	9.0	6.3	9.0	16	21	16	21	24.0	27.0	23	26	10.0	12.0
Cadmium (Total)	µg/L		0.09	0.10	0.10	0.12	0.10	0.11	0.01	0.02	0.02	0.02	0.04	0.05	0.04	0.05	0.07	0.09	0.07	0.09	0.22	0.26	0.22	0.25	0.12	0.14
Copper (Total)	µg/L	100	11	12	32	38	30	35	1	2	5.4	6.5	77	99	77	99	18	20	18	20	71.0	81.0	70	80	35	40
Iron (Total)	µg/L		400	530	800	850	790	850	290	530	460	780	210	360	210	360	350	440	350	440	550	640	540	630	380	600
Lead (Total)	µg/L	80	0.87	0.98	2.3	2.7	2.3	2.7	0.95	1.7	0.46	0.54	0.25	0.25	0.25	0.25	0.73	0.88	0.73	0.88	2.2	2.7	2.1	2.7	1.1	1.4
Manganese (Total)	µg/L		580	630	1,200	1,200	1,100	1,200	200	440	620	1,000	190	310	190	310	340	380	340	380	1,200	1,300	1,200	1,300	620	700
Phosphorus (Total)	µg/L		50	50	50	50	50	50	50	50	50	50	61	79	61	79	50	50	50	50	50	50	50	50	50	50
Zinc (Total)	µg/L	400	29	33	66	76	63	71	13.0	22.0	10.0	12.0	4.8	8	4.8	8	31	59	31	59	140	200	140	200	73	110
Nitrite	µg/L		190	240	440	550	410	510	10	12	140	260	75	120	75	120	130	150	130	150	510	640	490	620	130	200
Ammonia N, Total	µg/L		1,100	1,400	2,400	3,000	2,300	2,800	69	130	970	1,600	4,500	4,500	4,500	4,500	680	830	680	830	2,800	3,500	2,700	3,400	840	1,300
Ammonia N, Unionized	µg/L	500	42	53	91	110	87	110	2.6	4.9	37	61	170	170	170	170	26	32	26	32	110	130	100	130	32	49
Cyanide (Total)	µg/L	500	10	10	11	11	14	14	10	10	10	10	330	480	330	480	13	13	13	13	10	10	10	10	10	10
Cyanide (WAD)	µg/L		1.0	1.0	1.1	1.1	1	1	1.0	1.0	1.2	1.2	16	29	16	29	1.3	1.3	1.3	1.3	1.0	1.0	1.0	1.0	1.0	1.0
Sulfate	µg/L		69,000	81,000	41,000	50,000	37,000	45,000	3,300	4,800	170,000	260,000	450,000	760,000	450,000	760,000	59,000	68,000	59,000	68,000	200,000	240,000	200,000	230,000	130,000	200,000
Fluoride	µg/L		760	810	1,500	1,500	1,400	1,500	60	60	280	320	530	840	530	840	490	510	490	510	1,600	1,600	1,600	1,600	860	940

4.0 WATERCOURSE MIXING ZONE ASSESSMENT

The mixing zone assessment of the watercourses adjacent to the mine site was conducted using the predicted effluent and receiver flows and concentrations. The assessment of the watercourse mixing zones downstream of the FDPs included a review of the effluent quality at set distances (e.g., 100 and 250 m) from the FDPs. Many of the FDPs are located on small tributaries. In these cases, the mixing zone was defined to include the tributary from the FDP to an ultimate receiver downstream (i.e., larger lakes or rivers). In almost all cases, the effluent mixing zone extended into the ultimate downstream lake / river receivers. This is illustrated conceptually on Figure 4-1, which shows the FDP and mixing zone points 100 m and 250 m downstream in a watercourse. Water quality at these mixing zone points was calculated based on dilution ratios of the effluent and the background hydrology for the dry (regulatory) and normal flow conditions. The POPCs were determined at 100 m, 250 m and at the confluence with the ultimate receiver for the dry and climate normal conditions.

Figure 4-1: Conceptual Representation of Mixing Zone Assessment



Mixing zones in the ultimate receivers (i.e., Valentine Lake, Victoria Lake Reservoir, Victoria River) were modelled using CORMIX. The mixing zone boundary (i.e., the location in the ultimate receiver where the water quality will meet the CWQG-FAL once fully mixed) in the ultimate receivers was expected to occur between 100 and 300 m from the outlet of the small tributaries containing FDPs. CORMIX mixing zone assessment boundaries were assigned at 100 and 200 m distances to validate this expectation.

The concentration of the POPCs at the end of the mixing zone is expected to reach the CWQG- FAL or baseline concentrations. The Province of Newfoundland and Labrador is a signatory party to CCME and has supported the establishment of CCME Canadian Environmental Quality Guidelines (CCME 2001), including those for the protection of aquatic life (i.e., CWQG-FAL). Where CWQG- FAL are not available for some discharge parameters, it is recommended that guidelines from other jurisdictions be used. In particular, those established by the British Columbia Ministry of Environment and Climate Change Strategy (2017) are appropriate and were used for sulfate.

Expected water quality for each FDP is summarized in Table 4-1 to Table 4-4.

Table 4-1: Watercourse Mixing Zone Assessment for Leprechaun Complex and Process Plant and TMF Complex FDPs (Regulatory Scenario - Dry Condition)

Parameter, units	CWQG-FAL Long-term	LP-FDP-01			LP-FDP-02			LP-FDP-03			LP-FDP-04			LP-FDP-05			PP-FDP-01			PP-FDP-02		
		100m	250m	At Lake	100m	200m	At Lake	100m	200m	At Lake	100m	200m	At Lake	100m	200m	At Lake	100m	200m	At Lake	100m	200m	At Lake
Aluminum (Total), µg/L	100	483	479	433	542	533	530	543	534	568	173	172	172	259	258	249	210	206	263	232	228	144
Arsenic (Total), µg/L	5	73	72	62	87	85	84	87	85	93	4	3	3	100	99	93	70	68	93	73	71	24
Cadmium (Total), µg/L	0.04	0.09	0.09	0.08	0.11	0.10	0.10	0.11	0.10	0.11	0.01	0.01	0.01	0.02	0.02	0.02	0.04	0.04	0.05	0.04	0.04	0.02
Copper (Total), µg/L	2	73	72	62	87	85	84	87	85	93	4	3	3	99	98	93	70	68	93	72	70	21
Iron (Total), µg/L	300	688	685	640	745	736	733	746	737	769	394	393	392	777	772	742	273	267	338	335	332	288
Lead (Total), µg/L	1	58	58	49	69.3	67.6	67.0	70	68	74	2.4	1.7	1.4	79.6	78.8	74.0	56	54	74	57.5	55.5	16.2
Manganese (Total), µg/L	210	1,028	1,019	911	1,166	1,145	1,137	1,168	1,147	1,225	304	303	302	996	988	942	220	215	288	285	282	238
Phosphorus (Total), µg/L	4	50	50	50	50	50	50	50	50	50	50	50	50	50	50	51	70	70	77	76	76	70
Zinc (Total), µg/L	4-10.2[b]	293	289	247	347	339	336	348	340	370	16	13	11	398	394	370	280	273	370	289	279	85
Nitrite (N), µg/L	60	468	463	394	556	542	537	557	543	593	9	9	9	259	256	241	89	87	112	88	85	28
Ammonia (N), total, µg/L	689	2,571	2,541	2,172	3,044	2,970	2,945	3,051	2,977	3,244	89	89	89	1,592	1,576	1,485	3,150	3,066	4,165	3252	3139	955
Ammonia (N) Unionized, µg/L	19	97.7	96.6	82.5	115.7	112.9	111.9	115.9	113.1	123.3	3.4	3.4	3.4	60.5	59.9	56.4	120	117	158	359	347	100
Cyanide (Total), µg/L	-	367	362	309	434	424	420	436	425	463	23	19	17	497	492	463	352	343	463	13.7	13.2	3.8
Cyanide (WAD), µg/L	5	0.3	0.3	0.4	0.2	0.2	0.2	0.2	0.2	0.1	1.0	1.0	1.0	1.2	1.2	1.2	20.6	20.0	26.9	21.1	20.4	6.6
Sulfate, µg/L	128,000 [a]	39,900	39,443	33,836	47,070	45,951	45,576	47,184	46,060	50,117	2,269	2,247	2,236	258,646	255,979	240,629	531,026	516,767	703,103	546,376	527,102	153,177
Fluoride, µg/L	120	1,181	1,167	1,001	1,394	1,361	1,350	1,397	1,364	1,485	60	60	60	319	316	301	605	590	782	620	600	216

Notes:

- [a] Sulfate Guideline is for British Columbia Ministry of Environment and Climate Change Strategy 2017 for the protection of aquatic life
  [b] 4 µg/L for Valentine Lake and Victoria Lake Reservoir and 10.2 µg/L for the Victoria River (based on hardness, pH and DOC)
- Baseline concentration for some parameters (e.g., aluminum, zinc, iron) are above CWQG-FAL. See Table 2-3.
- Detection limit for Phosphorus is 50 µg/L.

Table 4-2: Watercourse Mixing Zone Assessment for Marathon Complex FDPs (Regulatory Scenario - Dry Condition)

Parameter, units	**CWQG-FAL Long-term**	**MA-FDP-01**			**MA-FDP-1B**			**MA-FDP-02**			**MA-FDP-03**			**MA-FDP-04**		
		100m	**250m**	**At Lake**	**100m**	**200m**	**At Lake**	**100m**	**200m**	**At Lake**	**100m**	**200m**	**At River**	**100m**	**200m**	**At River**
Aluminum (Total), µg/L	100	197	172	73	192	183	88	534	527	516	367	363	449	422	417	333
Arsenic (Total), µg/L	5	39	34	12	30	29	12	89	87	86	59	58	73	96	94	73
Cadmium (Total), µg/L	0.04	0.06	0.05	0.02	0.08	0.07	0.03	0.22	0.22	0.21	0.15	0.14	0.18	0.12	0.12	0.09
Copper (Total), µg/L	2	40	34	13	30	29	13	89	87	86	57	56	72	95	94	72
Iron (Total), µg/L	300	252	220	94	215	204	100	587	580	568	462	458	531	713	706	586
Lead (Total), µg/L	1	31.4	27.0	9.7	24.1	22.8	9.7	70.9	69.9	68.4	45.4	44.8	57.5	76.3	75.2	57.5
Manganese (Total), µg/L	210	377	324	118	393	372	159	1,152	1,137	1,112	749	738	941	997	984	758
Phosphorus (Total), µg/L	4	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Zinc (Total), µg/L	4-10.2[b]	158	136	49	121	115	49	355	350	342	228	224	288	381	376	288
Nitrite (N), µg/L	60	168	146	59	208	198	90	595	587	574	382	376	482	417	411	315
Ammonia (N), total, µg/L	689	903	778	291	1122	1063	460	3,280	3,236	3,166	2,107	2,077	2,662	2,312	2,281	1,747
Ammonia (N) Unionized, µg/L	19	34.3	29.6	11.0	42.6	40.4	17.5	125	123	120	80.1	78.9	101.2	87.9	86.7	66.4
Cyanide (Total), µg/L	-	202	174	68	156	148	68	444	438	429	288	284	362	477	471	362
Cyanide (WAD), µg/L	5	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.1	1.0	1.0	1.0
Sulfate, µg/L	128,000[a]	99,430	85,413	30,758	78,319	74,171	31,623	230,371	227,281	222,376	147,724	145,611	186,852	247,867	244,549	186,852
Fluoride, µg/L	120	410	360	166	520	495	242	1,424	1,405	1,376	932	920	1,165	825	815	636

Notes:

[a] Sulfate Guideline is for British Columbia Ministry of Environment and Climate Change Strategy (2017) for the protection of aquatic life
[b] 4 µg/L for Valentine Lake and Victoria Lake Reservoir and 10.2 µg/L for the Victoria River (based on hardness, pH and DOC)

Table 4-3: Watercourse Mixing Zone Assessment for Leprechaun Complex and Processing Plant and TMF Complex FDPs (Climate Normal and Mean Effluent Concentrations)

Parameter, units	CWQG-FAL Long-term	LP-FDP-01			LP-FDP-02			LP-FDP-03			LP-FDP-04			LP-FDP-05			PP-FDP-01			PP-FDP-02		
		100m	250m	At Lake	100m	200m	At Lake	100m	200m	At Lake	100m	200m	At Lake	100m	200m	At Lake	100m	200m	At Lake	100m	200m	At Lake
Aluminum (Total), µg/L	100	315	309	258	474	456	450	355	332	355	147	143	140	184	173	144	210	206	263	232	228	144
Arsenic (Total), µg/L	5	5.0	4.9	3.8	17.1	16.3	16.0	11.1	10.1	11.1	1.1	1.1	1.1	4.3	4.2	4.1	70	68	93	73	71	24
Cadmium (Total), µg/L	0.04	0.039	0.038	0.030	0.076	0.072	0.071	0.05	0.05	0.05	0.01	0.01	0.01	0.02	0.02	0.02	0.04	0.04	0.05	0.04	0.04	0.02
Copper (Total), µg/L	2	5.0	4.9	3.8	23.7	22.5	22.1	14.9	13.5	14.9	1.1	1.1	1.1	5.2	4.8	3.6	70	68	93	72	70	21
Iron (Total), µg/L	300	333	332	320	663	644	637	529	505	529	290	290	290	445	422	356	273	267	338	335	332	288
Lead (Total), µg/L	1	0.5	0.5	0.5	1.8	1.7	1.7	1.3	1.2	1.3	0.5	0.4	0.4	0	0	0	56	54	74	57.5	55.5	16.2
Manganese (Total), µg/L	210	349	345	304	932	894	881	630	587	630	200	200	200	593	549	424	220	215	288	285	282	238
Phosphorus (Total), µg/L	4	50	50	50	50	50	50	50	50	50	50	50	50	51	52	55	70	70	77	76	76	70
Zinc (Total), µg/L	4-10.2[b]	14	14	11	50	47	47	33	30	33	7.3	6.6	6.3	10	9	8	280	273	370	289	279	85
Nitrite (N), µg/L	60	79	77	58	324	308	302	200	181	200	9	8	8	132	120	84	89	87	112	88	85	28
Ammonia (N), total, µg/L	689	471	458	346	1774	1685	1654	1,133	1,026	1,133	65	64	64	916	832	587	3,150	3,066	4,165	3,252	3,139	955
Ammonia (N) Unionized, µg/L	19	1.3	1.2	0.9	4.8	4.5	4.5	3.1	2.8	3.1	0.2	0.2	0.2	2.5	2.2	1.6	120	117	158	359	347	100
Cyanide (Total), µg/L	-	10	10	10	11	11	11	12	12	12	10	10	10	10	10	10	352	343	463	13.7	13.2	3.8
Cyanide (WAD), µg/L	5	1.0	1.0	1.0	1.1	1.1	1.1	1.2	1.2	1.2	1.0	1.0	1.0	1.2	1.2	1.1	20.6	20.0	26.9	21.1	20.4	6.6
Sulfate, µg/L	128,000[a]	28,212	27,382	20,118	30,495	29,005	28,495	18,633	16,950	18,633	2,237	2,120	2,058	160,150	144,635	99,619	531,026	516,767	703,103	546,376	527,102	153,177
Fluoride, µg/L	120	335	326	251	1114	1059	1041	701	637	701	60	60	60	267	247	188	605	590	782	620	600	216

Notes:

[a] Sulfate Guideline is for British Columbia Ministry of Environment and Climate Change Strategy (2017) for the protection of aquatic life

[b] 4 µg/L for Valentine Lake and Victoria Lake Reservoir and 10.2 µg/L for the Victoria River (based on hardness, pH and DOC)

Table 4-4: Watercourse Mixing Zone Assessment for Marathon Complex FDPs (Climate Normal and Mean Effluent Concentrations)

Parameter, units	CWQG-FAL Long-term	MA-FDP-01			MA-FDP-1B			MA-FDP-02			MA-FDP-03			MA-FDP-04		
		100m	250m	At Lake	100m	200m	At Lake	100m	200m	At Lake	100m	200m	At River	100m	200m	At River
Aluminum (Total), µg/L	100	126	111	53	59	56	53	437	422	400	263	258	207	432	400	204
Arsenic (Total), µg/L	5	7.5	6.5	2.9	3.2	3.1	2.9	8.1	7.8	7.4	11.0	10.8	9.0	8.1	7.7	5.4
Cadmium (Total), µg/L	0.04	0.04	0.03	0.02	0.02	0.02	0.02	0.14	0.13	0.13	0.09	0.09	0.07	0.09	0.08	0.04
Copper (Total), µg/L	2	8.4	7.4	3.3	3.7	3.5	3.3	34.8	33.5	31.8	27.3	26.7	20.2	24.9	22.9	10.4
Iron (Total), µg/L	300	171	151	74	83	79	74	245	237	226	314	310	276	319	307	231
Lead (Total), µg/L	1	0.5	0.4	0.3	0.3	0.3	0.3	1.4	1.4	1.3	1.0	0.9	0.8	0.8	0.8	0.5
Manganese (Total), µg/L	210	156	135	56	65	61	56	628	606	574	491	480	373	452	418	211
Phosphorus (Total), µg/L	4	50	50	50	50	50	50	50	50	50	52	52	52	51	51	52
Zinc (Total), µg/L	4-10.2[b]	15	14	7	8	7	7	94	91	86	55	54	41	52	48	22
Nitrite (N), µg/L	60	64	57	28	31	30	28	16	16	15	190	186	140	93	86	40
Ammonia (N), total, µg/L	689	320	279	125	141	133	125	62	60	59	1,049	1,024	773	600	551	254
Ammonia (N) Unionized, µg/L	19	0.9	0.8	0.3	0.4	0.4	0.3	0.2	0.2	0.2	2.8	2.8	2.1	1.6	1.5	0.7
Cyanide (Total), µg/L	-	11	11	10	11	10	10	10	10	10	10	10	10	10.0	10.0	10.0
Cyanide (WAD), µg/L	5	1.1	1.1	1.0	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Sulfate, µg/L	128,000[a]	27,142	23,521	9,829	11,280	10,556	9,829	101,152	97,593	92,397	77,068	75,220	56,520	91,819	84,179	37,018
Fluoride, µg/L	120	254	227	125	136	131	125	1,025	991	941	648	634	489	623	576	283

Notes:

[a] Sulfate Guideline is for British Columbia Ministry of Environment and Climate Change Strategy (2017) for the protection of aquatic life
[b] 4 µg/L for Valentine Lake and Victoria Lake Reservoir and 10.2 µg/L for the Victoria River (based on hardness, pH and DOC)

5.0 MIXING ZONE ASSESSMENT FOR ULTIMATE RECEIVERS

An AC assessment for the three ultimate receivers of Valentine Lake, Victoria Lake Reservoir, and the Victoria River was completed to determine the assimilative capacity and mixing potential of the FDPs during the operation phase of the Project. As discussed in Section 4.0, the assimilative capacity in the ultimate receivers is based on the water quality at the outlet of the tributaries receiving effluent from the FDPs, with the exception of the FDP associated with the polishing pond in Victoria Lake Reservoir (PP-FDP-01).

Near-field modelling of mixing in the ultimate receivers was performed using CORMIX, Version 11.0. CORMIX is a United States Environmental Protection Agency supported mixing zone model and decision support system for environmental impact assessment of regulatory mixing zones resulting from point source discharges (Doneker and Jirka 2017). The system can be used for the analysis, prediction, and design of aqueous toxic or conventional effluent discharges into diverse waterbodies. The major emphasis is on the geometry and dilution / assimilation characteristics of the initial mixing zone. The basic CORMIX methodology relies on the assumption of steady state ambient conditions, meaning CORMIX generates an instantaneous prediction of the effluent plume or mixing zone from the discharge point. The near-field CORMIX model incorporates effluent outfall design and provides a high resolution of effluent mixing.

5.1 MODEL INPUTS

The required model inputs for the receiving environment include water temperature, flow velocity, and water depth. Average water depths for the outfall locations and over the plume length were estimated based on available bathymetry information.

Bottom roughness in CORMIX is expressed as Manning's "n" and converted internally to a friction factor based on average water depth. The friction factor has limited impact on modelling results and is important only for far-field diffusion. A Manning's n value of 0.035 was selected for use in the model based on available information about bottom sediments.

Wind is not a sensitive variable in near-field mixing modelling. Wind is non-directional in CORMIX and it is used for surface heat transfer and ambient mixing only. A mean annual wind speed of 3.8 m/s was used in the model and it was derived based on CALMET data for 2017-2019 (EC 2020).

The receiving water and effluent were assumed to be freshwater with an average annual water temperature of 9 degrees Celsius (°C), based on data from water quality stations NF02YO0107 and NF02YN0001 (NLDMAE 2019).

The CORMIX methodology contains systems to model single-port discharge, multiport diffuser discharges, and surface discharge sources. The surface discharge option was selected for FDPs discharging to tributaries before outflowing to the ultimate receivers (Valentine Lake, Victoria Lake Reservoir, Victoria River). The single port discharge option was selected for the outfall pipe from the polishing pond (PP-FDP-01) to Victoria Lake Reservoir. Effluent flow rate from the polishing pond was 237,600 m^3/day (2.75 cubic metres per second), which represents the 95th percentile flow from the water treatment plant over 10 years.

CORMIX requires input parameters, which characterize the effluent, ambient environment, and outfall design and are summarized for the three model locations in Table 5-1.

The conservative modeling conditions are based on maximum effluent concentrations, low flow (7Q10) conditions in the receiving environment and assuming no contaminant decay, sedimentation, and reduction/oxidation kinetics in the mixing zones.

Table 5-1: CORMIX Input Data

Parameter, units	**MA-FDP-01**	**MA-FDP-02**	**MA-FDP-03/04**	**LP-FDP-01**	**LP-FDP-02**	**LP-FDP-03/05**	**LP-FDP-04**	**PP-FDP-01**	**PP-FDP-02**	**Comments**
Receiver	Valentine Lake	Valentine Lake	Victoria River	Victoria Lake Reservoir	Victoria Lake Reservoir	Victoria Lake Reservoir	Victoria Lake Reservoir	Victoria Lake Reservoir	Victoria Lake Reservoir	
7Q10 Effluent Flow at Receiver, m^3/day	59.6	214	2,016	135	85	2,129	0.75	988	135	Pond Seepage at Dry Conditions
7Q10 Total Flow at Receiver, m^3/day	433	250	2,810	220	97	2,338	41	237,859	673	Regional Regression and Max ETP pumping rate
Mean Effluent Flow at Receiver, m^3/day	1,352	1,637	5,882	712	868	5,159	257	2,753	571	Regional Regression
Mean Total Flow at Receiver, m^3/day	8,830	2,489	21,114	2,612	1,157	9,488	1,174	61,554	11,174	Regional Regression
Effluent and Receiver Water Temperature, ˚C	9	9	9	9	9	9	9	9	9	Average annual temperature at NF02YO0107 and NF02YN0001
Receiver Depth at Discharge, m	1	1	1	1	1	1	1	10	1	Assumed per Bathymetry information
Receiver Average Depth in Mixing Zone, m	1.3	1.3	1	1.3	1.3	1.3	1.3	13	1.3	30% increase from Depth at Discharge for CORMIX stability
Receiver Width, m	unbounded	unbounded	50	unbounded	unbounded	unbounded	unbounded	unbounded	unbounded	
Receiver 7Q10 Flow, m^3/day			527,040							MAF in Victoria River at the boundary of the LAA
Receiver Velocity, m/s	0.02	0.02		0.02	0.02	0.02	0.02	0.02	0.02	Conservative Current Velocity in Lake.

Table 5-1: CORMIX Input Data

Parameter, units	MA-FDP-01	MA-FDP-02	MA-FDP-03/04	LP-FDP-01	LP-FDP-02	LP-FDP-03/05	LP-FDP-04	PP-FDP-01	PP-FDP-02	Comments
Manning's n	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	Assumed based on bottom roughness
Horizontal Angle (sigma)	90º	90º	90º	90º	90º	90º	90º	90º	90º	Angle between the dominant ambient current direction to the plan projection of the outfall channel
Bottom slope at discharge, %	1	1	1	1	1	1	1	1	1	Estimates slope at outfall
Average Wind Speed, m/s	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	CALMET data for 2017-2019
Discharge outlet width, m	1	1	1	1	1	1	1	---	1	Outfall channel: 1 m wide and slopes 2:1

5.2 MODEL RESULTS

For presentation purposes, the initial effluent concentration for an arbitrary parameter prior to discharge was assigned at 100 milligrams per litre (mg/L). The dilution ratios in the near-field mixing zone were calculated in CORMIX based on this effluent concentration. The dilution ratios were multiplied by the baseline concentrations for the POPCs to calculate concentrations at various distances from the outfall.

The extent of the mixing zones in the ultimate receivers were determined in terms of dilution ratios for the maximum effluent flow rate expected to enter each receiving waterbody. Table 5-2 and Table 5-3 summarize the dilution ratios expected in each receiving waterbody under the regulatory and normal flow scenarios.

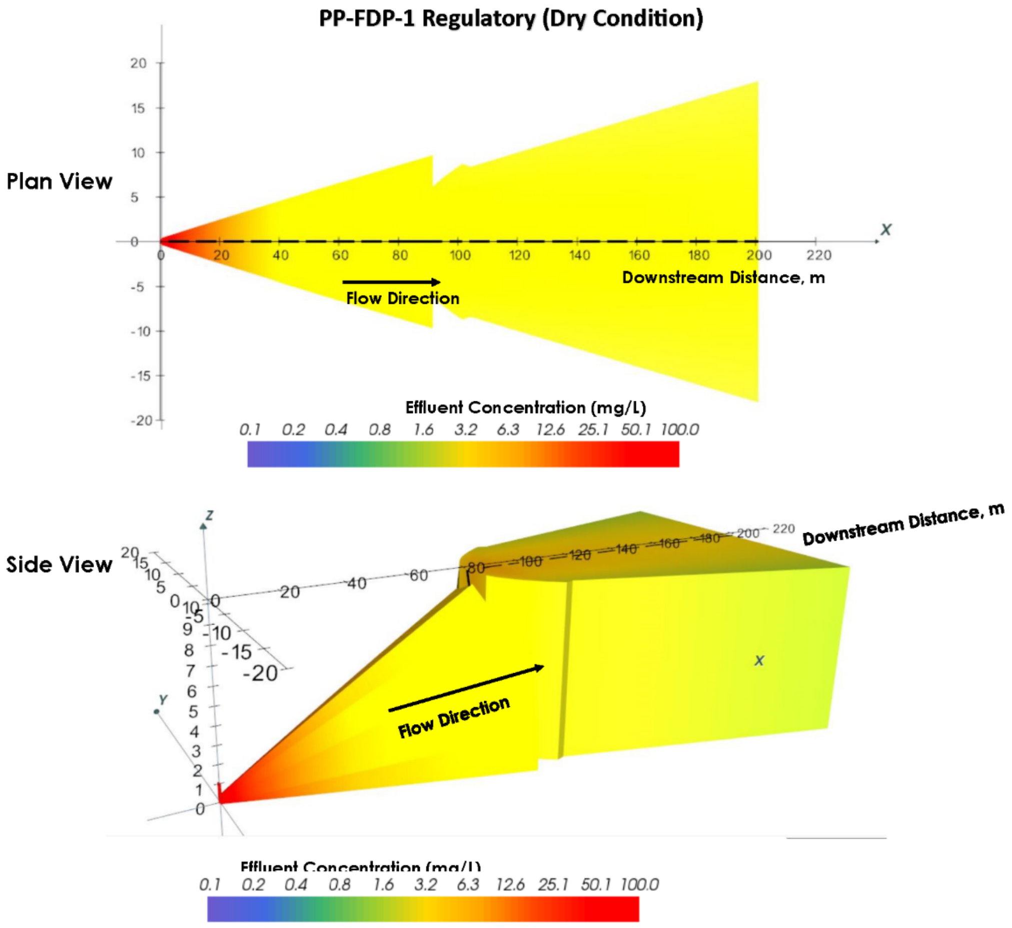
Expected water quality at 100 m from the discharge point in the three ultimate receivers for the POPCs is listed in Table 5-4 and Table 5-6. Expected water quality at 200 m is listed in Table 5-5 and Table 5-7.

Figure 5-1 and Figure 5-2 present the plan and side views of the simulated effluent plume concentration discharged from the outfall (location PP-FDP-1) at a water depth of 10 m, assuming an initial effluent concentration of 100 mg/L for an arbitrary parameter prior to discharge.

For the regulatory scenario at the Leprechaun Complex and Process Plant and TMF Complex, water quality within the first 100 m of the mixing zone meets the CWQG-FAL at most FDPs. The only exception is the combined effluent from LP-FDP-03 and LP-FDP-05, which has potential exceedances for arsenic, copper, lead, zinc and fluoride. These exceedances are due to elevated background concentrations in the tributaries, conservative assumptions of effluent flow and lower assimilative capacity of the watercourse. Additionally, the effluent concentrations were assumed at the MDMER monthly limits, which are higher than the predicted concentrations in the effluent discharge during operation. For average flow conditions at the Leprechaun Complex and Process Plant and TMF Complex, the marginal exceedance at the end of the mixing zone is noted only for zinc. The main reason for the exceedance is that zinc has elevated background concentrations in the tributaries, and it was conservatively assumed in the effluent at the MDMER monthly limit. Based on extrapolated dilution ratios for the regulatory scenario and average conditions, the ultimate extent of the mixing zone is expected to extend approximately 300 m from the outfall. At this distance, all parameters will meet the CWQG-FAL.

The Marathon Complex has exceedances for zinc at 100 and 200 m into the mixing zone for MA-FDP-02, and MA-FDP-03/04 for both the regulatory and average flow conditions. Also, exceedances for aluminum, iron and manganese were observed in the combined effluent from MA-FDP-03 and MA-FDP-04 in the regulatory scenario. These exceedances are due to conservative assumptions of the effluent flow and lower assimilative capacity of the watercourses. Additionally, the effluent concentrations were assumed at the MDMER monthly limits, which is a conservative assumption. Based on extrapolated dilution ratios for the average flow conditions, the ultimate extent of the mixing zone is expected to extend approximately 300 m from the outfall. At this distance, all parameters will meet the CWQG-FAL.

Figure 5-1: CORMIX Results for PP-FDP-1 Regulatory Scenario (Dry Conditions)



Dilution vs Downstream Distance

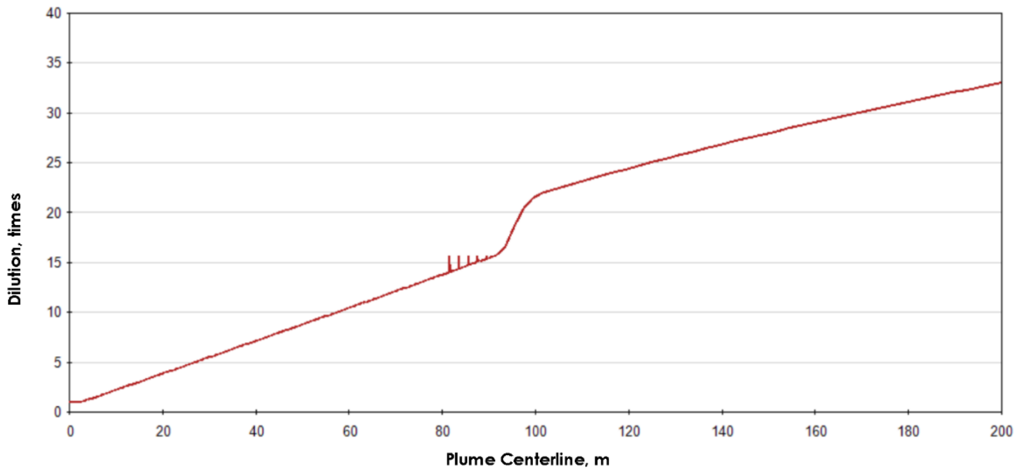
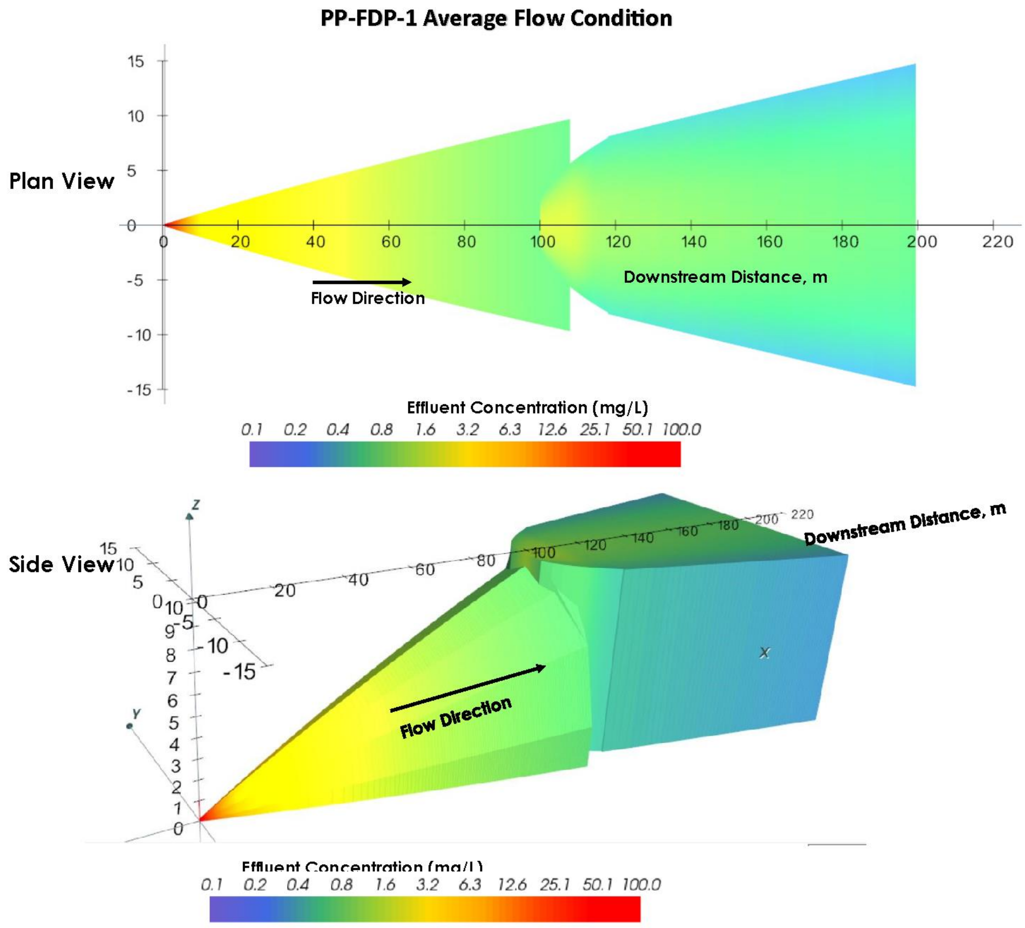
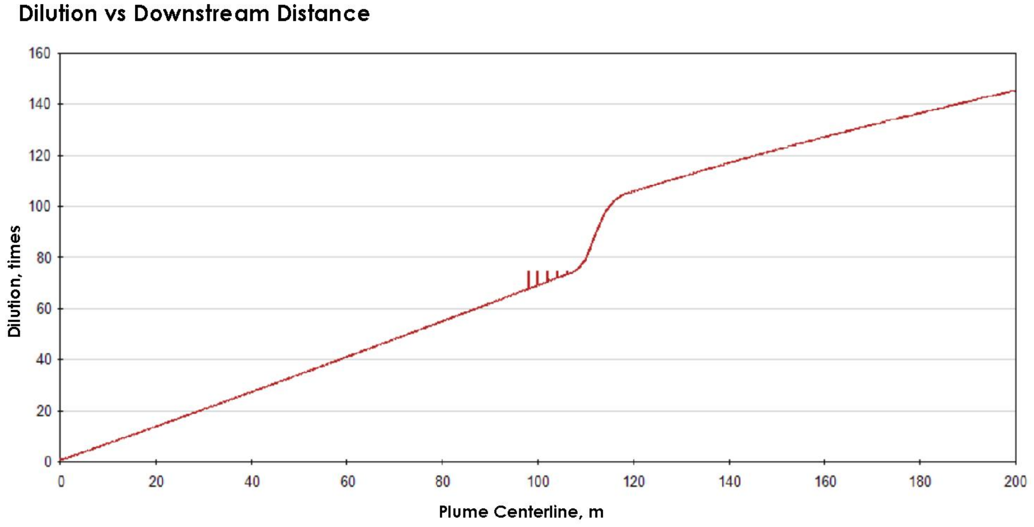


Figure 5-2: CORMIX Results for PP-FDP-1 Average Flow Scenario



PP-FDP-1 Average Flow Condition



Dilution vs Downstream Distance

Table 5-2: CORMIX Dilution Ratios for Regulatory Scenario (Dry Conditions)

Distance from Outfall	MA-FDP-01	MA-FDP-02	MA-FDP-03/04	LP-FDP-01	LP-FDP-02	LP-FDP-03/05	LP-FDP-04	PP-FDP-01	PP-FDP-02
5 m	7.4	5.3	7.6	5.1	6.0	6.5	26.9	1.4	8.5
10 m	10.1	6.5	10.4	6.5	11.0	7.2	79.9	2.2	9.5
25 m	12.2	17.1	12.5	22.1	80.8	10.5	219	4.7	11.3
50 m	32.2	63.4	15.7	76.6	206	13.8	506	8.8	14.9
75 m	64.7	121	16.7	144	365	15.9	869	13.0	29.2
100 m	103	189	17.6	223	551	17.3	1,289	22.0	51.6
150 m	197	353	19.3	413	994	18.9	2,278	27.8	107.7
200 m	307	547	20.9	639	1,513	20.1	3,435	33.2	175.9

Table 5-3: CORMIX Dilution Ratios for Average Conditions

Distance from Outfall	MA-FDP-01	MA-FDP-02	MA-FDP-03/04	LP-FDP-01	LP-FDP-02	LP-FDP-03/05	LP-FDP-04	PP-FDP-01	PP-FDP-02
5 m	7.6	6.4	6.6	6.6	7.1	7.7	7.0	3.9	7.9
10 m	8.4	7.2	7.2	7.2	7.8	8.5	7.8	7.2	8.7
25 m	11.0	10.6	8.6	10.6	10.5	11.1	10.5	17.2	11.1
50 m	14.1	13.9	11.2	13.9	13.5	14.1	13.5	34.2	14.1
75 m	16.3	15.9	13.1	16.0	15.4	16.3	15.4	51.6	16.2
100 m	17.9	17.4	14.6	17.5	17.4	17.9	17.3	82.0	17.8
150 m	19.9	19.0	16.8	19.2	31.8	19.9	30.1	111	19.9
200 m	21.0	20.0	18.5	20.1	64.8	21.1	62.3	132	21.1

Table 5-4: Results of CORMIX Modeling at the End of 100 m Mixing Zone of the Receiver (Leprechaun Complex and Process Plant and TMF Complex)

Parameter, units	CWQG-FAL Long-term	75th Percentile Baseline in Victoria Lake	Dry Conditions				Mean Baseline in Victoria Lake	Average Conditions			
			LP-FDP-01	LP-FDP-02	LP-FDP-03/05	LP-FDP-04		LP-FDP-01	LP-FDP-02	LP-FDP-03/05	LP-FDP-04
Aluminum (Total), µg/L	100	48	50	49	78	48	47	59	70	67	48
Arsenic (Total), µg/L	5	0.5	0.8	0.7	**5.8**	0.5	0.5	0.7	1.4	1.2	0.5
Cadmium (Total), µg/L	0.04	0.005	0.01	0.01	0.01	0.005	0.005	0.006	0.009	0.008	0.005
Copper (Total), µg/L	2	0.81	1.1	1.0	**6.1**	0.8	0.57	0.8	1.8	1.5	0.8
Iron (Total), µg/L	300	70.5	73	72	111	71	59.3	74	93	88	71
Lead (Total), µg/L	1	0.25	0.5	0.4	**4.5**	0.3	0.39	0.4	0.5	0.5	0.3
Manganese (Total), µg/L	210	12	16	14	82	12	9.7	26	60	50	12
Phosphorus (Total), µg/L	4	50	50	50	50	50	50	50	50	50	50
Zinc (Total), µg/L	4-10.2[b]	2.5	4	3	**23.8**	3	2.5	3.0	**5.0**	**4.5**	3
Nitrite (N), µg/L	60	16	18	17	49	16	14	16	31	27	16
Ammonia (N), total, µg/L	689	25	35	30	211	25	25	43	119	100	25
Ammonia (N) Unionized, µg/L	19	0.95	1.3	1.2	8.0	1.0	0.95	0.1	0.3	0.3	1.0
Cyanide (Total), µg/L	-	10	11	11	36	10	10	10	10	10	10
Cyanide (WAD), µg/L	5	1.0	1.0	1.0	0.9	1.0	1.0	1.0	1.0	1.0	1.0
Sulfate, µg/L	128,000 [a]	1,000	1,147	1,081	3,839	1,001	1,000	2,092	2,580	2,190	1,000
Fluoride, µg/L	120	60	64	62	**142**	60	60	71	116	104	60

Notes:

[a] Sulfate Guideline is for British Columbia Ministry of Environment and Climate Change Strategy 2017 for the protection of aquatic life
[b] 4 µg/L for Valentine Lake and Victoria Lake Reservoir and 10.2 µg/L for the Victoria River (based on hardness, pH and DOC)
Bold indicates exceedance of CWQG-FAL

Table 5-5: Results of CORMIX Modeling at the End of 200 m Mixing Zone of the Receiver (Leprechaun Complex and Process Plant and TMF Complete

Parameter, units	CWQG-FAL Long-term	75th Percentile Baseline in Victoria Lake Reserv.	Dry Conditions				Mean Baseline in Victoria Lake Reserv.	Average Conditions			
			LP-FDP-01	LP-FDP-02	LP-FDP-03/05	LP-FDP-04		LP-FDP-01	LP-FDP-02	LP-FDP-03/05	LP-FDP-04
Aluminum (Total), µg/L	100	48	49	48	74	48	47	58	53	64	48
Arsenic (Total), µg/L	5	0.5	0.6	0.6	**5.1**	0.5	0.5	0.7	0.7	1.1	0.5
Cadmium (Total), µg/L	0.04	0.005	0.01	0.01	0.01	0.005	0.005	0.006	0.006	0.008	0.005
Copper (Total), µg/L	2	0.81	0.9	0.9	**5.4**	0.8	0.57	0.7	0.9	1.4	0.6
Iron (Total), µg/L	300	70.5	71	71	105	71	59.3	72	68	84	63
Lead (Total), µg/L	1	0.25	0.3	0.3	**3.9**	0.3	0.39	0.4	0.4	0.4	0.4
Manganese (Total), µg/L	210	12	13	13	72	12	9.7	24	23	44	13
Phosphorus (Total), µg/L	4	50	50	50	50	50	50	50	50	50	50
Zinc (Total), µg/L	4-10.2[b]	2.5	3	3	**20.8**	3	2.5	2.9	3.2	**4.2**	2.6
Nitrite (N), µg/L	60	16	17	16	45	16	14	16	18	25	14
Ammonia (N), total, µg/L	689	25	28	27	185	25	25	41	50	89	26
Ammonia (N) Unionized, µg/L	19	0.95	1.1	1.0	7.0	1.0	0.95	0.1	0.1	0.2	0.1
Cyanide (Total), µg/L	-	10	10	10	33	10	10	10	10	10	10
Cyanide (WAD), µg/L	5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Sulfate, µg/L	128,000 [a]	1000	1,051	1,029	3,444	1,000	1,000	1,951	1,424	2,010	1,017
Fluoride, µg/L	120	60	61	61	**131**	60	60	69	75	97	60

Notes:

[a] Sulfate Guideline is for British Columbia Ministry of Environment and Climate Change Strategy 2017 for the protection of aquatic life
[b] 4 µg/L for Valentine Lake and Victoria Lake Reservoir and 10.2 µg/L for the Victoria River (based on hardness, pH and DOC)

Table 5-6: Results of CORMIX Modeling at the End of 100 m Mixing Zone of the Receiver (Marathon Complex)

Parameter, Units	CWQG-FAL Long-term	75th Percentile Baseline Valentine Lake	75th Percentile Baseline Victoria River	Dry Conditions				Mean Baseline Valentine Lake	Mean Baseline Victoria River	Average Conditions			
				MA-FDP-01	MA-FDP-01B	MA-FDP-02	MA-FDP-03/04			MA-FDP-01	MA-FDP-01B	MA-FDP-02	MA-FDP-03/04
Aluminum (Total), µg/L	100	15.0	**103.3**	16	16	18	**123**	14.2	76.5	16	16	36	85
Arsenic (Total), µg/L	5	0.5	0.5	0.6	1	1	5	0.5	0.5	0.6	0.6	0.9	1.1
Cadmium (Total), µg/L	0.04	0.005	0.005	0.005	0.01	0.01	0.02	0.005	0.005	0.006	0.006	0.012	0.009
Copper (Total), µg/L	2	0.75	0.7	1	1	1	**4.8**	0.52	0.67	0.7	0.7	2.3	2.0
Iron (Total), µg/L	300	25	239	26	26	28	255	25	167.5	28	28	37	175
Lead (Total), µg/L	1	0.25	0.25	0.3	0.3	0.6	**3.5**	0.25	0.25	0.3	0.3	0.3	0.3
Manganese (Total), µg/L	210	6.7	78.3	8	8	13	127	5.5	56.5	8	8	38	78
Phosphorus (Total), µg/L	4	50	50	50	50	50	50	50	50	50	50	50	50
Zinc (Total), µg/L	4-10.2[b]	2.5	2.5	3	3	4	**18.7**	2.5	2.5	3	3	**7**	**5**
Nitrite (N), µg/L	60	12	10	12	13	15	37	9	9	10	10	9	18
Ammonia (N), total, µg/L	689	25	25	28	29	42	175	25	25	31	31	27	76
Ammonia (N) Unionized, µg/L	19	0.95	0.95	1.0	1.1	1.6	6.6	0.95	0.95	0.1	0.1	0.1	0.2
Cyanide (Total), µg/L	-	10	10	11	11	12	30	10	10	10	10	10	10
Cyanide (WAD), µg/L	5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Sulfate, µg/L	128,000 [a]	1,000	1,000	1,289	1,297	2,171	11,560	1,000	1,000	1,493	1,493	6,253	4,803
Fluoride, µg/L	120	60	60	61	62	67	123	60	60	64	64	111	89

Notes:

[a] Sulfate Guideline is for British Columbia Ministry of Environment and Climate Change Strategy 2017 for the protection of aquatic life

[b] 4 µg/L for Valentine Lake and Victoria Lake Reservoir and 10.2 µg/L for the Victoria River (based on hardness, pH and DOC)

Bold indicates exceedance of CWQG-FAL

Table 5-7: Results of CORMIX modeling at the end of 200 m Mixing Zone of the Receiver (Marathon Complex)

Parameter, Units	CWQG-FAL Long-term	75th Percentile Baseline Valentine Lake	75th Percentile Baseline Victoria River	Dry Conditions				Mean Baseline Valentine Lake	Mean Baseline Victoria River	Average Conditions			
				MA-FDP-01	MA-FDP-01B	MA-FDP-02	MA-FDP-03/04			MA-FDP-01	MA-FDP-01B	MA-FDP-02	MA-FDP-03/04
Aluminum (Total), µg/L	100	15.0	**103.3**	15	15	16	**120**	14.2	76.5	16	16	33	84
Arsenic (Total), µg/L	5	0.5	0.5	0.5	1	1	4	0.5	0.5	0.6	0.6	0.8	1.0
Cadmium (Total), µg/L	0.04	0.005	0.005	0.005	0.01	0.01	0.01	0.005	0.005	0.006	0.006	0.011	0.008
Copper (Total), µg/L	2	0.75	0.7	1	1	1	**4**	0.52	0.67	0.7	0.7	2.1	1.7
Iron (Total), µg/L	300	25	239	25	25	26	253	25	167.5	27	27	35	173
Lead (Total), µg/L	1	0.25	0.25	0.3	0.3	0.37	**3.0**	0.25	0.25	0.3	0.3	0.3	0.3
Manganese (Total), µg/L	210	6.7	78.3	7	7	9	120	5.5	56.5	8	8	34	74
Phosphorus (Total), µg/L	4	50	50	50	50	50	50	50	50	50	50	50	50
Zinc (Total), µg/L	4 -10.2[b]	2.5	2.5	3	3	3	**16**	2.5	2.5	3	3	**7**	**5**
Nitrite (N), µg/L	60	12	10	12	12	13	33	9	9	10	10	9	16
Ammonia (N), total, µg/L	689	25	25	26	26	31	151	25	25	30	30	27	65
Ammonia (N) Unionized, µg/L	19	0.95	0.95	1.0	1.0	1.2	5.7	0.95	0.95	0.1	0.1	0.1	0.2
Cyanide (Total), µg/L	-	10	10	10	10	11	27	10	10	10	10	10	10
Cyanide (WAD), µg/L	5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Sulfate, µg/L	128,000 [a]	1,000	1,000	1,097	1,100	1,405	9,892	1,000	1,000	1,420	1,420	5,570	4,001
Fluoride, µg/L	120	60	60	60	61	62	113	60	60	63	63	104	83

Notes:

[a] Sulfate Guideline is for British Columbia Ministry of Environment and Climate Change Strategy 2017 for the protection of aquatic life

[b] 4 µg/L for Valentine Lake and Victoria Lake Reservoir and 10.2 µg/L for the Victoria River (based on hardness, pH and DOC)
Bold indicates exceedance of CWQG-FAL

6.0 POST-CLOSURE

The AC assessment was also completed for the closure period of the decommissioning, rehabilitation and closure phase of the Project and post-closure. During the closure period of this phase of the Project, where feasible, excess runoff from the TMF, waste rock piles, and other stockpiles (while present) will be directed to the Leprechaun and Marathon pits to accelerate filling. During the closure period, waste rock piles and the TMF will be rehabilitated with vegetated covers representing a period of water quality and Project transition. Post-closure, seepage and runoff quality will stabilize to more predictable conditions. Thus, the AC assessment extended out to post-closure conditions to represent water management pond effluent conditions when the pits fill and overflow, and waste rock piles and TMF are rehabilitated.

A description of local hydrological conditions during post-closure is presented in the water management plan (Stantec 2020a). The hydrology of watercourses and waterbodies receiving seepage and overflow from the TMF, waste rock piles and both pits and discharging to the ultimate receivers of Valentine Lake, Victoria River and Victoria Lake Reservoir were considered.

The hydrology of the receiving environment was assessed under climate normal conditions (Table 6-1). Regional regression relationships, presented in the Surface Water Resources VC (Chapter 7 of the EIS) between watershed area and flow were used to estimate the natural flow contribution.

Groundwater seepage quality discharging from the base of the Project components was conservatively modelled using GoldSim for the TMF and Marathon and Leprechaun waste rock piles (Stantec 2020a). Overflow discharging from the Marathon and Leprechaun pits were also simulated using GoldSim.

Table 6-1: Hydrology of Project Elements during Post-Closure

Project Component	Receiver	Contact Water, m^3/day	Non-Contact Surface Water, m^3/day	Dilution Ratio, times
TMF Seepage	Victoria River	1,611	18,875	11.7
Marathon Waste Rock Pile	Victoria River	1,898	18,771	9.9
Leprechaun Waste Rock Pile	Victoria Lake Reservoir	650	12,250	18.8
Marathon Pit	Victoria River	1,898	18,771	9.9
Leprechaun Pit	Victoria Lake Reservoir	468	11,804	25.2

Results of the post-closure mixing zone assessment for the ultimate receivers are presented in Table 6-2. The results indicate that the TMF seepage meets the CWQG-FAL. Also, overflow from the Leprechaun pit and Marathon pit meets CWQG-FAL at the end of the mixing zone at the ultimate receiver locations.

At the downstream end of the mixing zone, the seepage from the Marathon waste rock pile exceeded the CWQG-FAL for aluminum, copper and fluoride. Similarly, the seepage from the Leprechaun waste rock pile results in CWQG-FAL exceedances for zinc and fluoride at the end of the mixing zone. Mitigation measures may be required for the waste rock piles. For example, perimeter ditches can be maintained to collect seepage and to treat it passively in a constructed wetland or permeable reactive barrier and discharge as surface water.

Table 6-2: Results of Mixing Zone Assessment, Post-Closure

Parameter	CWQG-FAL Long-term	Receiver - Victoria River							Receiver - Victoria Lake Reservoir				
		Baseline	TMF Seepage	TMF in Receiver	Marathon WRP	Marathon WRP in Receiver	Marathon Pit	Marathon Pit in Receiver	Baseline	Leprechaun WRP	Leprechaun WRP at Receiver	Leprechaun Pit	Leprechaun Pit at Receiver
Aluminum (Total), µg/L	100	76.5	3.5	70.3	**600**	**129**	**120**	80.9	47	**600**	76.3	26	46.2
Arsenic (Total), µg/L	5	0.5	0.2	0.5	**8.8**	1.3	2.2	0.7	0.5	4.1	0.7	0.5	0.5
Cadmium (Total), µg/L	0.04	0.005	0.001	0.005	**0.200**	0.025	0.015	0.006	0.005	0.059	0.008	0.014	0.005
Copper (Total), µg/L	2	0.7	3.7	0.9	**48**	**5.5**	2	0.8	0.6	**15**	1.3	**19**	1.3
Iron (Total), µg/L	300	168	8.9	154.0	180	169	320	183	59	210	67	110	61.3
Lead (Total), µg/L	1	0.25	0.01	0.2	**2.1**	0.4	0.23	0.2	0.39	0.32	0.4	0.09	0.4
Manganese (Total), µg/L	210	57	7.4	52	**940**	146	200	71	10	**510**	36	190	17
Phosphorus (Total), µg/L	4	50	2.4	45.9	50	50	50	50	50	50	50	47	50
Zinc (Total), µg/L	4-10 [b]	2.5	0.21	2.3	**71.0**	9.4	5.3	2.8	2.5	**39**	**4.4**	1.5	2.5
Nitrite (N), µg/L	60	9	3.5	8.5	10	9.1	91	17	14	0.9	13.3	28	14.6
Ammonia (N), total, µg/L	689	25	92.9	30.8	32	25.7	130	35.6	25	5.1	23.9	**1,700**	91.4
Ammonia (N) Unionized, µg/L	19	0.95	3.5	0.08	3.5	0.07	14	0.10	0.95	0.56	0.06	**190**	0.25
Cyanide (Total), µg/L	-	10	3.1	9.4	10	10.0	8.7	9.9	10	0.22	9.5	2.6	9.7
Cyanide (WAD), µg/L	5	1.0	2.5	1.1	1.0	1.0	0.9	1.0	1.0	0.0	0.9	0.4	1.0
Sulfate, µg/L	128,000 [a]	1,000	3,640	1,225	**170,000**	18,088	49,000	5,853	1,000	4,200	1,170	**130,000**	6,114
Fluoride, µg/L	120	60	7	56	**1,600**	**216**	69	61	60	**1,600**	**142**	**190**	65

Notes:

[a] Sulfate Guideline is for British Columbia Ministry of Environment and Climate Change Strategy 2017 for the protection of aquatic life

[b] 4 µg/L for Valentine Lake and Victoria Lake Reservoir and 10.2 µg/L for the Victoria River (based on hardness, pH and DOC)

Bold indicates exceedance of CWQG-FAL

7.0 CONCLUSIONS

An assimilative capacity assessment was completed for the operation phase and post-closure conditions of the Project. These phases are anticipated to represent the worst-case conditions with respect to effluent quality. The assimilative capacity assessment was completed for the Project's effluent FDPs at the three ultimate receivers (i.e., Victoria Lake Reservoir, Valentine Lake and Victoria River). The assessment at ultimate receivers was conducted using the near-field mixing model (i.e., CORMIX).

Water quality in the mixing zone was assessed under regulatory and normal conditions. The regulatory operating conditions are considered worst case and conservative, while normal operating conditions are considered representative of the expected average discharge conditions.

For the Leprechaun Complex and Process Plant and TMF Complex, water quality at the end of the 100 m mixing zone for the regulatory scenario meets the CWQG-FAL for the most FDPs except for the combined effluent from LP-FDP-03 and LP-FDP-05, which has potential exceedances for arsenic, copper, lead, zinc and fluoride. These exceedances are due to the conservative assumption of effluent flow and low assimilative capacity of the watercourse. Additionally, the effluent concentrations were assumed at the MDMER levels, which is a very conservative assumption. Based on extrapolated dilution ratios for the regulatory scenario, it is expected that the ultimate mixing zone extends approximately 300 m from the outfall, at which point all parameters will meet the CWQG-FAL.

The Marathon Complex, for the regulatory scenario, has exceedances for zinc at the 100 m and 200 m mixing zone for MA-FDP-02, and MA-FDP-03/04. Also, exceedances for aluminum, iron, and manganese were observed in the combined effluent from MA-FDP-03 and MA-FDP-04. These exceedances are due to conservative assumptions of the effluent flow and low assimilative capacity of the watercourse. Additionally, the effluent concentrations were assumed at the MDMER limits, which is a very conservative assumption. Based on extrapolated dilution ratios for the regulatory scenario, it is expected that the ultimate mixing zone will extent approximately 300 m from the outfall, at which point all parameters will meet the CWQG-FAL.

During the post-closure period of the decommissioning, rehabilitation and closure phase, some exceedances are predicted in the Victoria River and Victoria Lake Reservoir for aluminum, copper, zinc, and fluoride. Mitigation measures should be considered, such as maintaining perimeter ditching during closure / post-closure to convey seepage to a passive wetland treatment system.

8.0 CLOSURE

This report has been prepared for the sole benefit of the Marathon Gold Corporation (MGC). This report may not be used by any other person or entity without the express written consent of Stantec Consulting Ltd. and MGC.

Any use that a third party makes of this report, or any reliance on decisions made based on it, are the responsibility of such third parties. Stantec Consulting Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made, or actions taken, based on this report.

The information and conclusions contained in this report are based upon work undertaken by trained professional and technical staff in accordance with generally accepted engineering and scientific practices current at the time the work was performed. Conclusions and recommendations presented in this report should not be construed as legal advice.

The conclusions presented in this report represent the best technical judgment of Stantec Consulting Ltd. based on the data obtained from the work. If any conditions become apparent that differ from our understanding of conditions as presented in this report, we request that we be notified immediately to reassess the conclusions provided herein.

9.0 REFERENCES

BC Ministry of Environment and Climate Change Strategy. 2017. British Columbia Approved Water Quality Guideline: Aquatic Life, Wildlife, & Agriculture - Summary Report. Retrieved from https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/water-quality-guidelines/approved-wqgs/wqg_summary_aquaticlife_wildlife_agri.pdf

Canadian Council of Ministers of the Environment (CCME). 2001. Canadian Water Quality Guidelines for the Protection of Aquatic Life. Arsenic.

Canadian Council of Ministers of the Environment (CCME). 2003. Canadian Water Quality Guidelines for the Protection of Aquatic Life: Guidance on the Site-Specific Application of water quality guidelines in Canada: Procedures for deriving numerical water quality objectives. In: Canadian Environmental Quality Guidelines. Winnipeg

Doneker, R.L. and Jirka, G.H. 2017. CORMIX User Manual: A Hydrodynamic Mixing Zone Model and Decision Support for Pollutant Discharges into Surface Waters, Report prepared for U.S. Environmental Protection Agency.

NLDMAE (Newfoundland and Labrador Department of Municipal Affairs and Environment). 2019. Description and History (Real time water quality monitoring program). March 12. Available online at: https://www.mae.gov.nl.ca/waterres/rti/rtwq/desc.html.

Environment and Climate Change Canada (2020) Canadian Climate Normals 1981-2010 Station Data. https://climate.weather.gc.ca/climate_normals/results_1981_2010_e.html?stnID=6615&autofwd=1 Newfoundland and Labrador Department of Municipal Affairs and Environment (NLDMAE). 2017. *Estimation of Low Flows for the Province of Newfoundland and Labrador - A User's Guide.* Retrieved from Newfoundland and Labrador Department of Municipal Affairs and Environment: https://www.mae.gov.nl.ca/waterres/reports/estimation_streamflow/index.html

Stantec Consulting Ltd. 2020a. Valentine Lake Gold Project - Water Management Plan. Prepared for Marathon Gold Corporation.

Stantec Consulting Ltd. 2020b. Valentine Lake Gold Project – Leprechaun Complex and Process Plant and TMF Complex Water Quantity & Water Quality Modelling Report. Prepared for Marathon Gold Corporation.

Stantec Consulting Ltd. 2020c. Valentine Lake Gold Project – Marathon Water Quantity & Water Quality Modelling Report. Prepared for Marathon Gold Corporation.

Stantec Consulting Ltd. 2020d. Valentine Gold Project: 2019 Baseline Hydrology and Surface Water Quality Monitoring Program. Markham, Ontario: Stantec Consulting Ltd. Prepared for Marathon Gold Corporation.

Zadeh, S. 2012. *Low Flow Frequency Study for Newfoundland and Labrador.* Master of Engineering Thesis, Faculty of Engineering and Applied Science, Memorial University of Newfoundland.