DOMINION DIAMOND

APPENDIX 8E

SITE DISCHARGE WATER QUALITY MODELLING REPORT

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Abbreviations

Abbreviation	Definition
ANFO	ammonium nitrate fuel oil
Dominion Diamond	Dominion Diamond Ekati Corporation
e.g.,	for example
i.e.,	that is
MMER	Metal Mining Effluent Regulations
Project	Jay Project
TDS	total dissolved solids
TSS	total suspended solids
WRSA	waste rock storage area

Units of Measure

Unit	Definition
%	percent
>	greater than
≥	greater than or equal to
<	less than
m	metre
m^3	cubic metre
m^3/d	cubic metres per day
masl	metres above sea level
mg/L	milligrams per litre
mg $CaCO_3$/L	milligrams calcium carbonate per litre
mg N/L	milligrams nitrogen per litre

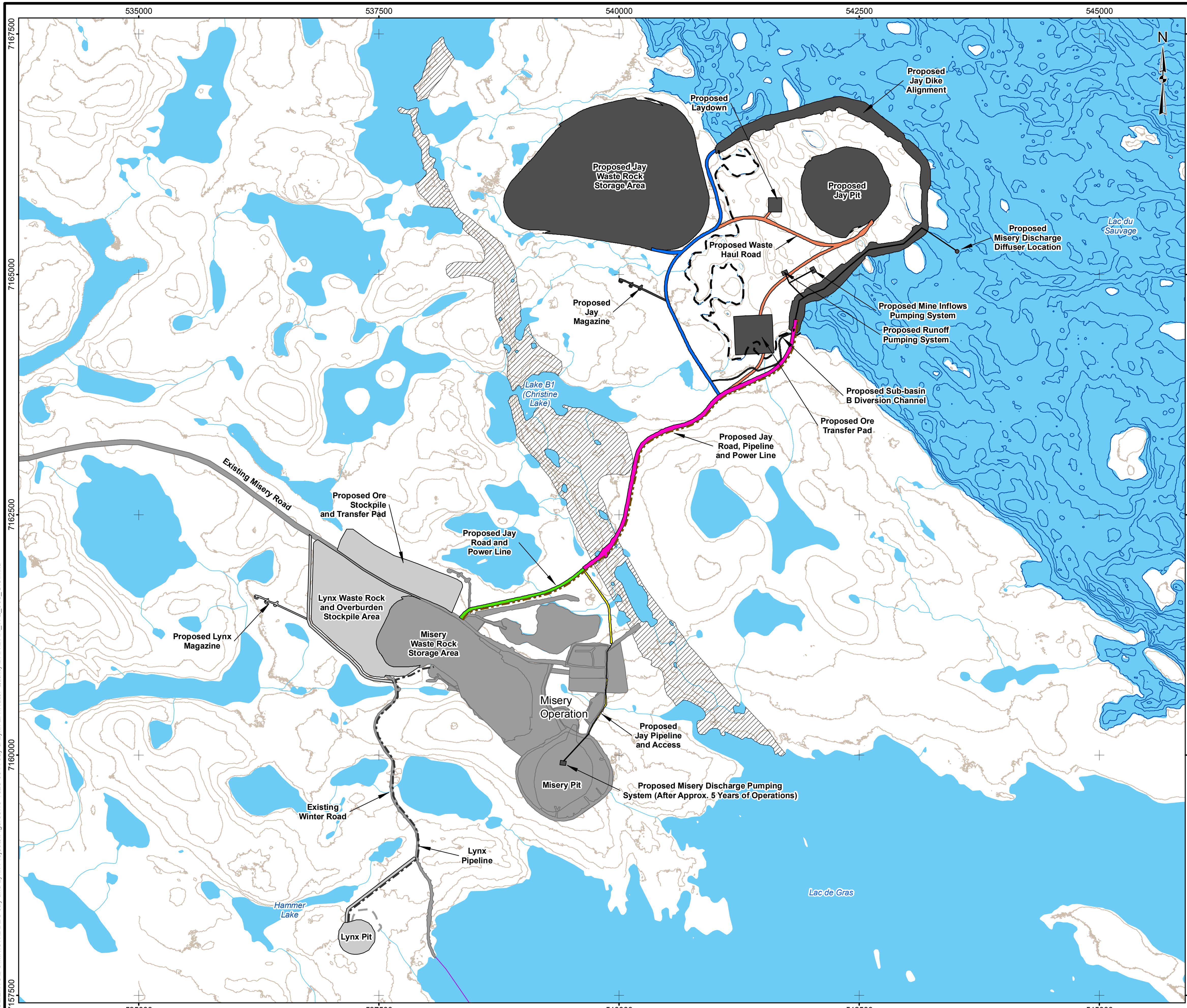
8E1 INTRODUCTION

Dominion Diamond Ekati Corporation (Dominion Diamond) proposes to mine kimberlite at the Jay Project (the Project) located in the Northwest Territories, Canada. To safely access and mine the kimberlite that occurs under Lac du Sauvage, a small area of Lac du Sauvage will be diked off and dewatered. The Jay kimberlite will be mined using open pit mining methods and will be processed using the existing processing facilities located at the Ekati Mine. The proposed mine site facilities at the Project are illustrated in Map 8E1-1.

The Project Mine Water Management Plan has been designed to minimize mine-related discharges to the receiving environment during the life of mine. During operations, water originating from the Jay Pit, including runoff from the Jay waste rock storage area (WRSA) that drains to the diked area, will be pumped to and stored in the mined-out Misery Pit. Once the total storage capacity has been exceeded, water stored in the Misery Pit will be discharged to Lac du Sauvage. At closure, saline minewater stored in the upper 50 metres (m) of the Misery Pit will be pumped to the bottom of the Jay open pit. Both pits will subsequently be capped with freshwater to produce meromictic conditions between the surface freshwater and the deeper saline water to limit the deeper saline water migrating into the receiving environment.

Waste rock will be permanently stored in the WRSA. During post-closure, runoff from this facility will report to Lac du Sauvage in perpetuity.

To assess the range of water quality conditions of site discharges during dewatering, operations, and closure, a site water quality model was developed. Site discharges are limited to pit discharges and WRSA runoff. A key purpose of the site water quality model was to project the composition of all site discharges to be used in the downstream surface water aquatic effects assessment to evaluate the surface water quality impacts of the Project on the receiving environment. The following report presents the model approach, assumptions, and results of the Project discharge water quality simulations.



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LEGEND

- EKATI MINE FOOTPRINT (MISERY OPERATION)
- WINTER ROAD
- BATHYMETRY CONTOUR (5 m INTERVAL)
- ELEVATION CONTOUR (10 m INTERVAL)
- WATERCOURSE
- WATERBODY
- ESKER

JAY PROJECT FOOTPRINT

- EXISTING SHORELINE OF DEWATERED AREA
- POWER LINE
- PROPOSED JAY PROJECT INFRASTRUCTURE
- PROPOSED JAY ROAD NORTH (HAUL ROAD)
- PROPOSED JAY ROAD (HAUL ROAD AND POWER LINE)
- PROPOSED JAY ROAD (HAUL ROAD, PIPELINE AND POWER LINE)
- PROPOSED JAY PIPELINE ROAD (ACCESS ROAD AND PIPELINE)
- PROPOSED OPERATION ROADS

LYNX PROJECT FOOTPRINT

- EXISTING SHORELINE OF DEWATERED LYNX LAKE
- LYNX PIPELINE
- LYNX PROJECT INFRASTRUCTURE

NOTES

ROAD, PIPELINES, AND POWER LINE ARRANGEMENT TO BE DETAILED AS PART OF FURTHER PRE-FEASIBILITY DESIGN. APPROXIMATE CORRIDOR WIDTHS ARE SHOWN.

REFERENCE

JAY PROJECT CONCEPTUAL ENGINEERING REPORT, EKATI MINE, DOC#: 1313280041-E14037-R-REV0-4060, DATED: MAY 13, 2014
JAY PROJECT DESIGN BASIS MEMORANDUM FOR PRE-FEASIBILITY DESIGN OF PROJECT ROADS AND PIPELINE BENCHES, DOC#: 1313280041-E14031-TM-REVD-2020, DATED: AUGUST 1, 2014
LIDAR AND BATHYMETRIC DATA OBTAINED FROM AURORA, 2013
WATER OBTAINED FROM CANVEC © NATURAL RESOURCES CANADA, 2012
DATUM: NAD83 PROJECTION: UTM ZONE 12N

DOCUMENT

DEVELOPER'S ASSESSMENT REPORT

1 0 1
SCALE 1:40,000 KILOMETRES

PROJECT
DOMINION DIAMOND
JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE

DEVELOPMENT FOOTPRINT OPERATIONS

Golder Associates

PROJECT	13-1328-0041		FILE No. DAR_WQ_008_GIS	
DESIGN	RK	17/07/14	SCALE AS SHOWN	REV 0
GIS	ANK	16/10/14	MAP 8E1-1	
CHECK	MH	16/10/14		
REVIEW	KM	16/10/14		

8E2 MODEL APPROACH

The Project Mine Water Management Plan and water balance (Appendix 3A) provided the basis for evaluating the expected site discharge water quality. Each water source that could influence water chemistry was identified and a source term chemistry profile was calculated or assigned based on geochemical test work or monitoring data. The following sections outline the water management plan, the conceptual water quality model, and key areas of uncertainty considered in the water quality model.

8E2.1 Mine Water Management Plan

The Project Mine Water Management Plan has been developed to manage water from the following site facilities:

- Jay WRSA;
- Jay open pit; and,
- Misery open pit.

As mentioned in Section 8E1, water will be managed to minimize the total volume of water discharged to the receiving environment. The water management strategy is discussed in terms of dewatering and operations, closure, and post-closure in the following sub-sections.

8E2.1.1 Phase 1: Dewatering and Operations

A small area of Lac du Sauvage will be diked off and dewatered to facilitate safe access and mining of the Jay Pit. During the dewatering period, water will be pumped from the diked area to Lac du Sauvage until total suspended solids (TSS) concentrations no longer meet discharge criteria for this constituent. At this point, any remaining water in the diked area of Lac du Sauvage will be pumped to the mined-out Lynx or Misery pits to settle the suspended sediment before discharge.

During operations, water reporting to the diked area and the Jay Pit will be pumped to the Misery Pit. Water balance modelling indicates the total volume of water (87.1 million cubic metres [m^3]) that needs to be managed through the Misery Pit during the life of the mine is approximately double the design capacity of the pit (41.3 million m^3). Excess water stored in the Misery Pit will be discharged to Lac du Sauvage to accommodate additional storage from inflows to the Jay Pit and the diked area of Lac du Sauvage. Water balance modelling indicates approximately five years will be required to fill the Misery Pit to the design storage capacity before discharge being required.

The majority of the water that will be managed through the Misery Pit originates from groundwater inflows to the Jay Pit. During the life of the mine, approximately 55.0 million m^3 of groundwater will be pumped from the Jay Pit. Hydrogeological modelling (Appendix 8A) indicates that the total dissolved solids (TDS) concentrations in Jay Pit groundwater inflows will increase throughout the life of the mine as mining advances and saline groundwater stored in the Canadian Shield (Fritz and Frape 1982) is upwelled into the open pit. To minimize TDS concentrations in the discharge to Lac du Sauvage, minewater pumped from the Jay Pit to the mine inflow sump will be pumped to the bottom of the Misery Pit. In this manner, water containing lower concentrations of TDS will be displaced vertically throughout the life of the mine by denser water containing higher concentrations of TDS originating from a deeper provenance in bedrock below the Jay Pit.

8E2.1.2 Phase 2: Closure

In the context of minewater management, the closure phase corresponds to the back-flooding period of the Misery and Jay pits. Water is not discharged to the receiving environment from the Project during the closure period. During closure, approximately 13.7 million m^3 of water will be pumped from the Misery Pit to the mined-out Jay Pit. The volume of water pumped from the Misery Pit to the Jay Pit will be replaced with freshwater pumped from Lac du Sauvage to develop a 60 m low-density freshwater cap (mixolimnion) over denser saline water with elevated concentrations of TDS (monimolimnion). Permanent segregation of waters with different densities is referred to as meromictic conditions. Therefore, the development of meromictic conditions in the Misery Pit will preclude the higher density water stored in the monimolimnion from discharging at surface to Lac de Gras (Section 8E2.1.3).

The total capacity of the Jay Pit is approximately 120 million m^3, including the storage capacity of the diked area in Lac du Sauvage. In addition to the 13.7 million m^3 of water pumped from the Misery Pit, the Jay Pit will be flooded with water from the following sources:

- groundwater inflows;
- wall rock runoff;
- WRSA runoff;
- pumped water from Lac du Sauvage;
- natural catchment runoff; and,
- direct precipitation.

Hydrodynamic modelling of the Jay Pit (Appendix 8G) indicates meromictic conditions will develop following back-flooding, permanently isolating approximately 38.3 million m^3 of minewater containing elevated concentrations of TDS from the lower density, freshwater stored in the overlying mixolimnion. Water balance modelling indicates the Jay Pit will require approximately four years to back-flood to the natural Lac du Sauvage lake elevation of 416.1 metres above sea level (masl).

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8E2.1.3 Phase 3: Post-Closure

The post-closure period commences following back-flooding of the Misery and Jay pits. At this time, the Misery Pit mixolimnion will overflow to Lac de Gras and a small amount of seepage (54 cubic metres per day [m^3/d]) from the monimolimnion will drain to the deep groundwater system and ultimately daylight in Lac de Gras.

The dike isolating the Jay Pit from the main body of Lac du Sauvage will be breached when water quality in the diked area meets regulatory water quality objectives for closure, establishing a direct connection between the Jay Pit and Lac du Sauvage in post-closure. As discussed in Section 8E2.1.2, hydrodynamic modelling (Appendix 8G) indicates approximately 38.3 million m^3 of minewater will be permanently isolated in the monimolimnion of the Jay Pit after meromictic conditions have been established. The hydrodynamic model indicates meromictic conditions will be established approximately 100 years into the post-closure. Over this period, a small proportion of the monimolimnion will mix with the mixolimnion, which is directly connected to Lac du Sauvage.

Runoff from the WRSA will continue to drain towards the diked area of Lac du Sauvage during post-closure. Once the dike is breached following back-flooding of the Jay Pit and the diked area, drainage from the WRSA will effectively flow directly to Lac du Sauvage.

8E2.2 Conceptual Water Quality Model

A stochastic site water quality model was developed for the Project using GoldSim version 11.1. GoldSim is a graphical, object-oriented mathematical model where all input constituents and functions are defined by the user and are built as individual objects or elements linked together by mathematical expressions. The object-based nature of the model is designed to facilitate understanding of the various factors, which control an engineered or natural system and predict the future performance of the system.

In GoldSim, each flow that could influence site discharge water quality for the Project was itemized and assigned a source term chemical profile based on geochemical testing of waste rock materials, observed mine site facility drainage at the Ekati Mine operations, and baseline surface and groundwater quality monitoring data. Waste site facilities that accumulate water (i.e., Misery Pit, Jay Pit) were treated as distinct reservoirs within the model. Inflow volumes and concentrations were included as inputs to each reservoir to account for chemical loadings from natural areas, disturbed areas, waste rock runoff and seepage, wall rock runoff, and groundwater inflows to project the chemistry of each mine site facility.

Water quality was simulated for each of the following discharges that could influence water quality downstream in Lac du Sauvage and Lac de Gras:

- Operations:
  - Misery Pit discharge to Lac du Sauvage.
- Post-closure:
  - Misery Pit overflow to Lac de Gras;
  - Misery Pit seepage to Lac de Gras;
  - Water displacement from the Jay Pit monimolimnion to Lac du Sauvage; and,
  - Jay WRSA.

The water quality model was designed to estimate discharge constituent concentrations on a daily timestep from Year -1, which corresponds to dewatering and pre-stripping of the diked area, to Year 215 (Calendar Year 2234), which is 200 years after the back-flooding of the Misery and Jay pits. The model was run iteratively for 200 realizations. Therefore, at each time step, a unique value is calculated based on randomly selected values for each of the stochastic inputs 200 times. Following the model run, average and 99th percentile discharge concentrations were calculated based on the 200 values calculated at each timestep to assess the range of conditions that could occur in each discharge source.

The model was designed to track the chemistry of the following water quality constituent groups:

- Conventional Constituents: TDS and hardness;
- Major Ions: calcium, chloride, fluoride, magnesium, potassium, sodium, and sulphate.
- Nutrients: nitrate, ammonium, and total phosphorus; and,
- Total and Dissolved Metals: aluminum, antimony, arsenic, barium, beryllium, bismuth, cadmium, chromium, cobalt, copper, iron, lead, lithium, manganese, mercury, molybdenum, nickel, selenium, silicon, silver, strontium, thallium, tin, titanium, uranium, vanadium, and zinc.

8E2.2.1 Pit Lake Model - Operations

During operations, minewater reporting to the Jay Pit will be pumped to the bottom of the mined-out Misery Pit and a pit lake will establish following back-flooding of the facility. As indicated in Section 8E2.1.1, hydrogeological modelling (Appendix 8A) indicates groundwater inflows and TDS concentrations will increase as mining of the Jay Pit advances. The resulting increase in TDS loadings will also increase concentrations in the Misery Pit since the pumping from the Jay Pit accounts for the majority of the water being managed through the Misery Pit. Therefore, to minimize the TDS concentrations in the discharge to Lac du Sauvage from the Misery Pit, water reporting to the Jay Pit will continue to be pumped to the bottom of the Misery Pit for the duration of operations. In this manner, lower TDS water is conceptually displaced vertically through the Misery Pit, and the minewater containing the highest TDS concentrations towards the end of the Project mine life can be stored permanently under meromictic conditions in the Misery Pit and Jay Pit monimolimnions.

To estimate the water quality of Project discharge from the Misery Pit during operations, the pit was conceptually designed as a vertical slice model. In this method, the pit was divided into eight, vertically stacked units, which were treated as distinct reservoirs in GoldSim. Table 8E2.2-1 provides the elevation range and volume selected for each reservoir in the vertical slice model. Within the model, each reservoir was linked to the overlying reservoir by a function of overflow. When a slice (or zone) was in the process of filling up with water, it was characterized as being “active.” Surface inputs, such as runoff, precipitation, and ice melt, were only applied to the active zone within each pit; however, the volume of water pumped from the Jay Pit was always directed to the lowest reservoir (Zone 1). If the simulated volume of an individual zone exceeded its capacity, excess water would overflow vertically and be included as an inflow to the overlying reservoir.

Table 8E2.2-1 Misery Pit Operational Vertical Slice Model Attributes

Zone	Elevation of Top Surface (masl)	Volume (million m^3)
1	258	4.91
2	301	4.91
3	332	4.91
4	358	4.91
5	380	4.91
6	402	5.46
7	420	5.00
8[(a)]	440	6.29

a) Operational surface level of Zone 8 is held at approximately 430 masl. The corresponding volume for this elevation is 2.57 million m^3.

masl = metres above sea level; m^3 = cubic metre.

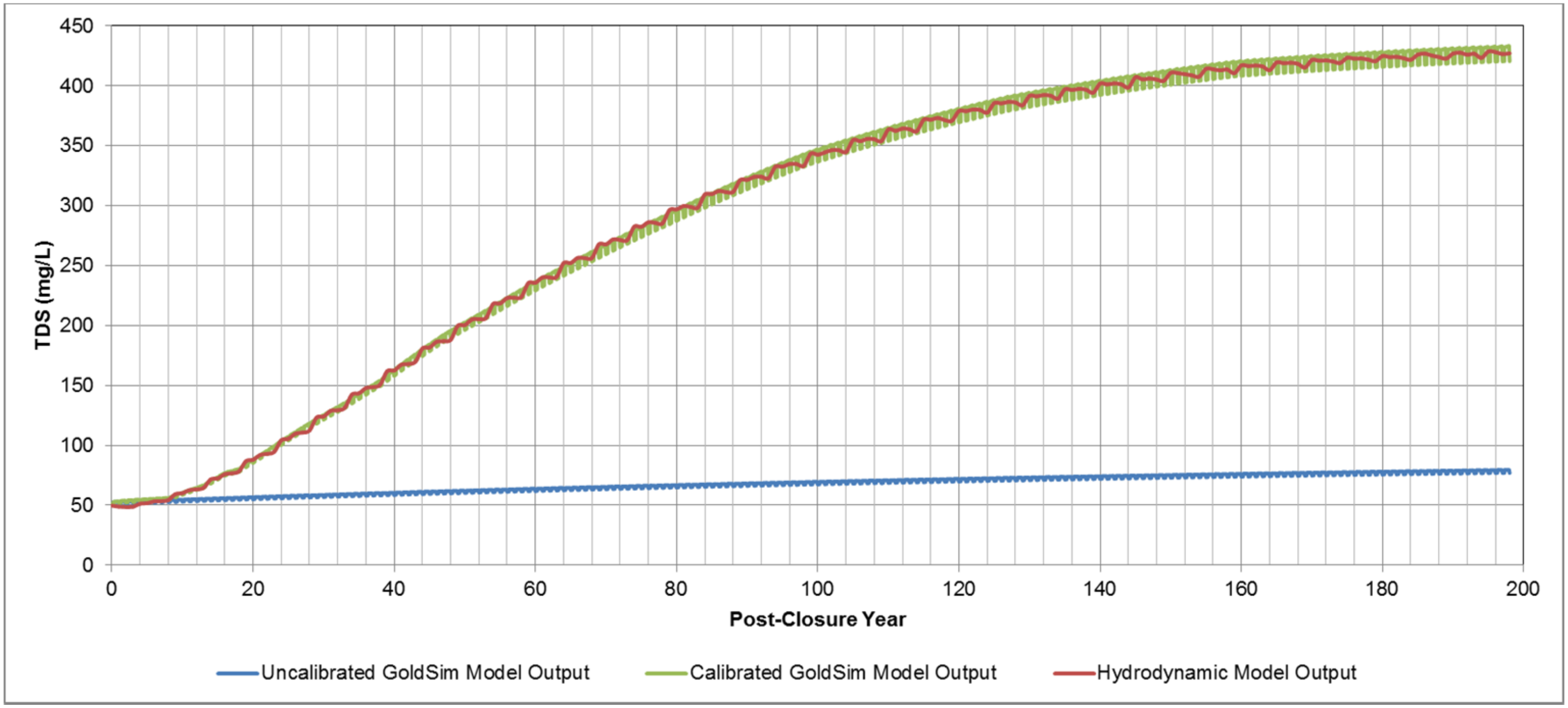
8E2.2.2 Pit Lake Models – Closure/Post-closure

8E2.2.2.1 Misery Pit

During closure and post-closure, the Misery pit lake was treated as a two-layered system with a freshwater mixolimnion overlying a monimolimnion containing elevated concentrations of TDS. At closure, the upper 50 m (13.7 million m^3) of water stored in Misery Pit Zones 6, 7, and 8 will be pumped to the bottom of the Jay Pit. The water removed from the Misery Pit will be replaced with freshwater pumped from Lac du Sauvage, wall rock runoff, natural catchment runoff, and direct precipitation to develop a 60 m freshwater cap. The Misery pit lake is maintained at a maximum storage elevation of 430 masl during operations; however, the spillway elevation is 440 masl. Therefore, the total capacity of the freshwater cap (16.8 million m^3) is greater than the volume of water pumped from the Misery Pit to the Jay Pit (13.7 million m^3).

The residual volume of water remaining in the Misery Pit (Zones 1 through 5) following removal of the water stored in the upper 50 m (Zones 6, 7, and 8) was assumed to be fully mixed during closure and represent the constituent concentrations of the monimolimnion. The projected TDS concentrations in the monimolimnion (5,500 milligrams per litre [mg/L]) and the mixolimnion (50 mg/L) immediately following back-flooding of the Misery Pit were used as inputs to the Misery Pit closure hydrodynamic model (Appendix 8F). The hydrodynamic model indicates a small proportion of the mixolimnion will mix with the monimolimnion, increasing TDS concentrations in the Misery Pit overflow discharge in the long-term (Figure 8E2.2-1). The GoldSim model was calibrated by increasing the total capacity of the mixolimnion and reducing the total capacity of the monimolimnion at the same rate. In this manner, mass is displaced from the monimolimnion to the mixolimnion. The capacity change of the mixolimnion and monimolimnion was calculated so that the mixolimnion TDS concentrations in the GoldSim model and the hydrodynamic model (Appendix 8G) matched (Figure 8E2.2-1).

Figure 8E2.2-1 Misery Pit – Simulated Mixomolimnion Total Dissolved Solids Concentrations



TDS = total dissolved solids; mg/L = milligrams per litre.

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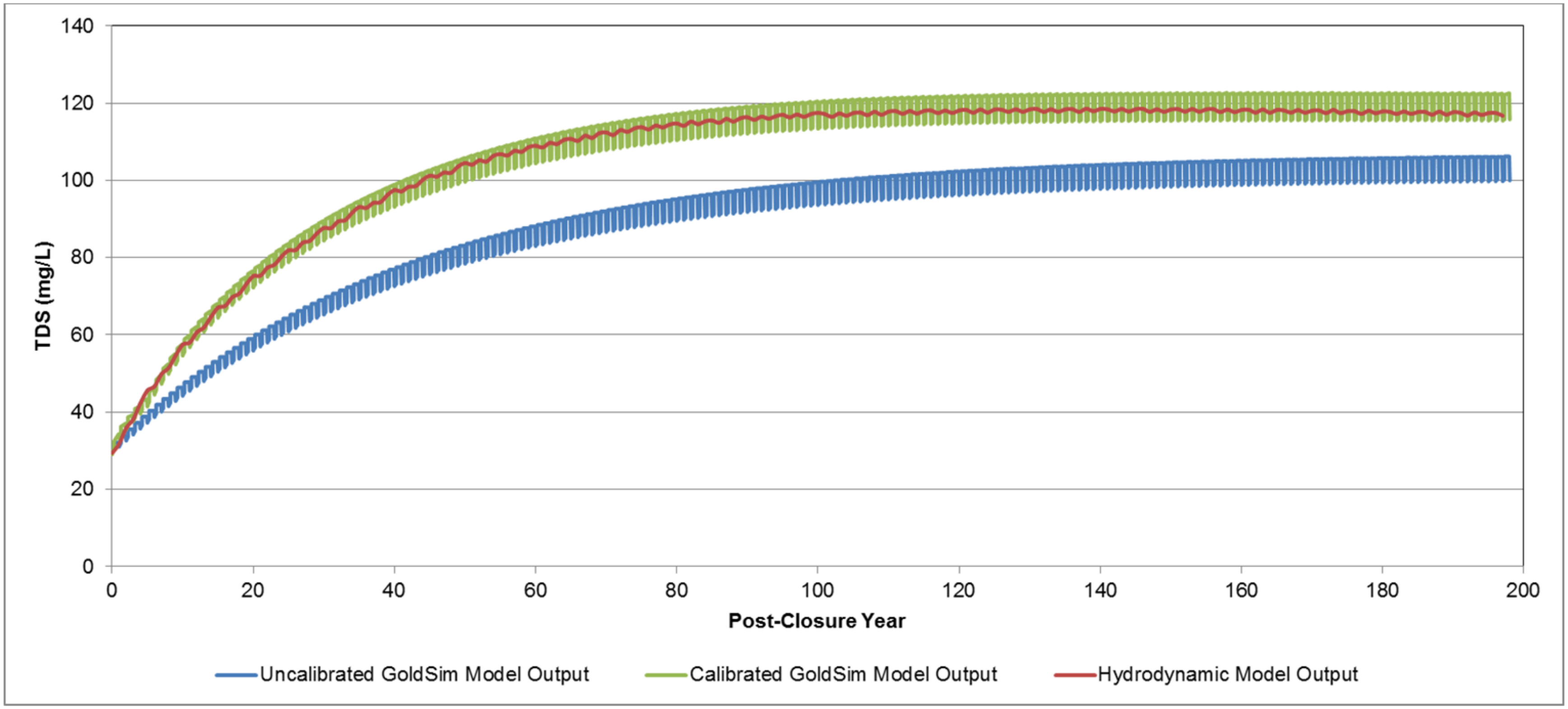
8E2.2.2.2 Jay Pit

In GoldSim, the Jay Pit was designed as a vertical slice model during the closure period. To be consistent with the Misery Pit, the Jay Pit was divided into eight distinct layers that were treated as reservoirs in the model. Wall rock runoff, catchment runoff, and direct precipitation report to the “active” reservoir and groundwater inflows report to the lowest layer (Zone 1) in the Jay Pit. Reservoirs would overflow to the overlying reservoir once their capacities’ had been exceeded. The lowest layer was assigned a total capacity of 16.1 million m^3, which is equivalent to the total volume of water transferred from the Misery Pit (13.7 million m^3) and the sum of other Jay inflows (i.e., runoff and groundwater inflows) reporting to the Jay Pit while water is being pumped from the Misery Pit. The remaining capacity (77.7 million m^3) of the Jay Pit was equally divided among the remaining zones (Zones 2 to 8) in the pit.

Following back-flooding, projected water quality conditions indicated the formation of a chemocline between water stored above and below Zone 3. For example, following back-flooding of the Jay Pit, the maximum projected TDS concentration simulated in Zones 4 to 8 was 50 mg/L, and the minimum concentration simulated in Zones 1 to 3 was 260 mg/L. During post-closure, Zones 1 to 3 were assumed to be a fully mixed monimolimnion and Zones 4 and above, including the diked area of Lac du Sauvage, were assumed to be a fully mixed mixolimnion.

The projected TDS concentrations in the monimolimnion (2,000 mg/L) and the mixolimnion (30 mg/L) immediately following back-flooding of the Jay Pit were used as inputs to the Misery Pit closure hydrodynamic model (Appendix 8F). The hydrodynamic model indicates a small proportion of the mixolimnion will mix with the monimolimnion, thereby increasing TDS concentrations in the Misery Pit overflow discharge in the long-term (Figure 8E2.2-2). Similar to the Misery Pit, the GoldSim model was calibrated for the Jay Pit by increasing the total capacity of the mixolimnion and reducing the total capacity of the monimolimnion at the same rate. In this manner, mass is displaced from the monimolimnion to the mixolimnion. The capacity change of the mixolimnion and monimolimnion was calculated so that the mixolimnion TDS concentrations in the GoldSim model and the hydrodynamic model (Appendix 8G) matched (Figure 8E2.2-2).

Figure 8E2.2-2 Jay Pit – Simulated Mixomolimnion Total Dissolved Solids Concentrations



TDS = total dissolved solids; mg/L = milligrams per litre.

The Jay Pit is located in Lac du Sauvage. Since the simulated water quality in Lac du Sauvage is beyond the scope of this site water quality model, the mass flux from the Jay Pit monimolimnion to the mixolimnion was included as a source term in the Lac du Sauvage hydrodynamic water quality model. Details of this model are provided in Appendix 8F.

8E2.2.3 Model Limitations and Uncertainty

Care was taken to incorporate known processes as understood during model development. However, in natural systems and complex man-made systems, observed conditions, particularly daily, will almost certainly vary with respect to estimated conditions. Water quality modelling requires the use of many assumptions due to the uncertainty related to determining the physical and geochemical characteristics of a complex system. The prediction of water quality is based on several inputs (surface flows, groundwater flows and seepage, baseline water quality, and geochemical characterization), all of which have inherent variability and uncertainty. The water quality model has attempted to incorporate natural processes and mineral weathering of mine materials, and combine them with flows to develop predictions for water quality, all for a mine that has not yet been developed. Given all of the inherent uncertainties, the results of the water quality model should be used as a tool to aid in the design of monitoring programs and mine planning, to develop mitigation strategies, and to outline potential risks rather than to provide absolute concentrations.

The following key assumptions have been made in the water quality modelling:

- The source term water quality chemistry profiles used in the modelling are representative of their respective input sources. The inherent assumption in the model is that geochemistry, surface, and groundwater quality data obtained as part of the baseline programs adequately and conservatively represent the input sources and will continue to do so in the future. Data were selected to generate input water qualities based primarily on available lab testing, field data, and where necessary, professional judgement.
- There is complete mixing of all water sources in the site reservoirs (during operations) and in the Jay and Misery pit mixolimnions and monimolimnions during closure and post-closure.
- The model simulates the expected range of dissolved concentrations for the constituents considered. Total concentrations will be the same as or higher than the dissolved concentrations, as influenced by concentrations of TSS. Particulate concentrations were calculated on the assumption that 15 mg/L of TSS may be present, but that any TSS in excess of that would settle and not remain in the water column.
- Measured water quality constituents that were less than the analytical detection limit have been assumed equal to half the detection limit for modelling purposes (as is the convention for water quality related calculations and modelling).
- Runoff from the WRSA maintains the same source term chemistry independent of the season, and does not improve over time. The stochastic nature of the inputs for this term allows the variability due to seasonality to be applied when the model is run stochastically. It is considered conservative that the resultant water quality of the WRSA runoff does not improve with time.

- Runoff from undisturbed areas and areas that have been dewatered are assigned the natural Lac du Sauvage baseline water quality. Runoff from roads and developed areas are assumed to be reclaimed at closure, and are assigned the natural Lac du Sauvage baseline water quality in post-closure.
- Alkalinity is not calculated in the water quality model. Since an alkalinity value is required to calculate the concentrations of TDS in the Project discharges, freshwater within the pits (i.e., the layers that are filled with a freshwater cap) is assumed to have the natural Lac du Sauvage baseline alkalinity (4.1 mg/L), while alkalinity in water affected by groundwater inflows is assumed the groundwater baseline alkalinity (155 mg/L).

The data and approach used to estimate future water quality are commensurate with industry best practices (Maest 2006; MEND 2009; INAP 2009) and are believed to provide a reasonable approximation of the system, as currently understood, within the context of the assumptions used in the model. Changes in the Project mine plan, mine design, or mine life will necessarily result in changes to water quality predictions. Ultimately, even the best of models cannot compare with operational monitoring data. Once the Project is operational, monitoring of water quality, and periodic re-assessment of effects predictions and/or remedial measures, will be required.

8E3 MODEL INPUT PARAMETERS

In the water quality model, a source term chemistry profile was assigned or calculated for each flow component based on geochemical test data or baseline monitoring results for the various water sources contributing chemical load. The following sub-sections provide the input data chosen to represent the expected water quality of each chemical loading source.

8E3.1 Precipitation

The composition of direct precipitation was assumed to be pure water containing no measurable TDS concentration.

8E3.2 Surface Runoff

The diked area of Lac du Sauvage, the Jay Pit, and the Misery Pit capture natural runoff and disturbed area runoff. In the site water quality model, natural runoff is water flowing over natural ground surfaces and runoff is water coming in contact with exposed mine materials (e.g., waste rock, roads). Baseline surface water quality data representative of monitoring locations within Lac du Sauvage were used to represent the quality of natural runoff. Background water quality data in Lac du Sauvage were collected between 2004 and 2013 at various surface water quality monitoring locations (Map 8.2-6 in Section 8.2.5.1). The data used were collected during open water conditions by ERM Rescan between 2004 and 2012 and by Golder Associates Ltd. in 2013 (Section 8.2.5.1). The median concentration from the monitoring results was used as a model input source term for runoff water (Table 8E3.2-1).

Table 8E3.2-1 Natural Runoff Water Chemical Profile

Constituent	Unit	Value
Conventional Constituents		
Alkalinity	mg $CaCO_3$/L	4.1
Major Ions		
Calcium	mg/L	0.83
Chloride	mg/L	0.25
Fluoride	mg/L	0.010
Magnesium	mg/L	0.58
Potassium	mg/L	0.53
Sodium	mg/L	0.56
Sulphate	mg/L	1.2
Nutrients		
Nitrate	mg N/L	0.0025
Nitrogen – Ammonia	mg N/L	0.0070
Phosphorus, dissolved	mg/L	0.0064
Dissolved Metals		
Aluminum	mg/L	0.0033
Antimony	mg/L	0.000010
Arsenic	mg/L	0.00031
Barium	mg/L	0.0011
Beryllium	mg/L	0.0000050
Bismuth	mg/L	0.0000050
Cadmium	mg/L	0.0000025
Chromium	mg/L	0.000030
Cobalt	mg/L	0.0000050
Copper	mg/L	0.00057
Iron	mg/L	0.0037
Lead	mg/L	0.0000050
Lithium	mg/L	0.0012
Manganese	mg/L	0.58
Mercury	mg/L	0.00000025
Molybdenum	mg/L	0.000025
Nickel	mg/L	0.00028
Selenium	mg/L	0.000020
Silicon	mg/L	0.00011
Silver	mg/L	0.0000025
Strontium	mg/L	0.0053
Thallium	mg/L	0.0000050
Tin	mg/L	0.000025
Titanium	mg/L	0.000050
Uranium	mg/L	0.000021
Vanadium	mg/L	0.000025
Zinc	mg/L	0.00040

mg $CaCO_3$/L = milligrams calcium carbonate per litre; mg/L = milligrams per litre; mg N/L = milligrams nitrogen per litre.

8E3.3 Groundwater

Groundwater reporting to the Jay Pit during operations represents the greatest flow component that requires management, and will be the primary control on pit sump water quality. Groundwater reporting to the open pit will be a function of the following two sources:

- shallow groundwater from Lac du Sauvage resulting from the dewatering cone of depression; and,
- deeper saline connate water.

The results of groundwater quality monitoring presented in the hydrogeological modelling appendix (Appendix 8A) were used to estimate the composition of groundwater that could passively inflow into the Jay open pit during operations and closure. A depth profile was developed to evaluate the variability of groundwater composition with depth as TDS concentrations are known to vary with depth in groundwater in the Canadian Shield. Subsequently, constituents that were correlated ($r \geq 0.7$) with TDS were identified, and included some major ions (e.g., calcium, chloride, sodium, and magnesium) and strontium. Slopes, intercepts, and correlation coefficients for each of these constituents are provided in Table 8E3.3-1. The slopes and intercepts were used to derive groundwater concentrations of these major ions and strontium throughout the duration of the model.

Table 8E3.3-1 Attributes of Correlated Constituents

Constituent	Unit	Slope	Y-intercept	Correlation Coefficient
Major Ions				
Calcium	mg/L	0.22	-32.55	1.0
Chloride	mg/L	0.62	-108.76	1.0
Magnesium	mg/L	0.0077	20.3725	0.86
Sodium	mg/L	0.13	6.36	1.0
Strontium	mg/L	0.0042	-0.9392	0.99

mg/L = milligrams per litre.

Hydrogeological modelling (Appendix 8A) provided a profile of the TDS concentrations reporting to the Jay open pit from deeper connate water with time. In addition, this modelling provided an estimate of the percentage of lake water contributing load to the groundwater. TDS is expected to fluctuate in the lake as a result of mining activities and site water management. As such, the simulated TDS concentrations in Lac du Sauvage were mixed with the expected TDS concentrations of predicted volumes of connate water to determine a TDS concentration for groundwater reporting to the pit, according to the proportions indicated by the hydrogeological model results.

Constituents that did not exhibit a relationship with TDS in the groundwater quality database were estimated based on the range of results in the groundwater dataset. Input concentrations are equal to the median concentration measured in groundwater samples from the Ekati and Diavik mines, and the Jay Pit area. Groundwater quality concentrations for constituents not correlated with TDS are presented in Table 8E3.3-2.

Table 8E3.3-2 Non-Correlated Groundwater Chemistry Profile

Constituent	Unit	Value
Major Ions		
Fluoride	mg/L	0.24
Potassium	mg/L	9.5
Sulphate	mg/L	2.7
Nutrients		
Nitrate	mg N/L	0.0030
Nitrogen – Ammonia	mg N/L	0.12
Phosphorus, dissolved	mg/L	0.40
Dissolved Metals		
Aluminum	mg/L	0.0040
Antimony	mg/L	0.00010
Arsenic	mg/L	0.0027
Barium	mg/L	0.11
Beryllium	mg/L	0.00010
Bismuth	mg/L	0.00025
Cadmium	mg/L	0.00030
Chromium	mg/L	0.00050
Cobalt	mg/L	0.00030
Copper	mg/L	0.00010
Iron	mg/L	0.030
Lead	mg/L	0.00015
Lithium	mg/L	0.046
Manganese	mg/L	0.19
Mercury	mg/L	0.000025
Molybdenum	mg/L	0.026
Nickel	mg/L	0.0023
Selenium	mg/L	0.00010
Silicon	mg/L	6.2
Silver	mg/L	0.000050
Thallium	mg/L	0.00050
Tin	mg/L	0.00050
Titanium	mg/L	0.00050
Uranium	mg/L	0.00020
Vanadium	mg/L	0.00050
Zinc	mg/L	0.0010

mg/L = milligrams per litre; mg N/L = milligrams nitrogen per litre.

8E3.4 Waste Rock Storage Area Runoff Water Quality

Waste rock will be produced from mining of the Jay kimberlite pipe at the Project. These materials will be placed in the Jay WRSA (Map 8E1-1). The following waste rock units are expected to be mined at the Project:

- granite;
- metasediment; and,
- kimberlite.

Approximately 76 percent (%) of the waste rock to be produced at the Project is expected to be granite. Geochemical baseline testing indicates that the Jay granitic waste rock is generally non-potentially acid generating (Geochemistry Baseline Report; Annex VIII). However, approximately 24% of the waste rock produced at the Project is expected to be metasediment, which has been indicated to be potentially acid generating through geochemical baseline testing. A small percentage (0.0041%) of the waste rock to be produced at the Project is expected to be waste kimberlite, which is not expected to be potentially acid generating.

The chemistry profile of runoff from the WRSA was assigned constant values during spring melt (i.e., freshet) and the summer period, when runoff from the WRSA will exist. Concentrations observed through WRSA seepage flow monitoring at the Misery operations during the months of June through September 2001 to 2004 were selected to represent the input water quality in the Project site water quality model. As these seepage monitoring data represent WRSAs that contain a higher proportion of possibly acid-generating material, the inputs are considered to be conservative.

The inputs for the WRSA were developed stochastically, where the model is run iteratively and a random constituent concentration within a defined statistical distribution is selected for each realization. The following standardized screening process was used to develop a probability distribution for each constituent in the model:

- Step 1 – remove outliers from the measured data;
- Step 2 – fit suitable probability distributions to the remaining data;
- Step 3 – assess the goodness of fit for all applicable distributions to determine the most appropriate distribution type;
- Step 4 – generate a long-term time series according to the chosen distribution; and,
- Step 5 – calculate the mean from the time series.

Each constituent’s distribution was truncated by a minimum bound of 0 mg/L and a maximum bound of the highest observed concentration for that constituent. By running the model stochastically, each constituent will present a range of chemistry results rather than a single value, which accounts for the observed variability in the empirical dataset used to represent the WRSA runoff quality. Table 8E3.4-1 presents the average, 99th percentile, and maximum concentrations for each modelled constituent, as well as the distribution type.

Table 8E3.4-1 Waste Rock Storage Area Runoff Water Chemistry Profile

Constituent	Units	Average	99th Percentile	Maximum	Distribution Type
Major Ions					
Calcium	mg/L	30	135	151	Log Normal
Chloride	mg/L	24	95	103	Log Normal
Fluoride	mg/L	0.12	0.12	0.12	Uniform Range
Magnesium	mg/L	22	103	122	Log Normal
Potassium	mg/L	15	43	47	Log Normal
Sodium	mg/L	21	82	94	Log Normal
Sulphate	mg/L	63	148	159	Normal
Nutrients					
Nitrate	mg N/L	34	300	326	Log Normal
Nitrogen – Ammonia	mg N/L	19	159	183	Log Normal
Phosphorus, dissolved	mg/L	0.11	0.40	0.49	Log Normal
Dissolved Metals					
Aluminum	mg/L	0.35	1.8	2.1	Log Normal
Antimony	mg/L	0.0013	0.010	0.014	Log Normal
Arsenic	mg/L	0.0024	0.0052	0.0060	Normal
Barium	mg/L	0.11	0.46	0.58	Log Normal
Beryllium	mg/L	0.000025	0.000025	0.000025	Constant Value
Bismuth	mg/L	0.000067	0.00023	0.00024	Log Normal
Cadmium	mg/L	0.00022	0.00099	0.0012	Log Normal
Chromium	mg/L	0.0010	0.0053	0.0064	Log Normal
Cobalt	mg/L	0.014	0.067	0.078	Log Normal
Copper	mg/L	0.0062	0.011	0.014	Normal
Iron	mg/L	1.3	7.0	7.7	Log Normal
Lead	mg/L	0.0011	0.012	0.018	Log Normal
Lithium	mg/L	0.0057	0.0089	0.0090	Uniform Range
Manganese	mg/L	0.57	3.1	3.4	Log Normal
Mercury	mg/L	0.000025	0.000040	0.000040	Uniform Range
Molybdenum	mg/L	0.0055	0.028	0.031	Log Normal
Nickel	mg/L	0.020	0.050	0.051	Log Normal
Selenium	mg/L	0.0011	0.0050	0.0059	Log Normal
Silicon	mg/L	2.5	4.0	4.0	Uniform Range
Silver	mg/L	0.000099	0.00044	0.00047	Log Normal
Strontium	mg/L	0.22	1.1	1.35	Log Normal
Thallium	mg/L	0.000084	0.00026	0.00030	Log Normal
Tin	mg/L	0.00014	0.00053	0.00063	Log Normal
Titanium	mg/L	0.0057	0.032	0.039	Log Normal
Uranium	mg/L	0.047	0.36	0.40	Log Normal
Vanadium	mg/L	0.00067	0.0014	0.0014	Normal
Zinc	mg/L	0.028	0.18	0.21	Log Normal

mg/L = milligrams per litre; mg/L N = milligrams nitrogen per litre.

8E3.5 Pit Wall Runoff Water Quality

Lithological units in the exposed wall rocks of the open pits will influence the Jay and Misery pit water chemistry. The exposed units include granite, metasediment, and kimberlite. Each unit exposed in the wall rock was assigned a freshet chemistry profile calculated as the median concentration observed during the first five weeks of humidity cell testing and a steady-state concentration applied to the remaining runoff months, calculated as the median value over the last five weeks of humidity cell testing. Median freshet constituent concentrations were based on eleven granite, three metasediment, and nine kimberlite humidity cells. Humidity cell tests ran for a period of 15 and 126 weeks.

During operations, at each timestep, the relative proportion of exposed wall rock units was calculated. Table 8E3.5-1 provides the surface areas for the Jay Pit annually through the life of mine. At closure, units below the pit lake surface were assumed to be inert and only the exposed units above the pit lake were considered when calculating the relative proportion of exposed units. The chemistry profile assigned to wall rock units (Table 8E3.5-2) during freshet (June) and steady-state runoff (July to October) were mixed in the relative proportions of exposed wall rock units at each timestep. Additional conservatism was introduced into the model by assigning the wall rock runoff the maximum of the mixed humidity cell constituent concentrations or the WRSA facility drainage chemistry profile.

Table 8E3.5-1 Wall Rock Lithological Proportions

Start Date of Period	Project Phase	Metasediments (%)	Granite (%)	Kimberlite (%)
<1-Oct-2019	Dewatering	0	0	0
1-Oct-2019	Operations	16	77	7.3
1-Oct-2020	Operations	16	77	7.3
1-Oct-2021	Operations	25	61	14
1-Oct-2022	Operations	26	58	16
1-Oct-2023	Operations	26	57	17
1-Oct-2024	Operations	26	57	17
1-Oct-2025	Operations	26	57	17
1-Oct-2026	Operations	25	57	18
1-Oct-2027	Operations	24	57	19
1-Oct-2028	Operations	23	58	19
1-Oct-2029	Operations	22	58	20
31-Dec-2029	Operations	21	58	21
1-Jan-2030	Operations	32	68	0
>1-Jan-2030	Closure	32	68	0

Note: Based on the 2013 Jay Project Mine Plan.
% = percent; < = less than; > = greater than.

Table 8E3.5-2 Wall Rock Humidity Cell Water Chemistry Profiles

Constituent	Unit	Granite		Kimberlite		Metasediment	
		Freshet	Steady-State	Freshet	Steady-State	Freshet	Steady-State
Major Ions							
Calcium	mg/L	4.1	2.9	11	9.9	5.5	1.6
Magnesium	mg/L	1.0	0.70	25	17	3.1	1.2
Potassium	mg/L	7.9	3.0	39	20	17	2.9
Sodium	mg/L	3.4	1.0	16	1.0	3.0	0.78
Sulphate	mg/L	4.0	1.5	107	20	52	23
Nutrients							
Phosphorus, dissolved	mg/L	0.15	0.15	0.15	0.15	0.15	0.075
Dissolved Metals							
Aluminum	mg/L	0.099	0.068	0.0050	0.0080	0.083	0.48
Antimony	mg/L	0.0057	0.0029	0.0045	0.0043	0.0019	0.00018
Arsenic	mg/L	0.0041	0.0010	0.0056	0.0048	0.0074	0.00050
Barium	mg/L	0.0083	0.0066	0.070	0.15	0.039	0.063
Beryllium	mg/L	0.00025	0.00025	0.00025	0.00025	0.00025	0.00058
Bismuth	mg/L	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025
Cadmium	mg/L	0.000025	0.000025	0.000049	0.000025	0.00015	0.00045
Chromium	mg/L	0.00025	0.00025	0.0015	0.00075	0.00025	0.00025
Cobalt	mg/L	0.000053	0.000050	0.00030	0.00010	0.019	0.058
Copper	mg/L	0.0021	0.0046	0.0038	0.011	0.0015	0.20050
Iron	mg/L	0.015	0.015	0.015	0.015	0.028	0.43
Lead	mg/L	0.00075	0.000070	0.00055	0.00011	0.00060	0.0094
Lithium	mg/L	0.007	0.0020	0.00050	0.00050	0.065	0.033
Manganese	mg/L	1.0	0.70	25	17	3.1	1.2
Mercury	mg/L	0.000010	0.00050	0.00010	0.00050	0.000010	0.00050
Molybdenum	mg/L	0.0014	0.00033	0.078	0.0078	0.00070	0.000038
Nickel	mg/L	0.00035	0.00025	0.0084	0.0042	0.15	0.21
Selenium	mg/L	0.00050	0.00050	0.0020	0.00050	0.00050	0.00050
Silicon	mg/L	2.5	1.8	9.7	9.0	5.8	5.4
Silver	mg/L	0.000010	0.0000050	0.000080	0.0000075	0.0000050	0.000025
Strontium	mg/L	0.049	0.019	0.27	0.22	0.057	0.018
Thallium	mg/L	0.000070	0.000025	0.000085	0.000050	0.000050	0.000050
Tin	mg/L	0.000050	0.000050	0.000050	0.000050	0.00085	0.000050
Titanium	mg/L	0.0050	0.0050	0.0050	0.0050	0.0050	0.0028
Uranium	mg/L	0.0013	0.00095	0.00031	0.00038	0.00026	0.0027
Vanadium	mg/L	0.0035	0.0010	0.0050	0.0045	0.00050	0.00050
Zinc	mg/L	0.0071	0.0070	0.0030	0.0020	0.052	0.17

mg/L = milligrams per litre.

A block model was not available for the Misery Pit at the time the water quality model was developed. The exposed wall rock in the Misery Pit is estimated to be approximately 52% metasediment and 48% granite at the end of mining (ERM Rescan 2013). Wall rock runoff chemistry was calculated using these proportions and the same humidity cell results used to calculate the wall rock runoff chemistry for the Jay Pit. Similarly, the maximum of the prorated humidity cell constituent concentrations or the WRSA runoff chemistry profile was assigned to the Misery Pit wall rock runoff to add additional conservatism into the water quality model predictions.

Nitrate and ammonium were not measured in the humidity cell tests (Table 8E3.5-2). Since ammonium and nitrate are related to the use of explosives, the natural runoff source term concentrations (Table 8E3.2-1) were assigned to the wall rock runoff source term for the Misery Pit since any residual ammonium nitrate fuel oil (ANFO) resulting from mining of the Misery Pit is assumed to be flushed out of the system before using this facility to store water pumped from the Jay Pit.

8E3.6 Explosives Usage

Mining of the Jay Pit will require the use of both ANFO and emulsion explosives. Ammonium and nitrate in minewater can originate from wastage of ANFO during blasting misfires and powder spills while loading blast holes. Development of waste rate assumptions can introduce uncertainty into predictions of nitrate concentrations; therefore, median concentrations of ammonium (5.1 milligrams nitrogen per litre [mg N/L]) and nitrate (22.6 mg N/L) measured in Ekati Mine pit sumps was assigned as a surrogate source terms to minewater pumped from the Jay Pit to the Misery Pit.

8E3.7 Developed Areas Runoff Water Quality

Developed areas in the site water quality model include constructed roads or gravel pads intended for buildings or other mine site infrastructure. The runoff from these areas was assigned the WRSA runoff source term water quality profile.

As mentioned in Section 8E3.5, the WRSA contains elevated concentrations of ammonium and nitrate due residual ANFO stored in the existing Ekati Mine WRSAs. Since developed areas are not expected to contain residual ANFO, nitrate and ammonium in these drainages were assigned the natural runoff source term concentration (Table 8E3.2-1).

8E3.8 Particulate Matter

The GoldSim model predicts the concentrations of dissolved constituents in each discharge. Total concentrations were calculated by adding the natural particulate, calculated as the difference of the natural runoff source term total and dissolved concentrations, to the simulated dissolved concentrations in Project discharges. Additionally, a theoretical TSS concentration was added to each discharge source to reflect the changes in sediment quality as a result of exposing mine materials. Median solid phase chemistries for each lithological unit (Annex VIII) were prorated based on the relative proportion of the lithological units that are expected to influence the discharge TSS concentrations in water pumped from the Misery Pit to Lac du Sauvage during operations, overflow from Misery pit lake to Lac de Gras during post-closure, and runoff from the Jay WRSA to Lac du Sauvage in post-closure.

During operations, runoff from the Jay WRSA will report to the diked area of Lac du Sauvage and be subsequently pumped to the Misery Pit. During this period, it is assumed that particulate matter originating from the Jay WRSA will have settled before water being discharged from the Misery Pit and TSS in the Misery Pit discharge is assumed to originate from the wall rock runoff. TSS concentrations in the Misery Pit discharge were assigned a particulate composition of 48% granite and 52% metasediment to reflect the relative proportion of these units exposed in the Misery Pit wall (ERM Rescan 2013). During post-closure, runoff from the Jay WRSA will drain directly to Lac du Sauvage. Particulate concentrations in this drainage were prorated based on the relative proportion of waste rock produced during the last year of mining since these are the materials that will be stored at the surface of the WRSA during post-closure.

Although the Misery Pit and site sedimentation ponds will limit TSS concentrations in site discharges, a conservative TSS concentration of 15 mg/L was applied to all discharges from the Project, which is equal to the maximum authorized monthly mean concentration in the Metal Mining Effluent Regulations (MMER 2012). Particulate concentrations applied to each discharge are provided in Table 8E3.8-1.

Table 8E3.8-1 Theoretical Particulate Concentrations

Constituent	Units	Misery Pit[a]	Jay WRSA[a]
Major Ions			
Calcium	mg/L	0.15	0.17
Magnesium	mg/L	0.15	0.044
Potassium	mg/L	0.32	0.30
Sodium	mg/L	0.36	0.44
Nutrients			
Phosphorus, dissolved	mg/L	0.0075	0.0062
Dissolved Metals			
Aluminum	mg/L	1.2	1.2
Antimony	mg/L	0.000078	0.000038
Arsenic	mg/L	0.00012	0.000038
Barium	mg/L	0.0087	0.0091
Beryllium	mg/L	0.00012	0.000026
Bismuth	mg/L	0.000015	0.000015
Cadmium	mg/L	0.000026	0.0000038
Chromium	mg/L	0.0018	0.0011
Cobalt	mg/L	0.00023	0.000044
Copper	mg/L	0.00043	0.000090
Iron	mg/L	0.37	0.14
Lead	mg/L	0.00028	0.00024
Lithium	mg/L	-	-
Manganese	mg/L	0.15	0.044
Mercury	mg/L	0.000085	0.000075
Molybdenum	mg/L	0.000018	0.0000075
Nickel	mg/L	0.00066	0.00011
Selenium	mg/L	0.000034	0.0000038
Silicon	mg/L	-	-
Silver	mg/L	0.000051	0.0000038
Strontium	mg/L	0.0048	0.0063
Thallium	mg/L	0.0000053	0.0000030
Tin	mg/L	-	-
Titanium	mg/L	0.032	0.014
Uranium	mg/L	0.00025	0.000075
Vanadium	mg/L	0.00087	0.00017
Zinc	mg/L	0.0010	0.00063

a) Based on a maximum TSS concentration of 15 mg/L.
mg/L = milligrams per litre; TSS = total suspended sediment.

8E4 RESULTS

Water will be discharged from the following locations during the life of the Project:

- Operations:
  - Misery Pit discharge to Lac du Sauvage.
- Post-closure:
  - Misery Pit overflow to Lac de Gras;
  - Misery Pit seepage to Lac de Gras;
  - water displacement from the Jay Pit monimolimnion to Lac du Sauvage; and,
  - Jay Pit seepage to Lac de Gras.

The closure phase of the Project is included in the water quality model; however, this period is defined as the back-flooding of the Misery and Jay pits and no discharge occurs from the Project during this time.

As discussed in Section 8E2.2, the site water quality model was designed to project the composition of site discharges on a daily time step during operations, closure, and post-closure of the Jay Project. The model was run iteratively for 200 realizations. Therefore, at each time step for each constituent, a unique value is calculated based on randomly selected values for each of the stochastic inputs 200 times. Following the model run, average and 99th percentile discharge concentrations were calculated from the 200 values calculated at each timestep. To facilitate results presentation, maximum daily average and maximum daily 99th percentile values were calculated for each of the following model snapshots:

- Late Operations – during discharge from Misery Pit (2024 to 2029); and,
- Post-Closure (2033 onwards).

For the purpose of discussing the model results, model sensitivities are referred to as the average and 99th percentile scenarios in this document. The following subsections present the projected water chemistry of the Project discharges listed above. Simulated results are presented for the full list of constituents presented in Section 8E2.2 of this appendix; however, when discussing projected water quality trends and peak modelled concentrations, emphasis is given to the following constituents, that based on Golder Associates Ltd.'s experience, have been previously identified as constituents of concern at diamond mines in northern Canada: TDS, chloride, nitrate, and total phosphorus.

8E4.1 Operations – Misery Pit Discharge

During operations, water reporting to the diked area and the Jay Pit will be pumped to the Misery Pit. Water balance modelling indicates the total volume of water (87.1 million m^3) that needs to be managed through the Misery Pit during the life of mine is approximately double the design capacity of the pit (41.3 million m^3). Excess water stored in the Misery Pit will be discharged to Lac du Sauvage to accommodate additional storage from inflows to the Jay Pit and the diked area.

The majority of the water that will be managed through the Misery Pit originates from groundwater inflows to the Jay Pit. During the life of the mine, approximately 55.0 million m^3 of groundwater will be pumped from the Jay Pit. Hydrogeological modelling (Appendix 8C) indicates TDS concentrations in the Jay Pit groundwater inflows will increase throughout the life of the mine as mining advances. To minimize TDS concentrations in the discharge to Lac du Sauvage, water pumped from the Jay Pit will be pumped to the bottom of the Misery Pit. In this manner, lower TDS water will be displaced vertically throughout the life of the mine by higher TDS water originating from a deeper provenance in bedrock below the Jay Pit.

Water stored in the surface layer of the Misery Pit will be diluted with water from the following sources:

- direct precipitation;
- Jay Pit wall rock runoff (pumped to the Misery Pit with the Jay Pit groundwater inflows);
- Jay diked area catchment runoff (pumped to the surface of the Misery Pit);
- Misery Pit wall rock runoff; and,
- natural runoff draining to the Misery Pit.

Water balance modelling indicates approximately five years will be required to fill the Misery Pit to the design storage capacity before discharge being required. Maximum discharge concentrations are provided in Table 8E4.1-1 and time series presenting the projected operational discharge concentrations from the Misery Pit are presented in Attachments 8E-1 (average scenario) and 8E-2 (99^{th} percentile scenario).

DOMINION DIAMOND

Table 8E4.1-1 Simulated Maximum Misery Pit Discharge Concentrations

Constituent	Units	Maximum Concentrations in Misery Discharge – Mean Daily Values				Maximum Concentrations in Misery Discharge – 99th Percentile Daily Values			
		Late Operations		Post-Closure		Late Operations		Post-Closure	
		Under Ice	Open Water	Under Ice	Open Water	Under Ice	Open Water	Under Ice	Open Water
Conventional Constituents									
pH[(a)]	pH units	6.5 – 9.0	6.5 – 9.0	6.5 – 9.0	6.5 – 9.0	6.5 – 9.0	6.5 – 9.0	6.5 – 9.0	6.5 – 9.0
Total Dissolved Solids	mg/L	2,925	2,091	435	422	2,977	2,183	479	465
Total Suspended Solids[(b)]	mg/L	15	15	15	15	15	15	15	15
Hardness[(c)]	mg $CaCO_3$/L	1,638	1,156	267	259	1,694	1,228	448	436
Alkalinity	mg $CaCO_3$/L	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1
Major Ions									
Calcium	mg/L	601	421	89	86.7	610	434	121	117.9
Chloride	mg/L	1712	1196	235	228	1719	1204	257	250
Fluoride	mg/L	0.13	0.10	0.015	0.015	0.13	0.10	0.015	0.015
Magnesium	mg/L	33	25	10.6	10.3	41	35	35.4	34.4
Potassium	mg/L	6.3	5.4	5.5	5.4	12.7	10.8	13.8	13.5
Sodium	mg/L	384	270	56.9	55.2	390	277	75.6	73.4
Sulphate	mg/L	18	15	21.0	20.4	41	35	46.6	45.4
Nutrients									
Nitrate	mg N/L	20	16	1.57	1.53	67	57	1.57	1.53
Nitrogen - Ammonia	mg N/L	5.4	4.6	0.367	0.356	34.8	29.6	0.367	0.356
Phosphorus, dissolved	mg/L	0.2	0.2	0.051	0.050	0.2	0.2	0.141	0.137
Phosphorus, total	mg/L	0.22	0.16	0.059	0.057	0.23	0.20	0.148	0.145

Table 8E4.1-1 Simulated Maximum Misery Pit Discharge Concentrations

Constituent	Units	Maximum Concentrations in Misery Discharge – Mean Daily Values				Maximum Concentrations in Misery Discharge – 99th Percentile Daily Values			
		Late Operations		Post-Closure		Late Operations		Post-Closure	
		Under Ice	Open Water	Under Ice	Open Water	Under Ice	Open Water	Under Ice	Open Water
Dissolved Metals									
Aluminum	mg/L	0.100	0.085	0.127	0.123	0.480	0.407	0.540	0.526
Antimony	mg/L	0.00042	0.00035	0.00093	0.00090	0.00276	0.00234	0.00310	0.00302
Arsenic	mg/L	0.0017	0.0014	0.00156	0.00151	0.0020	0.0017	0.00198	0.00193
Barium	mg/L	0.063	0.053	0.0376	0.0366	0.136	0.115	0.1470	0.1431
Beryllium	mg/L	0.000064	0.000050	0.000111	0.000108	0.000064	0.000050	0.000111	0.000108
Bismuth	mg/L	0.00014	0.00010	0.000089	0.000086	0.00014	0.00012	0.000089	0.000086
Boron	mg/L	0.01353	0.01149	0.01809	0.01762	0.02970	0.02520	0.03237	0.03151
Cadmium	mg/L	0.00016	0.00013	0.000094	0.000092	0.00029	0.00025	0.000316	0.000307
Chromium	mg/L	0.00037	0.00031	0.00035	0.00035	0.00149	0.00126	0.00165	0.00161
Cobalt	mg/L	0.0042	0.0036	0.0076	0.0074	0.0183	0.0155	0.0206	0.0201
Copper	mg/L	0.0038	0.0032	0.0181	0.0176	0.0051	0.0043	0.0189	0.0184
Iron	mg/L	0.36	0.30	0.409	0.398	1.91	1.62	2.146	2.089
Lead	mg/L	0.00038	0.00032	0.00102	0.00099	0.00318	0.00270	0.00357	0.00348
Lithium	mg/L	0.024	0.018	0.0108	0.0105	0.024	0.018	0.0108	0.0105
Manganese	mg/L	0.17	0.14	0.184	0.179	0.86	0.73	0.959	0.934
Mercury	mg/L	0.000024	0.000021	0.000084	0.000081	0.000026	0.000022	0.000086	0.000084
Molybdenum	mg/L	0.013	0.0098	0.00257	0.00250	0.015	0.0125	0.00958	0.00933
Nickel	mg/L	0.0080	0.0068	0.0298	0.0290	0.0153	0.0130	0.0298	0.0290
Selenium	mg/L	0.00031	0.00027	0.00037	0.0003644	0.00138	0.00117	0.00155	0.001511
Silicon	mg/L	3.3	2.5	1.42	1.38	3.4	2.7	1.46	1.42
Silver	mg/L	0.000036	0.000031	0.000034	0.0000332	0.000126	0.000107	0.000139	0.0001353
Strontium	mg/L	11	8.0	1.60	1.56	12	8.1	1.89	1.83

Table 8E4.1-1 Simulated Maximum Misery Pit Discharge Concentrations

Constituent	Units	Maximum Concentrations in Misery Discharge – Mean Daily Values				Maximum Concentrations in Misery Discharge – 99th Percentile Daily Values			
		Late Operations		Post-Closure		Late Operations		Post-Closure	
		Under Ice	Open Water	Under Ice	Open Water	Under Ice	Open Water	Under Ice	Open Water
Dissolved Metals (continued)									
Thallium	mg/L	0.00026	0.00019	0.000046	0.000045	0.00027	0.00021	0.000098	0.000096
Tin	mg/L	0.00027	0.00021	0.000125	0.000122	0.00029	0.00025	0.000195	0.000190
Titanium	mg/L	0.0017	0.0014	0.00228	0.00222	0.0088	0.0075	0.00987	0.00960
Uranium	mg/L	0.013	0.011	0.0148	0.0144	0.099	0.084	0.1112	0.1083
Vanadium	mg/L	0.00036	0.00031	0.00046	0.00045	0.00044	0.00038	0.00055	0.00053
Zinc	mg/L	0.0093	0.0079	0.0210	0.0204	0.0483	0.0410	0.0544	0.0530
Total Metals									
Aluminum	mg/L	1.3	1.3	1.3	1.3	1.7	1.6	1.7	1.7
Antimony	mg/L	0.00050	0.00043	0.00101	0.00098	0.00284	0.00242	0.00318	0.00310
Arsenic	mg/L	0.0018	0.0015	0.00167	0.00163	0.0021	0.0018	0.00210	0.00205
Barium	mg/L	0.072	0.061	0.046	0.045	0.145	0.124	0.156	0.152
Beryllium	mg/L	0.000183	0.000169	0.000230	0.000227	0.000183	0.000169	0.000230	0.000227
Bismuth	mg/L	0.00015	0.00012	0.000104	0.000101	0.00016	0.00013	0.000104	0.000101
Boron	mg/L	0.01367993	0.01163771	0.01824	0.01777	0.02984775	0.02534572	0.03252	0.03166
Cadmium	mg/L	0.00019	0.00016	0.000121	0.000118	0.00032	0.00028	0.000342	0.000334
Chromium	mg/L	0.0022	0.0021	0.0022	0.0021	0.0033	0.0031	0.0035	0.0034
Cobalt	mg/L	0.0045	0.0038	0.0078	0.0076	0.0185	0.0158	0.0209	0.0203
Copper	mg/L	0.0042	0.0036	0.0185	0.0180	0.0055	0.0047	0.0193	0.0188
Iron	mg/L	0.73	0.67	0.78	0.77	2.28	1.99	2.51	2.46
Lead	mg/L	0.00066	0.00060	0.00130	0.00127	0.00346	0.00298	0.00385	0.00376
Lithium	mg/L	0.024	0.018	0.0108	0.0105	0.024	0.018	0.0108	0.0105
Manganese	mg/L	0.17	0.15	0.188	0.183	0.87	0.74	0.963	0.938

Table 8E4.1-1 Simulated Maximum Misery Pit Discharge Concentrations

Constituent	Units	Maximum Concentrations in Misery Discharge – Mean Daily Values				Maximum Concentrations in Misery Discharge – 99th Percentile Daily Values			
		Late Operations		Post-Closure		Late Operations		Post-Closure	
		Under Ice	Open Water	Under Ice	Open Water	Under Ice	Open Water	Under Ice	Open Water
Total Metals (continued)									
Mercury	mg/L	0.000109	0.000105	0.000168	0.000166	0.000111	0.000107	0.000171	0.000168
Molybdenum	mg/L	0.013	0.0098	0.00259	0.00252	0.015	0.0125	0.00960	0.00934
Nickel	mg/L	0.0087	0.0075	0.0305	0.0297	0.0159	0.0136	0.0305	0.0297
Selenium	mg/L	0.00035	0.00030	0.00041	0.00040	0.00142	0.00121	0.00159	0.00154
Silicon	mg/L	3.3	2.5	1.42	1.38	3.4	2.7	1.46	1.42
Silver	mg/L	0.000087	0.000082	0.000085	0.000084	0.000177	0.000158	0.000190	0.000187
Strontium	mg/L	11	8.0	1.61	1.56	12	8.1	1.89	1.83
Thallium	mg/L	0.00026	0.00019	0.000052	0.000050	0.00027	0.00021	0.000104	0.000101
Tin	mg/L	0.00027	0.00021	0.000125	0.000122	0.00029	0.00025	0.000195	0.000190
Titanium	mg/L	0.033	0.033	0.034	0.034	0.041	0.039	0.042	0.041
Uranium	mg/L	0.013	0.011	0.0151	0.0147	0.099	0.084	0.1114	0.1085
Vanadium	mg/L	0.00123	0.00117	0.00133	0.00132	0.00131	0.00124	0.00141	0.00140
Zinc	mg/L	0.010	0.0089	0.0220	0.0214	0.049	0.0420	0.0554	0.0540

a) Assumed pH value based on observed results in the baseline geochemistry test results.
b) Assumed TSS concentration based on observed baseline water quality results.
c) Theoretical hardness calculated based on simulated calcium and magnesium concentrations.
mg $CaCO_3$/L = milligrams calcium carbonate per litre; mg/L = milligrams per litre; mg N/L = milligrams nitrogen per litre; > = later than.

Simulated discharge concentrations to Lac du Sauvage from the Misery Pit are seasonal for all constituents. For example, peak discharge concentrations occur during the winter months as result of ice formation concentrating the chemical load in the upper layer of the Misery Pit. During freshet, concentrations decrease as a result of ice melt and are further reduced during the open water season.

The following two trends were observed in projected concentrations of constituents in the Misery Pit discharge during operations for the average scenario:

- constituent concentrations gradually increase throughout the mine life (e.g., TDS, chloride, nitrate, total phosphorus, arsenic); and,
- concentrations of constituents decrease throughout the mine life (e.g., sulphate, aluminum, cobalt, copper, iron, nickel).

During mining of the Jay Pit, groundwater inflows increase from 7,700 m^3/d to 21,300 m^3/d (Appendix 8A) and account for the majority of the water managed through the Misery Pit during the life of the mine. Therefore, as mining advances, the relative proportion of Jay groundwater in the Misery Pit increases. Constituents that are projected to have higher concentrations in the Jay groundwater compared to the other sources draining to the Misery Pit (e.g., wall rock runoff and natural runoff) increase in the Misery Pit discharge during the life of the mine. Constituents that were projected to have lower concentrations in the Jay groundwater compared to the other sources draining to the Misery Pit resulted in a decrease in the Misery Pit discharge concentrations during the life of the mine.

Similar trends are also reported for the 99th percentile scenario (Attachment 8E-2). However, some constituents (e.g., nitrate, barium, and silver) that were reported to increase in the Misery Pit discharge in the average scenario were projected to decrease in the 99th percentile scenario. This is the result of the projected groundwater concentration being greater than the mixed average concentration of all other flows reporting to the Misery Pit (e.g., runoff, direct precipitation, natural runoff), but less than the 99th percentile mixed concentration of all other sources reporting to the Misery Pit. Therefore, since the groundwater accounts for the majority of the water managed through the Misery Pit during operations, water pumped from the Jay Pit enriches concentrations of these constituents in the average scenario, but dilutes them in the 99th percentile scenario. However, projected 99th percentile concentrations are always greater than the projected average scenario concentrations.

The TDS loading rate from the Jay Pit increases as a result of groundwater inflows increasing from 7,700 m^3/d to 21,300 m^3/d with a corresponding TDS increase of 300 mg/L to 7,300 mg/L, respectively (Appendix 8A). Since the Jay Pit groundwater inflows account for approximately 63% of the total water managed through the Misery Pit during operations, TDS concentrations in the Misery Pit also demonstrate an associated increase, with maximum concentrations occurring during the final year of the mine life. Maximum TDS concentrations in the discharge from the Misery Pit are projected to be 2,925 mg/L under ice and 2,091 mg/L during the open water season in the last year of mining (Year 10) for the average model scenario. Maximum projected under ice and open water discharge concentrations from the Misery Pit slightly increase to 2,977 mg/L and 2,183 mg/L, respectively for the 99th percentile model scenario (Table 8E4.1-1).

Chloride is directly correlated to TDS and continually increases during the life of the mine with maximum concentrations occurring during the last year of mining. For the average scenario, peak under ice average and open water chloride concentrations were projected to be 1,712 mg/L and 1,196 mg/L, respectively in the Misery Pit discharge. Chloride concentrations were marginally higher than the average scenario during under ice (1,719 mg/L) and open water (1,204 mg/L) conditions in the 99^{th} percentile scenario.

Projected concentrations of nitrate also increase during the life of the mine (Attachment 8E-1). Although nitrate is a component of TDS, it is not directly correlated to TDS at the Project. Nitrate originates from wastage of ANFO during blasting misfires and powder spills while loading blast holes. As discussed in Section 8E3.6, development of waste rate assumptions can introduce uncertainty into predictions of nitrate concentrations; therefore, the median nitrate concentration (22.6 mg N/L) measured in Ekati mine pit sumps was assigned as a surrogate source term to minewater pumped from the Jay open pit to the Misery Pit. Since groundwater inflows increase through the life of the mine (Table 8E4.1-1), nitrate concentrations in the Misery Pit demonstrate an associated increase. Maximum average scenario under ice (20 mg N/L) and open water (16 mg N/L) nitrate concentrations occur during the last year of mining.

The Misery Pit discharge nitrate concentrations are sensitive to the WRSA runoff, which is pumped to the upper layer of the Misery Pit via the diked area. As indicated in Section 8E3.4, the Jay WRSA runoff water chemistry profile was entered into the model as a stochastically derived input. The 99^{th} percentile runoff water quality from this facility is 300 mg N/L, versus the mean value of 33.8 mg N/L. As a result, the 99^{th} percentile scenario nitrate concentrations increase to 67 mg N/L under ice and 57 mg N/L during the open water season (Table 8E4.1-1).

Total phosphorus was also not observed to be correlated to TDS in the groundwater dataset selected for the Project (Section 8E3.3). The groundwater chemistry profile was assigned the maximum total phosphorus concentration (0.4 mg/L) in comparison to all other model source terms. Therefore, as the groundwater inflows increase as mining of the Jay Pit advances, total phosphorus loadings to the Misery Pit increase resulting in a gradual increase in total phosphorus concentrations in the Misery Pit discharge (Appendix 8E-1). Maximum under ice and open water total phosphorus concentrations were projected to be 0.22 mg/L and 0.16 mg/L, respectively for the average scenario and 0.23 mg/L and 0.2 mg/L, respectively for the 99^{th} percentile scenario (Table 8E4.1-1).

8E4.2 Post-Closure

8E4.2.1 Misery Pit

During closure, approximately 13.7 million m^3 of water will be pumped from the Misery Pit to the mined-out Jay Pit. The volume of water pumped from the Misery Pit to the Jay Pit will be replaced with freshwater pumped from Lac du Sauvage to produce a 60 m low-density freshwater cap (mixolimnion) over denser saline water with elevated concentrations of TDS (monimolimnion). The post-closure period for the Misery Pit commences following back-flooding of the pit. At this time, the mixolimnion will overflow to Lac de Gras and a small amount of seepage (54 m^3/d) from the monimolimnion will drain to Lac de Gras.

Hydrodynamic modelling (Appendix 8F) indicates that a small proportion of the water stored in the monimolimnion will interact with the mixolimnion before meromictic conditions being established in the Misery Pit. Therefore, during the post-closure period, water stored in the Misery Pit mixolimnion will be a mixture of the following water sources:

- water displaced vertically from the monimolimnion;
- water pumped from Lac du Sauvage during the closure period;
- wall rock runoff;
- natural runoff; and,
- direct precipitation.

Maximum discharge concentrations during post-closure are provided in Table 8E4.1-1 and time series presenting the projected post-closure discharge concentrations from the Misery Pit are presented in Appendices 8E-1 (average scenario) and 8E-2 (99^{th} percentile scenario). Concentrations of all constituents increase during post-closure to maximum long-term steady state concentrations approximately 200 years into the post-closure period (Attachments 8E-1 and 8E-2). Although concentrations increase during the post-closure period, the maximum concentrations are much less than the peak concentrations observed during operations (Table 8E4.1-1).

The monimolimnion contains residual water pumped from the Jay Pit during operations. As such, projected concentrations in the monimolimnion are much higher than in the mixolimnion. However, hydrodynamic modelling indicates that meromictic conditions will develop and permanently isolate the monimolimnion from mixing with the overlying freshwater cap in the Misery Pit. Maximum post-closure Misery Pit monimolimnion concentrations are presented in Table 8E4.2-1.

The walls of the Misery Pit will be surrounded with permafrost and hydrogeological modelling indicates there will be no groundwater inflows to the pit during the post-closure period. Therefore, seepage lost from the base of the Misery Pit will be replaced with water stored in the mixolimnion. As a result, concentrations in the monimolimnion will decrease to the projected long-term steady state concentrations in the mixolimnion (Table 8E4.1-1) as mass is transported to Lac de Gras. However, this reduction in monimolimnion concentrations was not considered in the water quality model development to provide a conservative estimate of post-closure discharges to Lac de Gras (Appendix 8G).

8E4.2.2 Jay Pit Monimolimnion

As discussed in Section 8E4.2.1, approximately 13.7 million m^3 of water will be pumped from the Misery Pit to the mined out Jay Pit. The total capacity of the Jay Pit is approximately 120 million m^3, including the diked area in Lac du Sauvage. The water pumped from the Misery Pit to the Jay Pit is diluted with water from the following sources:

- groundwater inflows;
- wall rock runoff;
- natural runoff; and,
- direct precipitation.

Hydrodynamic modelling of the Jay Pit (Appendix 8F) indicates meromictic conditions will develop following back-flooding of the Jay Pit, permanently isolating approximately 38.3 million m^3 from the lower density, freshwater stored in the overlying mixolimnion. Maximum projected monimolimnion concentrations are provided in Table 8E4.2-1. Since the concentrations in the monimolimnion contain residual operational minewater, concentrations of several constituents, including TDS, chloride, nitrate, and total phosphorus, are elevated.

Before the development of meromictic conditions, the hydrodynamic model also indicates some water stored in the Jay Pit monimolimnion will mix with the overlying mixolimnion. The volume of monimolimnion water mixing with the mixolimnion was assigned the maximum projected concentrations in the monimolimnion (Table 8E4.2-1). This exchange of mass is accounted for in the Lac du Sauvage lake hydrodynamic water quality model. Details related to simulated mixolimnion and lake water concentrations are provided in Appendix 8F.

Table 8E4.2-1 Simulated Maximum Misery Pit and Jay Pit Monimolimnion Concentrations

Constituent	Units	Maximum Concentrations in Post-Closure Discharges – Mean Daily Values	
		Misery Monimolimnion	Jay Monimolimnion
Conventional Constituents			
pH[(a)]	pH units	6.5 - 9.0	6.5 - 9.0
Total Dissolved Solids	mg/L	5,520	2,005
Hardness[(b)]	mg $CaCO_3$/L	3,145	1,139
Alkalinity	mg $CaCO_3$/L	155	155
Major Ions			
Calcium	mg/L	1,173	420
Chloride	mg/L	3,359	1,199
Fluoride	mg/L	0.11	0.077
Magnesium	mg/L	52	22
Potassium	mg/L	5.0	3.5
Sodium	mg/L	737	267
Sulphate	mg/L	5.5	3.3

Table 8E4.2-1 Simulated Maximum Misery Pit and Jay Pit Monimolimnion Concentrations

Constituent	Units	Maximum Concentrations in Post-Closure Discharges – Mean Daily Values	
		Misery Monimolimnion	Jay Monimolimnion
Nutrients			
Nitrate	mg N/L	22	11
Nitrogen - Ammonia	mg N/L	5.0	2.5
Phosphorus, dissolved	mg/L	0.18	0.12
Dissolved Metals			
Aluminum (Al)	mg/L	0.026	0.013
Antimony	mg/L	0.00023	0.00012
Arsenic	mg/L	0.0015	0.0011
Barium	mg/L	0.053	0.036
Beryllium	mg/L	0.000058	0.000038
Bismuth	mg/L	0.00012	0.000080
Cadmium	mg/L	0.00014	0.000093
Chromium	mg/L	0.00027	0.00019
Cobalt	mg/L	0.0013	0.00052
Copper	mg/L	0.0031	0.0012
Iron	mg/L	0.089	0.044
Lead	mg/L	0.00021	0.00010
Lithium	mg/L	0.021	0.014
Manganese	mg/L	52	22
Mercury	mg/L	0.000024	0.000012
Molybdenum	mg/L	0.012	0.0075
Nickel	mg/L	0.0051	0.0020
Selenium	mg/L	0.00012	0.000072
Silicon	mg/L	2.8	1.9
Silver	mg/L	0.000026	0.000018
Strontium	mg/L	23	8.0
Thallium	mg/L	0.00022	0.00015
Tin	mg/L	0.00024	0.00016
Titanium	mg/L	0.00063	0.00036
Uranium	mg/L	0.0028	0.0013
Vanadium	mg/L	0.00030	0.00020
Zinc	mg/L	0.0038	0.0016

a) Assumed pH value based on observed results in the baseline geochemistry test results.

b) Theoretical hardness calculated based on simulated calcium and magnesium concentrations.

mg $CaCO_3$/L = milligrams calcium carbonate per litre; mg/L = milligrams per litre; mg N/L = milligrams nitrogen per litre.

8E4.2.3 Jay Waste Rock Storage Area

The Jay WRSA area will drain directly to Lac du Sauvage during post-closure. A chemical profile was assigned to drainage from the WRSA. In this manner, the constituent concentrations do not change in response to climate variations (i.e., freshet) and the runoff concentrations are independent of the volume of runoff draining from the WRSA. As indicated in Section 8E3.4, to account for variability in Jay WRSA runoff quality, a statistical distribution was developed based on WRSA monitoring results at the Ekati Mine. In GoldSim, the distribution was randomly sampled at each timestep to assign a WRSA runoff chemistry profile. The model was run for 200 realizations so representative mean and 99th percentile runoff chemistry profiles could be calculated for the Jay WRSA facility drainage. Simulated runoff chemistry profiles are presented in Table 8E4.2-2.

Nitrate in the WRSA originates from use of ANFO in the development of the open pit. Since ANFO is highly soluble, it is expected that it will be leached from the WRSA through time. However, depletion of nitrogen was not considered in the water quality model to provide a conservative source term into the Lac du Sauvage aquatic effects assessment, but it is expected that long-term WRSA facility nitrate concentrations will be much lower than the value (34 mg/L) presented in Table 8E4.2-2.

Table 8E4.2-2 Simulated Jay Waste Rock Storage Area Runoff Concentrations

Constituent	Units	Concentrations in Jay Waste Rock Storage Area Runoff – Post-Closure	
		Average	Maximum
Conventional Constituents			
pH[(a)]	pH units	6.5–9.0	6.5–9.0
Total Dissolved Solids	mg/L	349	1,672
Total Suspended Solids[(b)]	mg/L	15	15
Hardness[(c)]	mg $CaCO_3$/L	163	879
Alkalinity	mg $CaCO_3$/L	4.1	4.1
Major Ions			
Calcium	mg/L	30	151
Chloride	mg/L	24	103
Fluoride	mg/L	0.12	0.12
Magnesium	mg/L	22	122
Potassium	mg/L	14.5	47.0
Sodium	mg/L	21	94
Sulphate	mg/L	63	159
Nutrients			
Nitrate	mg N/L	34	326
Nitrogen – Ammonia	mg N/L	19.3	183.0
Phosphorus, dissolved	mg/L	0.1	0.5
Phosphorus, total	mg/L	0.12	0.49

Table 8E4.2-2 Simulated Jay Waste Rock Storage Area Runoff Concentrations

Constituent	Units	Concentrations in Jay Waste Rock Storage Area Runoff – Post-Closure	
		Average	Maximum
Dissolved Metals			
Aluminum	mg/L	0.352	2.086
Antimony	mg/L	0.00127	0.01447
Arsenic	mg/L	0.0024	0.0060
Barium	mg/L	0.105	0.585
Beryllium	mg/L	0.000025	0.000025
Bismuth	mg/L	0.00007	0.00024
Cadmium	mg/L	0.00022	0.00115
Chromium	mg/L	0.00100	0.00637
Cobalt	mg/L	0.0142	0.0778
Copper	mg/L	0.0062	0.0136
Iron	mg/L	1.29	7.68
Lead	mg/L	0.00108	0.01847
Lithium	mg/L	0.006	0.009
Manganese	mg/L	0.57	3.40
Mercury	mg/L	0.000025	0.000040
Molybdenum	mg/L	0.006	0.0314
Nickel	mg/L	0.0197	0.0511
Selenium	mg/L	0.00107	0.00586
Silicon	mg/L	2.5	4.0
Silver	mg/L	0.000099	0.000470
Strontium	mg/L	0	1.3
Thallium	mg/L	0.00008	0.00030
Tin	mg/L	0.00014	0.00063
Titanium	mg/L	0.0057	0.0389
Uranium	mg/L	0.047	0.398
Vanadium	mg/L	0.00067	0.00144
Zinc	mg/L	0.0284	0.2080
Total Metals			
Aluminum	mg/L	1.5	3.2
Antimony	mg/L	0.00131	0.01451
Arsenic	mg/L	0.0024	0.0061
Barium	mg/L	0.115	0.594
Beryllium	mg/L	0.000051	0.000051
Bismuth	mg/L	0.00008	0.00026
Cadmium	mg/L	0.00022	0.00115
Chromium	mg/L	0.0021	0.0074
Cobalt	mg/L	0.0142	0.0779

Table 8E4.2-2 Simulated Jay Waste Rock Storage Area Runoff Concentrations

Constituent	Units	Concentrations in Jay Waste Rock Storage Area Runoff – Post-Closure	
		Average	Maximum
Total Metals (continued)			
Copper	mg/L	0.0063	0.0137
Iron	mg/L	1.43	7.82
Lead	mg/L	0.00132	0.01871
Lithium	mg/L	0.006	0.009
Manganese	mg/L	0.57	3.41
Mercury	mg/L	0.000100	0.000115
Molybdenum	mg/L	0.006	0.0314
Nickel	mg/L	0.0198	0.0512
Selenium	mg/L	0.00107	0.00586
Silicon	mg/L	2.5	4.0
Silver	mg/L	0.000102	0.000474
Strontium	mg/L	0	1.4
Thallium	mg/L	0.00009	0.00030
Tin	mg/L	0.00014	0.00063
Titanium	mg/L	0.019	0.052
Uranium	mg/L	0.047	0.398
Vanadium	mg/L	0.00083	0.00160
Zinc	mg/L	0.029	0.2086

a) Assumed pH value based on observed results in the baseline geochemistry test results.
b) Assumed TSS concentration
c) Calculated hardness based on simulated calcium and magnesium concentrations.
mg $CaCO_3$/L = milligrams calcium carbonate per litre; mg/L = milligrams per litre; mg N/L = milligrams nitrogen per litre.

8E5 DISCUSSION AND CONCLUSIONS

A model was developed to estimate the Project discharge water quality to Lac du Sauvage (during operations and post-closure) and Lac de Gras (during post-closure) daily. During operations, the only discharge from the mine site is minewater pumped from the Misery Pit to Lac du Sauvage. Water balance modelling (Appendix 8A) indicates the majority of minewater to be managed through the Misery Pit during operations originates from groundwater flowing to the Jay Pit. As a result, the quality of the discharge from the Misery Pit is mainly influenced by changes to water quality in the Jay groundwater. Two distinct trends were observed in projected concentrations from the Misery Pit:

- constituent concentrations gradually increase throughout the mine life (e.g., TDS, chloride, nitrate, total phosphorus arsenic) ; and,
- concentrations of constituents decrease throughout the mine life (e.g., sulphate, aluminum, cobalt, copper, iron, nickel).

Constituents that increased through operations were simulated to have concentrations greater in the Jay Pit groundwater in comparison to the mixed concentrations of all other drainages reporting to the Misery Pit (e.g., natural runoff, wall rock runoff, and direct precipitation) and vice versa for constituents that had decreasing concentrations in the Misery Pit discharge during the life of the mine.

At closure, approximately 13.7 million m^3 of water will be pumped from the Misery Pit to the mined-out Jay Pit. The water pumped from the Misery Pit will be replaced with freshwater pumped from Lac du Sauvage to develop a freshwater cap. Modelling of the freshwater cap water quality in the Misery Pit during post-closure indicates that concentrations of modelled constituents are similar to existing conditions but increase as a result of mixing with water stored in the monimolimnion and wall rock runoff. However, long-term steady state concentrations are much generally less than the maximum projected operational water quality.

Water stored in the monimolimnion of the Misery Pit is composed of residual minewater pumped from the Jay Pit during operations, and concentrations of several constituents (e.g., TDS, chloride, nitrate, and total phosphorus) are higher in comparison to concentrations in the freshwater cap. Hydrodynamic modelling indicates the monimolimnion will not mix with the mixolimnion in the long-term and as a result, the elevated concentrations in the monimolimnion are not expected to influence surface water quality in the long-term. A small amount of seepage is expected to drain from the monimolimnion to Lac de Gras; however, the seepage rate is so low (54 m^3/d) that it is not expected to have an effect on Lac de Gras surface water quality.

The Jay Pit monimolimnion also has elevated concentrations of several constituents (e.g., TDS, chloride, nitrate, and total phosphorus) since it is a mixture of minewater stored in the Misery Pit during operations, groundwater inflows, and wall rock runoff. Hydrodynamic modelling of this facility indicates the mixolimnion will mix with a component of the monimolimnion and this mass exchange was included in the Lac du Sauvage lake hydrodynamic model (Appendix 8G). However, in the long-term, the hydrodynamic model indicates meromictic conditions will establish in the Jay Pit, permanently isolating the monimolimnion mixing with the overlying mixolimnion, which includes Lac du Sauvage.

Runoff from the Jay WRSA will report to Lac du Sauvage during post-closure. A randomly generated chemistry profile was assigned to this drainage based on an observed distribution in WRSA monitoring results from the Ekati Mine. Concentrations of several constituents (e.g., TDS, chloride, nitrate, and total phosphorus) are higher in the WRSA runoff in comparison to existing conditions in Lac du Sauvage; however, the total runoff from the WRSA only accounts for small component of the total Lac du Sauvage watershed and is not expected to have an effect on the surface water quality in Lac du Sauvage.

8E6 REFERENCES

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8E7 GLOSSARY

Term	Definition
Back-flooding	A reversal of flow of water at the water table resulting from changes in precipitation.
Bedrock	The solid rock (harder than 3 on Moh's scale of hardness) underlying soils and the regolith in depths ranging from zero (where exposed to erosion) to several hundred metres.
Constituent	An individual chemical, property, or measurement in water and fish tissue (e.g., aluminum, chloride, total dissolved solids)
Dewatering	Removal of water from a natural waterbody by pumping or draining.
Dike	A natural or artificial slope or wall to regulate water levels.
Discharge	The volumetric rate of flow of water in a watercourse at a specified point, expressed in units of cubic metres per second or equivalent.
Freshet	A sudden overflow of a stream caused by heavy rain or nearby thawing of snow or ice. Can be seasonal surface runoff associated with spring melt.
Geochemistry	The chemistry of the composition and alterations of solid matter such as sediments or soil.
Groundwater	That part of the subsurface water that occurs beneath the water table, in soils and geologic formations that are fully saturated.
Groundwater (deep)	Ancient fossil or connate water that occupies pores and crevices in the bedrock below the permafrost layer.
Groundwater (shallow)	Water that occupies pores and crevices in the rock and soil of the active layer above the permafrost layer.
Groundwater discharge	Release of groundwater from a subsurface zone of saturation.
Groundwater flow	The movement of water through interconnected voids in the phreatic zone.
Holomictic lake	A waterbody, such as a lake, where at least once per year, physical mixing occurs between the surface and the deep waters
Inflow	Water flowing into a lake.
Kimberlite	Igneous rocks that originate deep in the Earth’s mantle and intrude the Earth’s crust. These rocks typically form narrow pipe-like deposits that sometimes contain diamonds.
Meromictic conditions	Permanent segregation of waters with different densities
Metasediment Rock	Sedimentary rocks that have been modified by metamorphic processes.
Minewater	Includes runoff from facilities associated with mine development and all water pumped or flowing out of any pit or underground mine. Minewater will need to be managed and monitored prior to discharge to the environment.
Mixolimnion	The uppermost portion of a meromictic waterbody that behaves as holomictic lake
Monimolimnion	The lower portion of a meromictic waterbody that does not circulate much and is generally anoxic and saltier than the rest of the waterbody
Nutrients	Elements or chemicals essential to growth or repair of organic bodies, including carbon, oxygen, nitrogen, phosphorus, and silica.
Parameter	A particular physical, chemical, or biological property that is being measured in a groundwater system; whatever it is you measure in a groundwater system.
Particulate Matter	Any aerosol that is released to the atmosphere in either solid or liquid form.
Percentile (e.g., 98%)	The 98th percentile is the specific value (e.g., air quality ground-level concentration) below which 98% of the observed or modelled values occur (and only 2% of the values exceed the 98th percentile).
Runoff	The portion of water from rain and snow that flows over land to streams, ponds or other surface waterbodies. It is the portion of water from precipitation that does not infiltrate into the ground, or evaporate.
Salinity	The concentration of soluble salts in water measured as total dissolved solids.

Term	Definition
Sediment	Solid material that is transported by, suspended in, or deposited from water. It originates mostly from disintegrated rocks; it also includes chemical and biochemical precipitates and decomposed organic material, such as humus. The quantity, characteristics and cause of the occurrence of sediment in streams are influenced by environmental factors. Some major factors are degree of slope, length of slope soil characteristics, land usage and quantity and intensity of precipitation.
Seepage	Slow water movement in subsurface. Flow of water from man-made retaining structures. A spot or zone, where water oozes from the ground, often forming the source of a small spring.
Stochastic	1) Random, specifically, involving a random variable. 2) Involving chance or probability.
Total Dissolved Solids	The dissolved matter found in water comprised of mineral salts and small amounts of other inorganic and organic substances.
Total Suspended Solids	The amount of suspended substances in a water sample. Solids, found in wastewater or in a stream, which can be removed by filtration. The origin of suspended matter may be artificial or anthropogenic wastes or natural sources such as silt.
Waste Rock	Rock moved and discarded in order to access resources.
Waste Rock Storage Areas	Engineered landforms in which waste rock from mining activities is stored.
Water quality	A measure of concentrations of contaminants, or naturally occurring minerals, in water. Lower the concentrations of a particular contaminant lead to better water quality.
Water table	The upper surface of groundwater or that level below which the soil is saturated with water.