# APPENDIX B

## Operations and Closure – Mount Polley Mine Water Balance

17 October 2016

OPERATIONS AND CLOSURE

# Mount Polley Mine Water Balance Model

**Submitted to:**
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REPORT

**Reference Number: 1411734-167-R-Rev0-16000**

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# Executive Summary

Mount Polley Mining Corporation (MPMC) retained Golder Associates Ltd. (Golder) to prepare a Technical Assessment Report (TAR) in support of the Long-term Water Management Plan (LTWMP) that will include operations through closure and post-closure mining phases.

Mining operations at the Mount Polley Mine (the Mine) were suspended following a foundation failure of the Tailings Storage Facility (TSF) Perimeter Embankment on 4 August 2014. MPMC resumed restricted operations in August 2015, with the tailings being deposited within Springer Pit. Authorization to use the TSF for resumed tailings deposition was received by MPMC on 23 June 2016; however, due to the timelines required in developing this report, for the purpose of this document, use of the TSF is assumed from July 2016.

This site-wide water balance model (SWWBM) was developed for the Mine using GoldSim™ (Version 11.1) software. The SWWB is being used to support short- and long-term water management planning, and will form the basis of effluent treatment and discharge options.

Two operational Mine management scenarios were evaluated with this water balance:

- restricted operations - until 30 June 2016
- full operations – 1 July 2016 to 30 June 2020

Additional scenarios were evaluated for closure and post-closure. Closure is defined as the first two years (1 July 2020 to 30 June 2022) following the end of operations, followed by post-closure from 1 July 2022 to 31 December 2050.

The SWWBM was calibrated and validated based on past and current Mine conditions, and used to generate a range of stochastic climate scenarios (0.5 percentile to 99.5 percentile) to probabilistically assess Mine water management alternatives. The Mine has a positive water balance; consequently, water will need to be discharged under mean climate conditions. A summary of key findings is provided below:

- During dewatering of the Springer Pit (2016 and 2017), the mean annual discharge is approximately 7.5 $Mm^3$.
- During future operations (2018 to 2020), the mean annual discharge is approximately 5.9 $Mm^3$.
- During closure (2021 and 2022), the mean annual discharge is approximately 3.8 $Mm^3$.
- The maximum annual discharge for 99.5 percentile extreme wet conditions is 9.9 $Mm^3$ in 2017.
- The Springer Pit is projected to be dewatered to the elevation of the deposited tailings by the second quarter 2018, or as late as the fourth quarter 2018, under extreme wet (99.5 percentile) conditions.
- The mean pond volume in the TSF during full operations is expected to reach approximately 1.5 $Mm^3$ on 1 July each year.
- The maximum TSF pond elevation during full operations (99.5 percentile) is approximately 3.7 $Mm^3$.

- Because discharge from the Mine is constrained in 2017 by natural flows in Hazeltine Creek, there is some potential for carry-over volume in the TSF to 2018 under extreme wet conditions. In all other years there is no carry over.
- During full operations, the mean annual volume of makeup water drawn from Polley Lake is approximately 2.0 $Mm^3$. Under extreme dry conditions (99.5 percentile), the estimated annual makeup water volume is 2.8 $Mm^3$.
- Permanent pit lakes are projected to develop in the combined Phase 4 Cariboo-Springer Pit and the Wight Pit.
- Post-closure, the combined Cariboo-Springer Pit Lake is projected to reach the overflow elevation of 1,050 masl between 2042 and 2044. The effect of climate change was assessed using the conservative Representative Concentration Pathways (RPC) 8.5 scenario, and this affected Springer pit lake filling to 1,050 masl by only a few months.
- Post-closure, the Wight Pit Lake will reach the overflow elevation of 926 masl by 2026.
- A seasonal pond will develop in the Boundary Pit, which will not reach the overflow elevation of 1,073 masl.
- PAG material placed in the combined Cariboo-Springer Pit will have a final elevation of 1,004 masl. Post-closure, this will be inundated and covered by the pit lake before 2025.

In addition to the Base Case, four additional contingencies were evaluated:

1) Base Case with rewetting of the tailings in the TSF.
2) Base Case with Mine Care and Maintenance starting 1 July 2017.
3) Base Case with no discharge from the Mine during April and May 2017.
4) Base Case with no controlled discharge from the Mine after 30 March 2017.

# Study Limitations

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**ATTACHMENT B**
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**ATTACHMENT C**
Predictions of Hydrogeological Conditions near the Springer and Cariboo Pits - Long-Term Technical Assessment Report - Mount Polley Mine

**ATTACHMENT D**
Preliminary Predictions of Groundwater Seepage for the Boundary Pit - Mount Polley Mine

**ATTACHMENT E**
Preliminary Predictions of Groundwater Seepage for the Wight Open Pit at Closure - Mount Polley Mine

**ATTACHMENT F**
Predictions of Hydrogeological Conditions near the Tailings Storage Facility during Closure - Long-Term Technical Assessment Report – Mount Polley Mine

**ATTACHMENT G**
Mount Polley Mine Technical Assessment Report: Climate Change Projections.

# 1.0 INTRODUCTION

Mount Polley Mining Corporation (MPMC) retained Golder Associates Ltd. (Golder) to prepare a Technical Assessment Report (TAR) in support of the Long-term Water Management Plan (LTWMP) that covers the operations through closure and post-closure mining phases, as defined in the TAR (Section 2.3.3).

Mining operations at the Mount Polley Mine (the Mine) were suspended following a foundation failure of the Tailings Storage Facility (TSF) Perimeter Embankment at Corner 1 on 4 August 2014. MPMC resumed restricted operations in August 2015, with the tailings being deposited within Springer Pit. Authorization to resume using the TSF for tailings deposition was received by MPMC on 23 June 2016; however, due to the timelines required in developing this report, for the purpose of this document, use of the TSF is assumed from July 2016.

This report presents the site-wide water balance model (SWWBM), based on the Cariboo-Springer Pit Phase 4 Mine plan, which includes the 970 metre (m) raise on the TSF to facilitate deposition associated with the return to full operations (Golder, 2015a). The work presented in this report is as follows:

- a brief summary of the background physical setting at the project site (Section 2.0)
- an overview of the climate and hydrology at the site (Section 3.0)
- an overview of surface and groundwater considerations (Section 4.0)
- a presentation of the SWWBM (Section 5.0)
- results of the SWWBM (Section 6.0)

## 2.0 BACKGROUND

The Mine is a copper and gold mine operated by MPMC. The Mine is 56 kilometers (km) northeast of Williams Lake, British Columbia. The Mine began production in 1997 and operated until October 2001, when operations were suspended for economic reasons. In March 2005, the Mine restarted production and it had been in continuous operation up to the time of the TSF foundation failure. Ore is crushed and processed by selective flotation to produce a copper-gold concentrate. The maximum mill throughput rate was approximately 6 to 8 million tonnes per year (22,000 tonnes per day).

The project location is shown in Figure 1, while the Mine site layout is shown in Figure 2. The Mine is located between Polley Lake and Bootjack Lake. The Mine operates with an annual water surplus. During its first stage of development (1997 to 2001), the Mine recycled water from the TSF for reuse in the milling process. It was not necessary for the Mine to discharge water during the initial period of operation. When the Mine re-opened in 2005, a surplus of water was present and a permit amendment was sought to allow discharge of treated surplus water into Hazeltine Creek (MPMC 2009). This amendment, issued in 2013 for Permit 11678 under the BC *Environmental Management Act* (EMA), imposed certain limits for effluent quality, non-toxicity requirements, and target levels for specific analytes in Hazeltine Creek, as well as the following volume limits:

- A maximum annual discharge of 1.4 million cubic metres ($Mm^3$) could be discharged.
- The permitted discharge amount was not to exceed 35% of the daily flow of Hazeltine Creek.

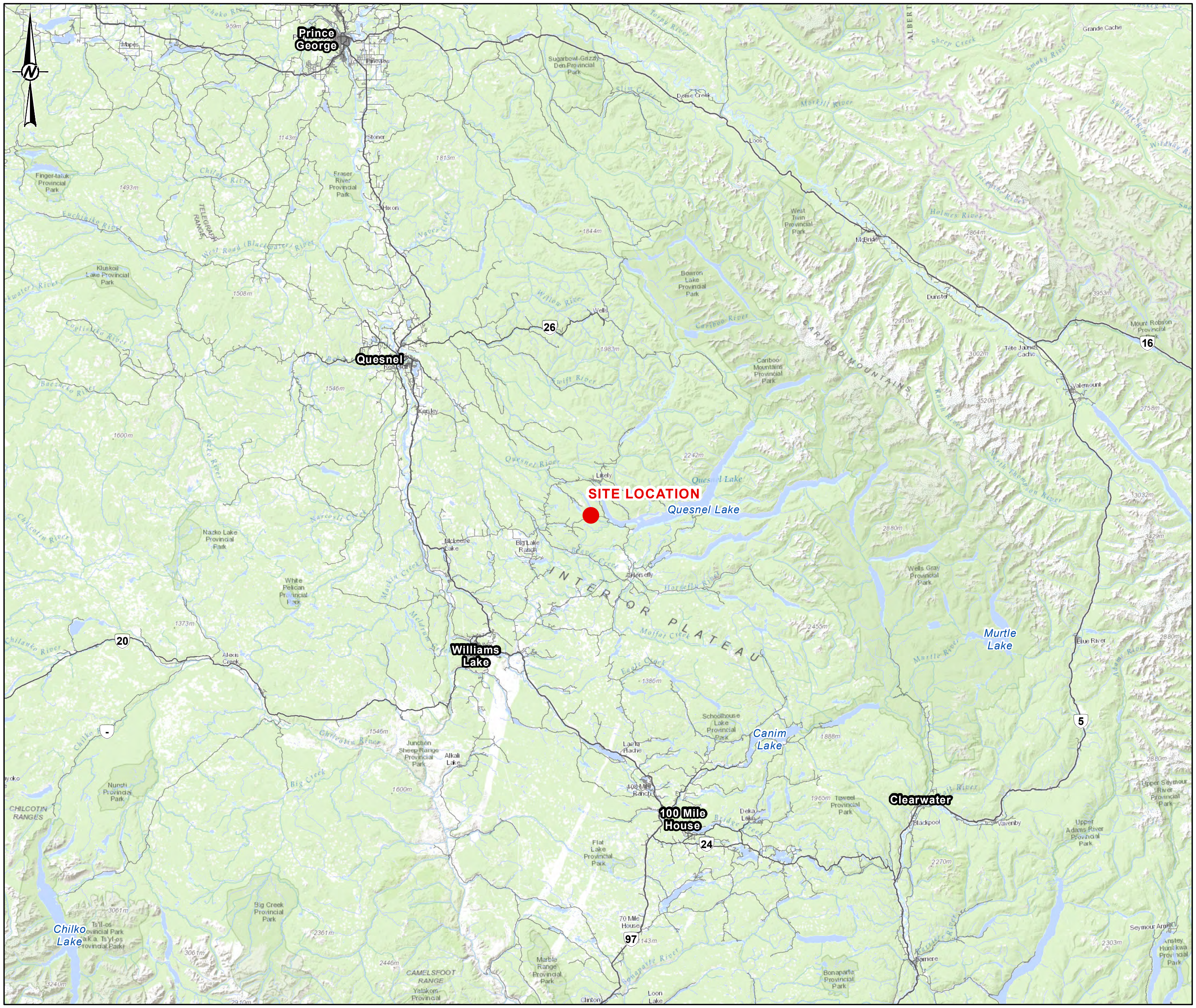
The Mine has continued to expand its operation, resulting in an increased Mine footprint as well as an increase in the contact water to be managed. To address the increased contact water volumes, prior to the TSF foundation failure, MPMC was actively pursuing an interim water management measures using a reverse osmosis treatment plant with discharge of treated water to Polley Lake. The reject water from the reverse osmosis plant was to be directed to the TSF. The proposed application of reverse osmosis was intended for a short period (approximately four years) and not as a suitable technology post-closure.

Prior to the TSF foundation failure on 4 August 2014, contact water flowed or was pumped to the TSF and was recycled to the mill as process water. Operations were suspended until August 2015, when restricted operations commenced with mining and milling of 4 million tonnes (Mt) of ore. Under restricted operations, tailings, process water, and Mine contact water have been pumped and stored in Springer Pit. In April 2016, authorization was received to allow 5 Mt of ore to be processed, which would allow mining to continue under restricted operations until late June 2016.

A Veolia Actiflo® water treatment plant (WTP) was commissioned in December 2015, and discharge of treated Mine water from the Perimeter Embankment Till Borrow Pond (PETBP) commenced. The design capacity of the WTP is 0.23 cubic metres per second ($m^3/s$), but actual performance achieved closer to 0.18 $m^3/s$ in the current configuration. In May 2016, a direct pipeline from Springer Pit to the WTP was installed to maximize the effective discharge rate. On 11 March 2016, MPMC obtained a temporary authorization to bypass the WTP, provided water quality and total flow limits in the EMA Permit 11678 are met. To date, this bypass has not been used and all discharge is through the WTP. In recent weeks, flows near the Permit limit of 0.3 $m^3/s$ have been achieved by passing the water conveyed directly from Springer Pit through the WTP in "passive mode". The allowable maximum annual discharge is currently 9.47 $Mm^3$ (0.3 $m^3/s$). The water balance model assumes that the maximum annual discharge will be increased to 10.4 $Mm^3$ (0.33 $m^3/s$) after 1 July 2016.

Mine effluent is discharged into the upper Hazeltine Creek channel, which flows to a diffuser at Quesnel Lake. The design capacity of the diffuser is 0.6 $m^3/s$, and during high flows in Hazeltine Creek, the discharge of Mine water is curtailed or halted to avoid overflow of Mine effluent to the surface of Quesnel Lake.

In 2015, a weir with a sluice gate was installed at the outlet channel of Polley Lake (Figure 3) to regulate flows to Hazeltine Creek. The sluice gate is currently operated to detain freshet runoff in Polley Lake to reduce peak flows and to release the flow over later summer, fall, and winter months. This allows increased discharge of Mine effluent during the freshet period (April to June). The weir also allows detainment of flows to accommodate ongoing construction associated with creek rehabilitation following the TSF foundation failure. Discharge to Quesnel Lake via the Hazeltine Creek channel is scheduled to continue until November 2017, then a pipeline is proposed to convey Mine effluent directly to the diffuser in Quesnel Lake, which would allow Hazeltine Creek to be rehabilitated for fish access.




LEGEND

- SITE LOCATION
- ROAD
- WATERCOURSE
- WATERBODY


0 25 50
1:1,250,000 KILOMETRES

REFERENCES
1. INSET MAP DATA OBTAINED FROM GEOBASE®.
2. BASEMAP OBTAINED FROM ESRI. USED UNDER LICENCE, ALL RIGHTS RESERVED.
3. ROAD, WATERCOURSE AND WATERBODY DATA OBTAINED FROM IHS INC.
4. DATUM: NAD 1983 UTM ZONE 10N

CLIENT
MOUNT POLLEY MINING CORPORATION
IMPERIAL METALS

PROJECT
WATER MANAGEMENT PLAN - SITE WATER BALANCE MODEL

TITLE
LOCATION OF MOUNT POLLEY MINE

CONSULTANT
Golder Associates

| | |
|---|---|
| YYYY-MM-DD | 2015-05-29 |
| DESIGNED | JR |
| PREPARED | CD |
| REVIEWED | RM |
| APPROVED | JV |

| PROJECT NO. | CONTROL | REV. | FIGURE |
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LEGEND

WATER COLLECTION SYSTEMS

- CLEAN WATER DITCH
- CONTACT WATER DITCH
- PIPELINE
- CONTOUR (10m)

0 750 1,500

1:30,000 METRES

REFERENCES

1. CONTOURS AND PROJECT IMAGERY OBTAINED FROM SNC LAVALIN (2014)
2. WATER CATCHMENT AREAS INTERPOLATED BY GOLDER ASSOCIATES LTD.
3. BASE IMAGERY SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEX, GETMAPPING, AEROGRID, IGN, IGP, SWISSTOPO, AND THE GIS USER COMMUNITY
4. DATUM: NAD 1983 UTM ZONE 10N

CLIENT

MOUNT POLLEY MINING CORPORATION
IMPERIAL METALS

PROJECT

WATER MANAGMENT PLAN - SITE WATER BALANCE MODEL

TITLE

MINE SITE LAYOUT

CONSULTANT

Golder Associates

| | |
|---|---|
| YYYY-MM-DD | 2015-06-09 |
| DESIGNED | APB |
| PREPARED | RH / CD |
| REVIEWED | RM |
| APPROVED | RM |

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*Figure 3: Polley Lake Weir with Sluice Gate for Controlled Release of Flow*

# 3.0 CLIMATE AND HYDROLOGY

## 3.1 Climate

The Mine is in the Cariboo region of British Columbia, approximately 56 km northeast of Williams Lake. This region experiences high spatial climate variation due to its topographical complexity. MPMC has operated climate stations on site since 1995, although records are not continuous. From 1995 through 2012, MPMC maintained one climate station at the mill site that measured and recorded rainfall and temperature. In 2012, this was replaced with two stations: one near the mill site and one adjacent to the TSF. These new stations measure and record wind speed and direction, relative humidity, solar radiation, temperature, and rainfall. The details of these stations are shown in Table 1. The locations of the Mine weather stations are shown in Figure 4, and climate data are provided in Attachment B.

The climate of the Mine site was characterized using the Environment Canada (EC) station in the nearby community of Likely, as well as the three on-site climate stations.

**Table 1: Local and Regional Climate Stations for the Mount Polley Mine**

| Station Name | ID | Northing (m N)[(a)] | Easting (m E) | Elevation (masl)[(b)] | Data Type | Period of Record |
|---|---|---|---|---|---|---|
| Likely | 1094616 | 5828785 | 599332 | 724 | Temperature, rainfall, snowfall, total precipitation | 1974–1993 |
| Mill Site Weather Station | N/A | 5822420 | 592495 | 1,181 | Rainfall, temperature | 1995–2012 |
| Weather Station #1 (near mill) | N/A | 5822420 | 592792 | 1,171 | Rainfall, temperature, relative humidity, solar radiation, wind speed, wind direction | 2012–present |
| Weather Station #2 (TSF) | N/A | 5819955 | 594059 | 964 | Rainfall, temperature, relative humidity, solar radiation, wind speed, wind direction | 2012–present |

a) UTM Coordinate system - Zone 10U.

b) Elevation for on-site climate stations measured with handheld GPS device.

masl = metres above sea level; N/A = not applicable; TSF = Tailings Storage Facility.

During the winter, snowpack is measured at four snowcourse sites at least once per month, with more frequent measurements typically being recorded during the snowmelt phase. The details of these stations are provided in Table 2, and their locations are shown on Figure 4.


LEGEND

◆ CLIMATE STATION

— CONTOUR (10m)

0 750 1,500

1:30,000 METRES

REFERENCES
1. CONTOURS AND PROJECT IMAGERY OBTAINED FROM SNC LAVALIN (2014)
2. WATER CATCHMENT AREAS INTERPOLATED BY GOLDER ASSOCIATES LTD.
3. BASE IMAGERY SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEX, GETMAPPING, AEROGRID, IGN, IGP, SWISSTOPO, AND THE GIS USER COMMUNITY
4. DATUM: NAD 1983 UTM ZONE 10N

CLIENT
MOUNT POLLEY MINING CORPORATION
IMPERIAL METALS

PROJECT
WATER MANAGMENT PLAN - SITE WATER BALANCE MODEL

TITLE
MOUNT POLLEY CLIMATE AND SNOWCOURSE STATIONS

CONSULTANT

Golder Associates

| | |
|---|---|
| YYYY-MM-DD | 2015-06-02 |
| DESIGNED | APB |
| PREPARED | CD |
| REVIEWED | RM |
| APPROVED | RM |

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**Table 2: Local Snowcourse Stations at the Mount Polley Mine**

| Station Name | ID | Northing (m N)[a] | Easting (m E) | Approximate Elevation (masl)[b] | Period of Record |
|---|---|---|---|---|---|
| Snowcourse # 1 (near Mill) | N/A | 5823182 | 592792 | 1,171 | 1997–2010, 2015–current |
| Snowcourse # 2 (near TSF) | N/A | 5819976 | 594092 | 964 | 1997–current |
| Snowcourse # 3 | N/A | 5823895 | 593632 | 976 | 2012–current |
| Snowcourse # 4 | N/A | 5823537 | 590835 | 1,112 | 2015–current |

a) UTM Coordinate system - Zone 10U.

b) Elevation for on-site climate stations measured with handheld GPS device.

masl = metres above sea level; N/A = not applicable; TSF = Tailings Storage Facility.

### 3.1.1 Temperature

The community of Likely is approximately 9 km northeast of the Mine at 724 metres above sea level (masl). The elevation of the Mine ranges from about 920 masl to 1,200 masl, and therefore the average temperatures are generally 0.3 to 1.0°C cooler than recorded at Likely.

Monthly values for the Likely climate station are shown in Table 3. Temperatures at Likely are generally mild to cold, with average monthly temperatures ranging from 15.1°C in July to -6.6°C in January.

**Table 3: Likely Climate Station Monthly Temperatures (1974 to 1993)**

| Month | Temperature (°C) | | |
|---|---|---|---|
| | Average | Maximum | Minimum |
| January | -6.6 | -2.9 | -11.1 |
| February | -4.5 | 0.6 | -9.4 |
| March | -0.8 | 5.8 | -6.0 |
| April | 4.0 | 11.3 | -2.1 |
| May | 9.1 | 16.3 | 2.3 |
| June | 12.8 | 19.8 | 6.0 |
| July | 15.1 | 22.7 | 8.1 |
| August | 15.1 | 22.3 | 7.8 |
| September | 10.7 | 17.3 | 4.0 |
| October | 4.7 | 10.6 | 0.1 |
| November | -1.3 | 2.4 | -4.8 |
| December | -5.6 | -2.1 | -9.2 |
| **Annual** | **4.4** | **10.3** | **-1.2** |

### 3.1.2 Precipitation

Long-term precipitation time series representative of the climate conditions at the Mine were derived using the long-term regional data from the Likely station (1974 to 1993) and available local data from the three Mine climate stations (1995 to 2015).

The Mine experiences high summer precipitation due to summer storms, with the lowest precipitation occurring in February. Precipitation typically occurs as snowfall starting in November and accumulates until March. Average annual precipitation at the Mine is estimated to be 670 mm. Estimated 1:200-year dry, average, and 1:200-year wet precipitation depths are shown in Table 4.

**Table 4: Long-Term Precipitation at the Mount Polley Mine (1974 to 2015)**

| Month | Precipitation (mm) | | | | |
|---|---|---|---|---|---|
| | **Average** | **1:200-Year Dry** | **1:25-Year Dry** | **1:25-Year Wet** | **1:200-Year Wet** |
| January | 50.8 | 26.9 | 33.3 | 72.0 | 82.9 |
| February | 37.5 | 19.8 | 24.5 | 53.1 | 61.1 |
| March | 42.8 | 22.7 | 28.0 | 60.7 | 69.8 |
| April | 49.5 | 26.2 | 32.4 | 70.2 | 80.7 |
| May | 53.5 | 28.3 | 35.1 | 75.8 | 87.3 |
| June | 78.2 | 41.4 | 51.3 | 111 | 128 |
| July | 58.9 | 31.2 | 38.6 | 83.4 | 96.0 |
| August | 52.2 | 27.6 | 34.2 | 73.9 | 85.1 |
| September | 48.2 | 25.5 | 31.5 | 68.3 | 78.6 |
| October | 58.2 | 30.8 | 38.1 | 82.5 | 94.9 |
| November | 53.5 | 28.3 | 35.1 | 75.8 | 87.3 |
| December | 85.6 | 45.3 | 56.1 | 121.3 | 140 |
| **Annual** | **670** | **354** | **438** | **948** | **1091** |

Note: No precipitation data were available for 1994. Includes Likely climate station data (1974 to 1993).

The 1:25-year dry and wet, as well as the 1:200-year dry and wet precipitation values were determined by distributing the average annual precipitation (derived based on Likely and Mine stations) among the months based on average percentage of precipitation for each month.

### 3.1.3 Evaporation

Currently at the Mine, there are two climate stations that measure and record precipitation (rain), temperature, wind speed and direction, solar radiation, and relative humidity every 5 to 30 minutes. Lake (open water) evaporation is calculated based on measured climate parameters such solar radiation, wind speed, and temperature, using the Penman equation (Penman 1948). Lake evaporation estimates have been derived for 2005 through 2012. Lake evaporation shows a typical seasonal profile, with no evaporation in the winter months and maximum evaporation in the summer months. Average annual lake evaporation at the Mine is estimated to be 404 mm. Estimated average monthly and annual lake evaporation values are provided in Table 5.

**Table 5: Estimated Monthly and Annual Lake Evaporation (1997 to 2012)**

| Month | Lake Evaporation (mm) |
|---|---|
| January | 0 |
| February | 0 |
| March | 0 |
| April | 0 |
| May | 52.0 |
| June | 94.3 |
| July | 102 |
| August | 88.8 |
| September | 48.1 |
| October | 18.2 |
| November | 0.3 |
| December | 0 |
| **Annual** | **404** |

Note: Derived from data measured at on-site climate stations, pro-rated with long-term data from Likely Climate Station (19 years).

### 3.1.4 Future Climate Change Projections

Current operations are scheduled until 2020, and therefore adjustments for future climate change are not required. However, over the longer term into post-closure, climate change may become significant. Although the current water balance focuses on the current operations, pit lake filling (Section 6.6) extends several decades into post-closure; therefore, the potential effects of climate change should be considered.

The effect of climate change on precipitation and temperature can be assessed using results from global circulation models (GCMs) that have been run to forecast changes under different climate scenarios. The resolution of these models is typically spatially coarse. For example, the Canadian Earth System Model CanESM2 (Chylek et al. 2011) has a horizontal resolution of 310 km (2.81 degrees), which limits the application to local changes, particularly in mountainous environments. Statistical downscaling and interpolation techniques are available to provide greater resolution. An approach that is used in British Columbia is PRISM (Parameter-elevation Regressions on Independent Slopes Model), which is an expert system that uses point data and a digital elevation model to generate gridded estimates of climate parameters (Daley et al. 2002). In British Columbia and North America, PRISM-generated data for historical conditions and for future climate scenarios are available from the ClimateBC online resource (Wang et al. 2012).

PRISM-generated values from ClimateBC have been used to assess future changes to temperature and precipitation (Attachment G). Results from the CanESM2 are available for two scenarios: RCP 4.5 and RCP 8.5. RCPs (Representative Concentration Pathways) refer to climate scenarios and indicate the additional climate forcing ($W/m^2$) in the year 2100 (e.g., 4.5 $W/m^2$). RCP 8.5 is the more conservative (warmer) scenario (Figure 5), although there are indications that the projected $CO_2$ forcings for RCP 8.5 are too extreme to be realized (Inman 2011).

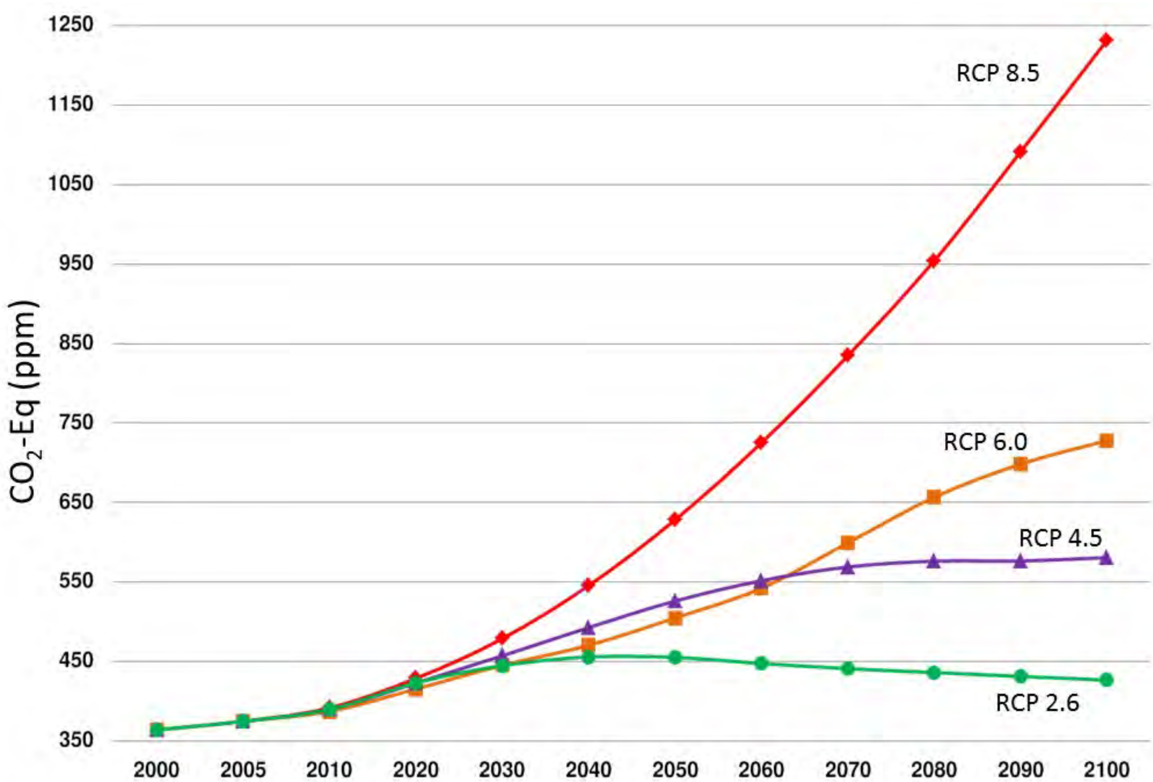



*Figure 5: C02 Equivalent Climate Forcing's for Representative Pathway Concentrations (RCP) Scenarios.*

Source: Moss et al. (2008).

Changes relative to current conditions were determined for the RCP 4.5 and RCP 8.5 scenarios for years 2025, 2055, and 2085. The relative changes determined from the ClimateBC data were added to the Current (2016) Mount Polley Mine monthly values to derive future average monthly and annual values for 2025, 2055, and 2085. The projected annual climate parameters for Current (2016) conditions and for RCP 4.5 and RCP 8.5 scenarios for 2025, 2055, and 2085 are summarized in Table 6. The climate change scenarios are based on the CanESM2 model values provided from the ClimateBC online resource. In general, the future climate change scenarios indicate warmer, wetter conditions, with increased evaporation and reduced snowfall.

**Table 6: Projected Annual Mount Polley Climate from CanESM2 Model**

| Scenario | Year | Mean Annual Temp (°C) | Change in Mean Annual Temp (°C) | Precipitation (mm) | Rainfall (%) | Snowfall (%)[a] | Evaporation (mm) |
|---|---|---|---|---|---|---|---|
| Current | 2016 | 4.4 | 0 | 670 | 67 | 33 | 404 |
| RCP 4.5 | 2025 | 5.9 | 1.5 | 692 | 67 | 33 | 457 |
| | 2055 | 7.3 | 2.9 | 694 | 73 | 27 | 524 |
| | 2085 | 8.1 | 3.7 | 721 | 74 | 26 | 547 |
| RCP 8.5 | 2025 | 6.0 | 1.6 | 689 | 67 | 33 | 458 |
| | 2055 | 8.4 | 4 | 718 | 74 | 26 | 557 |
| | 2085 | 11.1 | 6.7 | 742 | 84 | 16 | 644 |

a) After sublimation loss.

RCP = representative concentration pathway.

## 3.2 Site Drainage and Surface Hydrology

The Mine is drained by three main watersheds: the Hazeltine Creek (30.2 $km^2$) at Quesnel Lake, the Edney Creek (87.4 $km^2$) at Quesnel Lake, and the Morehead Creek (11.2 $km^2$) watersheds (Figure 6). The Hazeltine Creek watershed includes Polley Lake and conveys all water from Polley Lake, the east side of the Mine, and the area surrounding the TSF. The Morehead Creek watershed includes the Bootjack Lake catchment area (11.2 $km^2$). The watershed areas listed here exclude the Mine, which covers part of the original watersheds.

Both the Hazeltine Creek and the Morehead Creek watersheds were significantly altered by historical water diversions. Bootjack Creek, a small remnant of which now flows into Polley Lake via Bootjack Creek, historically conveyed water from Bootjack Lake to Hazeltine Creek. In 1913, flow from Bootjack Lake was reversed by miners (not associated with MPMC) damming the east end of Bootjack Lake and digging a new outlet westward to Morehead Creek. Around the same time, a water control structure was built at the outlet of Polley Lake (Hazeltine Creek), and Hazeltine Creek water was diverted to the Bullion Pit to support hydraulic mining. Flow from Polley Lake to Hazeltine Creek was restored with the abandonment of mining at the Bullion Pit during World War II. However, the flow from Bootjack Lake to Hazeltine Creek was never restored.

Prior to the TSF foundation failure, Edney Creek flowed into and Hazeltine Creek near Quesnel Lake. The mouths of the two creeks have now been separated, and Edney Creek and Hazeltine Creek now both discharge directly into Quesnel Lake.

Adopted design flows for Hazeltine Creek and other Mine drainages are provided in Table 7.

**Table 7: Adopted Design Flows**

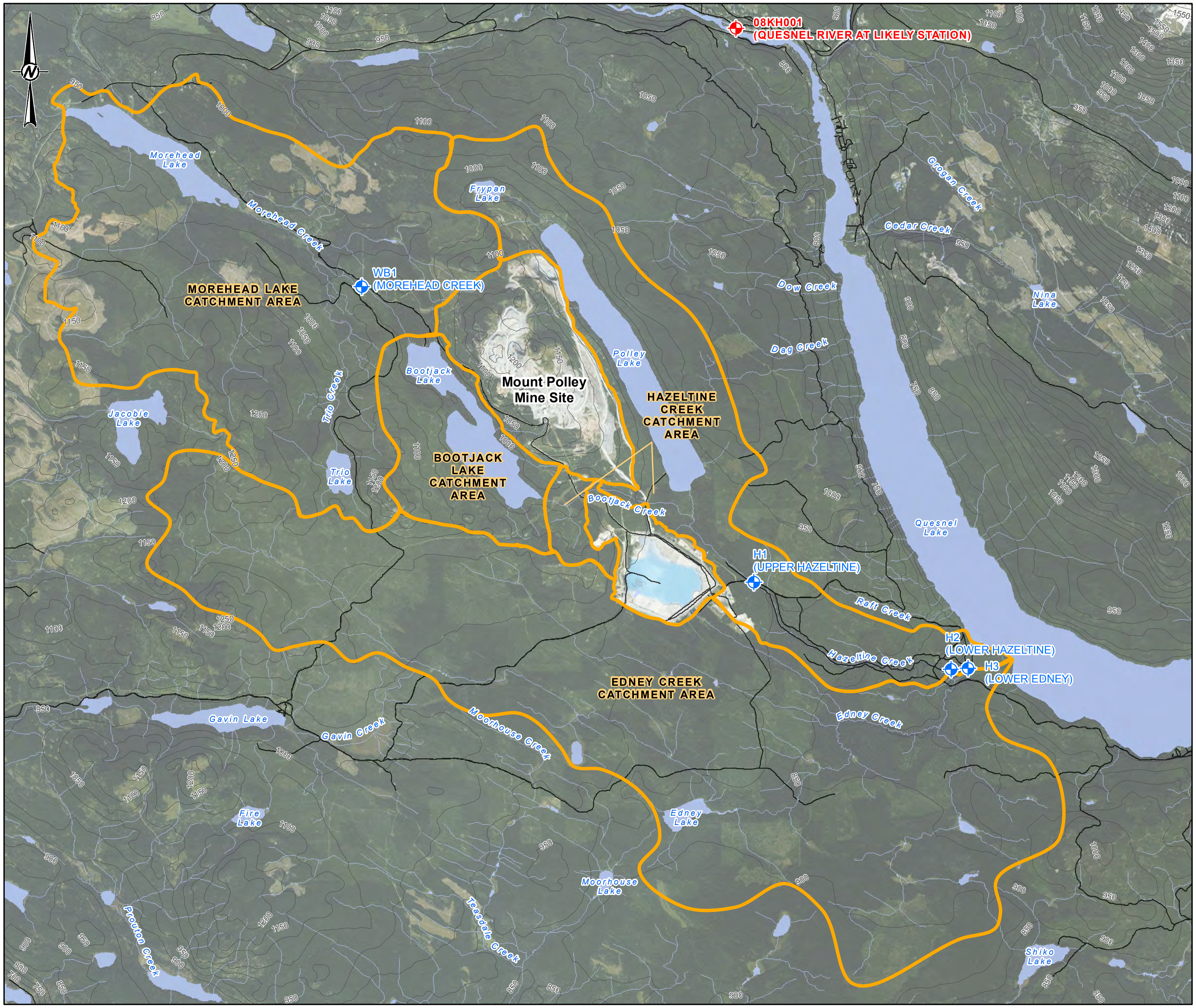
| Location | Area[a] (km$^2$) | Discharge ($m^3/s$) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | MAD | Mean 7-Day Low Flow | 7Q10 Low Flow | MAF | Q10 | Q100 | Q200 |
| Polley Lake Outlet (including Lake Area) | 21.4 | 0.17 | 0.014 | 0.0015 | 1.5 | 2.3 | 3.4 | 3.6 |
| Upper Hazeltine Creek Gauge (H1) | 24.3 | 0.19 | 0.016 | 0.0017 | 1.6 | 2.5 | 3.7 | 4.0 |
| Lower Hazeltine Creek (H2) | 28.6 | 0.21[b] | 0.018[2] | 0.0019 | 1.8 | 2.8 | 4.2 | 4.5 |
| Morehead Creek (outlet of Bootjack Lake) | 11.2 | 0.09 | 0.007 | 0.0008 | 0.9 | 1.4 | 2.1 | 2.2 |
| Edney Creek (above Hazeltine confluence) | 87.4 | 0.68 | 0.058 | 0.0061 | 4.2 | 6.5 | 9.7 | 10.4 |

a) Catchment areas provided by MPMC.

b) Adjusted by a factor of 1.12 from H1 based on measured flows at H2.

Source: Golder 2015b.

MAD = mean annual discharge; MAF = mean annual flood; Q10 = 1:10-year flow; Q100 = 1:100-year flow; Q200 = 1:200-year flow; MPMC = Mount Polley Mining Corporation.




LEGEND

- MPMC HYDROMETRIC STATION
- ENVIRONMENT CANADA HYDROMETRIC STATIONS
- WATER CATCHMENT AREA
- CONTOUR (50m)
- ROAD
- WATERCOURSE
- WATERBODY

0 2 4
1:80,000 KILOMETRES

**REFERENCES**
1. CONTOURS, ROAD, WATERCOURSE AND WATERBODY DATA OBTAINED FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
2. WATER CATCHMENT AREAS INTERPOLATED BY GOLDER ASSOCIATES LTD.
3. BASE IMAGERY SOURCE: ESRI, DIGITALGLOBE, GEOEYE, I-CUBED, USDA, USGS, AEX, GETMAPPING, AEROGRID, IGN, IGP, SWISSTOPO, AND THE GIS USER COMMUNITY
4. DATUM: NAD 1983 UTM ZONE 10N

CLIENT
MOUNT POLLEY MINING CORPORATION
IMPERIAL METALS

PROJECT
WATER MANAGEMENT PLAN - SITE WATER BALANCE MODEL

TITLE
**MAJOR DRAINAGES AND FLOW MONITORING STATIONS**

CONSULTANT
Golder Associates

| | |
|---|---|
| YYYY-MM-DD | 2016-06-02 |
| DESIGNED | RM |
| PREPARED | RH / CD |
| REVIEWED | RM |
| APPROVED | RM |

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## 3.3 Pit Groundwater Hydrology

Groundwater flow has been assessed for these open pits at the Mine:

- Springer and Cariboo pits
- Wight Pit
- Boundary Pit

The analysis is described in a series of technical memoranda (Attachments C, D, and E) and summarized below.

### 3.3.1 Springer and Cariboo Pits

As of May 2016, all tailings and Mine water are being pumped to and stored in the Springer Pit. Dewatering of the Springer Pit commenced in December 2015 after a short-term approval to discharge treated Mine water was received by MPMC. For the modelling described in this document, tailings deposition in the Springer Pit will continue until late June 2016, when the TSF becomes operational. The water stored in the Springer Pit will be drawn down and discharged, and deposited tailings will be removed from the pit and transferred to the TSF. The Springer Pit and the Cariboo Pit will be mined to the ultimate depths of approximately 878 and 938 masl elevation, respectively.

During closure, the Springer Pit and the Cariboo Pit will be allowed to flood. Once the pit lake level is above approximately 1,028 masl, these two pit lakes will merge and form a single pit lake. The spillway for this pit lake will be approximately 1,050 masl. Potentially acid generating (PAG) materials will be placed in the combined Cariboo-Springer Pit at closure and stored underwater (Section 6.6) to mitigate acid generation and metal leaching, in accordance with standard Mine waste handling practices (MEND 2015).

A hydrogeological assessment was conducted to predict the quantity of long-term groundwater seepage from both the Springer and the Cariboo pits towards Bootjack Lake for the Phase 4 Cariboo-Springer Pit Mine plan (Golder 2016). The analysis considered placing waste rock in the ultimate pit prior to the pit lake formation. As the pit lake level increases between 1,020 masl and 1,030 masl, seepage in the range of 10 to 100 $m^3$/d from the Springer Pit Lake into the subsurface was predicted to occur (Table 8). Seepage was found to gradually increase to approximately 400 $m^3$/d when the pit lake reaches the spillway at 1,050 masl. In the Cariboo Pit, seepage towards the Bootjack Lake of approximately 20 $m^3$/d was predicted to occur only when the pit lake level approaches 1,050 masl. At this elevation, Phase 4 Cariboo-Springer Pit Lake was predicted to act as a “flow-through” lake with groundwater recharge occurring from the uplands, northeast from both pits, and recharge to groundwater occurring towards southwest.

**Table 8: Predicted Groundwater Flows for the Springer and Cariboo Pit**

| Pit Lake Elevation (masl) | Springer Pit | | Cariboo Pit | |
|---|---|---|---|---|
| | Groundwater Flow ($m^3/d$) | | Groundwater Flow ($m^3/d$) | |
| Base Case | Into the Lake | Out of the Lake | Into the Lake | Out of the Lake |
| 880 (dewatered pit) | 520 | 0 | 600[(a)] | 0[(a)] |
| 940 | 510 | 0 | 610 | 0 |
| 960 | 490 | 0 | 610 | 0 |
| 980 | 460 | 0 | 590 | 0 |
| 1,000 | 420 | 0 | 540 | 0 |
| 1,020 | 320 | 10 | 460 | 0 |
| 1,030 | 300 | 100 | 420 | 0 |
| 1,040 | 280 | 250 | 380 | 0 |
| 1,050 | 270 | 400 | 320 | 20 |
| **Upper Bound** | | | | |
| 1,050 | 440 | 880 | 500 | 90 |
| **Lower Bound** | | | | |
| 1,050 | 190 | 220 | 250 | 0 |

a) These values represent conditions when the Cariboo Pit is fully dewatered (i.e., the base of the Cariboo Pit is at ~938 masl).

Source: Attachment C.

### 3.3.2 Wight Pit

Hydrogeological modelling was carried out for the Wight Pit (Attachment E). The results from the hydrogeological model indicate that under steady-state conditions, groundwater inflow to the Wight Pit is projected to gradually decrease from 2,600 $m^3/d$ at of 880 masl, to 600 $m^3/d$ at 926 masl (Table 9; Attachment E).

**Table 9: Predicted Groundwater Flows for the Wight Pit**

| Pit Lake Elevation (masl) | Groundwater Flow ($m^3/d$) | |
|---|---|---|
| | Into the Lake | Out of the Lake |
| **Base Case** | | |
| 880 | 2,600 | 0 |
| 900 | 2,500 | 0 |
| 910 | 2,100 | 0 |
| 920 | 800 | 0 |
| 926 | 600 | 500 |
| **Lower Reasonable Bound** | | |
| 926 | 400 | 300 |
| **Upper Reasonable Bound** | | |
| 926 | 700 | 800 |

Source: Attachment E.

### 3.3.3 Boundary Pit

At present, hydrogeological data specific to the Boundary Pit are not available. However, MPMC indicated that seepage was not observed along the pit walls while mining. This is considered reasonable due to the relatively shallow depth of the Boundary Pit and depth to water table measured at monitoring wells that were installed near other Mine facilities. It is thus considered likely that the water table was located near or below the floor of the Boundary Pit before mining at this location commenced.

Although seepage to the Boundary Pit from the surrounding rock mass is not expected, seepage out of this pit could occur due to water entering this pit via surface water runoff and direct precipitation. The potential seepage rates out of the pit were estimated for input to the pit water balance and to characterize a potential seepage pathway originating from this pit (Attachment D).

Seepage rates out of the Boundary Pit were estimated from a Darcy's Law calculation that considers changes in the dimensions of the seepage area as the pit is being flooded. The estimated seepage rate from the Boundary Pit when the pit lake surface level is 5 m above its base (1,073 masl) is approximately 59 $m^3$/d, with a potential range between 35 $m^3$/d and 177 $m^3$/d due to uncertainty in bedrock permeability (Table 10). Seepage outflow is estimated to decrease as the height of water column above the pit bottom decreases as shown Table 10.

**Table 10: Estimated Seepage Outflows from Boundary Pit**

| Surface Water Level (masl) | Estimated Groundwater Outflow ($m^3$/d) | | |
|---|---|---|---|
| | Lower Bound | Base Case | Upper Bound |
| 1,068 | 2 | 3 | 10 |
| 1,069 | 6 | 10 | 29 |
| 1,070 | 12 | 20 | 61 |
| 1,071 | 16 | 26 | 79 |
| 1,072 | 32 | 53 | 159 |
| 1,073 | 35 | 59 | 177 |

Source: Attachment D.

## 3.4 Seepage from the Tailings Storage Facility

Seepage from the TSF is collected in the seepage collection systems installed upstream and downstream of the till core. These systems drain to three seepage collection ponds (located downgradient of each of the South, Main, and Perimeter Embankments):

- Main Embankment Seepage Pond
- Perimeter Embankment Till Borrow Pond (PETBP)
- South Embankment Seepage Collection Pond

Data from the seepage collection systems before the TSF foundation failure were provided by MPMC staff. Approximately 87.2 liters per second (L/s) was measured to be draining to the three collection ponds before the TSF foundation failure.

A hydrogeological assessment was carried out to estimate the seepage rates and the potential seepage pathways from the TSF to the downgradient discharge areas during the closure phase (Attachment F). The assessment utilized a three-dimensional numerical model to represent the TSF and the surrounding areas based on the conceptual understanding of hydrogeological conditions that was derived using the available Mine data.

Figure 7 shows a time history of the Base Case predictions of seepage rates from the TSF. Similar to pre-TSF foundation failure operational conditions, groundwater flow towards the TSF was predicted to be generally from the northwest, originating from the area of Bootjack Lake and Mount Polley. Predicted groundwater flow within the TSF footprint was directed radially from the TSF towards Hazeltine Creek to the east, Edney Creek to the southeast, and Edney Creek tributaries to the southwest. The predicted average total seepage from the TSF in the first year of closure was approximately 47.2 L/s (Attachment F). The estimated seepage for each year of closure are provided in Attachment A.

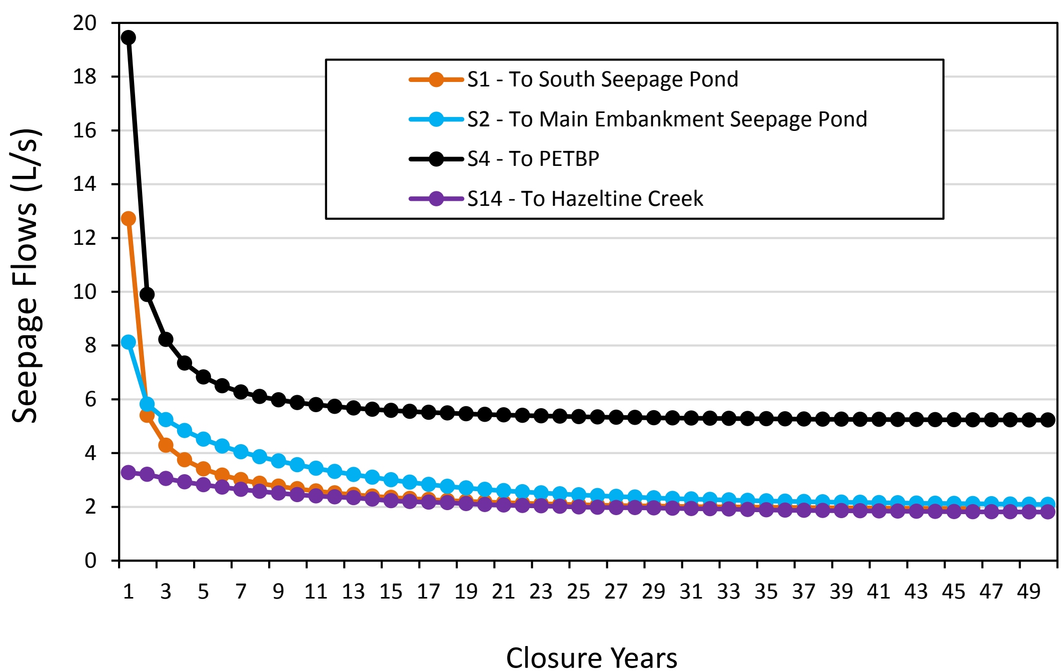



*Figure 7: Seepage Flows from the Tailings Storage Facility during Closure*

Source: Attachment F.

# 4.0 OVERVIEW OF MINE WATER MANAGEMENT AT MOUNT POLLEY

## 4.1 Objectives

The main objective of this LTWMP at the Mine is to define the practices that will help prevent the accumulation of contact water at the Mine, and to prevent unplanned and/or non-compliant releases of untreated contact water to the environment. The following strategies are proposed to meet this objective:

- to the extent practical, reduce the volume of non-contact water by diverting non-contact water away from disturbed areas
- treat and discharge excess Mine water so that minimal water accumulates with minimal carry-over from year to year, for conditions up to the 1-in-200-year wet conditions
- maintain a minimum pond volume of 1 $Mm^3$ in the TSF for the operation of reclaim pumps
- maintain adequate tailings beaches, with the goal of a minimum of 100-m-long beaches

There will be minimal storage of Mine water on site; however, during freshet (April through June) and extreme storm events, the volume of Mine water runoff will exceed the discharge and treatment capacity. Therefore, temporary detention of the freshet and extreme storm runoff volume will be necessary to equalize effluent discharge flows.

## 4.2 Surface Water Management

A network of channels, ponds, and pumping systems is operated by MPMC for managing surface water at the Mine. Surface water is segregated by contact and non-contact water:

- **Non-contact water**—water that has not been physically or chemically altered by mining or milling activities. Non-contact water is understood as runoff originating from upgradient areas unaltered by mining activity that does not come into contact with mining areas. It is typically diverted to the maximum extent practicable and allowed to discharge directly to the receiving environment (Figure 2).
- **Contact water**—water that may have been physically or chemically altered by mining or milling activities. This water generally requires treatment before releasing to the environment. To the extent practicable, contact water is recirculated for internal use to reduce the amount of fresh water supply from natural sources.

The contact/non-contact water systems are currently managed to minimize mixing of these waters. Examples include the following:

- keeping runoff originating from areas unaltered by mining activities (non-contact water) separate from areas altered by mining activities (contact water), and diverting it to the natural conveyance channels
- diverting runoff from waste rock dumps and other disturbed areas that could contain sediment
- detaining contact stormwater in the active pits, waste rock stockpiles, and other areas that could contribute contaminants to site water

On November 2015, MPMC received approval to discharge treated water to Quesnel Lake via the Hazeltine Channel up to a maximum rate of 0.3 $m^3/s$ or 9.47 $Mm^3/yr$. The Mine began to discharge 1 December 2015. The installed WTP has been achieving an output of approximately 0.18 $m^3/s$. In March, MPMC received approval to bypass the WTP and discharge water directly from Springer Pit to the Hazeltine Channel as long as the effluent meets the bypass authorization and EMA Permit 11678 water quality limits; as of June 2016, this bypass has not been used. The Mine will be currently seeking an amendment to increase the maximum annual discharge by 10% to 10.4 $Mm^3$, which is equivalent to a sustained discharge of 0.33 $m^3/s$.

## 4.3 Groundwater Management

Groundwater that flows into the Springer Pit, the Cariboo Pit, and the underground workings are currently collected and mixed with Mine surface water for use as process water, or to be treated and discharged.

## 4.4 Mine Long-term Water Management Plan

This section provides a description of the proposed Mine LTWMP for the three mining phases:

- **Restricted Operations** will extend from present until early July 2016. Use of the TSF has not been authorized, and tailings and Mine water will continue to be deposited in the Springer Pit. A condition of the permit is that mining and milling shall cease if the Springer Pit Lake reaches an elevation of 1,030 masl (*Mines Act* Permit M-200). In March 2016, this was amended to allow the water level in the Springer Pit to increase to a maximum level of 1,042 masl until 31 August 2016. On 5 June 2016, the Springer Pit Lake elevation was 1,038.2 masl.
- **Full Operations** will extend from July 2016 until the second quarter of 2020. Full Operations will include:
  - Full mining and milling operations will resume, including deepening of the Cariboo and Springer Pits.
  - Tailings will be deposited in the TSF.
  - The Springer Pit will be dewatered.
  - Tailings previously deposited in the Springer Pit will be removed and transferred to the TSF.
- **Closure/post-closure phase**—the closure phase will extend from July 2020 to July 2030, and will include closure and reclamation activities as identified in the Mine Reclamation and Closure Plan (MPMC 2015). The post-closure period will continue indefinitely after the closure phase. Pit lakes will develop in the combined Cariboo-Springer Pit, the Wight Pit, and the Boundary Pit.

Summaries of tailings deposition during the restricted operations and full operations phases are in Table 11 and Table 12. A total of 33.9 Mt of tailings solids are to be deposited in the TSF under the current elevation 970 m design (Golder 2015a), which includes the tailings to be transferred from the Springer Pit.

### 4.4.1 Restricted Operations Phase

Prior to resumption of full mining, all mine contact water and tailings were deposited in Springer Pit for temporary storage. The tailings deposition schedule in the Springer Pit is shown in Table 11. The schedule is based on actual tailings deposition to 31 March 2016, and the MPMC Mine plan received 13 October 2015, and revised to 5 Mt.

Contact water from roads, haul roads, waste rock dumps, and other Mine areas north of Bootjack Creek either collects in sumps (Northwest [NW], 9K, Mine Drainage Creek, Mill Site, Wight Pit, Cariboo Pit) or flows directly to the Southeast Rock Disposal Site (SERDS), West, and Long ditches (Figure 2). The water that collects in the sumps is either pumped directly to the Springer Pit or to the SERDS, West, or Long ditches, which flow to the Central Collection Sump (CCS). Water in the TSF is currently pumped to the CCS. All water in the CCS is used for mill processing requirements, or reports to the PETBP for treatment prior to discharge to Hazeltine Channel. A direct pipeline from the Springer Pit to the WTP was commissioned in May 2016 to take advantage of passive settling of particulate matter in the pit, leading to better quality feed water to the WTP and increased flow rate through the WTP in “passive mode”.

The current *Mines Act* Permit M-200 authorizes mining and processing of up to 5 Mt for up to one year from the date of permit amendment (restricted operations) (July 9, 2015). The tailings deposition schedule for assumed restricted operations is shown in Table 11.

**Table 11: Tailings Deposition in Springer Pit**

| Phase | Period | Tailings Solids (tonnes) |
|---|---|---|
| Restricted Operations | Total to Mar 2016 | 3,462,000 |
| | April 2016 | 540,000 |
| | May 2016 | 540,000 |
| | June 2016 | 458,000 |
| | **Total** | **5,000,000** |

### 4.4.2 Full Operations Phase

Under full operations, the TSF will begin receiving tailings from July 2016, and tailings deposition in the Springer Pit will cease. The direct pipeline from Springer Pit to the WTP will remain operational until Springer Pit water is drawn down. Outside of the TSF, Mine contact water will either flow or be pumped to the SERDS and Long ditches, which flow to the CCS. Water from the CCS reports by gravity to the PETBP, where it will be treated and discharged though the pipeline from the Springer Pit to the WTP (Figure 2). When the inflows to the CCS exceed the discharge rate (typically during the freshet), excess contact water will be pumped to the TSF for temporary detention. At other times, water from the TSF will be pumped to the CCS for use in processing or treatment prior to discharge.

Mine water inflows into the TSF consist of:

- Water pumped with the tailings slurry.
- Precipitation and runoff into the TSF.
- Excess water pumped from the water management structures for temporary storage in the TSF, during the freshet and high precipitation events.
- Water pumped to the TSF to provide makeup water to meet process requirements and to maintain the minimum pond volume in the TSF necessary for operation of the reclaim pumps. This makeup water would typically be required during the winter and extreme dry years. Initially, makeup water will be drawn from the Springer Pit as it is dewatered. Predictions for Springer Pit dewatering are in Section 5.10. Later, makeup water will be drawn from Polley Lake (Section 6.4.1), if necessary.

The assumed tailings deposition schedule for the TSF during the full operation phase is shown in Table 12, which was based on the MPMC Mine plan received 13 October 2015. Total tonnage of tailings under the 970- masl embankment is 33.9 Mt, which includes 5 Mt of tailings that have been previously deposited in the Springer Pit. Currently, it is assumed that tailings in the Springer Pit will be pumped as a slurry to the TSF. Options for tailings removal are being assessed.

**Table 12: TSF Tailings Deposition Schedule (Full Operations)**

| Phase | Period | Direct to TSF (tonnes) | Transferred from Springer Pit (tonnes) |
|---|---|---|---|
| Full Operations | 2016 Q3 | 2,024,000 | N/A |
| | 2016 Q4 | 1,906,000 | N/A |
| | 2017 Q1 | 1,862,000 | N/A |
| | 2017 Q2 | 2,002,000 | N/A |
| | 2017 Q3 | 2,024,000 | N/A |
| | 2017 Q4 | 1,902,000 | 138,000 |
| | 2018 Q1 | 1,862,000 | 900,000 |
| | 2018 Q2 | 2,002,000 | 1,900,000 |
| | 2018 Q3 | 2,024,000 | 1,100,000 |
| | 2018 Q4 | 1,902,000 | 962,000 |
| | 2019 Q1 | 1,862,000 | N/A |
| | 2019 Q2 | 2,002,000 | N/A |
| | 2019 Q3 | 2,024,000 | N/A |
| | 2019 Q4 | 1,902,000 | N/A |
| | 2020 Q1 | 1,600,000 | N/A |
| | 2020 Q2 | N/A | N/A |
| **Total** | | **28,900,000** | **5,000,000** |

### 4.4.3 Closure and Post-closure Phase

An updated Mine Reclamation and Closure Plan was prepared by MPMC (2015). The following objectives to the closure and reclamation have been identified:

- long-term preservation of water quality within and downstream of decommissioned operations
- long-term stability of the TSF
- removal of all access roads, ponds, ditches, pipelines, structures, and equipment not required during Mine closure
- long-term stabilization of all exposed materials that are susceptible to erosion
- establishment of a self-sustaining vegetative cover consistent with existing forestry, grazing, and wildlife needs
- natural integration of disturbed lands into the surrounding landscape and restoration of the natural appearance of the area

The following sections provide an overview of the closure and post-closure management strategies for the TSF and the pits. More detail regarding the closure and post-closure management of the Mine facilities is in the Mine Reclamation and Closure Plan (MPMC 2015).

#### *4.4.3.1 Tailings Storage Facility*

The surface of the TSF will be converted into a forested and wetlands site. Approximately 15% of the surface area of the TSF basin will be covered with water, with the remainder of the area being vegetated with indigenous species of trees, shrubs, and grasses. The pond level within the TSF will be controlled by an overflow spillway constructed at an abutment. The spillway will be sized to manage the probable maximum flood. The downstream embankment slopes will be pushed down to a slope of 2H:1V, and these slopes and the 3H:1V buttress slopes will be covered with selected overburden materials and seeded with grasses and legumes to provide a stable vegetation mat that resists erosion. The seepage collection ponds and recycle pumps will be retained after closure until monitoring results indicate that the water quality from the TSF is suitable for direct release to the environment.

The tailings deposition plan will maintain the supernatant pond at the centre of the facility, against the natural topography. Within the last year of deposition, prior to closure, the deposition plan will change to push the pond closer to Corner 5, where the spillway is located, and at the same time reduce the pond volume. The operational spillway will limit the size of the pond and maintain the majority of the tailings in an unsaturated state.

The tailings conveyance system will be removed immediately following cessation of operations. The reclaim barge, pumps, and pipeline will be utilized for supplementary flooding of the open pits, as required, and will then be removed. Once open pit flooding is complete, the surface water diversion channel will be regraded to allow natural runoff through the tailings area.

#### 4.4.3.2 Pit Lakes

Approximately 191 ha of the Mine property are projected to be open pits at closure, which includes Cariboo-Springer Pit, Wight Pit, and Boundary Pit. All of the pits will be allowed to flood during closure, creating pit lakes.

Little or none of the upper pit walls can be reclaimed due to the steep terrain and poor access, and as permitted under Section 10.7.14 of the Health, Safety and Reclamation Code for Mines in British Columbia, they will not be re-vegetated. If any benches are safely accessible by foot at closure, they will be broadcast-seeded with a native grasses and forbs seed mixture, and potentially fertilized. If access allows, these areas will then be hand-planted with seedlings, which grow naturally on colluvial veneers and steep droughty sites in the region, such as of lodgepole pine, black cottonwood, sitka alder, and common juniper.

As described in Section 3.3, upon completion of operations, the Springer Pit will be allowed to flood and will spill over to the Cariboo Pit, and the two pits will form a single pit lake. Upon completion of underground operations (portal located in the bottom of the Wight Pit), the Wight Pit will be allowed to fill to the spillover into Polley Lake of 926 masl.

The Boundary Pit is a small pit (0.4 ha that will not be reclaimed), and observations throughout operations indicate that the water exists in a roughly steady state (does not overflow).

# 5.0 SITE WIDE WATER BALANCE MODEL

## 5.1 Model Software

An Excel-based deterministic SWWBM was originally developed by Knight Piésold Ltd. (KP 2004) for water management at the Mine. Over time, the model has been adapted by MPMC as the Mine has developed. The Excel-based water balance was designed to track and predict overall Mine water accumulation, and MPMC has previously used the Excel-based site water balance for operational and planning purposes.

A new site-wide operational and predictive water balance model has been developed by Golder using GoldSim™ (Version 11.1). GoldSim allows dynamic, complex interactions within the water system to be represented through a visual, modular framework. All input parameters and functions are defined by the user and are built as individual objects or elements linked together by mathematical expressions. GoldSim is widely used for mine water quantity studies. The GoldSim model now supersedes the Excel-based model. Benefits of converting the Excel-based water balance to GoldSim include the following GoldSim capabilities:

- Deterministic and probabilistic simulations can be run within the model, allowing statistics and probabilities to be assigned to the model outputs.
- Simulation periods can be varied within the same model.
- The model framework can be easily adjusted to account for changing/future conditions at the Mine, allowing the model to be used as an operational and planning tool.
- Water quantity and water quality modules can be directly linked, allowing both models to be updated simultaneously when evaluating various sensitivity scenarios of alternative water management strategies.

Hydrological parameters such as runoff coefficients, seepage flows, snow pack accumulation, and snowmelt have been largely retained from the Excel-based model.

## 5.2 Model Objectives

The SWWBM has been developed for the Mine with the following objectives:

- simulate current and future site water management, including a transition from restricted operations to full operations, and into closure and post-closure
- determine water detention requirements in the TSF
- develop strategies and assess timelines for Springer Pit dewatering
- determine pumping capacities between the TSF, Springer Pit, the CCS, the PETBP, and other major facilities at the Mine
- provide support for assessment of water treatment and discharge options
- couple with a water quality module to assess site and discharge water quality during operations and into closure and post-closure

The following sections are an overview of the SWWBM inputs and assumptions.

## 5.3 General Assumptions

General assumptions applied to model development were as follows:

- No seepage is lost from the ponds or sumps (i.e., all ponds and sumps are assumed to be lined).
- Direct precipitation, evaporation, and seepage loss from ditches are assumed to be negligible.
- Precipitation occurs as snow from December to February, and as rain or a mixture of rain and snow in all other months.
- Snowmelt occurs in the months of March, April, and May as a percentage of the maximum snowpack at the end of February (5% in March, 90% in April, and 5% in May).

### 5.3.1 Water Treatment Plant Operation

An amendment in November 2015 to Permit 11678 under the BC *Environmental Management Act* allows the Mine to discharge 9.47 $Mm^3$ of treated water per year (0.3 $m^3/s$) in the short term. Currently, feed water to the WTP is being sourced from Springer Pit.

Prior to 4 May 2016, Mine contact water from the PETBP was pumped to the WTP at a controlled rate. A direct pipeline from the Springer Pit to the WTP was completed 4 May 2016. The Actiflo system has a design flow rate of 0.23 $m^3/s$ (20,000 $m^3/d$). The existing maximum authorized total discharge rate is 0.3 $m^3/s$. When feed water already meets Permit 11678 water quality limits, feed water flows exceeding the design flow may be passed through the WTP in a passive treatment mode as determined by online instrumentation, whereby reagents are not added and mechanical mixing is not active. Details are provided in Appendix E of the TAR (Operations Treatment). In recent weeks, discharge has averaged 0.29 $m^3/s$ with the WTP operating in passive mode.

## 5.4 Model Scope and Flow Diagram

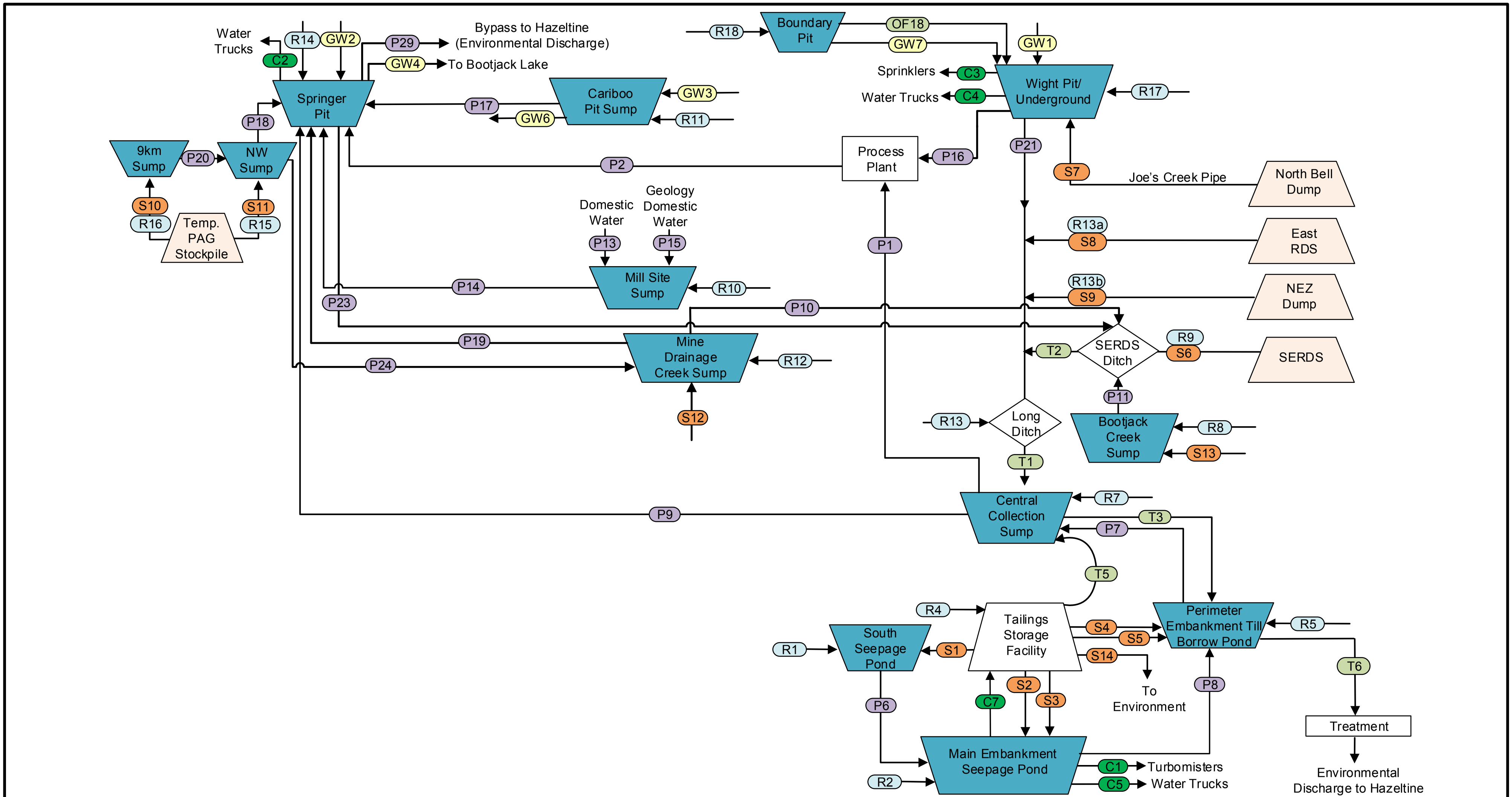
The scope and structure of the SWWBM is outlined in conceptual process flow diagrams for each phase of Mine life: restricted operations (Figure 8), full operations (Figure 9), closure (Figure 10), and post-closure (Figure 11). The flow diagrams illustrate the water circuit system at the Mine, including the operational storage and conveyance of water. The water management facilities within the SWWBM are:

- South Embankment Seepage Collection Pond (SESCP)
- Main Embankment Seepage Collection Pond (MESCP
- TSF
- PETBP
- CCS

- Bootjack Creek Sump
- SERDS Ditch
- Mill Site Sump
- Cariboo Pit Sump
- Mine Drainage Creek Sump
- Long Ditch
- Springer Pit
- NW Sump
- 9K Sump
- Wight Pit
- the Mill

The following flow types are represented in the model:

- direct precipitation and evaporation
- runoff
- seepage (includes baseflows)
- water consumption flows (turbomisters, sprinklers, and water trucks)
- pumped flows between facilities
- transfer flows (gravity flows between facilities)




Runoff (R)
Seepage Flow (S)
Water consumption (C)
Pumped Flows (P)
Groundwater Flows (GW)
Transfer Flows (T)

Flow Path

**Note**: Evaporation and Direct Precipitation are modelled for all ponds, but are not shown on this diagram

Golder Associates

CLIENT Imperial Metals Ltd.
Mount Polley Mining Corporation

DRAWN APB DATE May, 19, 2016

CHECKED RGM DATE May, 19, 2016

SCALE Not to Scale

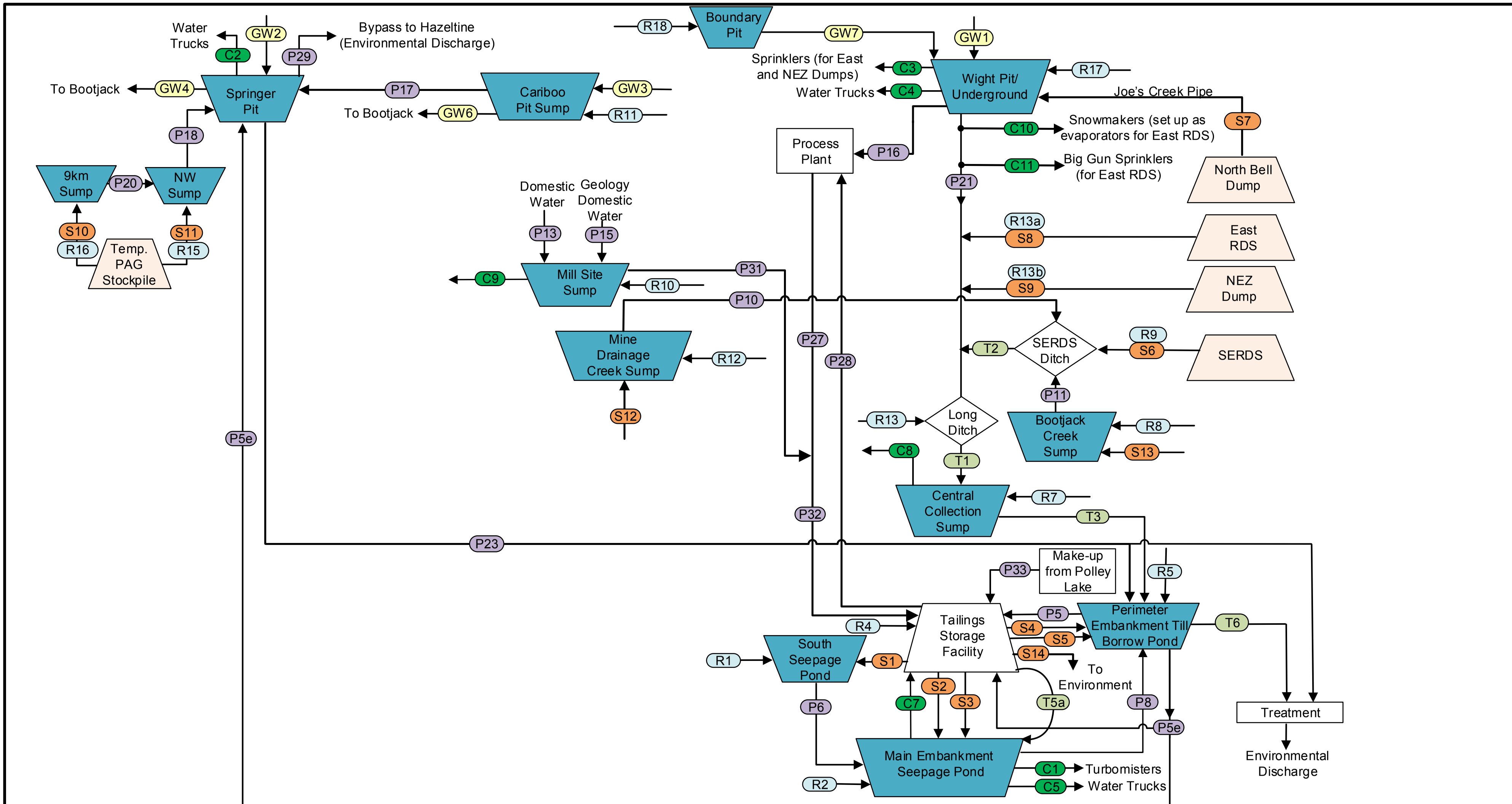
PROJECT No 1411734/12000

TITLE

**Site Wide Water Balance**
**Restricted Operations**
**April 2016 – July 2016**

FIGURE No 8

REV No 0




Runoff (R)
Seepage Flow (S)
Water consumption (C)
Pumped Flows (P)
Groundwater Flows (GW)
Transfer Flows (T)

Flow Path

**Note**: Evaporation and Direct Precipitation are modelled for all ponds, but are not shown on this diagram

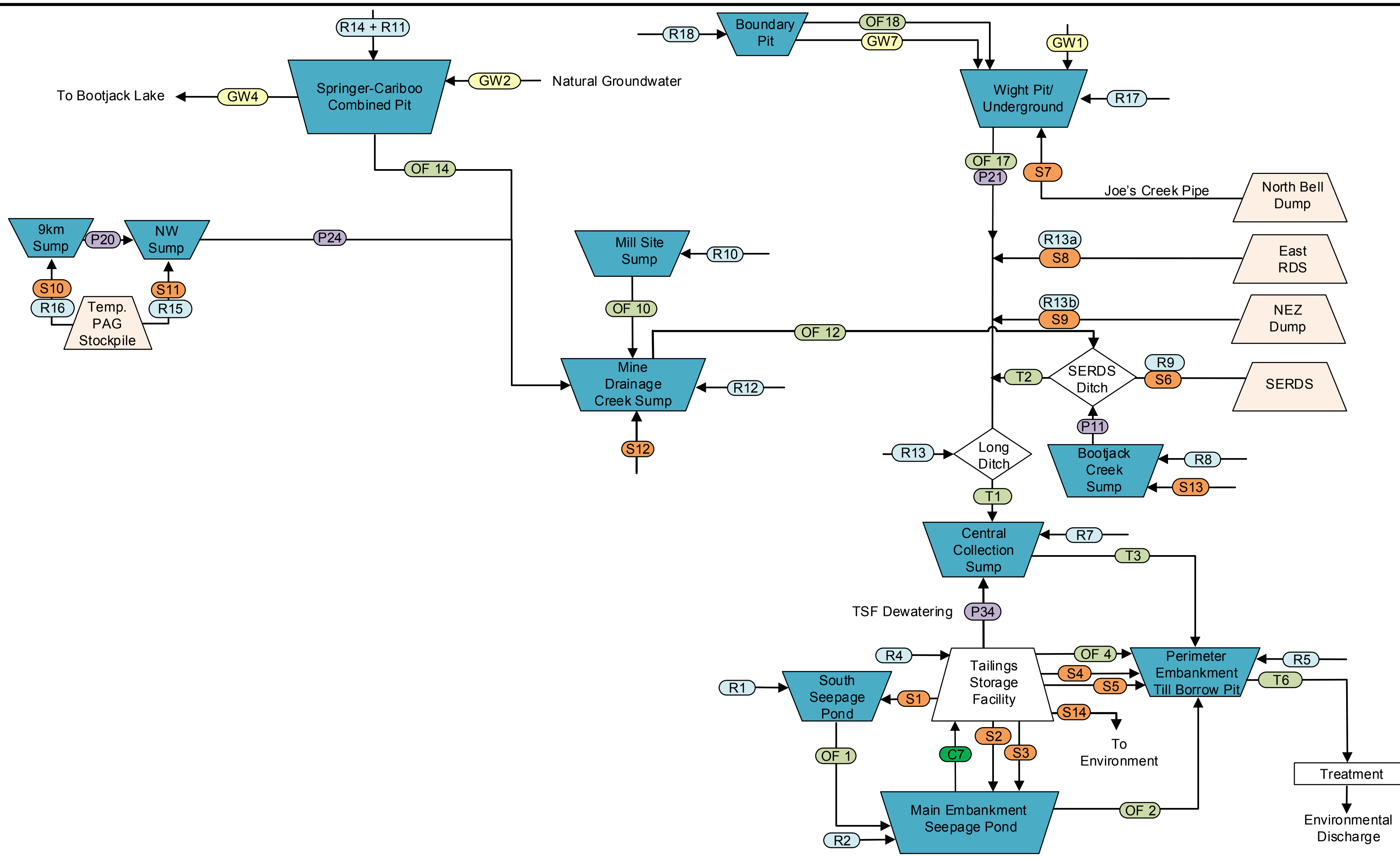
Golder Associates

| | | | |
|---|---|---|---|
| CLIENT | Imperial Metals Ltd.<br>Mount Polley Mining Corporation | | |
| DRAWN | APB | DATE | Jun 08, 2016 |
| CHECKED | RGM | DATE | Jun 08, 2016 |
| SCALE | Not to Scale | PROJECT No | 1411734/12000 |

TITLE

**Site Wide Water Balance**
**Future Operations**
**July 2016 – July 2020**

FIGURE No 9 REV No 0




Runoff (R)
Seepage Flow (S)
Pumped Flows (P)
Groundwater Flows (GW)
Transfer Flows (T) / Overflow (OF)
Flow Path

**Note**:
- Evaporation and Direct Precipitation are modeled for all ponds, but are not shown on this diagram.
- Temporary PAG Stockpile will be rehandled to Springer Pit starting Q4 2018

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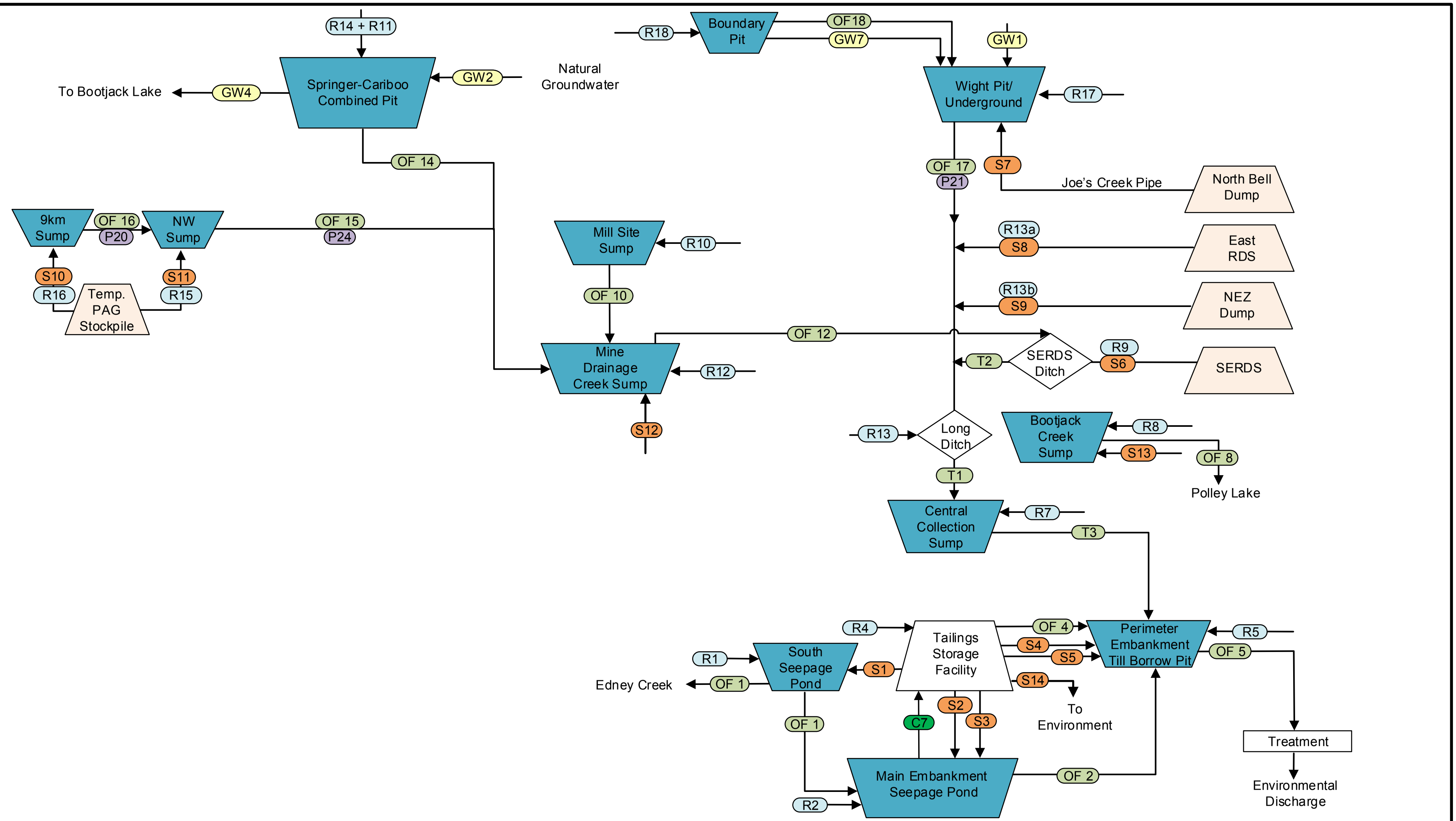
| | | | |
|---|---|---|---|
| CLIENT | Imperial Metals Ltd.<br>Mount Polley Mining Corporation | | |
| DRAWN | APB | DATE | May 19, 2016 |
| CHECKED | RGM | DATE | May 19, 2016 |
| SCALE | Not to Scale | PROJECT No | 1411734/12000 |

TITLE

**Site Wide Water Balance**
**Closure**
**July 2020-July 2022**

FIGURE No 10 | REV No 0




Runoff (R)
Seepage Flow (S)
Pumped Flows (P)
Groundwater Flows (GW)
Transfer Flows (T) / Overflow (OF)
Flow Path

**Note**:
- Evaporation and Direct Precipitation are modeled for all ponds, but are not shown on this diagram.
- Temporary PAG Stockpile will be rehandled to Springer Pit starting Q4 2018

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| | | | |
|---|---|---|---|
| CLIENT | Imperial Metals Ltd.<br>Mount Polley Mining Corporation | | |
| DRAWN | APB | DATE | May 19, 2016 |
| CHECKED | RGM | DATE | May 19, 2016 |
| SCALE | Not to Scale | PROJECT No | 1411734/12000 |

TITLE

**Site Wide Water Balance**
**Post-Closure**
**July 2022 Onwards**

FIGURE No 11

REV No 0

The SERDS Ditch and the Long Ditch have been included in the model as conveyance elements. They do not store water, but the model tracks the various inflows to these elements and transfers the cumulative flows to the CCS.

The primary flows in the model are summarized in Table 13. A complete list of flows for different Mine phases is provided in Attachment A.

**Table 13: Primary Mine Water Flows**

| Flow Group | Component | Flow Label |
|---|---|---|
| Hydrology | Precipitation | N/A[(a)] |
| | Evaporation | N/A[(a)] |
| | Runoff | All flows labelled R[(b)] |
| Consumption | Sprinklers | C3,C7 |
| | Turbomisters | C1 |
| | Water truck usage | C2, C4, C5 |
| Seepage (from TSF) | South Seepage Pond inflow | S1 |
| | PETBP | S4, S5 |
| | Main Embankment Seepage Pond | S2, S3 |
| | Seepage to environment | S14 |
| | Tailings drainage to CCS | T5 |
| Groundwater flows | Wight Pit groundwater inflow | GW1 |
| | Springer Pit groundwater inflow | GW2 |
| | Cariboo Pit groundwater inflow | GW3 |
| | Springer Pit groundwater outflow | GW4 |
| | Cariboo Pit groundwater outflow | GW6 |
| Pumped flows – outflows from Wight Pit | Process water | P16 |
| | Dewatering to Long Ditch | P21 |
| Pumped flows – inflows to Springer Pit | Tailings slurry from the mill | P2 |
| | Pumped flow from CCS | P9 |
| | Pumped flow from Mill Site Sump | P14 |
| | Pumped flow from Cariboo Pit Sump | P17 |
| | Pumped flow from NW Sump | P18 |
| | Pumped flow from Mine Drainage Creek Sump | P19 |
| Pumped flows – pit dewatering | Springer Pit lake dewatering to SERDS | P23 |
| | Springer Pit lake dewatering to WTP | P29 |
| Pumped flows – mill site and process flows | Process water from CCS | P1 |
| | Geology domestic water effluent to Mill Site Sump | P15 |
| | Mill domestic water into Mill Site Sump | P13 |
| Pumped flows – outflows from TSF | Process water demand | P28 |
| Discharge from PETBP | Treated discharge to environment | T6 |
| Overflows | Wight Pit to Long Ditch | OF17 |
| | Cariboo-Springer Pit to Mine Drainage Creek Sump | OF14 |
| | TSF to PETBP | OF4 |
| | PETBP to Environment | OF5 |

a) Evaporation and direct precipitation flows not shown on process flow diagram.

b) No flows were assigned specifically for snowpack. Instead, snowpack was accumulated in the model and applied to the runoff flows as snowmelt.

N/A = not applicable; TSF = Tailings Storage Facility; PETBP = Perimeter Embankment Till Borrow Pond; CCS = Central Collection Sump; SERDS = Southeast Rock Dump.

## 5.5 Climate Inputs

### 5.5.1 Deterministic Climate Inputs

The model features a deterministic mode, which allows the user to select from six predefined climate scenarios, as well as one custom (manual) input. The predefined climate scenarios are as follows:

- average annual precipitation data, derived based on long-term EC[1] and local data (as described in Section 3.1)
- current climate conditions—measured precipitation and evaporation data up to the end of September 2015, with average precipitation and evaporation used for subsequent months
- 1:25-year wet and dry annual precipitation (Table 4)
- 1:200-year wet and dry annual precipitation (Table 4)

A manual climate condition can be defined by the user to simulate actual weather forecasts or extreme events. Annual average lake evaporation is used for the deterministic mode, and snowpack is accumulated within the model based on the assumption that snow accumulates from December to February, with a 5%, 90%, and 5% melting in March, April, and May, respectively.

### 5.5.2 Stochastic Climate Inputs

GoldSim has stochastic elements, allowing uncertainty to be represented in model input data. GoldSim uses the Monte Carlo method to sample stochastic elements for probabilistic simulations. A stochastic generator was developed within the GoldSim SWWBM to probabilistically simulate natural climatic variation at the Mine. The stochastic generator operates on a monthly basis, and generates random sequences of monthly precipitation over the simulation period (one such random sequence is called a “realization”).

The benefits of the stochastic generator are as follows:

- The model generates precipitation inputs for each realization that are randomly drawn from a seasonally representative distribution.
- The statistics (i.e., mean and standard deviation) of stochastically generated values are representative of those of observed data.
- The approach can be used to generate multiple sequences of precipitation, each being equally likely as those that have occurred historically. GoldSim can then collate results for each rainfall sequence scenario to produce probabilistic results. As many time series can be generated, more extreme weather conditions (both wet and dry) can be simulated and tested in the SWWBM than are available in the measured historical precipitation data.

[1] https://wateroffice.ec.gc.ca/

An analysis of variance was performed on historical monthly precipitation data to test whether consecutive monthly precipitation totals were auto-correlated (i.e., whether one month was influenced by a previous month). It was important to determine whether there was auto-correlation to properly understand the underlying trends of the monthly precipitation time series. The analysis of variance confirmed that months were not auto-correlated.

The monthly values were then log-transformed, and the distribution of the values fit to a normal distribution. A normal distribution is a type of probability distribution (mathematical representation of the relative likelihood of an uncertain variable having specific values). All distribution types use a set of arguments to specify the relative likelihood for each possible value. The arguments for the normal distribution are the mean and standard deviation. The monthly means and standard deviations of the log-transformed monthly precipitation values were therefore determined. The standard deviations were adjusted based on trial and error so that the annual mean of the stochastically generated results agreed with the mean of the historical data. The monthly input arguments (mean and standard deviation) are shown in Attachment A.

The derived monthly means and standard deviations of the log-transformed precipitation values were defined in GoldSim's stochastic element to generate random values based on a normal distribution. The inverse logarithms were then determined for each generated value to calculate the monthly precipitation value (in mm). The stochastic generator was set to perform 1,000 realizations to create a sample size that was sufficiently large and accounted for a range of conceivable climatic scenarios for the study period.

Table 14 shows a summary of the precipitation depths generated by the stochastic generator and compared with the values obtained from frequency analysis of the historical annual data.

**Table 14: Stochastic Climate Generator Statistics**

| Climate Scenario | Stochastically Generated Annual Precipitation (mm) | Historical Annual Precipitation (mm) |
|---|---|---|
| Average | 668 | 670 |
| 1:200-year dry | 419 | 354 |
| 1:25-year dry | 482 | 438 |
| 1:25-year wet | 918 | 948 |
| 1:200-year wet | 1,086 | 1,091 |

## 5.6 Hydrology Inputs

The following sections describe the processes and inputs that define the hydrology in the model.

### 5.6.1 Runoff Parameters

Runoff in the SWWBM is estimated using seasonal runoff coefficients. Runoff coefficients represent the proportion of rainfall for runoff or seepage, and account for losses due to evaporation, storage, and infiltration. The runoff coefficients account for the following seasons:

- dry—July to October
- winter—November to February
- freshet—March to June

The runoff coefficients are defined for six catchment types:

- exposed tailings
- disturbed areas (cleared areas – not including pit surfaces, roads, or rock dump storage)
- rock disposal sites
- open pits
- undisturbed catchments
- haul and access roads

The seasonal runoff coefficients for each catchment type are presented in Table 15. The runoff coefficients were determined from the MPMC water balance model (largely based on a water balance prepared by KP [2004]) and revised based on runoff measurements and model calibration (Section 5.9).

**Table 15: Seasonal Runoff Coefficients**

| Catchment Type | Dry | Winter | Freshet |
|---|---|---|---|
| Exposed tailings | 0.3 | 0.6 | 0.9 |
| Disturbed areas | 0.0 | 0.3 | 0.9 |
| Rock disposal sites | 0.0 | 0.1 | 0.6 |
| Open pits | 0.5 | 0.75 | 0.9 |
| Undisturbed catchments | 0.35 | 0.4 | 0.42 |
| Haul roads and access roads (a) | 0.0 | 0.15 | 0.9 |
| Mill site area (a,b) | 0.0 | 0.1 | 0.1 |

a) Defined subsequent to the Knight Piésold water balance report (KP 2004).

b) Calibrated parameter.

A constant baseflow seepage depth of 25 mm/month (300 mm/yr) for rock disposal sites is included in the SWWBM to provide flows during the dry and winter months. The seepage value is based on measured flows in the NW Ditch and Long Ditch during the calibration period (Section 5.9). Seepage from the waste rock dumps to groundwater is assumed to be equal to the recharge value of 30% of the mean annual precipitation (Golder 2016).

### 5.6.2 Hazeltine Creek Flows

Until November 2017, effluent will be discharged to Quesnel Lake via the Hazeltine Creek channel. Mine effluent plus natural runoff is discharged to Quesnel Lake via a pipeline and diffuser, the intake of which is located at the upper sediment pond near the mouth of Hazeltine Creek. The design capacity of the diffuser is 0.6 $m^3$/s. As natural flows in Hazeltine Creek increase above 0.25 $m^3$/s, discharge from the Mine is curtailed to avoid Mine effluent reporting to the surface of Quesnel Lake. In addition, outflow from Polley Lake is regulated by a sluice gate and weir. Total live storage in Polley Lake is approximately 4 $Mm^3$; while effluent is being discharged to Hazeltine Creek, the sluice gate is assumed to temporarily store the freshet runoff into Polley Lake during April through June, and release this water over the remainder of the year. This allows increased discharge of Mine effluent through the diffuser during freshet. It will also allow flows to be regulated during instream construction, such as rehabilitation of fish habitat in Hazeltine Creek.

Until November 2017 (with the commissioning of direct conveyance between the Mine and the Quesnel Lake diffuser), discharge of Mine water will be affected by the flow in Hazeltine Creek. Stochastic flows are generated in the water balance to support a probabilistic assessment of Mine discharges and water quality for 2016 and 2017.

Runoff into Polley Lake is estimated using natural area runoff coefficients with a baseflow component. Direct precipitation and evaporation for Polley Lake are accounted for. The constant baseflow component was adjusted to give an average annual outflow of 0.17 $m^3$/s (Table 16).

**Table 16: Annual Runoff ($m^3$/s) based on Derived Hazeltine Flows**

| Location | Area | Average | 0.5 Percentile | 99.5 Percentile |
|---|---|---|---|---|
| Outlet of Polley Lake | 21.4[(a)] | 0.17 | 0.06[(b)] | 0.32[(c)] |
| Upper Hazeltine (H1) | 24.3 | 0.19 | 0.07 | 0.36 |
| Lower Hazeltine (H2) | 28.6 | 0.21 | 0.09[(b)] | 0.40[(c)] |

a) Includes Polley Lake Area of approximately 4 $km^2$.

b) Scaled linearly by catchment area relative upper Hazeltine (H1) value.

c) Scaled proportional to the catchment area ratio to the power 0.75 relative upper Hazeltine (H1) value.

Source: KP 2014.

Downstream of Polley Lake, stochastic flows from the natural catchment areas were provided by scaling the average monthly flow by a scaling factor that is given by the ratio of the current monthly stochastic rainfall plus snowmelt, divided by the average rainfall plus snowmelt for that month. The objective of the stochastic analysis is not to forecast future rainfall and Hazeltine Creek flows, but rather to generate a series of realizations that capture the natural variability in Hazeltine Creek, and to link the stochastic Hazeltine Creek flow to the stochastic precipitation.

Summary of the generated monthly and annual stochastic flows in Hazeltine Creek are summarized in Table 17. Direct comparison with measured historical flows in upper Hazeltine is difficult, because the stochastic flows include the effect of Polley Lake weir regulation. The most appropriate comparison is the annual flow values. Average values show good agreement with the derived Hazeltine flows (Table 16); however, the range of variability of the stochastic flows for the 0.5 percentile and the 99.5 percentile is somewhat less than the variability predicted from frequency analysis (Table 17).

**Table 17: Generated Stochastic Monthly and Annual Flows**

| Month | Polley Lake Outflow ($m^3/s$) | | | Upper Hazeltine Creek (H1) ($m^3/s$) | | | Lower Hazeltine Creek (H2) ($m^3/s$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Average | 0.5% | 99.5% | Average | 0.5% | 99.5% | Average | 0.5% | 99.5% |
| Jan | 0.15 | 0.07 | 0.19 | 0.15 | 0.08 | 0.19 | 0.16 | 0.08 | 0.20 |
| Feb | 0.15 | 0.07 | 0.19 | 0.15 | 0.08 | 0.19 | 0.16 | 0.08 | 0.20 |
| Mar | 0.20 | 0.09 | 0.52 | 0.20 | 0.09 | 0.55 | 0.21 | 0.09 | 0.57 |
| Apr | 0 | 0 | 0.31 | 0.04 | 0.01 | 0.40 | 0.08 | 0.03 | 0.49 |
| May | 0.01 | 0 | 0.38 | 0.08 | 0.02 | 0.52 | 0.16 | 0.04 | 0.70 |
| Jun | 0.05 | 0 | 0.77 | 0.09 | 0.01 | 0.92 | 0.14 | 0.02 | 1.07 |
| Jul | 0.17 | 0 | 0.64 | 0.19 | 0.01 | 0.71 | 0.21 | 0.01 | 0.78 |
| Aug | 0.19 | 0.02 | 0.54 | 0.20 | 0.02 | 0.57 | 0.20 | 0.02 | 0.59 |
| Sep | 0.28 | 0.09 | 0.94 | 0.29 | 0.09 | 0.97 | 0.30 | 0.09 | 1.00 |
| Oct | 0.32 | 0.13 | 0.79 | 0.33 | 0.14 | 0.81 | 0.34 | 0.14 | 0.84 |
| Nov | 0.35 | 0.15 | 0.85 | 0.36 | 0.16 | 0.88 | 0.37 | 0.16 | 0.91 |
| Dec | 0.15 | 0.07 | 0.19 | 0.15 | 0.08 | 0.19 | 0.16 | 0.08 | 0.20 |
| **Annual** | **0.17** | **0.09** | **0.29** | **0.19** | **0.10** | **0.32** | **0.21** | **0.11** | **0.35** |

## 5.6.3 Catchment Areas

To model runoff, direct precipitation, and evaporation, the catchment areas for each storage element were defined in the model. Delineated catchments are shown in Figure 12; catchment areas are shown in Table 18. A total area of 2,892,500 $m^2$ or 22% of the total Mine area reports directly to the TSF.

**Table 18: Catchment Areas for Storage/Conveyance Elements**

| Storage/ Conveyance Element | Total Reporting Area ($m^2$) |
|---|---|
| South Seepage Pond | 385 |
| Main Embankment Seepage Pond | 376,900 |
| TSF upstream catchment | 622,800 |
| TSF | 2,269,700 |
| PETBP (includes foundation failure Sump) | 524,300 |
| Central Collection Sump | 438,600 |
| Bootjack Creek Sump | 175,200 |
| SERDS Ditch | 1,537,600 |
| Mill Site Sump | 1,630 |
| Cariboo Pit Sump | 1,320,400 |
| Mine Drainage Creek Sump | 1,115,900 |
| Long Ditch | 2,494,000 |
| Springer Pit | 651,900 |
| Northwest Sump | 330,200 |
| 9K km Sump | 698,800 |
| Wight Pit | 413,900 |
| Boundary Pit | 23,400 |
| **Total Reporting Area ($m^2$)** | **12,995,500** |

TSF = Tailings Storage Facility; SERDS = Southeast Rock Dump Site.

## 5.7 Storage Capacities

Storage curves were available for the following major storage elements:

- Springer Pit
- Cariboo Pit
- TSF
- PETBP

Details regarding the storage-elevation curves can be found in the Attachment A. The maximum capacities for the facilities listed above are presented in Table 19.

**Table 19: Maximum Capacities for Major Storage Facilities**

| Storage Facility | Maximum Capacity ($Mm^3$) |
|---|---|
| Springer Pit[(a)] | 14.8 |
| Cariboo Pit [(a)] | 5.2 |
| Combined Phase 4 Cariboo-Springer Pit (end of currently permitted Mine life) | 30.3 |
| TSF – current layout [(b)] | 2.1 |
| PETBP | 0.17 |
| CCS (current volume – to continue during 970- masl embankment raise) | 0.051 |

a) Represents current individual pit volumes (i.e., before pits are combined or further mined).

b) Capacity changes over the course of operations as tailings are deposited.

CCS = Central Collection Sump; masl = metres above sea level.

PATH: \\golder.gds\gal\burnaby\CAD-GIS\Client\1413803\1411734\PRODUCTION\12000_WATER_MANAGEMENT\MXD\Report\Water_Balance_Modelling_Report\1411734_12000_FIG_11_CATCHMENT_AREA.mxd


**LEGEND**

- WATER CATCHMENT AREA
- WATER COLLECTION DITCH
- CONTOUR (10m)

0 750 1,500

1:30,000 METRES

**REFERENCES**

1. CONTOURS AND PROJECT IMAGERY OBTAINED FROM SNC LAVALIN (2014)
2. WATER CATCHMENT AREAS INTERPOLATED BY GOLDER ASSOCIATES LTD.
3. BASE IMAGERY SOURCE: ESRI, DIGITALGLOBE, GEOEYE, I-CUBED, USDA, USGS, AEX, GETMAPPING, AEROGRID, IGN, IGP, SWISSTOPO, AND THE GIS USER COMMUNITY
4. DATUM: NAD 1983 UTM ZONE 10N

CLIENT
MOUNT POLLEY MINING CORPORATION
IMPERIAL METALS

PROJECT
WATER MANAGEMENT PLAN - SITE WATER BALANCE MODEL

TITLE
**WATER CATCHMENT AREAS**

CONSULTANT
Golder Associates

| | |
|---|---|
| YYYY-MM-DD | 2015-05-29 |
| DESIGNED | JR |
| PREPARED | RH |
| REVIEWED | RM |
| APPROVED | JV |

| PROJECT NO. | CONTROL | REV. | FIGURE |
|---|---|---|---|
| 14-11734 | 12000 | 0 | 12 |

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

## 5.8 Flow Derivation and Logic

This section describes the model logic for pumped, seepage (from the TSF), groundwater, consumption, and transfer flows. The derivation of runoff flows were discussed in Section 5.6.

### 5.8.1 Pumped Flows

Maximum pumping rates for each pumped flow are shown in Attachment A. With the exception of flows P13, P15, P16, and P19, which were measured at 545 $m^3$/d, 2.5 $m^3$/d, 7,631 $m^3$/d, and 4,360 $m^3$/d respectively, all maximum pumping rates have been assumed. Although pump specifications were available for several pumps on site, not enough information was available to determine the energy losses of the pumping systems. Therefore, assumed maximum pumping capacities were based on Golder's engineering judgement. The assumed pumping rates would not materially affect the results of the Springer Pit water level, or the predicted dates of reaching critical elevations under any scenario.

#### *5.8.1.1 Operational Pumping Rules – Restricted Operations and Full Operations*

In general, all water management facilities are pumped dry within the SWWMB. However, certain facilities have special operational pumping logic to manage high flows:

- **Wight Pit**—The Wight Pit has a maximum pumping capacity to the mill process water tank of approximately 0.09 $m^3$/s (P16). If inflow rates exceed this, the remaining water is diverted into the Long Ditch (P21).
- **PETBP**—Water is sent to the Main Embankment Seepage Pond (provided this pond is below freeboard elevation) to provide flow for the turbomisters and sprinklers on the TSF (P25). All excess water is then pumped to the CCS to be pumped to the Springer Pit (P7). There is approximately 170,000 $m^3$ of contingency storage in the PETBP. If this contingency storage is depleted, the CCS is full, and the pumps to the Springer Pit are operating at maximum capacity, water is pumped to the TSF for temporary detention (P5).

#### *5.8.1.2 Operational Pumping Rules – Closure/Post-closure*

All pumped flows will be terminated as of Closure (1 July 2020, in the model), with the exception of the following:

- 9K Sump to NW PAG Sump (P20)
- NW Sump to Mine Drainage Creek Sump (P24)
- Mine Drainage Creek Sump to SERDS Ditch (P10)
- Bootjack Creek Sump to SERDS Ditch (P11)
- Wight Pit/Underground to Long Ditch (P21)
- South Embankment Seepage Collection Pond to Main Embankment Seepage Collection Pond (P6)
- Main Embankment Seepage Collection Pond to PETBP (P8)

#### *5.8.1.3 Mill Process Flows – Restricted and Full Operations*

The mill process water requirements are based on 2.0 $m^3$/t of tailings. Interstitial water sequestered in the deposited tailings is based on 0.347 $m^3$/t of tailings deposited.

### 5.8.2 Tailings Storage Facility Seepage Flows

Seepage flows from the TSF (S1 to S5) have been measured for post-TSF foundation failure conditions by MPMC staff, and constant seepage rates based on these measurements have been applied in the model. During closure, seepage has been estimated from a three-dimensional numerical groundwater flow model based on available data and conceptual understanding (Attachment F). Seepage from the TSF has been defined to flow year-round in the SWWBM. The TSF seepage rates are presented in Section 3.4.

### 5.8.3 Consumption Flows

Consumption flows were calculated by MPMC staff, and are modelled according to the following logic:

- turbomisters operate from May to October
- sprinklers operate from July to October
- water trucks withdraw water at variable rates from July through October

Consumption flow rates are presented in Attachment A.

## 5.9 Model Calibration/Validation – Existing Conditions

The ability of the GoldSim SWWBM to replicate site conditions was assessed based on measured flows from the NW Ditch and the Long Ditch, and measured water elevations in the Springer Pit. The calibration period is September 2014 to April 2015. The primary parameters for calibration are runoff coefficients, and base flows for waste rock areas (Section 5.6.1). The validation period is from May 2015 to April 2016, and is based on pit lake elevation and accumulated volume of water and tailings in Springer Pit.

### 5.9.1 Northwest Ditch

Spot-measurements were available for the NW Ditch for the months of September, October, and November 2014, and for March and April 2015. A comparison between these spot-measurements and the average monthly results is shown in Figure 13. The comparison shows that the SWWBM captures the range of flows that occur in the NW Ditch.

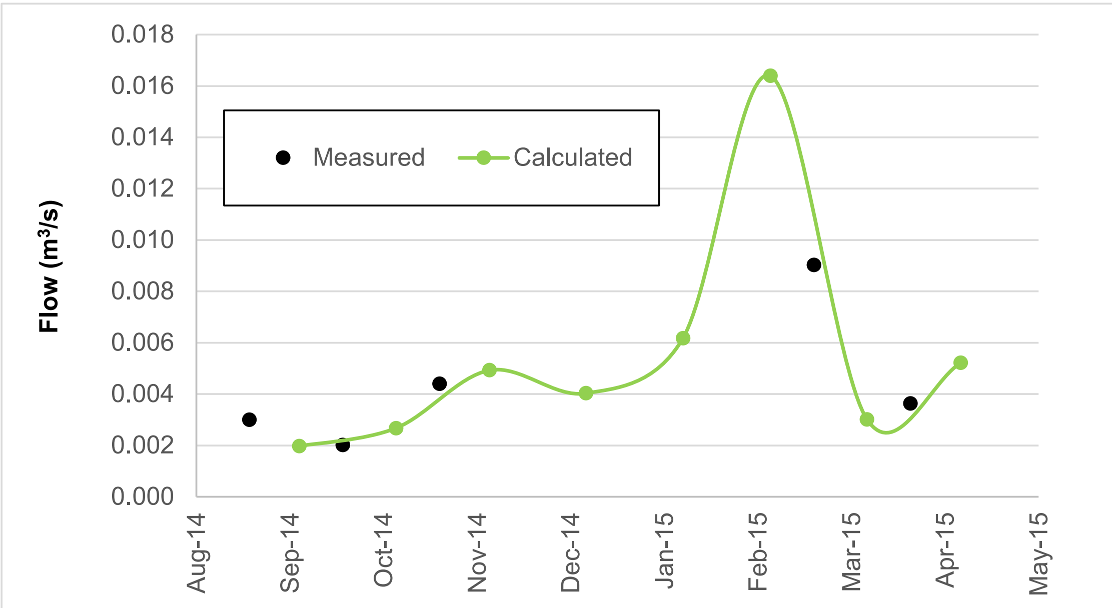


*Figure 13: Northwest Ditch Measured Spot Flows and Calculated Flows between September 2014 and April 2015*

### 5.9.2 Long Ditch

Spot-measurements were available for September 2014, as well as March and April 2015, for Long Ditch. A comparison between these spot-measurements and the average monthly results are shown in Figure 14. The SWWBM appears to possibly underestimate the flows in the freshet (although it is possible the synoptic measurements did not capture variability of freshet), but reasonably represents the flows during the dryer months of September 2014, as well as April 2015.

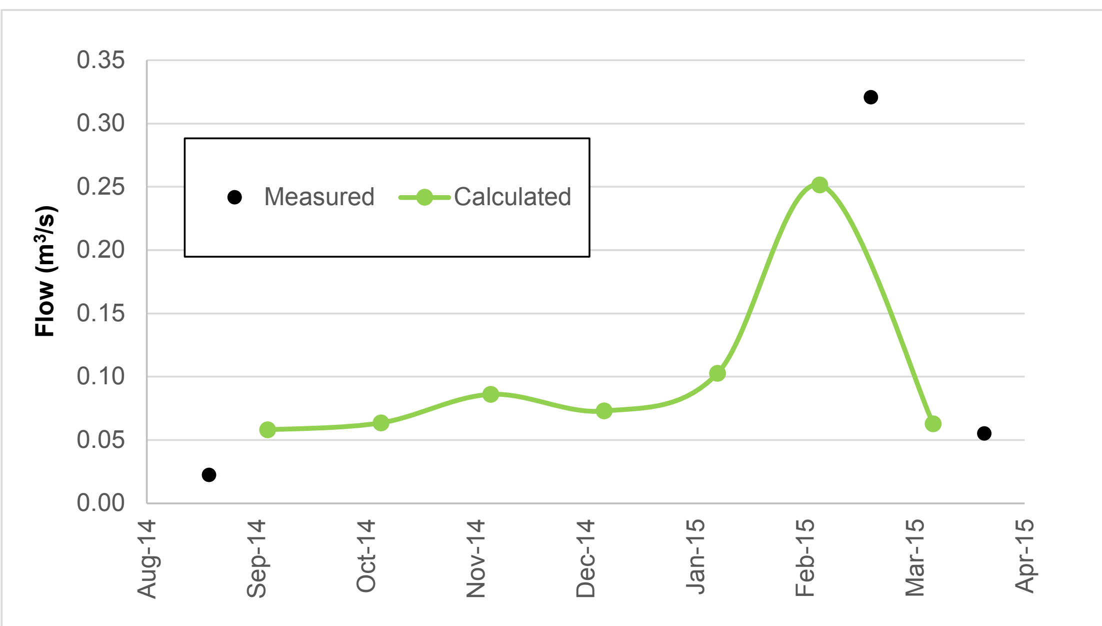


*Figure 14: Long Ditch Measured Spot Flows and Calculated Flows between September 2014 and April 2015*

### 5.9.3 Springer Pit

The measured and simulated Springer Pit lake elevations for the post-TSF foundation failure conditions through to April 1, 2016, are shown in Figure 15, and in Figure 16 for accumulated volume (water plus tailings solids). Simulated values have used measured monthly rainfall and snowmelt data provided by MPMC. The initial water elevation is 957.6 masl at the end of September 2014.

There is generally good agreement between simulated and modelled levels and volumes, although the water balance tends to overpredict water volume, and therefore produces conservatively high values. The largest discrepancy was during May and June 2015, when the measured inflow was 0.44 $Mm^3$, while the model predicted 1.32 $Mm^3$ of inflow (Table 20). Note that this was during an unusual period of weather in 2015, with early snowmelt (snowpack melted by end of March 2015) and extreme dry conditions from April 2015 through June 2015 (104 mm of rainfall or 57% of normal). For other months, the agreement between measured and calculated is generally good (Figure 17).

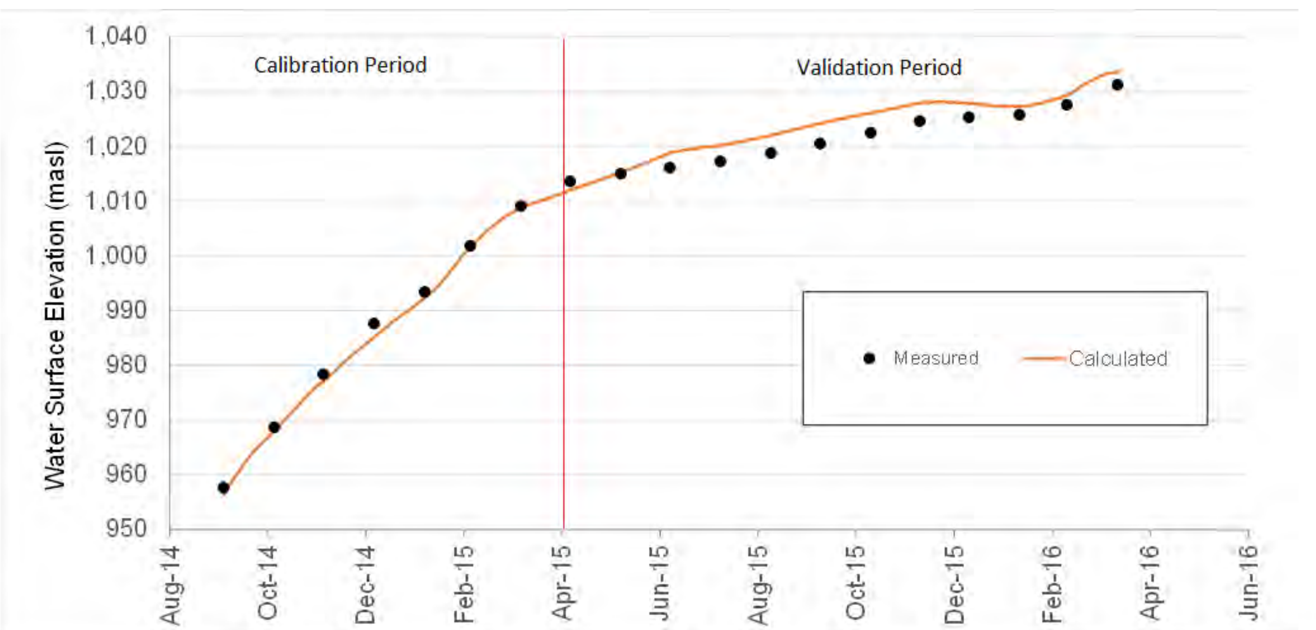


*Figure 15: Comparison of Measured and Calculated Water Elevations for Springer Pit*

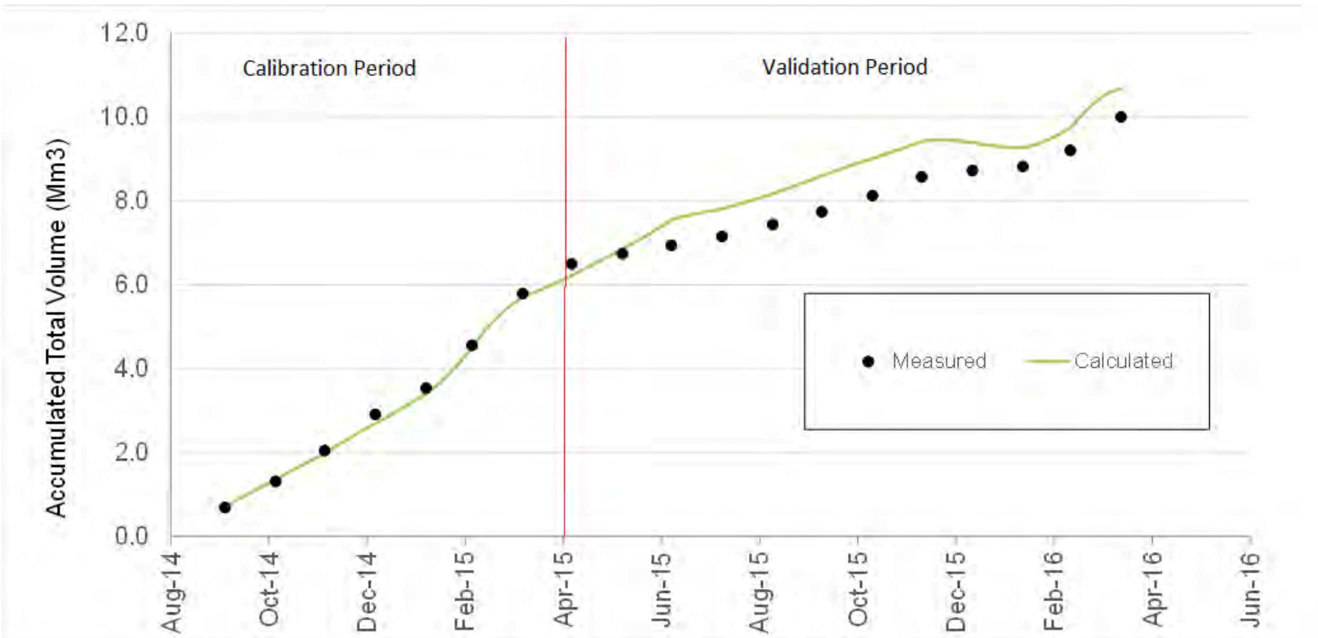


*Figure 16: Springer Pit Accumulated Water Volume (Mm$^3$) since September 2014*

**Table 20: Monthly Changes in Springer Pit Lake, Total Volume (Mm$^3$).**

| Date | Period | Measured (1) | Calculated | Difference |
|---|---|---|---|---|
| Oct-15 | Calibration | 0.62 | 0.66 | 0.04 |
| Nov-14 | | 0.73 | 0.63 | -0.10 |
| Dec-14 | | 0.87 | 0.71 | -0.16 |
| Jan-15 | | 0.62 | 0.72 | 0.10 |
| Feb-15 | | 1.02 | 1.09 | 0.07 |
| Mar-15 | | 1.24 | 1.19 | -0.05 |
| Apr-15 | | 0.71 | 0.53 | -0.18 |
| May-15 | Validation | 0.24 | 0.63 | 0.39 |
| Jun-15 | | 0.20 | 0.69 | 0.49 |
| Jul-15 | | 0.21 | 0.26 | 0.05 |
| Aug-15 | | 0.29 | 0.36 | 0.08 |
| Sep-15 | | 0.30 | 0.43 | 0.12 |
| Oct-15 | | 0.39 | 0.41 | 0.03 |
| Nov-15 | | 0.45 | 0.40 | -0.05 |
| Dec-15 | | 0.15 | -0.02 | -0.18 |
| Jan-16 | | 0.09 | -0.11 | -0.20 |
| Feb-16 | | 0.38 | 0.46 | 0.08 |
| Mar-16 | | 0.80 | 0.92 | 0.12 |
| | **Total** | **9.31** | **9.98** | **0.66** |

1) Based on changes in lake elevation.

A statistical measure of model performance is the Nash-Sutcliffe efficiency (NSE) (Nash and Sutcliffe 1970). The NSE is similar to the coefficient of determination ($r^2$), but is a measure of the explained variance about the line of perfect agreement (Figure 17), rather than about the linear regression. Based on all months, the calculated NSE is 0.6686, with 1.0 being perfect model prediction.

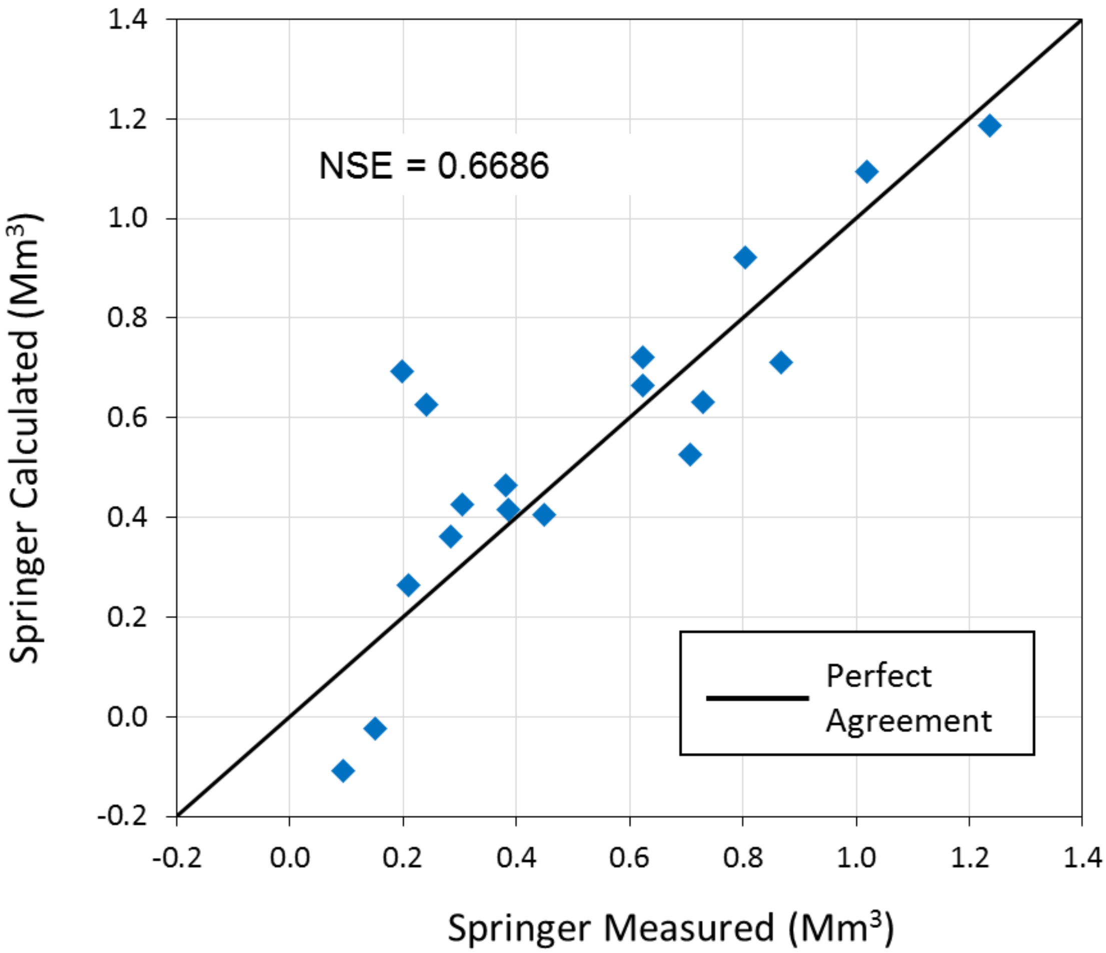


*Figure 17: Monthly Change ($Mm^3$) in Springer Pit Lake Volume (water plus solids)*

## 5.10 Model Simulation

The simulation was carried out for the period of 1 April 2016, to 31 December 2024, to capture the following Mine life stages:

- restricted operations–to 30 June 2016
- full operations–1 July 2016 to 30 June 2020
- closure/post-closure–1 July 2020 until attainment of steady state conditions

The model was run with probabilistic climate inputs for the purposes of this assessment. For each facility, water levels relating to the mean, $90^{th}$ and 99.5 percentile climate conditions are shown. These results correspond to average, 1-in-10-year wet, and 1-in-200-year wet conditions, respectively. The model assumes that the current CCS and PETBP would remain in operation.

Model pond volumes and elevations were provided initial values as of 1 April 2016. The initial values are based on survey measurements provided by MPMC.

### 5.10.1 Assumptions

The following assumptions are incorporated into the model simulations:

- initial Springer Pit Lake volume as of 1 April 2016—9,997,500 $m^3$
- initial Cariboo Pit Lake volume as of 1 April 2016—364,600 $m^3$
- tailings tonnage stored in Springer Pit as of 1 April 2016—3.46 Mt
- snowpack as of as of 1 April 2016: stochastic generated
- volume stored in Polley Lake (live storage) as of 1 April 2016—0 $m^3$
- no rewetting of existing drained tailings in the TSF (also see Contingency 1, Section 6.5)
- WTP capacity as of 1 April 2016—0.30 $m^3/s$
- WTP capacity after 1 July 2016—0.33 $m^3/s$
- discharge of effluent to Hazeltine Creek channel until November, 2017
- direct pipeline from WTP to diffuser in Quesnel Lake operational 1 December 2017

# 6.0 RESULTS

Results are summarized in this section for the following:

- discharge quantity of treated Mine effluent
- Springer Pit dewatering
- TSF pond elevation and volume
- PETBP volume
- Polley Lake makeup water volume
- pit lake water elevation during closure

## 6.1 Discharge Quantity of Treated Mine Effluent

### 6.1.1 Full Operations

The daily variation in the total Mine water discharge for the mean, the 90th, and the 99.5 percentiles[2] during full operations is shown in Figure 18. Annual discharge volumes are shown in Table 21.

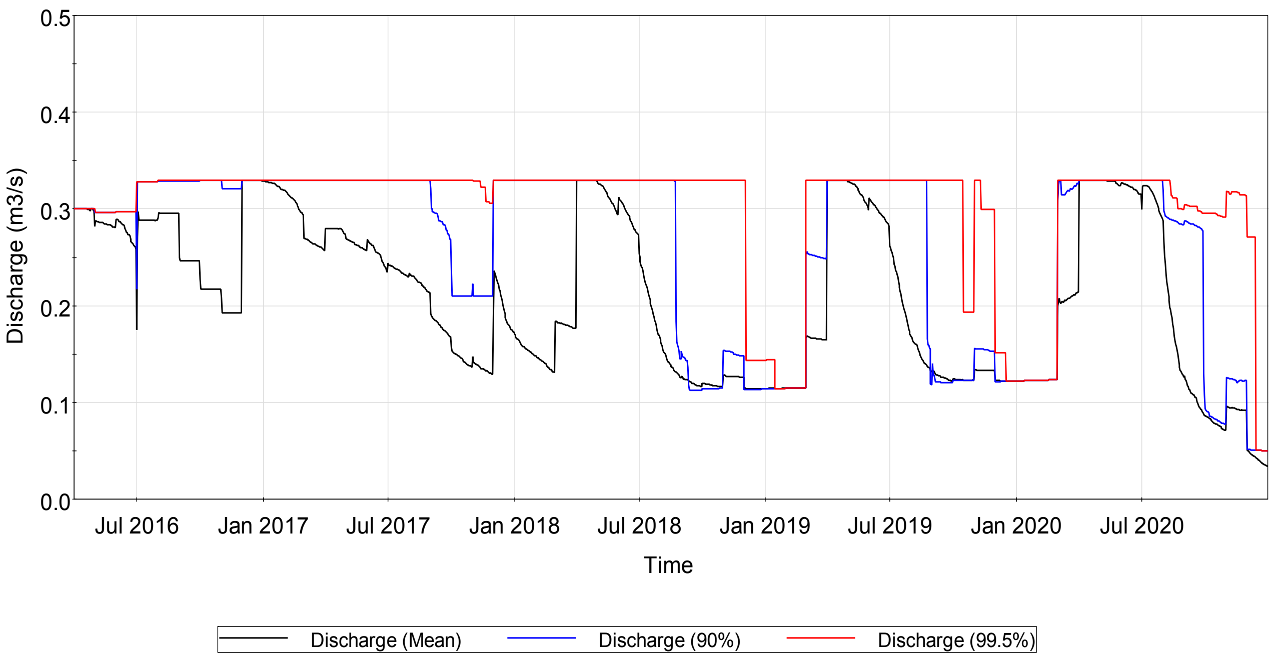


*Figure 18: Discharge of Mine Water during Full Operations*

[2] 90 and 99.5 percentiles correspond approximately to the 1:10-year wet and 1:200-year wet return periods, respectively.

**Table 21: Annual Discharge of Mine Water during Full Operations**

| Year | Annual Discharge | | | | | |
|---|---|---|---|---|---|---|
| | Mean | | 90th Percentile | | 99.5 Percentile | |
| | $m^3$ | $m^3/s$ | $m^3$ | $m^3/s$ | $m^3$ | $m^3/s$ |
| 2016 | 7,662,800 | 0.24 | 8,470,300 | 0.27 | 8,765,300 | 0.28 |
| 2017 | 7,379,300 | 0.23 | 8,864,200 | 0.28 | 9,914,100 | 0.31 |
| 2018 | 5,896,800 | 0.19 | 7,181,000 | 0.23 | 9,128,500 | 0.29 |
| 2019 | 5,805,000 | 0.18 | 6,573,600 | 0.21 | 7,912,900 | 0.25 |
| 2020 | 5,904,300 | 0.19 | 6,800,700 | 0.22 | 8,105,100 | 0.26 |

### 6.1.2 Closure/Post-closure

The daily variation in the total of treated plus bypassed Mine water discharge for the mean, the 90th, and the 99.5 percentiles during closure and post-closure to 2050 is shown in Figure 19. Annual discharge volumes are shown in Table 22. Annual discharge is reduced from 2020 to 2021 as the open pits are allowed to fill.

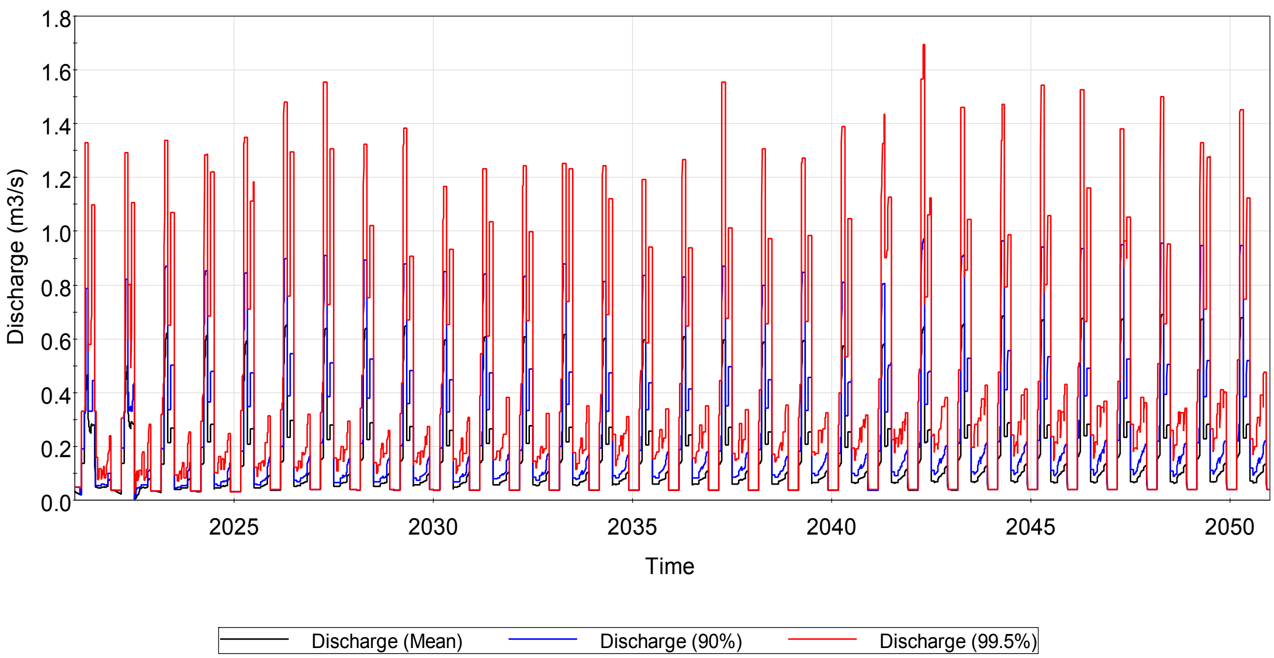


*Figure 19: Discharge of Mine Water during Closure and Post-Closure*

**Table 22: Annual Discharge of Mine Water during Closure and Post-closure**

| Year | Annual Discharge | | | | | |
|---|---|---|---|---|---|---|
| | Mean | | 90th Percentile | | 99.5 Percentile | |
| | $m^3$ | $m^3/s$ | $m^3$ | $m^3/s$ | $m^3$ | $m^3/s$ |
| 2021 | 3,853,100 | 0.12 | 4,889,900 | 0.16 | 6,534,800 | 0.21 |
| 2022 | 3,821,900 | 0.12 | 4,913,900 | 0.16 | 6,491,600 | 0.21 |
| 2023 | 4,003,800 | 0.13 | 4,999,400 | 0.16 | 6,945,300 | 0.22 |
| 2024 | 4,109,800 | 0.13 | 5,164,400 | 0.16 | 6,709,100 | 0.21 |
| 2025 | 4,049,100 | 0.13 | 5,269,700 | 0.17 | 6,908,200 | 0.22 |
| 2030 | 4,213,500 | 0.13 | 5,201,100 | 0.16 | 6,349,700 | 0.20 |
| 2035 | 4,356,600 | 0.14 | 5,315,600 | 0.17 | 6,932,800 | 0.22 |
| 2040 | 4,303,400 | 0.14 | 5,241,600 | 0.17 | 6,592,300 | 0.21 |
| 2045 | 5,009,500 | 0.16 | 6,198,500 | 0.20 | 7,755,800 | 0.25 |
| 2050 | 5,034,500 | 0.16 | 6,184,400 | 0.20 | 8,447,000 | 0.27 |

## 6.2 Springer Pit Dewatering

Simulated Springer Pit lake water elevations are shown in Figure 20 for the mean, and 90th, and 99.5 percentiles. The simulations are run from initial value on 1 April 2016, volume of 9,997,500 $m^3$.

The mean projection is for the Springer Pit to be dewatered to the elevation of the tailings by first quarter of 2018, although under extreme wet conditions (99.5 percentile), the pit lake could persist until late 2018.

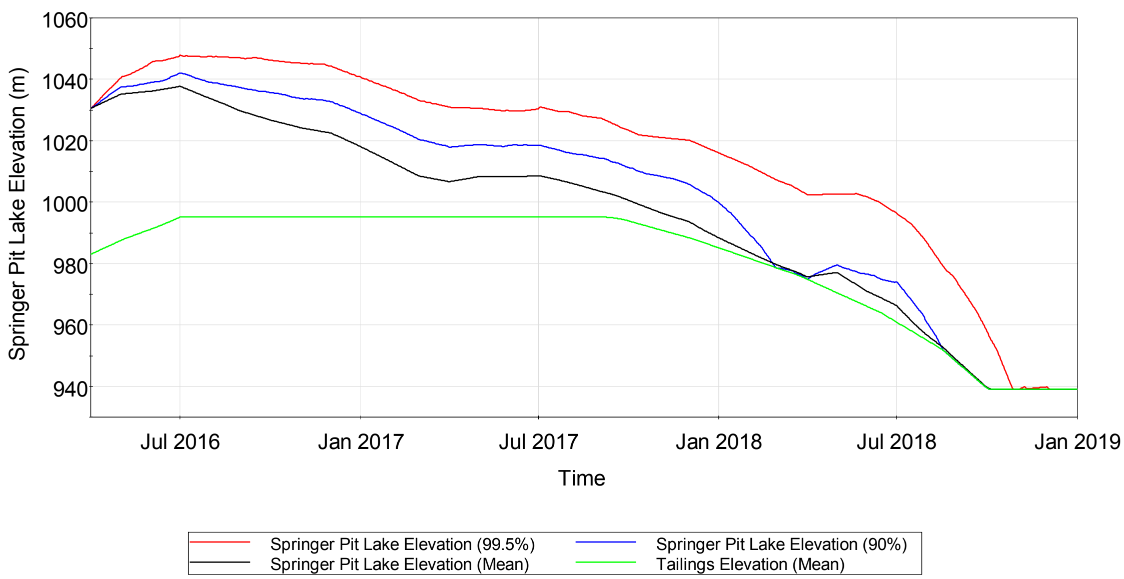


*Figure 20: Springer Pit Water Elevations Simulated from 1 April 2016*

Once the Springer Pit is dewatered, it is expected that temporary ponding will occur during freshet, as options for dewatering are limited (Figure 21). During the freshet, runoff to the CCS is given priority for treatment and discharge through the WTP, and therefore pumping from the Springer Pit is curtailed. It is assumed that there is no pumping from the Springer Pit to the TSF. Under extreme conditions, water would be pumped from the TSF to the Springer Pit during the freshet to maintain sufficient TSF freeboard. Temporary ponding of water in the Springer Pit represents a potential operational water management issue that can be addressed though pit mining operations and construction of pit sumps. This accumulation can likely be reduced with further optimization of the pumping logic and operational water management.

From third quarter of 2020, the Springer Pit begins to refill with water (Figure 21).

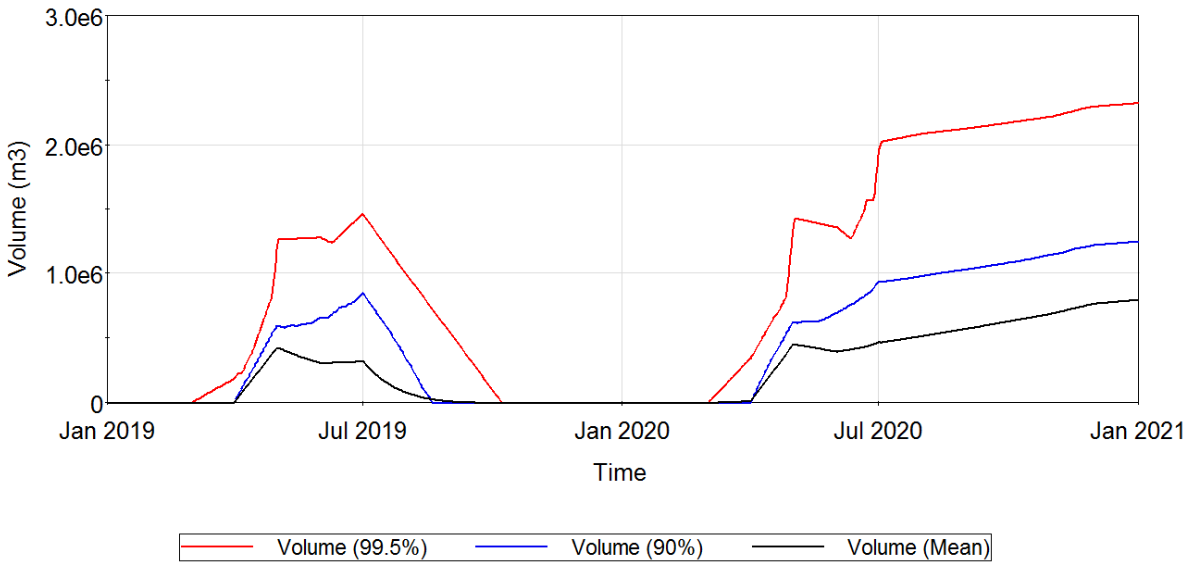


*Figure 21: Springer Pit Sump Water Volume ($Mm^3$)*

## 6.3 Tailings Storage Facility

Temporary detention of water will be necessary to manage the large runoff volumes generated during freshet (typically April to June, inclusive). The inflows during freshet will exceed treatment and discharge capacities, and detention volume is required to prevent uncontrolled release from the PETBP and to equalize the flow for treatment. Because of the large freshet volumes, it will be necessary to utilize the TSF for temporary detention; however, a principal objective of the LTWMP is to not accumulate water on site (including in the TSF), and to not carry over water from year to year, even under extreme wet conditions. The SWWBM has been used to assess the required detention volume external to the TSF, while also assessing the corresponding detention volume required in the TSF under average to extreme wet conditions. Figure 22 shows the water volume in the TSF throughout full operations and into closure.

During full operations, the mean pond level reaches a maximum (99.5 percentile) of about 1.5 $Mm^3$ (950 masl) by 1 July 2016. During 2017, discharge from Mine is constrained by natural flows in Hazeltine Creek, and therefore the accumulated volume in the TSF is generally higher than in subsequent years (Figure 22). When the volume of water in the TSF reaches 3.5 $Mm^3$, water is pumped to the Springer Pit. Under 99.5 percentile extreme wet conditions, there is potential for a small volume of water to be carried over from 2017 to 2018. In subsequent years, if the proposed direct pipeline to the diffuser in Quesnel Lake is operational, the TSF pond is reduced to the minimum volume before the subsequent freshet.

During closure, the maximum pond volume at the spillway invert is approximately 250,000 $m^3$. The pond is expected to spill annually. In most years, the pond volume is reduced to zero by seepage and evaporation losses.

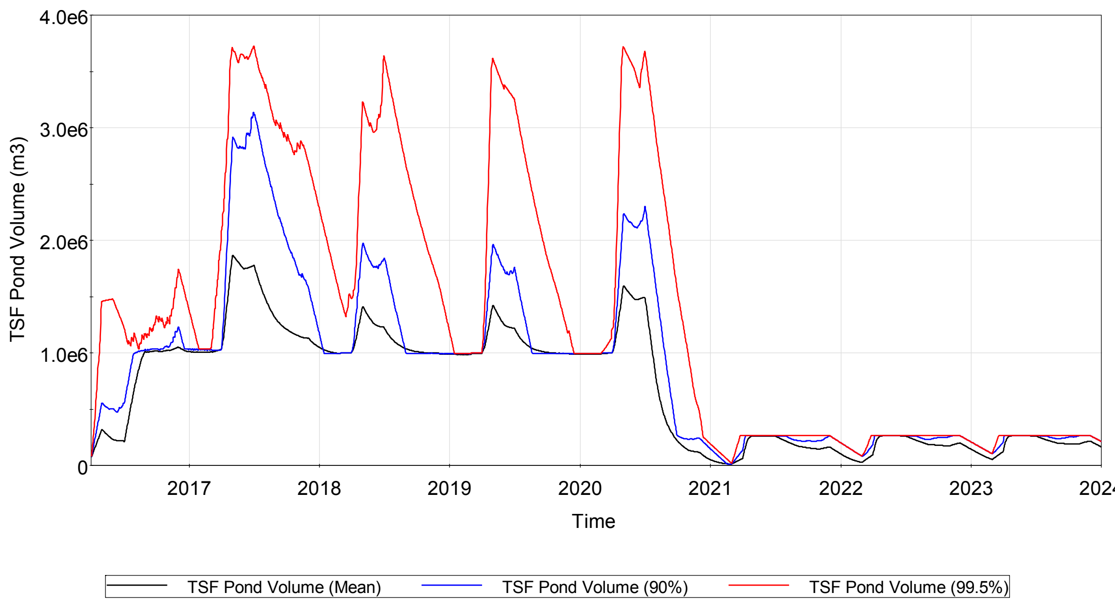


*Figure 22: Tailings Storage Facility Water Volumes during Full Operations and into Closure*

The maximum TSF pond elevation in closure (2020) is 969.2 masl for extreme 99.5 percentile wet conditions. This provides 0.8 m of freeboard to 970 masl (Figure 23). During post-closure, the maximum water elevation is controlled by the spillway invert at 965.7 masl.

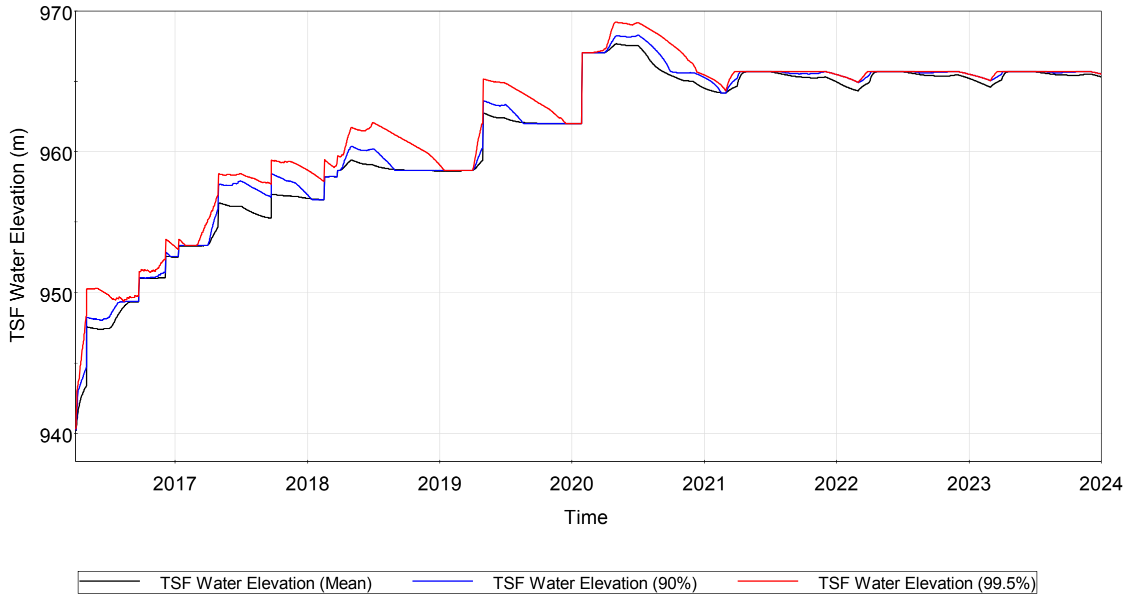


*Figure 23: Tailings Storage Facility Water Elevations during Full Operations and into Closure*

## 6.4 Perimeter Embankment Till Borrow Pond

Water flows from the CCS to the PETBP by gravity through an open channel, with culverts under the Hazeltine Creek access road. Because the buttress extension may cover the existing inflow ditch, culverts and a rock drain may be required at the base of the Corner 1 upon the final design PETBP (Golder 2015a).

The current maximum capacity of the PETBP is 170,000 m$^3$. When the water volume in the PETBP exceeds 150,000 m$^3$, pumps to the TSF are activated to avoid overflow. Under average climate conditions during full operations, the volume in the pond approaches 80,000 m$^3$ during the freshet. During closure, the pond will be allowed to fill and is assumed to discharge to the environment after treatment; however, this component of the model will be refined as the closure/post-closure water treatment and discharge system is tested and designed. During full operations, there are no occurrences of overflow from the PETBP under the simulated conditions (Figure 24).

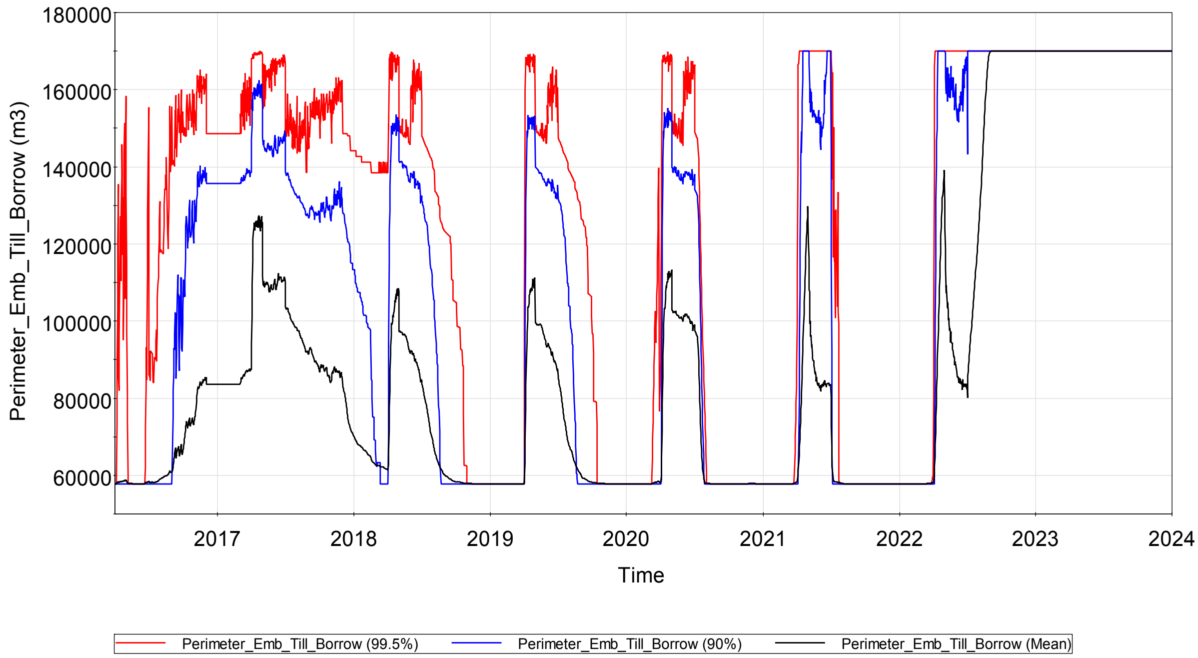


*Figure 24: Perimeter Embankment Till Borrow Pond Water Volumes*

### 6.4.1 Polley Lake Makeup Water

Typically during fall and winter months, runoff to the TSF and CCS is not sufficient to meet process water makeup requirements. Prior to July 2017, makeup water requirements can be met from the Springer Pit. Subsequently, makeup water will be supplied from Polley Lake. This water usage is currently permitted under MPMC's existing Conditional Water License 101763.

The daily variation in makeup water supply is shown in Figure 25 for mean, and 90$^{th}$ and 99.5 percentiles. Annual makeup volumes drawn from Polley Lake are shown in Table 23. Note that the 90$^{th}$ and 99.5 percentiles refer to extreme dry conditions.

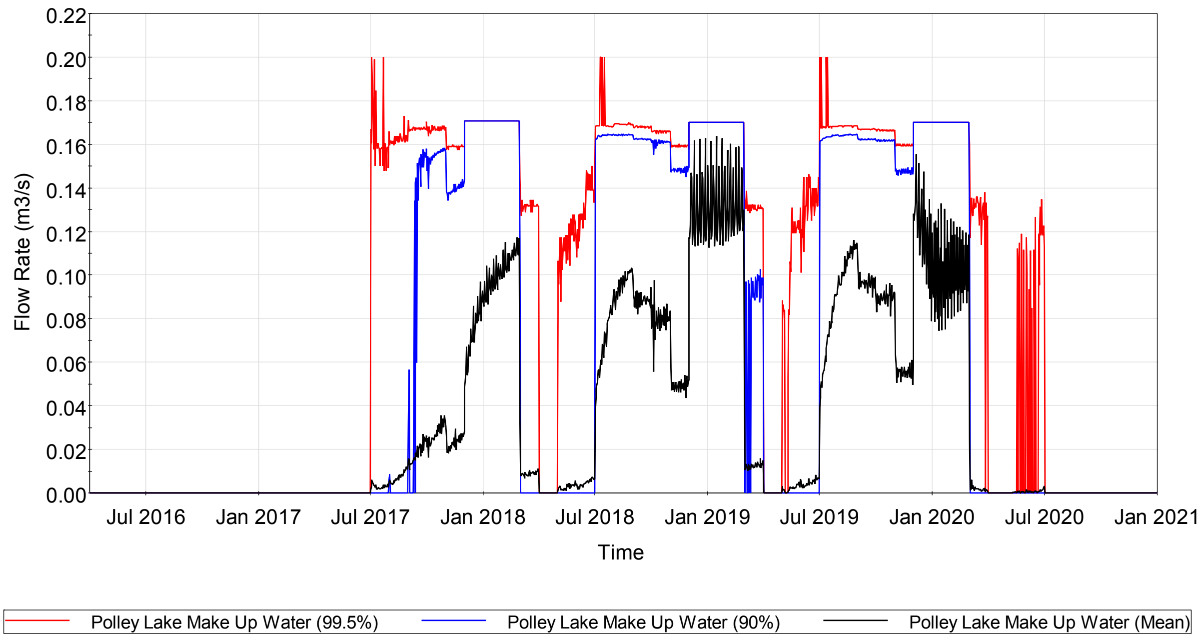


*Figure 25: Polley Lake Makeup Water ($m^3/s$)*

**Table 23: Annual Volume of Makeup Water Drawn from Polley Lake**

| Year | Total Makeup Volume ($m^3$) | | |
|---|---|---|---|
| | Mean | 90th Percentile | 99.5 Percentile |
| 2017 | 401,200 | 936,600 | 1,473,900 |
| 2018 | 1,921,700 | 2,400,600 | 2,655,600 |
| 2019 | 2,164,500 | 2,550,300 | 2,819,300 |
| 2020 | 544,000 | 563,200 | 630,900 |

## 6.5 Contingency Scenarios

Results presented above reflect the Base Case. In addition, the following contingency scenarios have been assessed:

1) Base Case with tailings rewetting.

2) Base Case with Care and Maintenance starting 1 July 2017.

3) Base Case with no discharge from the Mine during April and May 2017.

4) Base Case with no controlled discharge from the Mine after 30 March 2017.

Results are presented for the full operations phase.

### 6.5.1 Contingency 1: Base Case with Tailings Rewetting

The Base Case simulation does not account for water re-infiltrating and rewetting the existing tailings in the TSF, and is therefore conservative from the perspective of the volume of free water to be managed and discharged.

An exponential tailings drain down curve was developed for the TSF following the 2014 foundation failure (Golder, 2015c). On the basis of the drain down curve, approximately 4 $Mm^3$ of water has drained from the existing tailings in the TSF since the foundation failure in August 2014 until July 2016. Contingency 1 assumes that rewetting of the tailings occurs at an annual rate of 1 $Mm^3/y$ throughout operations, which gives a total volume “lost” to the existing tailings of approximately 3.8 $Mm^3$ throughout the full operation phase. The rate and total amount of water that will be lost to re-wetting is somewhat uncertain, because the amount of water that re-enters the drained tailings will not necessarily be the same as the volume that drained from them. This scenario provides an estimate of a fully rewetted condition; in reality, the outcome is expected to be somewhere in between the conservative Base Case and this scenario. For this reason, the Base Case has been used as a conservative estimate for the TAR.

The daily variation in discharge for the mean, the 90th, and the 99.5 percentiles is provided in Figure 26, and discharge volumes are presented in Table 24. There is a modest reduction in the annual discharge volume relative to the Base Case during full operations (Table 21).

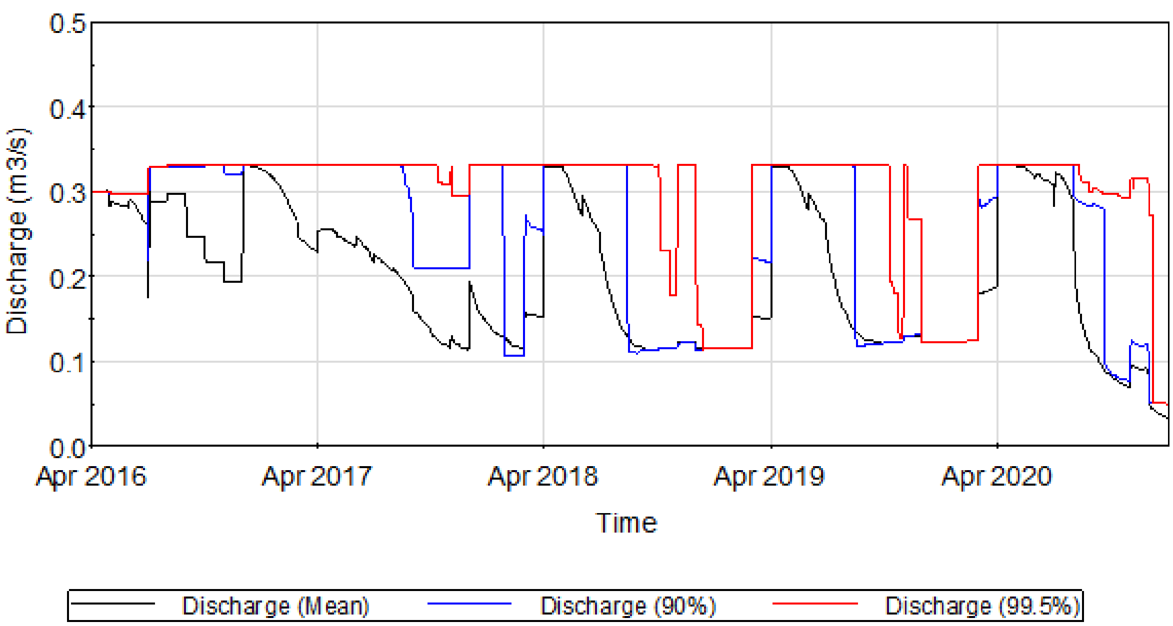


*Figure 26: Discharge of Mine Water for Contingency 1*

**Table 24: Annual Discharge of Mine Water for Contingency 1**

| Year | Annual Discharge ($m^3$) | | |
|---|---|---|---|
| | Mean | 90th Percentile | 99.5 Percentile |
| 2016 | 7,658,000 | 8,451,700 | 8,745,500 |
| 2017 | 6,630,900 | 8,319,400 | 9,240,500 |
| 2018 | 5,462,400 | 6,328,800 | 7,972,400 |
| 2019 | 5,564,400 | 6,306,800 | 7,476,000 |
| 2020 | 5,681,200 | 6,537,900 | 7,931,100 |

Projected Springer Pit water levels are shown in Figure 27. Generally the time to dewater to the elevation of the deposited tailings is reduced by about two months compared to the Base Case (Figure 20).

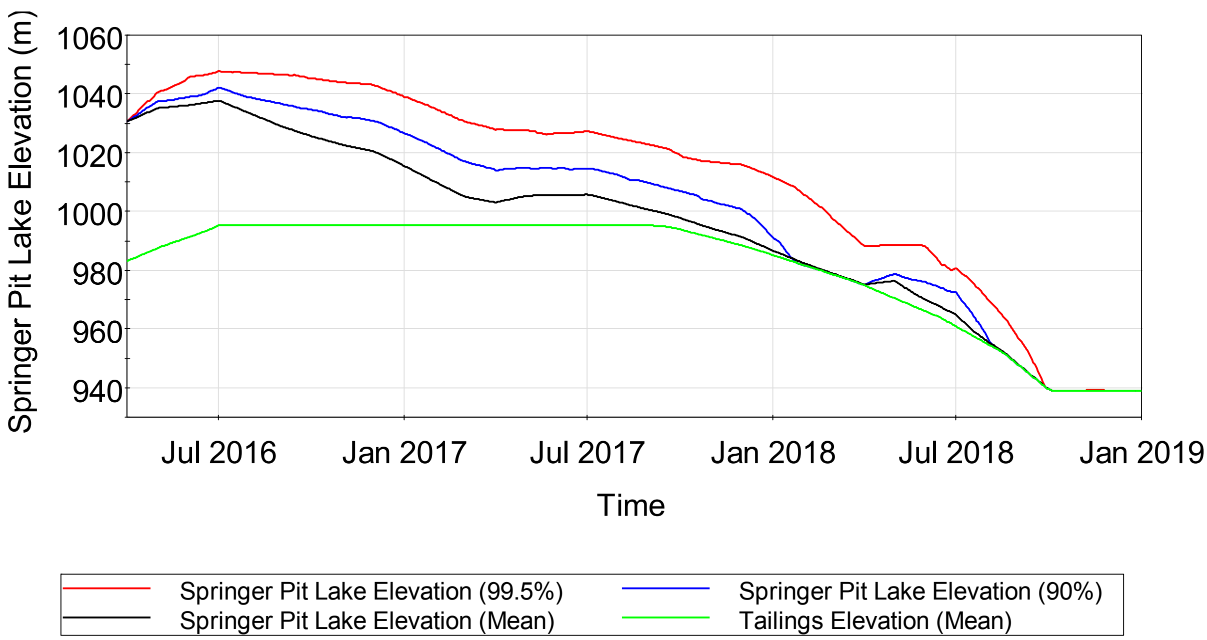


*Figure 27: Springer Pit Water Elevations for Contingency 1*

The projected TSF water volumes for Contingency 1 are shown in Figure 28. The peak volumes are reduced from the Base Case (Figure 22), and notably, for Contingency 1 there is no projected carry over under extreme wet conditions from 2017 to 2018.

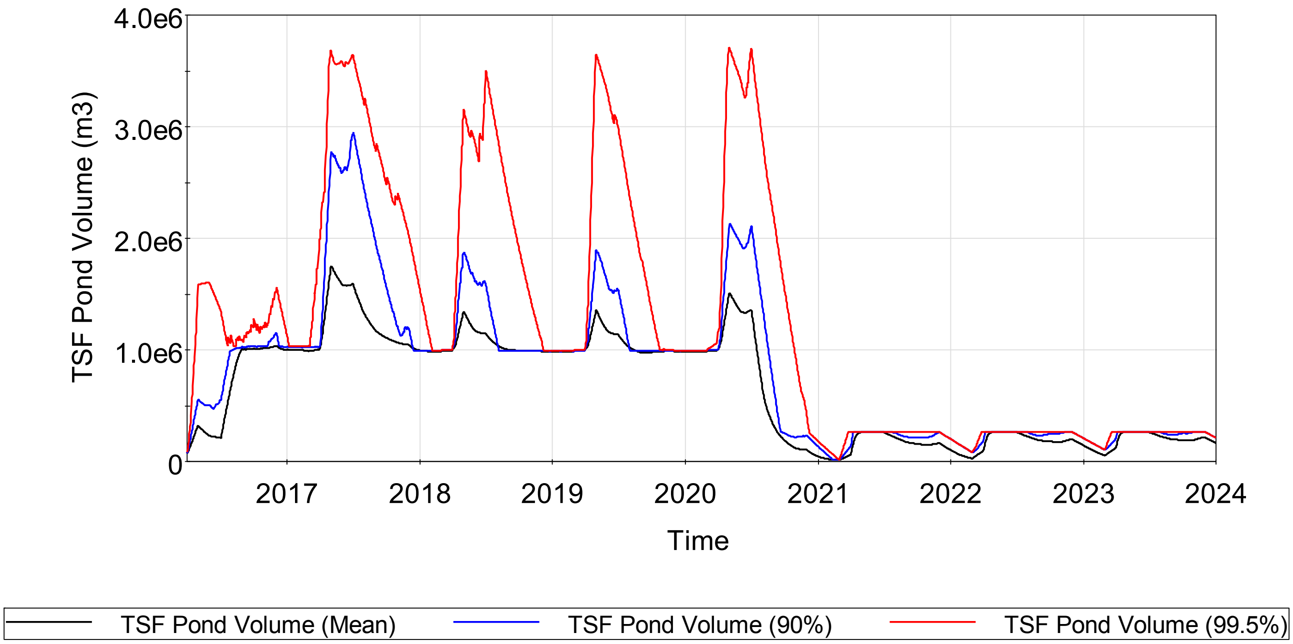


*Figure 28: Tailings Storage Facility Water Volumes during Full Operations and into Closure for Contingency 1*

### 6.5.2 Contingency 2: Base Case with Care and Maintenance Starting July 1, 2017

Contingency 2 represents a scenario whereby the Mine is put into Care and Maintenance as a consequence of low metal prices, or other economic, regulatory, or environmental reasons. Treatment and discharge continues as in the Base Case; however, there is no mining, milling, or deposition of tailings in the TSF. A five-year shut down is assumed.

The daily variation in discharge for the mean, the 90$^{th}$, and the 99.5 percentiles is provided in Figure 29 and discharge volumes in Table 25. There is a modest reduction in the annual discharge volume relative to the Base Case during the full operations phase (Table 21).

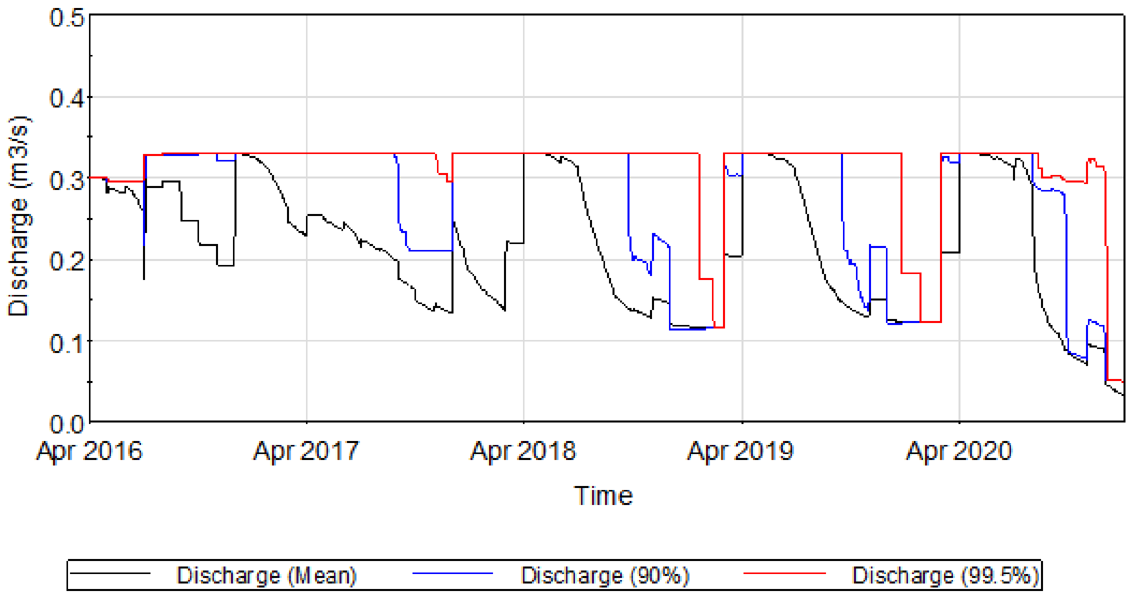


*Figure 29: Discharge of Mine Water for Contingency 2*

**Table 25: Annual Discharge of Mine Water for Contingency 2**

| Year | Annual Discharge ($m^3$) | | |
|---|---|---|---|
| | Mean | 90th Percentile | 99.5 Percentile |
| 2016 | 7,658,000 | 8,451,700 | 8,745,500 |
| 2017 | 6,959,100 | 8,735,100 | 9,763,700 |
| 2018 | 6,580,600 | 8,016,900 | 10,305,000 |
| 2019 | 6,375,900 | 7,310,100 | 8,925,200 |
| 2020 | 5,817,700 | 6,698,000 | 8,031,000 |

Projected Springer Pit water levels are shown in Figure 30. Results indicate that water volumes would be reduced during Care and Maintenance and remain below 1,030 masl.

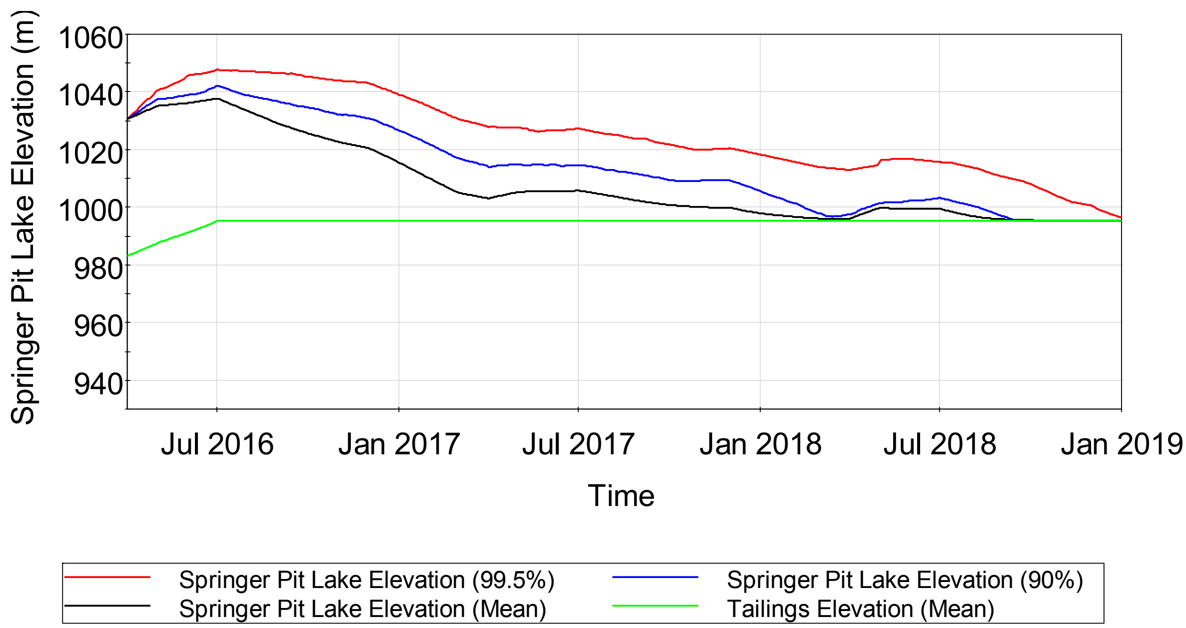


*Figure 30: Springer Pit Water Elevations for Contingency 2*

The projected TSF water volumes for Contingency 2 are shown in Figure 31. The peak volumes in 2017 are increased from the Base Case (Figure 22), and there continues to be carry over under extreme wet conditions from 2017 to 2018.

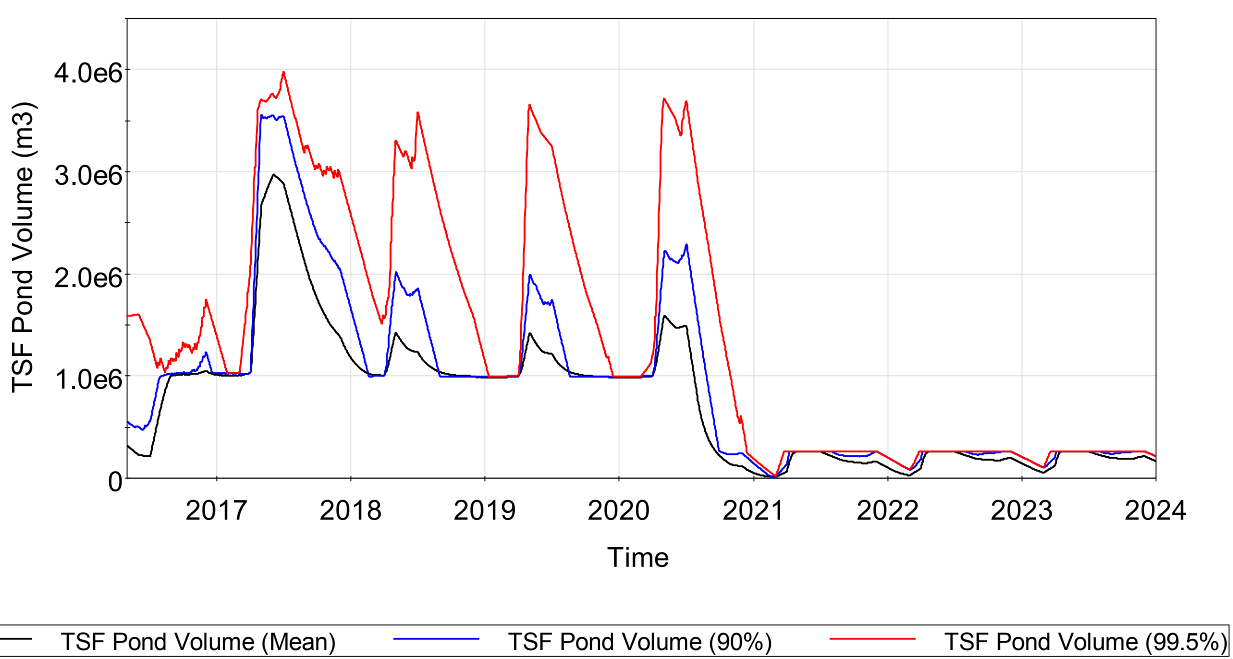


*Figure 31: Tailings Storage Facility Water Volumes during Full Operations and into Closure for Contingency 2*

### 6.5.3 Contingency 3: Base Case with No Discharge during April and May 2017

Contingency 3 represents an upset scenario where discharge of water from the Mine is interrupted for two months during the freshet of 2017. This scenario most likely represents a mechanical failure of the water treatment and discharge system.

The daily variation in discharge for the mean, the 90th, and the 99.5 percentiles is provided in Figure 32 and discharge volumes in Table 26. There is a reduction in the annual discharge volume relative to the Base Case in 2017, and an compensatory increase in discharge in 2018 (Table 21). In other years the discharge is essentially unchanged.

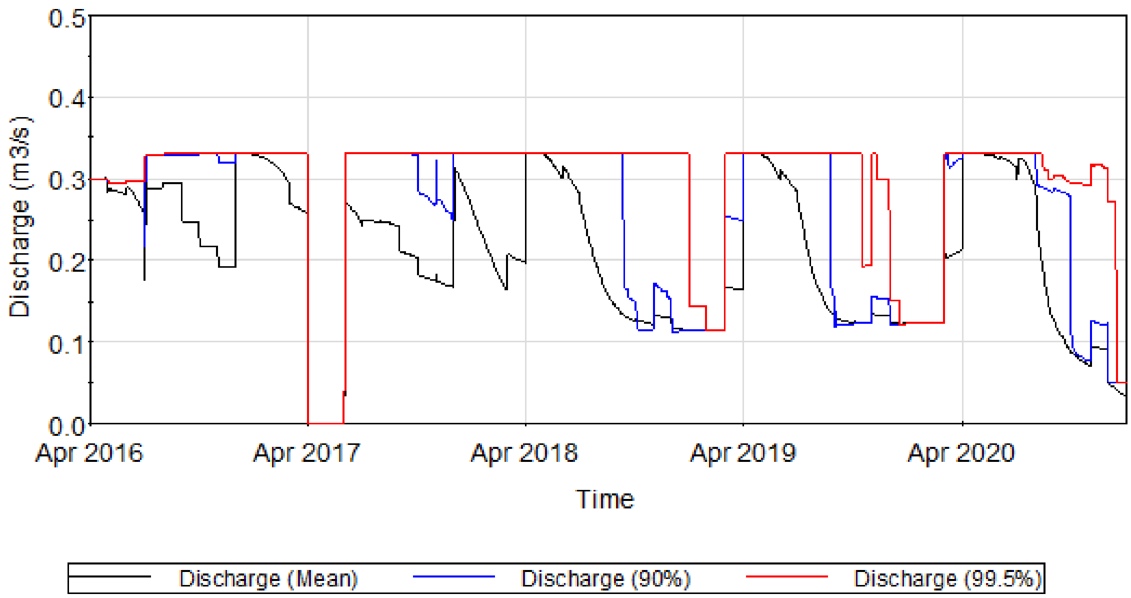


*Figure 32: Discharge of Mine Water during Operations for Contingency 3*

**Table 26: Annual Discharge of Mine Water for Contingency 3**

| Year | Annual Discharge ($m^3$) | | |
|---|---|---|---|
| | Mean | 90th Percentile | 99.5 Percentile |
| 2016 | 7,662,800 | 8,470,300 | 8,765,300 |
| 2017 | 6,550,000 | 7,745,200 | 8,433,000 |
| 2018 | 6,436,400 | 8,201,900 | 10,266,400 |
| 2019 | 5,806,800 | 6,574,000 | 7,914,200 |
| 2020 | 5,903,200 | 6,796,700 | 8,100,100 |

Projected Springer pit water levels are shown in Figure 33. Generally the time to dewater to the elevation of the deposited tailings is not substantially affected, except under extreme wet conditions (99.5 percentile), where dewatering to the base of Springer Pit is delayed by about two months compared to the Base Case (Figure 20).

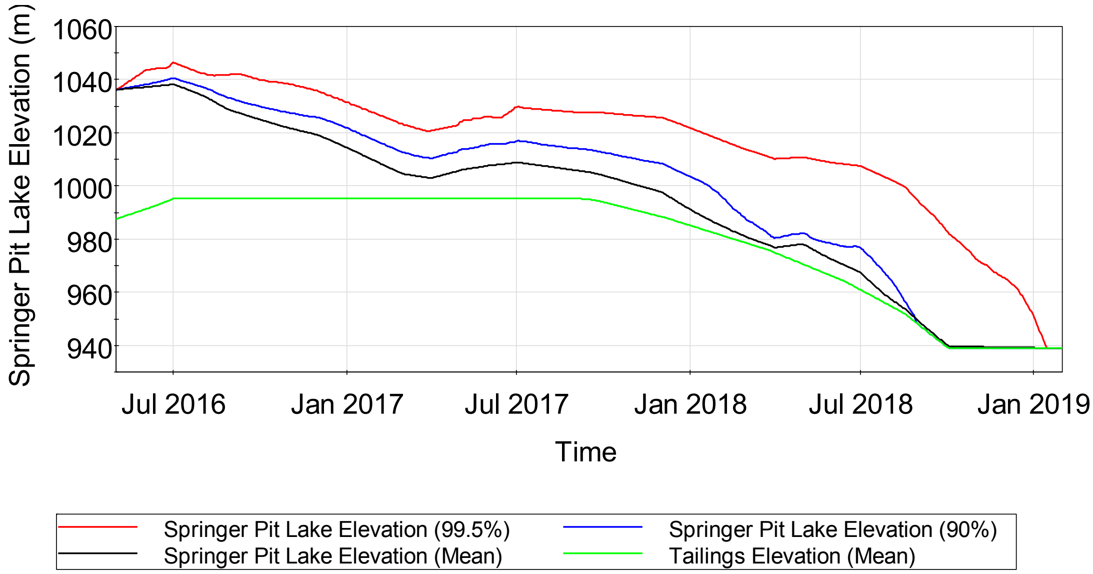


*Figure 33: Springer Pit Water Elevations for Contingency 3*

The projected TSF water volumes for Contingency 3 are given in Figure 34. The peak volumes are similar to the Base Case (Figure 22), and there continues to be carry over under extreme wet conditions from 2017 to 2018.

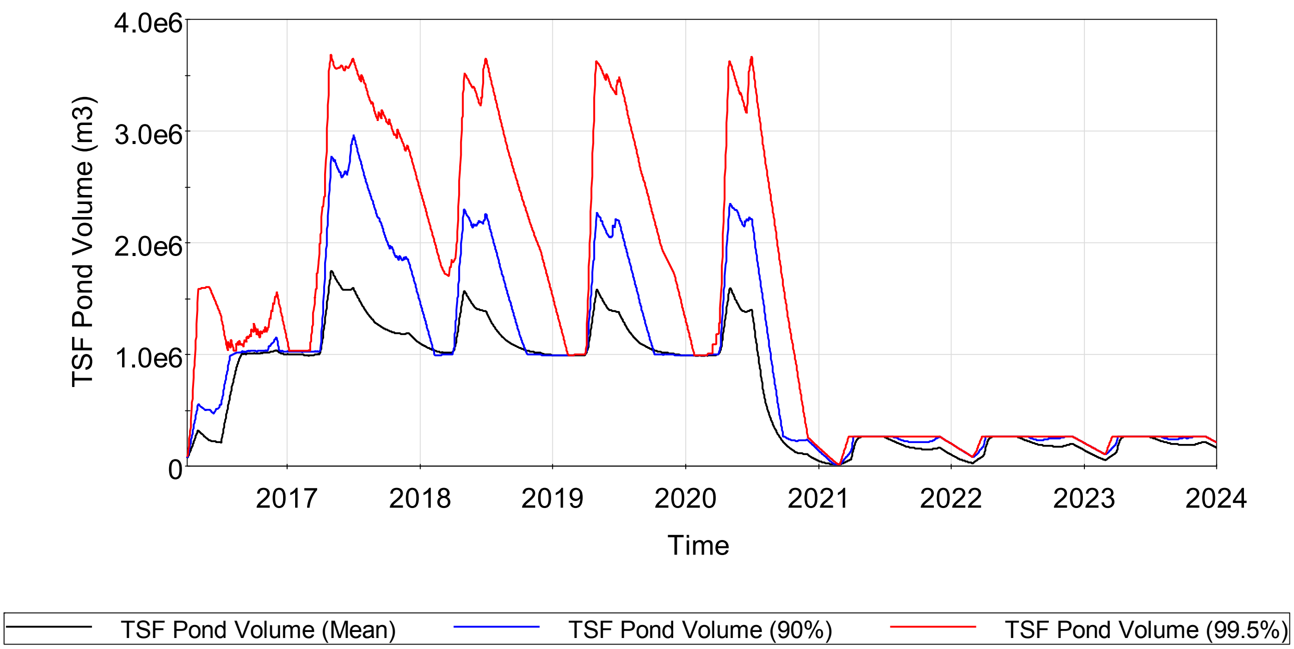


*Figure 34: Tailings Storage Facility Water Volumes during Full Operations and into Closure for Contingency 3*

### 6.5.4 Contingency 4: Base Case with No Controlled Discharge after 30 March 2017

Under the Contingency 4 scenario, discharge of treated water from the Mine is stopped after 30 March 2017. This hypothetical scenario is to assess the period of time that the Mine could continue to operate with no uncontrolled surface discharge (spills) from site. This scenario assumes all surplus water is pumped to and stored in the Springer Pit (not the TSF).

The daily variation in discharge for the mean, the 90th, and the 99.5 percentiles is provided in Figure 35 and discharge volumes in Table 27. From April 2017 through April 2018 there is no discharge from the Mine (Figure 35). Beginning in May 2018, for extreme wet conditions, the Springer Pit lake elevation reaches the overflow elevation of 1,050 masl (Figure 36), and uncontrolled discharge is simulated. For the mean scenario, the Springer Pit Lake reaches 1,050 masl by May 2019 (Figure 36).

Discharge in 2018 and 2019 (Figure 35, Table 27) represent uncontrolled discharge.

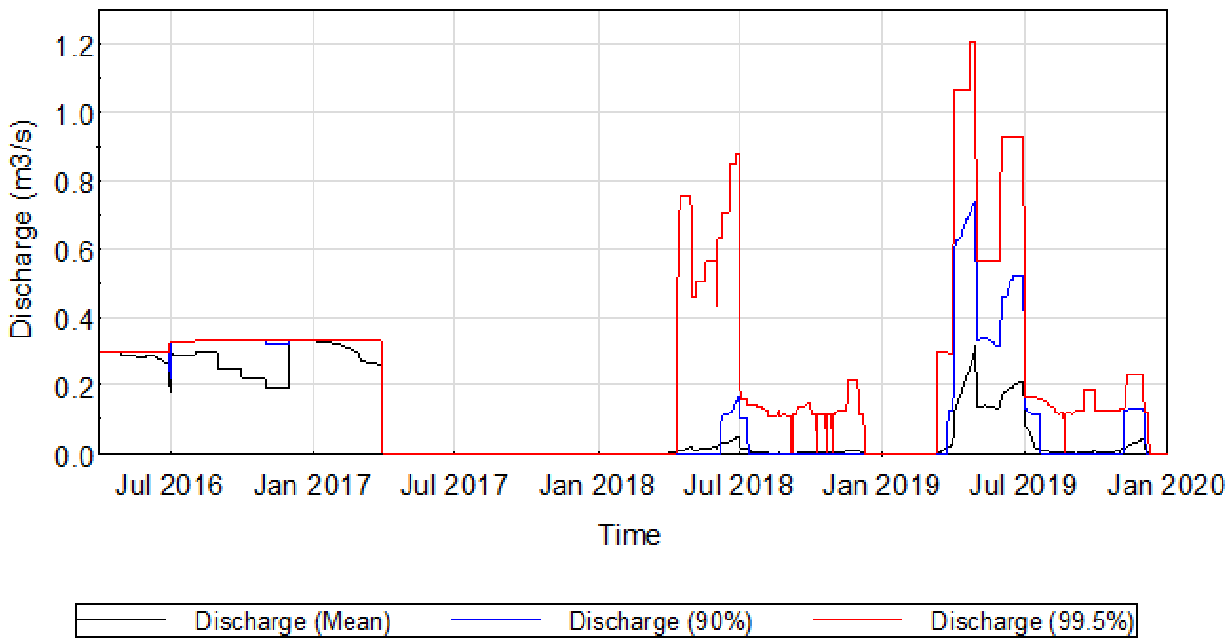


*Figure 35: Discharge of Mine Water for Contingency 4*

**Table 27: Annual Discharge of Mine Water for Contingency 4**

| Year | Annual Discharge ($m^3$) | | |
|---|---|---|---|
| | **Mean** | **90th Percentile** | **99.5 Percentile** |
| 2016 | 7,662,700 | 8,470,300 | 8,765,300 |
| 2017 | 2,281,800 | 2,509,100 | 2,509,100 |
| 2018 | 277,700 | 1,056,500 | 3,641,300 |
| 2019 | 2,205,500 | 3,891,600 | 6,423,400 |

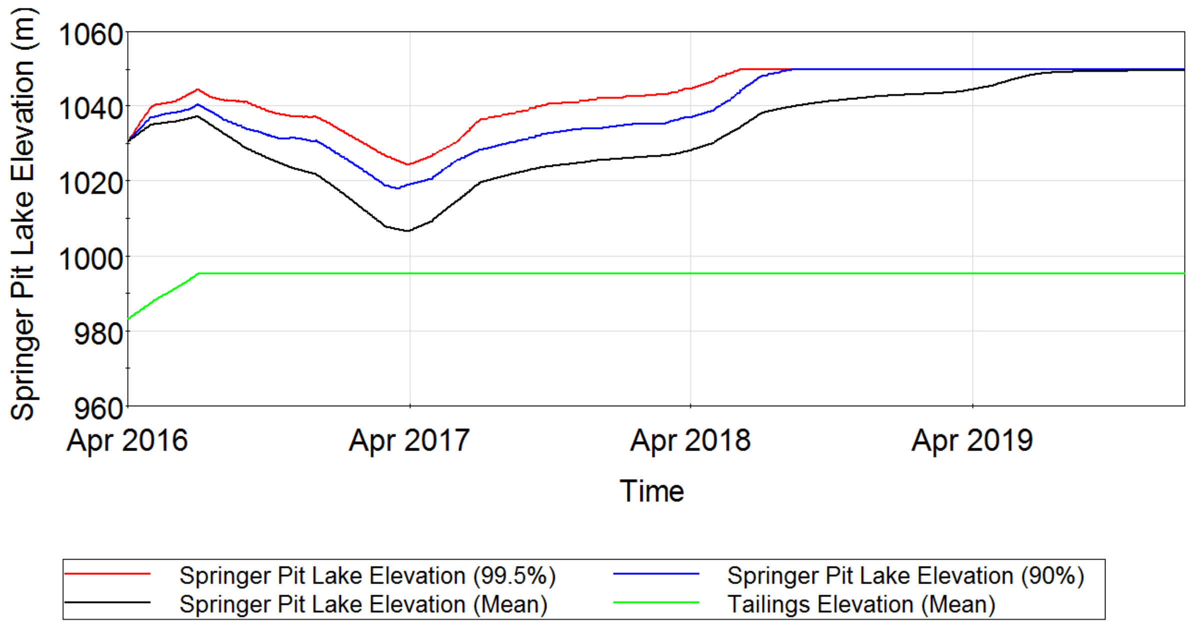


*Figure 36: Springer Pit Water Elevations for Contingency 4*

The projected TSF water volumes for Contingency 4 are shown in Figure 37. The peak water volumes for Contingency 4 for extreme wet conditions (99.5 percentile) are similar to the Base Case (Figure 37), however the mean peak water levels are generally higher.

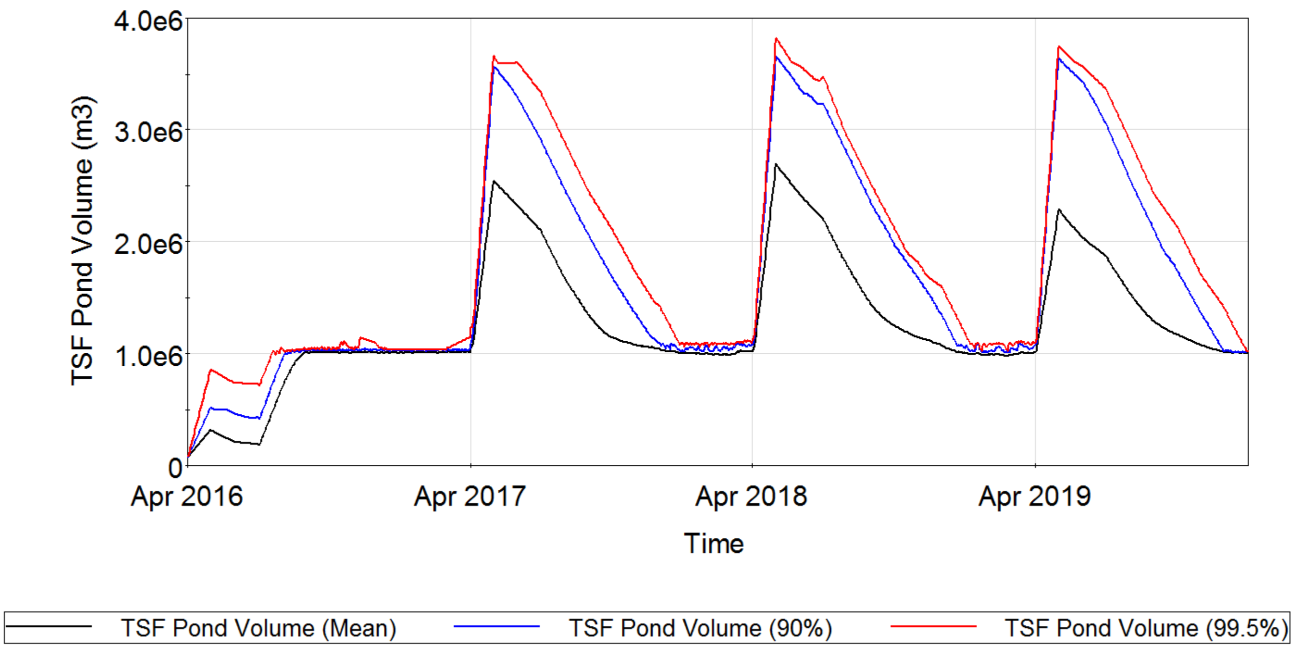


*Figure 37: Tailings Storage Facility Water Volumes for Contingency 4*

## 6.6 Pit Lakes during Closure

The formation of pit lakes in the combined Cariboo-Springer Pit, the Boundary Pit, and the Wight Pit were assessed during closure. Stochastic simulation results for mean, and 90th and 99.5 percentiles are provided. The simulations consider direct rainfall and runoff, groundwater seepage in and out of the pit, and evaporation losses.

### 6.6.1 Combined Cariboo-Springer Pit

The assumed final elevation of PAG material in the combined Phase 4 Cariboo-Springer Pit is 1,004 masl, which is based on uniform deposition across the Springer and Cariboo pits. Results of the simulation indicate that the water level will rise to cover the PAG material by approximately 2023 (Figure 38). If PAG material was placed only in the Springer Pit, the final elevation would be 1,017 masl, and it would be inundated by approximately 2025.

The pit lake is projected to reach the overflow elevation of 1,050 masl between 2042 and 2044 (Figure 38). The model assumed that, for centralized treatment and discharge, overflow is directed to the Mine Drainage Creek Sump, and then to the SERDS Ditch. Alternatively, if water quality were to meet discharge requirements, the overflow could be discharged directly to Bootjack Lake. Refinements to the model will be made as the closure/post-closure LTWMP is tested and designed.

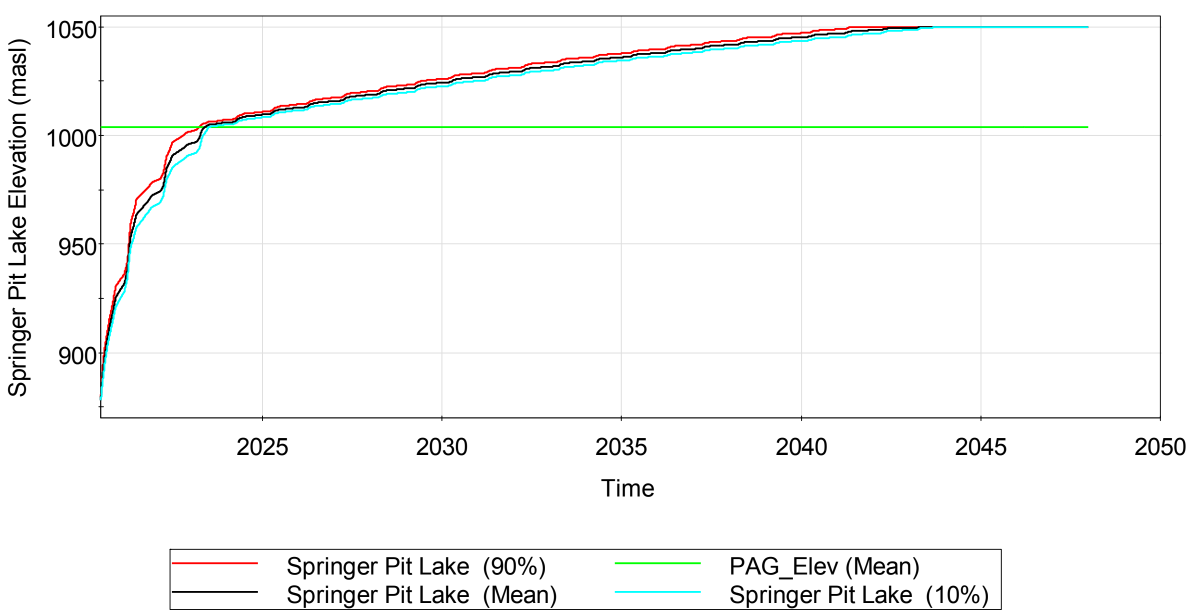


*Figure 38: Springer Pit Lake Elevation (masl).*

To assess the sensitivity of pit lake filling on future potential climate change, future precipitation and evaporation were adjusted based on the RCP 8.5 climate scenario (Section 3.1.4, Table 6). Monthly values were interpolated between Current, 2025, 2055, and 2085 values to provide monthly times series out to 2085. Average monthly precipitation accounting for climate change was input to the stochastic climate simulator of the SWWBM. Simulation of the Springer Pit filling during post-closure indicates that even for the conservative RCP 8.5 scenario, there is only a small effect on the pit lake development with projected fill times being affected by only a few months. With adjustment for climate change, the pit lake is projected to reach the overflow elevation of 1,050 masl between 2042 and 2044 (Figure 39).

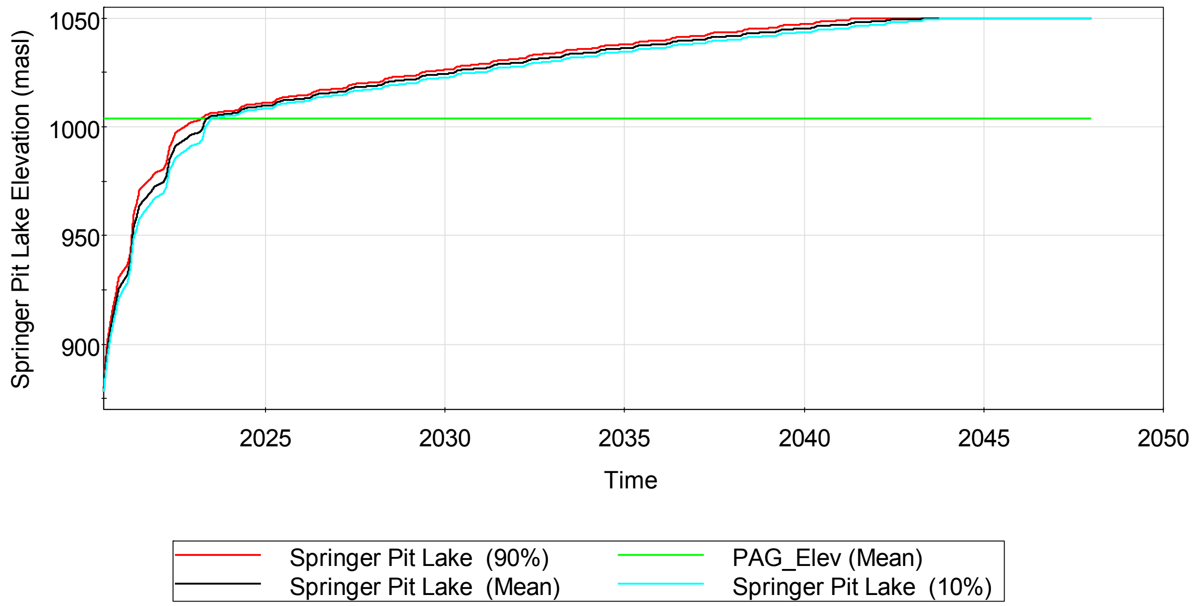


*Figure 39: Filling of Springer Pit under the RCP 8.5 Climate Change Scenario*

## 6.6.2 Boundary Pit

A seasonal pond will develop in the Boundary Pit, and the pond elevation is not expected to reach the overflow elevation of 1,073 masl (Figure 40). Seepage from the Boundary Pit is assumed to contribute to inflow to the Wight Pit.

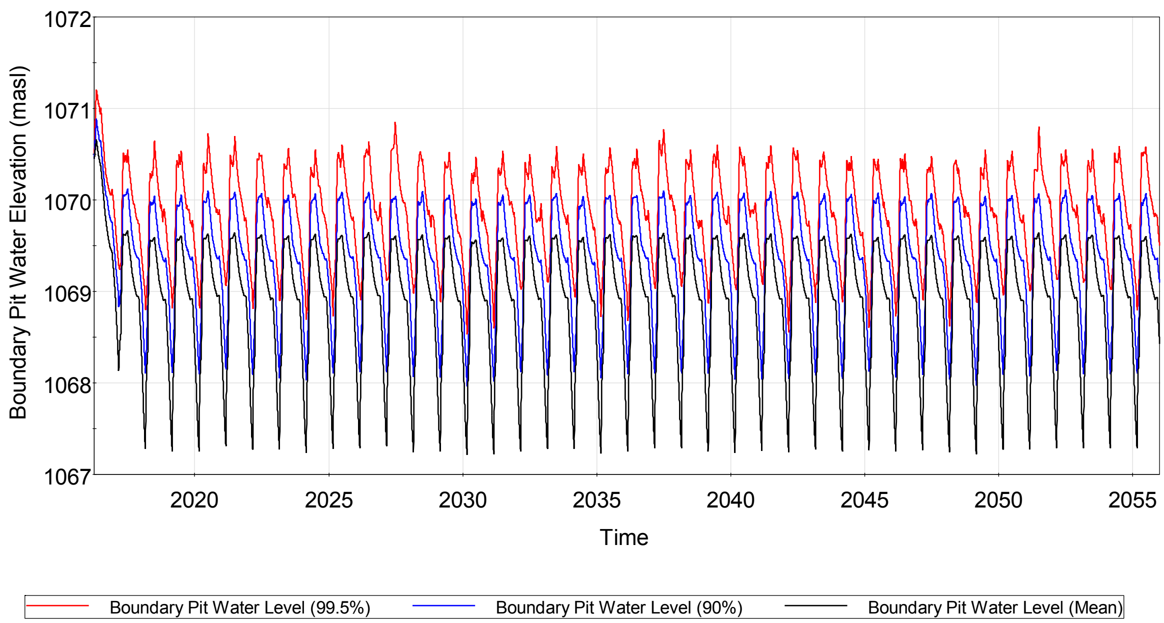


*Figure 40: Seasonal Boundary Pit Lake Elevation (masl)*

### 6.6.3 Wight Pit

The Wight Pit lake is projected to reach the overflow elevation of 926 masl before 2026 (Figure 41). For centralized treatment and discharge, the overflow is directed to the Long Ditch. Alternatively, if water quality were to meet discharge requirements, the overflow could be discharged directly to Polley Lake. Refinements to the model will be made as the closure/post-closure LTWMP is tested and designed.

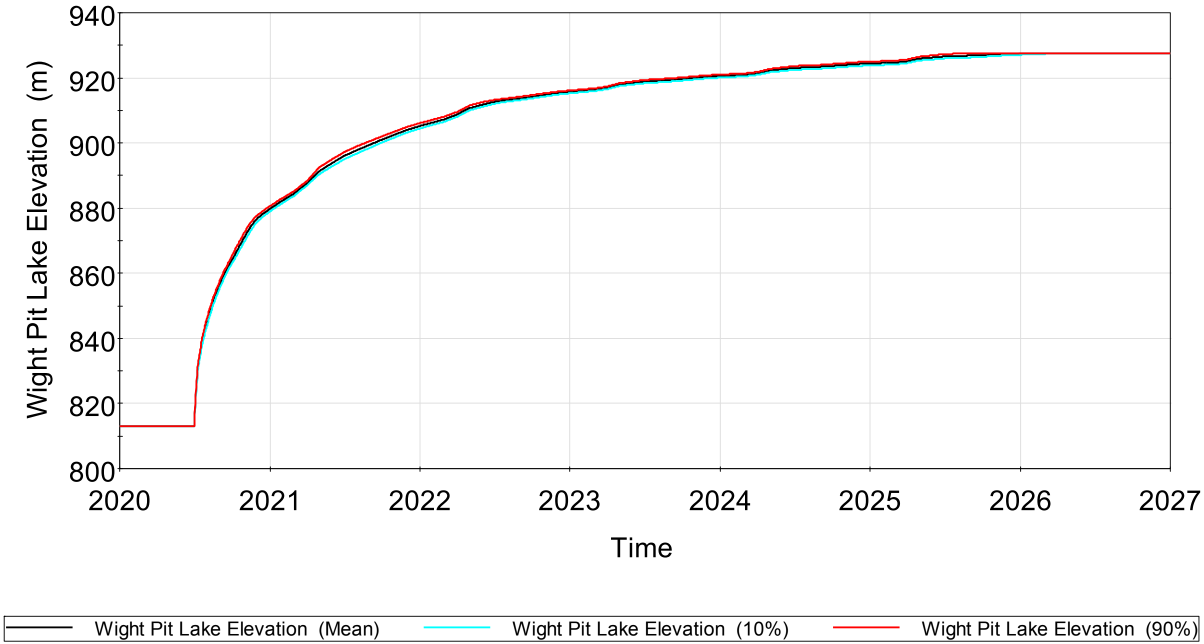


*Figure 41: Wight Pit Lake Elevation (masl)*

# 7.0 SUMMARY

A SWWBM was developed for the Mount Polley Mine using GoldSim (Version 11.1). The water balance is being used to support short- and long-term water management planning and will form the basis of effluent treatment and discharge options.

Two operational Mine management scenarios were evaluated with this water balance:

- restricted operations until June 2016 (for validation of model performance)
- full operations until July 1 2020

Additional scenarios were evaluated for the closure and post-closure phase. Closure is defined here as the first two years (3 July 2020 to June 2022) following the projected end of operations, followed by post-closure from July 2022 onwards.

The model was calibrated and validated based on past and current Mine conditions and used to generate a range of stochastic climate scenarios (0.5 percentile to 99.5 percentile) to probabilistically assess Mine water management. The main conclusions for the Base Case are as follows:

- During dewatering of the Springer Pit (2016 and 2017), the mean annual discharge is approximately 7.5 $Mm^3$.
- During full operations (2018 to 2020), the mean annual discharge is approximately 5.9 $Mm^3$.
- During closure (2021 and 2022), the mean annual discharge is approximately 3.8 $Mm^3$.
- The maximum annual discharge for 99.5 percentile extreme wet conditions is 9.9 $Mm^3$ in 2017.
- The Springer Pit is projected to be dewatered to the elevation of the deposited tailings by second quarter 2018, or as late as the fourth quarter 2018 under extreme wet (99.5 percentile) conditions.
- The mean pond volume in the TSF during full operations is expected to reach approximately 1.5 $Mm^3$ on 1 July each year.
- The maximum TSF pond elevation during full operations (99.5 percentile) is approximately 3.7 $Mm^3$.
- Because discharge from the Mine is constrained in 2017 by natural flows in Hazeltine Creek, there is some potential for carry-over volume in the TSF to 2018 under extreme wet conditions. In all other years there is no carry over.
- During full operations, the mean annual volume of makeup water drawn from Polley Lake is approximately 2.0 $Mm^3$. Under extreme dry conditions (99.5 percentile), the estimated annual makeup water volume is 2.8 $Mm^3$.
- Permanent pit lakes are projected to develop in the combined Phase 4 Cariboo-Springer Pit and the Wight Pit.

- The combined Phase 4 Cariboo-Springer Pit Lake is projected to reach the overflow elevation of 1,050 masl between 2042 and 2044. The effect of climate change was assessed using the conservative RPC 8.5 scenario, and this affected Springer Pit Lake filling to 1,050 masl in only a few months.
- The Wight Pit Lake is projected to reach the overflow elevation of 926 masl by 2026.
- A seasonal pond will develop in the Boundary Pit, which will not reach the overflow elevation of 1,073 masl.
- PAG material placed in the combined Phase 4 Cariboo-Springer Pit will have a final elevation of 1,004 masl. This will be inundated and covered by the pit lake before 2025.

In addition to the Base Case, four additional contingencies were evaluated:

1) Base Case with tailings rewetting in the TSF
2) Base Case with Care and Maintenance starting 1 July 2017
3) Base Case with no discharge from the Mine during April and May 2017
4) Base Case with no controlled discharge from the Mine after 30 March 2017

# 8.0 CLOSURE

The reader is referred to the Study Limitations, which precedes the text and forms an integral part of this report.

We trust this report satisfies your current requirements. If you have any questions or require further assistance, please do not hesitate to contact the undersigned.

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Oct 17, 2016

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Associate, Senior Water Resources Engineer

APB/JP/JV/RGM/it/kp/jc

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# ATTACHMENT A

## Model Inputs

# 1.0 FLOW INVENTORY

A description of the model flows for different mine phases are provided in Table A1 to Table A4. Direct precipitation, runoff and environmental discharge flows are numbered according to their associated elements, and are therefore not described herein.

**Table A1: Description of Flows for Restricted Operations**

| Flow Group | Component | Flow Label |
|---|---|---|
| Hydrology | Precipitation | N/A[(a)] |
| | Evaporation | N/A[(a)] |
| | Runoff | All flows labelled R[(b)] |
| Consumption | Turbomisters | C1 |
| | Water Truck Usage | C2, C5, C4 |
| | Sprinklers | C3,C7 |
| Seepage (from Tailings Storage Facility) | To South Seepage Pond | S1 |
| | To Main Embankment Seepage Pond | S2, S3 |
| | To Perimeter Embankment Till Borrow Pond (PETBP) | S4, S5 |
| | To Environment/Hazeltine Creek | S14 |
| Seepage (From other Facilities) | SERDS Dump to SERDS Ditch | S6 |
| | North Bell Dump to Wight Pit (via Joes Creek Pipe) | S7 |
| | East RDS to SERDS Ditch | S8 |
| | NEZ Dump to SERDS Ditch | S9 |
| | Temp. PAG Stockpile to 9km Sump | S10 |
| | Temp. PAG Stockpile to NW Sump | S11 |
| | to Mine Drainage Creek Sump | S12 |
| | To Bootjack Creek Sump | S13 |
| Groundwater Flows | Wight Pit Groundwater Inflow | GW1 |
| | Springer Pit Groundwater Inflow | GW2 |
| | Cariboo Pit Groundwater Inflow | GW3 |
| | Springer Pit Groundwater Outflow | GW4 |
| | Cariboo Pit Groundwater Outflow | GW6 |
| | Boundary Pit to Wight Pit | GW7 |
| Pumped Flows - Outflows from Wight Pit | Process Water | P16 |
| | Dewatering to Long Ditch | P21 |
| Pumped Flows – Inflows to Springer Pit | Tailings Slurry from the Mill | P2 |
| | Pumped flow from Central Collection Sump | P9 |
| | Pumped flow from Mill Site Sump | P14 |
| | Pumped flow from Cariboo Pit Sump | P17 |
| | Pumped flow from NW Sump | P18 |
| | Pumped flow from Mine Drainage Creek Sump | P19 |

| Flow Group | Component | Flow Label |
|---|---|---|
| Pumped Flows – Pit Dewatering | Springer Pit lake Dewatering to SERDS | P23 |
| | Springer Pit lake Dewatering to Bypass | P29 |
| Pumped Flows - Process Plant | Process Water from Central Collection Sump | P1 |
| Pumped Flows - Sumps | Geology Domestic Water Effluent to Mill Site Sump | P15 |
| | Mill Domestic Water into Mill Site Sump | P13 |
| | 9km Sump to NW Sump | P20 |
| | NW Sump to Mine Drainage Creek Sump | P24 |
| | Mine Drainage Creek Sump to SERDS Ditch | P10 |
| | PETBP to Central Collection Sump | P7 |
| | South Seepage Pond to Main Embankment Seepage Pond | P6 |
| | Main Embankment Seepage Pond to PETBP | P8 |
| | Bootjack Creek Sump to SERDS Ditch | P11 |
| Transfers | Long Ditch to Central Collection Sump | T1 |
| | SERDS ditch to Long Ditch | T2 |
| | Central Collection Sump | T3 |
| | Tailings Drainage to Central Collection Sump | T5 |
| | Treated Discharge to Environment from PETB | T6 |

a) Evaporation and direct precipitation flows not shown on process flow diagram.

b) No flows were assigned specifically for snowpack. Instead, snowpack was accumulated in the model and applied to the runoff flows as snowmelt.

N/A = not applicable; TSF = Tailings Storage Facility; PETBP = Perimeter Embankment Till Borrow Pond; CCS = Central Collection Sump; SERDS = Southeast Rock Dump.

**Table A2: Description of Flows for Future Operations**

| Flow Group | Component | Flow Label |
|---|---|---|
| Hydrology | Precipitation | N/A[(a)] |
| | Evaporation | N/A[(a)] |
| | Runoff | All flows labelled R[(b)] |
| Consumption | Turbomisters | C1, C9 |
| | Water Truck Usage | C2, C4, C5, C8 |
| | Sprinklers | C3,C7 |
| | Snowmakers | C10 |
| | Big Gun Sprinklers | C11 |
| Seepage (from Tailings Storage Facility) | To South Seepage Pond | S1 |
| | To Main Embankment Seepage Pond | S2, S3 |
| | To Perimeter Embankment Till Borrow Pond (PETBP) | S4, S5 |
| | To Environment/Hazeltine Creek | S14 |

| Flow Group | Component | Flow Label |
|---|---|---|
| Seepage (From other Facilities) | SERDS Dump to SERDS Ditch | S6 |
| | North Bell Dump to Wight Pit (via Joes Creek Pipe) | S7 |
| | East RDS to SERDS Ditch | S8 |
| | NEZ Dump to SERDS Ditch | S9 |
| | Temp. PAG Stockpile to 9km Sump | S10 |
| | Temp. PAG Stockpile to NW Sump | S11 |
| | to Mine Drainage Creek Sump | S12 |
| | To Bootjack Creek Sump | S13 |
| Groundwater Flows | Wight Pit Groundwater Inflow | GW1 |
| | Springer Pit Groundwater Inflow | GW2 |
| | Cariboo Pit Groundwater Inflow | GW3 |
| | Springer Pit Groundwater Outflow | GW4 |
| | Cariboo Pit Groundwater Outflow | GW6 |
| | Boundary Pit to Wight Pit | GW7 |
| Pumped Flows - Outflows from Wight Pit | Process Water | P16 |
| | Dewatering to Long Ditch | P21 |
| Pumped Flows – Inflows to Springer Pit | Pumped flow from Cariboo Pit Sump | P17 |
| | Pumped flow from NW Sump | P18 |
| | Emergency flow from PETBP | P5e |
| Pumped Flows – Pit Dewatering | Springer Pit lake Dewatering to SERDS | P23 |
| | Springer Pit lake Dewatering to Bypass | P29 |
| Pumped Flows – Process Plant Flows | Process flow from Tailings Storage Facility | P28 |
| | Process Return to Tailings Storage Facility | P27 |
| Pumped Flows - Sumps | PETBP to Tailings Storage Facility | P5 |
| | South Seepage Pond to Main Embankment Seepage Pond | P6 |
| | Main Embankment Seepage Pond to PETBP | P8 |
| | Mine Drainage Creek Sump to SERDS Ditch | P10 |
| | Bootjack Creek Sump to SERDS Ditch | P11 |
| | Mill Domestic Water into Mill Site Sump | P13 |
| | Geology Domestic Water Effluent to Mill Site Sump | P15 |
| | 9km Sump to NW Sump | P20 |
| | Mill Site Sump to Tailings Storage Facility | P31 |
| | Combined P27 and P31 | P32 |

| Flow Group | Component | Flow Label |
|---|---|---|
| Transfers | Long Ditch to Central Collection Sump | T1 |
| | SERDS ditch to Long Ditch | T2 |
| | Central Collection Sump | T3 |
| | Tailings Drainage to Main Embankment Seepage Pond | T5a |
| | Treated Discharge to Environment from PETB | T6 |
| Make Up Water | Tailings Storage Facility from Polley Lake | P33 |

a) Evaporation and direct precipitation flows not shown on process flow diagram.

b) No flows were assigned specifically for snowpack. Instead, snowpack was accumulated in the model and applied to the runoff flows as snowmelt.

N/A = not applicable; TSF = Tailings Storage Facility; PETBP = Perimeter Embankment Till Borrow Pond; CCS = Central Collection Sump; SERDS = Southeast Rock Dump.

**Table A3: Description of Flows for Closure**

| Flow Group | Component | Flow Label |
|---|---|---|
| Hydrology | Precipitation | N/A[(a)] |
| | Evaporation | N/A[(a)] |
| | Runoff | All flows labelled R[(b)] |
| Seepage (from Tailings Storage Facility) | South Seepage Pond Inflow | S1 |
| | Perimeter Embankment Till Borrow Pond (PETBP) | S4, S5 |
| | Main Embankment Seepage Pond | S2, S3 |
| | To Environment/Hazeltine Creek | S14 |
| Seepage (From other Facilities) | SERDS Dump to SERDS Ditch | S6 |
| | North Bell Dump to Wight Pit (via Joes Creek Pipe) | S7 |
| | East RDS to SERDS Ditch | S8 |
| | NEZ Dump to SERDS Ditch | S9 |
| | Temp. PAG Stockpile to 9km Sump | S10 |
| | Temp. PAG Stockpile to NW Sump | S11 |
| | to Mine Drainage Creek Sump | S12 |
| | To Bootjack Creek Sump | S13 |
| Groundwater Flows | Wight Pit Groundwater Inflow | GW1 |
| | Springer Pit Groundwater Inflow | GW2 |
| | Springer Pit Groundwater Outflow | GW4 |
| | Boundary Pit to Wight Pit | GW7 |
| Pumped Flows - Sumps | 9km Sump to NW Sump | P20 |
| | Bootjack Creek Sump to SERDS Ditch | P11 |
| | NW Sump to Mine Drainage Creek Sump | P24 |
| Pumped Flows - Outflows from TSF | Dewatering to CCS for Spillway Construction | P34 |

| Flow Group | Component | Flow Label |
|---|---|---|
| Overflow | South Seepage Pond to Main Embankment Seepage Pond | OF1 |
| | Main Embankment Pond to Perimeter Embankment Seepage Pond | OF2 |
| | From TSF to PETBP | OF4 |
| | Mill Site Sump to Mine Drainage Creek Sump | OF10 |
| | Mine Drainage Creek Sump to SERDS Ditch | OF12 |
| | from Springer/Cariboo Pit to Mine Drainage Creek Sump | OF14 |
| | form Wight Pit to Long Ditch | OF17 |
| Transfers | Long Ditch to Central Collection Sump | T1 |
| | SERDS Ditch to Long Ditch | T2 |
| | Central Collection Sump to PETBP | T3 |
| | Treated Discharge to Environment from PETB | T6 |

a) Evaporation and direct precipitation flows not shown on process flow diagram.

b) No flows were assigned specifically for snowpack. Instead, snowpack was accumulated in the model and applied to the runoff flows as snowmelt.

N/A = not applicable; TSF = Tailings Storage Facility; PETBP = Perimeter Embankment Till Borrow Pond; CCS = Central Collection Sump; SERDS = Southeast Rock Dump.

**Table A4: Description of Flows for Post-Closure**

| Flow Group | Component | Flow Label |
|---|---|---|
| Hydrology | Precipitation | N/A[(a)] |
| | Evaporation | N/A[(a)] |
| | Runoff | All flows labelled R[(b)] |
| Seepage (from Tailings Storage Facility) | South Seepage Pond Inflow | S1 |
| | Perimeter Embankment Till Borrow Pond (PETBP) | S4, S5 |
| | Main Embankment Seepage Pond | S2, S3 |
| | Seepage to Environment | S14 |
| Seepage (From other Facilities) | SERDS Dump to SERDS Ditch | S6 |
| | North Bell Dump to Wight Pit (via Joes Creek Pipe) | S7 |
| | East RDS to SERDS Ditch | S8 |
| | NEZ Dump to SERDS Ditch | S9 |
| | Temp. PAG Stockpile to 9km Sump | S10 |
| | Temp. PAG Stockpile to NW Sump | S11 |
| | to Mine Drainage Creek Sump | S12 |
| | To Bootjack Creek Sump | S13 |
| Groundwater Flows | Wight Pit Groundwater Inflow | GW1 |
| | Springer Pit Groundwater Inflow | GW2 |
| | Springer Pit Groundwater Outflow | GW4 |
| | Boundary Pit to Wight Pit | GW7 |

| Flow Group | Component | Flow Label |
|---|---|---|
| Overflow | South Seepage Pond to Main Embankment Seepage Pond | OF1 |
| | Main Embankment Pond to Perimeter Embankment Seepage Pond | OF2 |
| | From TSF to PETBP | OF4 |
| | Overflow to Environment/Hazeltine Creek from PETBP | OF5 |
| | Mill Site Sump to Mine Drainage Creek Sump | OF10 |
| | Mine Drainage Creek Sump to SERDS Ditch | OF12 |
| | from Springer/Cariboo Pit to Mine Drainage Creek Sump | OF14 |
| | NW Sump to Mine Drainage Creek Sump | OF15 / P24 |
| | NW Sump to Mine Drainage Creek Sump | OF16 / P20 |
| | form Wight Pit to Long Ditch | OF17 |
| Transfers | Long Ditch to Central Collection Sump | T1 |
| | SERDS Ditch to Long Ditch | T2 |
| | Central Collection Sump to PETBP | T3 |

a) Evaporation and direct precipitation flows not shown on process flow diagram.

b) No flows were assigned specifically for snowpack. Instead, snowpack was accumulated in the model and applied to the runoff flows as snowmelt.

N/A = not applicable; TSF = Tailings Storage Facility; PETBP = Perimeter Embankment Till Borrow Pond; CCS = Central Collection Sump; SERDS = Southeast Rock Dump.

## 2.0 STOCHASTIC CLIMATE INPUTS

Monthly precipitation values were log-transformed, and the distribution of the values fit to a normal distribution. The arguments for the normal distribution are the mean and standard deviation. The monthly means and standard deviations of the log-transformed monthly precipitation values were therefore determined. The standard deviations were adjusted based on trial and error so that the annual mean of the stochastically generated results agreed with the mean of the historical data. Table A5 shows the input arguments (mean and standard deviations) used to define the normal distribution stochastic element in GoldSim.

**Table A5: Stochastic Generator Normal Distribution Input Arguments**

| Month | Mean of the Log Transformed Monthly Precipitation Depths [(a)] | Adjusted Standard Deviation of the Log Transformed Monthly Precipitation Depths [(a)] |
|---|---|---|
| January | 1.60 | 0.23 |
| February | 1.48 | 0.21 |
| March | 1.54 | 0.22 |
| April | 1.61 | 0.23 |
| May | 1.70 | 0.24 |
| June | 1.87 | 0.27 |
| July | 1.65 | 0.24 |
| August | 1.63 | 0.23 |
| September | 1.72 | 0.25 |
| October | 1.72 | 0.25 |
| November | 1.67 | 0.24 |
| December | 1.84 | 0.26 |

a) Unitless.

## 3.0 CATCHMENT AREAS – MINE WATER MANAGEMENT FACILITIES

Table A6 shows the catchment areas based on land type for the mine water management facilities.

**Table A6: Catchment Areas Based on Land Type for Mine Water Management Facilities**

| Element | Rock Dump Storage Areas ($m^2$) | Disturbed Areas ($m^2$) | Pit Walls | Haul and Access Roads ($m^2$) | Undisturbed Areas ($m^2$) | Mill Site Areas | Maximum Pond Area ($m^2$) |
|---|---|---|---|---|---|---|---|
| South Seepage Pond | 0 | 0 | 0 | 0 | 0 | 0 | 385 |
| Main Embankment Seepage Pond + ABR | 214,910 | 124,490 | 0 | 0 | 0 | 0 | 37,550 |
| TSF Upstream Catchment | 0 | 63,800 | 0 | 238,430 | 320,560 | 0 | 0 |
| Perimeter Embankment Till Borrow Pit | 100,540 | 193,080 | 0 | 96,350 | 65,060 | 0 | 69,310 |
| Central Collection Sump | 0 | 122,210 | 0 | 67,920 | 248,419 | 0 | 21,830 |
| Bootjack Creek Sump | 0 | 70,050 | 0 | 103,990 | 0 | 0 | 1,130 |
| SERDS (includes Mill Site Area) | 401,240 | 313,060 | 0 | 165,456 | 383,920 | 273,920 | 0 |
| Mill Site Sump | 0 | 0 | 0 | 0 | 0 | 0 | 1,630 |
| Cariboo Pit Sump | 922,700 | 0 | 268,208 | 0 | 0 | 129,440 | 0 |
| Mine Drainage Creek Sump | 437,190 | 114,980 | 137,340 | 111,140 | 0 | 314,170 | 1,130 |
| Long Ditch | 892,508 | 1,137,433 | 0 | 261,430 | 202,650 | 0 | 0 |
| Springer Pit | 0 | 156,100 | 495,789 | 0 | 0 | 0 | 0 |
| NW Sump | 205,920 | 60,210 | 0 | 63800 | 0 | 0 | 240 |
| Nine KM Sump | 497,430 | 60,740 | 0 | 0 | 140,280 | 0 | 400 |
| Wight Pit | 162022 | 0 | 251,888 | 0 | 0 | 0 | 0 |
| Boundary Pit | 3511 | 0 | 9616 | 0 | 10286 | 0 | 0 |
| **Total Area ($m^2$)** | 4,730,479 | 3,553,587 | 1,162,841 | 1,369,946 | 1,573,825 | 717,530 | 133,605 |

At closure, the land types are reclaimed according to the schedule below:

- Haul Roads: Converted to Disturbed Land type, with 14% being converted in the 3rd year of closure and 22% converted in the 4th. The rest of the Haul Roads remain in place for site access.
- Waste Dumps: Converted to Disturbed Land type over the first 4 years of closure with 22% converted in year 1, 37% in year 2, 61% in year 3, and 100% in year4.
- Disturbed Land: Converted to Undisturbed Land type in years 5 to 20 after closure, with 25% in year 5, 50% in year 10, 75% in year 15 and 100% in year 20.

# 4.0 FLOW RATES

## 4.1 Pumped Flows

Maximum pumping rates are shown in Table A7, with the exception of flows P10, P13, P15, P16, P21 and P23. Pump specifications were available for several pumps on site; however, no information was available regarding the energy losses of the pumping systems. Therefore maximum pumping capacities were assumed based on Golder's engineering judgement. The assumed pumping rates would not materially affect the results of Springer Pit water level, or the predicted dates of reaching critical elevations under any scenario. Flows P1, P2, P27 and P28 are defined based on the process flow requirements from the Mill and as such are discussed later in this section.

**Table A7: Assumed Maximum Pumping Rates for Operational Flows**

| Flow ID | From | To | Assumed Flow Rate ($m^3/s$) |
|---|---|---|---|
| P5 | Perimeter Embankment Till Borrow Pit | TSF | 0.20 |
| P5e | Perimeter Embankment Till Borrow Pit | Springer Pit/TSF | 1.00 |
| P6 | South Seepage Pond | Main Embankment Seepage Pond | 0.10 |
| P7 | Perimeter Embankment Till Borrow Pit | Central Collection Sump | 0.20 |
| P8 | Main Embankment Seepage Pond | Perimeter Embankment Till Borrow Pond | 0.10 |
| P9 | Central Collection Sump | Springer Pit | 0.52 |
| P10 | Mine Creek Drainage Sump | SERDS Ditch | N/A [(a)] |
| P11 | Bootjack Creek Sump | SERDS Ditch | 0.10 |
| P13 | Mill Domestic Water | Mill Site Sump | N/A [(b)] |
| P14 | Mill Site Sump | Springer Pit | 0.10 |
| P15 | Geology/ Domestic Water | Mill Site Sump | N/A [(b)] |
| P16 | Wight Pit | Mill Process Water Tank | N/A [(c)] |
| P17 | Cariboo Pit | Springer Pit | 0.16 |
| P18 | NW Sump | Springer Pit | 0.11 |
| P19 | Mine Drainage Creek Sump | Springer Pit | 0.05 |
| P20 | 9 km Sump | NW Sump | 0.16 |
| P21 | Wight Pit | Long Ditch | N/A[(d)] |
| P23 | Springer Pit | Perimeter Embankment Till Borrow Pond | N/A [(d)] |
| P24 | NW Sump | Mine Drainage Creek Sump | 0.10 |
| P29 | Springer Pit | Environment via Bypass | 0.12 |
| P31 | Mill Site Sump | TSF | 0.10 |
| P33 | Polley Lake | TSF | 0.20 |

a) No maximum pump rate applied. This pumping demand is dynamic, and dependent on the required pumping rate to dewater the Mine Drainage Creek Sump.

b) Pump rate defined by measured domestic flow rates.

c) Measured pump rates.

d) Pump demand based on process flow demands and target volume; no maximum pump rate was needed in the model.

e) Discussed in Section 4.4 of the report.

N/A = Not applicable

Flows P1, P2, P27 and P28 are defined as follows:

- P1 and P28 are defined as the process water demand subtract P16 (flows from Wight Pit)
- P2 and P27 are defined as process water (including interstitial water) in addition to tailings solids

Domestic flows from the Geology station and Mill Site have been estimated by MPMC staff, and are shown in Table A8.

**Table A8: Domestic Flows into Mill Site Sump**

| Flow ID | Description | Flow Rate ($m^3/s$) |
|---|---|---|
| P13 | Domestic Water from Mill Site | 0.00003 |
| P15 | Domestic Water from Geology station | 0.0063 |

Note: Flow units shown here as defined in the GoldSim model

## 4.2 Tailings Storage Facility Seepage Flows

MPMC staff has measured post breach seepage flows from the TSF, and these are presented in Table A9.

**Table A9: Measured Seepage Flows from TSF Post-breach.**

| Flow ID | Description | Flow Rate ($m^3/s$) |
|---|---|---|
| S1 | From TSF to South Seepage Pond | 0.00095 |
| S2 | From TSF to Main Embankment Seepage Pond via South Toe Drain | 0.006 |
| S3 | From TSF to Main Embankment Seepage Pond via Main Toe/ Foundation Drain | 0.0061 |
| S4 | From TSF to Perimeter Embankment Till Borrow Pit via Perimeter Drain | 0 |
| S5 | From TSF to Perimeter Embankment Till Borrow Pit via Toe Drains | 0.080 |

**Table A10: Modeled Seepage flows from the TSF for Closure.**

| Closure Year | To South Seepage Pond | To Main Embankment Seepage Pond via South Toe Drain | To PETBP via Perimeter Drain | To Hazeltine Creek/Environment |
|---|---|---|---|---|
| | S1 ($m^3/s$) | S2 ($m^3/s$) | S4 ($m^3/s$) | S14 ($m^3/s$) |
| 1 | 0.0127 | 0.0081 | 0.0194 | 0.0033 |
| 2 | 0.0054 | 0.0058 | 0.0099 | 0.0032 |
| 3 | 0.0043 | 0.0052 | 0.0082 | 0.0030 |
| 4 | 0.0037 | 0.0048 | 0.0073 | 0.0029 |
| 5 | 0.0034 | 0.0045 | 0.0068 | 0.0028 |
| 6 | 0.0032 | 0.0043 | 0.0065 | 0.0027 |
| 7 | 0.0030 | 0.0040 | 0.0063 | 0.0026 |
| 8 | 0.0029 | 0.0039 | 0.0061 | 0.0026 |
| 9 | 0.0028 | 0.0037 | 0.0060 | 0.0025 |
| 10 | 0.0027 | 0.0036 | 0.0059 | 0.0024 |
| 11 | 0.0026 | 0.0034 | 0.0058 | 0.0024 |
| 12 | 0.0025 | 0.0033 | 0.0057 | 0.0024 |
| 13 | 0.0025 | 0.0032 | 0.0057 | 0.0023 |
| 14 | 0.0024 | 0.0031 | 0.0056 | 0.0023 |
| 15 | 0.0023 | 0.0030 | 0.0056 | 0.0022 |
| 16 | 0.0023 | 0.0029 | 0.0055 | 0.0022 |
| 17 | 0.0023 | 0.0028 | 0.0055 | 0.0022 |
| 18 | 0.0022 | 0.0028 | 0.0055 | 0.0022 |
| 19 | 0.0022 | 0.0027 | 0.0055 | 0.0021 |
| 20 | 0.0022 | 0.0026 | 0.0054 | 0.0021 |
| 21 | 0.0022 | 0.0026 | 0.0054 | 0.0021 |
| 22 | 0.0021 | 0.0026 | 0.0054 | 0.0020 |
| 23 | 0.0021 | 0.0025 | 0.0054 | 0.0020 |
| 24 | 0.0021 | 0.0025 | 0.0054 | 0.0020 |
| 25 | 0.0021 | 0.0024 | 0.0054 | 0.0020 |
| 26 | 0.0021 | 0.0024 | 0.0053 | 0.0020 |
| 27 | 0.0021 | 0.0024 | 0.0053 | 0.0020 |
| 28 | 0.0020 | 0.0024 | 0.0053 | 0.0020 |
| 29 | 0.0020 | 0.0023 | 0.0053 | 0.0020 |
| 30 | 0.0020 | 0.0023 | 0.0053 | 0.0019 |
| 31 | 0.0020 | 0.0023 | 0.0053 | 0.0019 |
| 32 | 0.0020 | 0.0023 | 0.0053 | 0.0019 |
| 33 | 0.0020 | 0.0023 | 0.0053 | 0.0019 |
| 34 | 0.0020 | 0.0022 | 0.0053 | 0.0019 |
| 35 | 0.0020 | 0.0022 | 0.0053 | 0.0019 |
| 36 | 0.0020 | 0.0022 | 0.0053 | 0.0019 |
| 37 | 0.0020 | 0.0022 | 0.0053 | 0.0019 |
| 38 | 0.0020 | 0.0022 | 0.0053 | 0.0019 |
| 39 | 0.0020 | 0.0022 | 0.0053 | 0.0019 |
| 40 | 0.0020 | 0.0022 | 0.0053 | 0.0018 |
| 41 | 0.0020 | 0.0022 | 0.0052 | 0.0018 |
| 42 | 0.0020 | 0.0021 | 0.0052 | 0.0018 |
| 43 | 0.0019 | 0.0021 | 0.0052 | 0.0018 |
| 44 | 0.0019 | 0.0021 | 0.0052 | 0.0018 |
| 45 | 0.0019 | 0.0021 | 0.0052 | 0.0018 |
| 46 | 0.0019 | 0.0021 | 0.0052 | 0.0018 |
| 47 | 0.0019 | 0.0021 | 0.0052 | 0.0018 |
| 48 | 0.0019 | 0.0021 | 0.0052 | 0.0018 |
| 49 | 0.0019 | 0.0021 | 0.0052 | 0.0018 |
| +50 | 0.0019 | 0.0021 | 0.0052 | 0.0018 |

## 4.3 Consumption Flows

The flow parameters for the turbomisters are shown in Table A11 and Table A12. Moving the turbomisters from their current locations would not materially change the model results.

**Table A11: Operational Days per Month for Turbomisters**

| Flow ID | From | Hours per Day | | | | | |
|---|---|---|---|---|---|---|---|
| | | May | June | July | August | September | October |
| C1 | Main Embankment Seepage Collection Pond | 10 | 10 | 15 | 15 | 12 | 10 |

**Table A12: Operational Flow Rates for Turbomisters**

| Flow ID | From | Evaporation Rates ($m^3$/hr) | |
|---|---|---|---|
| | | May, June and October | July to September |
| C1 | Main Embankment Seepage Collection Pond | 5.5 | 12.7 |

The flow parameters for the Sprinklers are shown in Table A13 and Table A14.

**Table A13: Operational Hours per Month for Sprinklers**

| Flow ID | From | Hours per Month | | | | | |
|---|---|---|---|---|---|---|---|
| | | May | June | July | August | September | October |
| C3 [(a)] | Wight Pit | 40 | 40 | 120 | 120 | 120 | 40 |
| C7 [(b)] | Main Embankment Seepage Collection Pond | 40 | 40 | 120 | 120 | 120 | 40 |

a) Combined hours per month for East RDS and NEZ Dumps.

b) Sprinkler Demand unknown at this time, and the consumption hours for C3 were applied to C7.

**Table A14: Operational Flow Rates for Sprinklers**

| Flow ID | From | Evaporation Rates ($m^3$/hr) | |
|---|---|---|---|
| | | May, June and October | July to September |
| C3 [(a)] | Wight Pit | 11.4 | 22.7 |
| C7 [(b)] | Main Embankment Seepage Collection Pond | 11.4 | 22.7 |

The flow parameters for water trucks are shown in Table A15 and Table A16 below.

**Table A15: Operational Days per Month for Water Trucks**

| Flow ID | From | Days per Month | | | | | |
|---|---|---|---|---|---|---|---|
| | | May | June | July | August | September | October |
| C2 | Springer Pit | N/A | N/A | N/A | N/A | N/A | N/A |
| C4 | Wight Pit | 10 | 5 | 20 | 20 | 15 | 10 |
| C5 | Main Embankment Seepage Collection Pond | 10 | 5 | 20 | 20 | 15 | 10 |

Note: C2 currently not operational in SWWBM.

**Table A16: Operational Flow Rates for Water Trucks**

| Flow ID | From | To | Flow Rates ($m^3$/day) |
|---|---|---|---|
| C2 | Springer Pit | Water Trucks | N/A |
| C4 | Wight Pit | Water Trucks | 540 |
| C5 | Main Embankment Seepage Collection Pond | Water Trucks | 270 |

## 4.4 Transfer Flows

The flow rates for the transfer flows were defined in the model as described in Table A17.

**Table A17: Definitions of Transfer Flows in SWWBM**

| Flow ID | From | To | Flow Definition |
|---|---|---|---|
| T1 | Long Ditch | Central Collection Sump | Flow rates determined by runoff and baseflow from the Long Ditch catchment |
| T2 | SERDS Ditch | Central Collection Sump | Flow rates determined by runoff and baseflow from the SERDS ditch catchment |
| T3 | Central Collection Sump | Perimeter Embankment Till Borrow Pond | Modelled as the overflow rate from the CCS |
| T5 | TSF | Central Collection Sump | Tailings Sump Transfer to CCS (during Restricted operations) |
| T5a | TSF | Main Embankment Seepage Pond | Tailings Sump Transfer to Main Embankment Seepage Pond |
| T6 | Perimeter Embankment Till Borrow Pond | Treatment Plant | Transfer for Treatment and Discharge |

# 5.0 STORAGE CHARACTERIZATION

Measured stage-storage curves were available for the following storage elements:

- Tailings Storage Facility
- Perimeter Embankment Till Borrow Pit
- Cariboo Pit
- Springer Pit
- Wight Pit
- Boundary Pit

Table A18 to Table A25 shows the state-storage curves for the facilities mentioned above. Two stage-storage curves are presented for the TSF, one for start of future operations, and the other for the start of closure. A stage-storage curve for the combined Springer and Cariboo Pit is also presented.

**Table A18: Stage-Storage Curve TSF Start of Future Operations (1 July 2016)**

| Elevation (masl) | Storage ($m^3$) |
|---|---|
| 947.0 | 185,300 |
| 947.5 | 301,100 |
| 948.0 | 464,600 |
| 948.5 | 649,400 |
| 949.0 | 856,100 |
| 949.5 | 1,083,900 |
| 950.0 | 1,329,900 |

**Table A19: Stage-Storage Curve TSF Start of Closure (1 July 2020)**

| Elevation (masl) | Storage ($m^3$) |
|---|---|
| 963.0 | 0 |
| 964.0 | 7,300 |
| 965.0 | 93,200 |
| 966.0 | 374,700 |
| 967.0 | 953,200 |
| 968.0 | 1,917,500 |
| 969.0 | 3,349,200 |
| 970.0 | 5,118,500 |

**Table A20: Stage-Storage Curve Perimeter Embankment Till Borrow Pond (PETBP)**

| Elevation (masl) | Storage ($m^3$) |
|---|---|
| 917 | 0 |
| 918 | 2,714 |
| 919 | 20,341 |
| 920 | 40,371 |
| 921 | 62,011 |
| 922 | 85,409 |
| 923 | 112,779 |
| 924 | 148,489 |
| 925 | 190,344 |

**Table A21: Stage-Storage Curve Cariboo Pit (Restricted Operations)**

| Elevation (masl) | Storage ($m^3$) |
|---|---|
| 1040 | 15,300 |
| 1045 | 39,100 |
| 1050 | 69,400 |
| 1055 | 124,500 |
| 1060 | 190,400 |
| 1065 | 283,600 |
| 1070 | 387,400 |
| 1075 | 529,700 |
| 1080 | 688,400 |
| 1085 | 883,500 |
| 1090 | 1,078,600 |
| 1094 | 1,234,600 |

**Table A22: Stage-Storage Curve Springer Pit (Restricted Operations)**

| Elevation (masl) | Storage ($m^3$) |
|---|---|
| 939 | 0 |
| 940 | 47,600 |
| 952 | 467,300 |
| 964 | 1,079,000 |
| 976 | 1,884,900 |
| 988 | 2,941,200 |
| 1000 | 4,253,600 |
| 1012 | 6,216,300 |
| 1024 | 8,554,400 |
| 1036 | 11,178,200 |
| 1048 | 14,243,900 |
| 1050 | 14,806,100 |

**Table A23: Stage-Storage Curve Combined Springer and Cariboo Pits (End of Operations)**

| Elevation (masl) | Storage ($m^3$) |
|---|---|
| 878 | 0 |
| 879 | 10,800 |
| 880 | 21,800 |
| 885 | 79,300 |
| 890 | 141,300 |
| 895 | 225,300 |
| 900 | 321,200 |
| 905 | 441,200 |
| 910 | 587,400 |
| 915 | 755,500 |
| 920 | 954,100 |
| 925 | 1,168,400 |
| 930 | 1,424,900 |
| 935 | 1,709,300 |
| 940 | 2,044,500 |
| 945 | 2,451,700 |
| 950 | 2,888,200 |
| 955 | 3,415,300 |
| 960 | 3,988,200 |
| 965 | 4,627,400 |
| 970 | 5,334,600 |
| 975 | 6,083,400 |
| 980 | 6,930,000 |
| 985 | 7,830,400 |
| 990 | 8,871,400 |
| 995 | 10,007,600 |
| 1,000 | 11,255,500 |
| 1,005 | 12,665,100 |
| 1,010 | 14,138,200 |
| 1,015 | 15,796,300 |
| 1,020 | 17,531,000 |
| 1,025 | 19,359,900 |
| 1,030 | 21,292,500 |
| 1,035 | 23,321,800 |
| 1,040 | 25,596,500 |
| 1,045 | 27,934,800 |
| 1,050 | 30,387,800 |

**Table A24: Stage-Storage Curve Wight Pit**

| Elevation (masl) | Storage ($m^3$) |
|---|---|
| 805 | 0 |
| 810 | 2,700 |
| 820 | 12,000 |
| 830 | 29,000 |
| 840 | 70,100 |
| 850 | 139,600 |
| 860 | 241,100 |
| 870 | 382,500 |
| 880 | 595,800 |
| 890 | 965,000 |
| 900 | 1,466,200 |
| 910 | 2,124,400 |
| 920 | 3,292,000 |
| 930 | 4,484,100 |

**Table A25: Stage-Storage Curve Boundary Pit**

| Elevation (masl) | Storage ($m^3$) |
|---|---|
| 1067 | 0 |
| 1068 | 200 |
| 1069 | 1,000 |
| 1070 | 3,400 |
| 1071 | 7,400 |
| 1072 | 14,500 |

Maximum pond areas for the remaining mine storage facilities were determined based on ortho-imagery and LiDAR data (MPMC 2014). Stage storage curves were then estimated based on assumed depths for each facility. A side-slope of 2H:1V was also assumed for each facility. The assumptions and derived storage capacities of these ponds are summarized in Table A26.

**Table A26: Estimated Storage Characteristics**

| Storage Element | Maximum Pond Area ($m^2$) | Assumed Depth (m) | Estimated Area at Bottom of Pond | Estimated Capacity ($m^3$) | Initial Pond Volume ($m^3$) |
|---|---|---|---|---|---|
| South Seepage Pond | 385 | 1 | 244 | 314 | 0 |
| Main Embankment Seepage Pond | 37,546 | 2.5 | 33,771 | 89,146 | 0 |
| Central Collection Sump | 21,823 | 2.5 | 18,968 | 50,989 | 0 |
| Bootjack Creek Sump | 1,130 | 1.5 | 763 | 1,419 | 0 |
| Mill Site Sump | 1,628 | 1.5 | 1,180 | 2,106 | 0 |
| Mine Drainage Creek Sump | 1,125 | 1.5 | 759 | 1,413 | 0 |
| NW Sump | 231 | 1 | 174 | 203 | 0 |
| Nine KM Sump | 400 | 1 | 256 | 328 | 0 |

# 6.0 POTENTIAL RECEIVING ENVIRONMENTS

Table A27 shows the catchment areas for the potential receiving environments.

**Table A27: Catchment Areas Based on Landtype for Potential Receiving Environment Waterbodies**

| Element | Total Watershed Area ($m^2$) | Disturbed ($m^2$) | Undisturbed Area ($m^2$) | Maximum Lake Area ($m^2$) |
|---|---|---|---|---|
| Bootjack Lake | 10,269,400 | 0 | 7,571,400 | 2,698,000 |
| Polley Lake (excluding Bootjack Creek Diversion) | 18,536,500 | 0 | 14,767,500 | 3,769,000 |
| Hazeltine Creek (excluding Polley Lake) | 10,691,000 | 735,510 | 9,955,510 | N/A |
| Bootjack Creek Diversion [(a)] | 1,708,000 | 214,500 | 1,493,500 | N/A |
| Edney Creek (at the mouth) | 87,400,000 | 0 | 87,400,000 | N/A |
| **Total Area ($m^2$)** | 128,604,900 | 950,010 | 121,187,910 | 6,467,016 |

Note: Rock Disposal Sites, Haul and Access Roads, Pit Walls and Mill Site areas not shown, as none of the receiving environments drain these land types.

a) Not a receiving environment waterbody, but included in the GoldSim model as part of the area contributing to Polley Lake.

N/A = not applicable.

## 6.1 Bootjack Lake

A hydrodynamic model of Bootjack Lake has been built to address the impact of the mine discharge on Bootjack Lake. The only discharge from the Mine site to Bootjack Lake is a groundwater seepage from Springer Pit (GW4). The only other impact on Bootjack Lake from the mine site is that the natural catchment of Bootjack Lake is reduced due to the Mine Site interception ditches that run along the slopes to the East of Bootjack Lake.

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# ATTACHMENT B
## Climate Data

| | | January | | | |
|---|---|---|---|---|---|
| **Source** | **Year** | **Total Rain (mm)** | **Total Snow (cm)** | **Total Precipitation (mm)** | **Snow Ground Last Day (cm)** |
| Likely | 1974 | | | | |
| | 1975 | 0 | 67.1 | 67.1 | |
| | 1976 | 18.5 | 78.2 | 96.8 | 0 |
| | 1977 | 14.5 | 19.3 | 33.8 | |
| | 1978 | 2.4 | 37.5 | 39.9 | 47 |
| | 1979 | 0 | 43.2 | 43.2 | 55 |
| | 1980 | 7.4 | 15 | 22.4 | 29 |
| | 1981 | 12.7 | 4.4 | 17.1 | 21 |
| | 1982 | 0 | 192.2 | 192.2 | 93 |
| | 1983 | 25.4 | 29.5 | 54.9 | 6 |
| | 1984 | 30.6 | 43.5 | 74.1 | 42 |
| | 1985 | 27 | 20.6 | 47.6 | 60 |
| | 1986 | | | | 20 |
| | 1987 | 5 | 29.8 | 34.8 | |
| | 1988 | 4.5 | 25.4 | 29.9 | 22 |
| | 1989 | 10 | 76.3 | 86.3 | 51 |
| | 1990 | 3.9 | 90.2 | 94.1 | 58 |
| | 1991 | 6.7 | 30.8 | 37.5 | |
| | 1992 | 34.5 | 55.5 | 90 | 16 |
| | 1993 | 0 | 34.8 | 34.8 | 57 |
| MPMC | 1995 | | | | |
| | 1996 | | | | |
| | 1997 | | | | |
| | 1998 | | 28.9 | 28.9 | 78.5 |
| | 1999 | | 59.4 | 59.4 | 148.2 |
| | 2000 | | 16 | 16 | 147 |
| | 2001 | | 0 | 0 | 120 |
| | 2002 | | 31 | 31 | 196 |
| | 2003 | | 10 | 10 | |
| | 2004 | | | 0 | |
| | 2005 | | 11 | 11 | 107 |
| | 2006 | 0 | 47 | 47 | 147 |
| | 2007 | 0 | | 0 | |
| | 2008 | 0 | 71 | 71 | 206 |
| | 2009 | 0 | 0 | 0 | 103 |
| | 2010 | 0.8 | 0 | 0.8 | 99 |
| | 2011 | 0 | 103 | 103 | 160 |
| | 2012 | 0 | 0 | 0 | 76 |
| | 2013 | 0 | 27 | 27 | 139 |
| | 2014 | 0 | 195 | 195 | 339 |
| | 2015 | 0 | 113 | 113 | 145 |
| | 2016 | 31.5 | 67 | 98.5 | 167 |

| February | | | |
|---|---|---|---|
| Total Rain (mm) | Total Snow (cm) | Total Precipitation (mm) | Snow Ground Last Day (cm) |
| | | | |
| 1 | 45.7 | 46.7 | |
| 0 | 91.4 | 91.4 | |
| 11 | 21.6 | 32.6 | |
| 1.2 | 11.5 | 12.7 | 26 |
| 2 | 60.2 | 62.2 | |
| 18.8 | 12 | 30.8 | 19 |
| 18.9 | 16 | 34.9 | 10 |
| 3.8 | 58.7 | 62.5 | 84 |
| 27 | 5 | 32 | 1 |
| 8.3 | 20 | 28.3 | 31 |
| 12.9 | 66.7 | 79.6 | 80 |
| 4.8 | 16.1 | 20.9 | 24 |
| 10.8 | 32.9 | 43.7 | 25 |
| 1.3 | 81.7 | 83 | 41 |
| 13.4 | 15.1 | 28.5 | 45 |
| 2 | 57.8 | 59.8 | 67 |
| 7.9 | 5.2 | 13.1 | 27 |
| 10.8 | 14.3 | 25.1 | |
| 0 | 3.4 | 3.4 | 52 |
| | | | |
| | | | |
| | | | |
| | 58.1 | 58.1 | 136.6 |
| | 60.4 | 60.4 | 208.6 |
| | 51 | 51 | 198 |
| | 7 | 7 | 127 |
| | 38 | 38 | 234 |
| | 38.8 | 38.8 | |
| | | 0 | |
| | 32 | 32 | 139 |
| 0 | 5 | 5 | 152 |
| 0 | | 0 | |
| 0 | 0 | 0 | 177 |
| 0 | 0 | 0 | 99 |
| 1.0 | 24 | 25.0 | 123 |
| 0 | 35 | 35 | 195 |
| 0 | 117 | 117 | 193 |
| 20.2 | 0 | 20.2 | 123 |
| 0 | 5 | 5 | 344 |
| 16.6 | 0 | 16.6 | 113 |
| 26.4 | 106 | 132.4 | 219 |

| March | | | |
|---|---|---|---|
| Total Rain (mm) | Total Snow (cm) | Total Precipitation (mm) | Snow Ground Last Day (cm) |
| | | | |
| 9.9 | 30.2 | 40.1 | |
| 9.4 | 34.8 | 44.2 | 0 |
| 0 | 53.1 | 53.1 | |
| 27.5 | 4.3 | 31.8 | 0 |
| 21.2 | 8.4 | 29.6 | |
| 4.1 | 61.4 | 65.5 | 18 |
| 18.1 | 4.2 | 22.3 | |
| 0 | 16.4 | 16.4 | 60 |
| 35 | 5.1 | 40.1 | |
| 16.4 | 5.2 | 21.6 | 0 |
| 0.2 | 15.8 | 16 | 59 |
| | | | 0 |
| 28.4 | 23.8 | 52.2 | |
| 29.3 | 18.9 | 48.2 | 17 |
| 10.7 | 17.9 | 28.6 | 29 |
| 3.8 | 14.6 | 18.4 | 34 |
| 2 | 63.4 | 65.4 | 19 |
| 8.4 | 0 | 8.4 | 0 |
| 15.5 | 20.4 | 35.9 | |
| | | | |
| | | | |
| | | | |
| | 38.7 | 38.7 | 175.3 |
| | 34.5 | 34.5 | 243.1 |
| | 0 | 0 | 190 |
| | 6 | 6 | 133 |
| | 37 | 37 | 271 |
| 0.25 | 40 | 40.25 | |
| | | 0 | |
| | 0 | 0 | 114 |
| 4.6 | 0 | 4.6 | 71 |
| 0 | | 0 | |
| 0 | 227 | 227 | 227 |
| 0 | 78 | 78 | 177 |
| 20.6 | | 20.6 | |
| 0 | 89 | 89 | 284 |
| 0 | 0 | 0 | 169 |
| 21.8 | 125 | 146.8 | 248 |
| 8.5 | 67 | 75.5 | 411 |
| 45.7 | 0 | 45.7 | 3 |
| 17.2 | 0 | 17.2 | 50 |

| April | | | |
|---|---|---|---|
| **Total Rain (mm)** | **Total Snow (cm)** | **Total Precipitation (mm)** | **Snow Ground Last Day (cm)** |
| | | | |
| 6.9 | 7.9 | 14.7 | |
| 46 | 26.4 | 72.4 | 0 |
| 21.6 | 9.8 | 31.4 | 0 |
| 26.2 | 2.3 | 28.5 | 0 |
| 29.8 | 20.5 | 50.3 | 0 |
| 24.3 | 0 | 24.3 | 0 |
| 39.4 | 22.7 | 62.1 | 0 |
| 8.6 | 14.4 | 23 | 0 |
| 16.6 | 0.2 | 16.8 | |
| 31.6 | 4.3 | 35.9 | 0 |
| 6.5 | 17.5 | 24 | 0 |
| 53.8 | 0.6 | 54.4 | 0 |
| 53.1 | 2.5 | 55.6 | 0 |
| 54.2 | 16.9 | 71.1 | |
| 13 | 9.8 | 22.8 | 0 |
| 45.7 | 2 | 47.7 | 0 |
| 22 | 3.6 | 25.6 | 0 |
| 50.5 | 2 | 52.5 | 0 |
| 80.1 | 0.2 | 80.3 | 0 |
| | | | |
| | | | |
| | | | |
| 49 | | 49 | |
| 10 | | 10 | |
| 19 | 0 | 19 | 0 |
| 35.5 | 0 | 35.5 | 0 |
| 45.1 | 0 | 45.1 | 0 |
| 106.8 | | 106.8 | |
| | | 0 | |
| | 0 | 0 | 0 |
| 29.8 | 0 | 29.8 | 0 |
| 123.0 | | 123.0 | |
| 116.21 | 0 | 116.21 | 98 |
| 21.4 | 0 | 21.4 | |
| 26.8 | 0 | 26.8 | 28 |
| 71.4 | 0 | 71.4 | 31 |
| 121 | 0 | 121 | 0 |
| 76 | 0 | 76 | 0 |
| 37.4 | 0 | 37.4 | 0 |
| 20.4 | 0 | 20.4 | 0 |
| 33.9 | 0 | 33.9 | 0 |

| May | | | |
|---|---|---|---|
| **Total Rain (mm)** | **Total Snow (cm)** | **Total Precipitation (mm)** | **Snow Ground Last Day (cm)** |
| | | | |
| 39.1 | 1 | 40.1 | 0 |
| 24.9 | 0 | 24.9 | 0 |
| 66.2 | 0 | 66.2 | 0 |
| 59.9 | 0 | 59.9 | 0 |
| 47.5 | 0 | 47.5 | 0 |
| 59.5 | 0 | 59.5 | 0 |
| 59.3 | 0 | 59.3 | 0 |
| 68.8 | 0 | 68.8 | 0 |
| 24.9 | 0 | 24.9 | 0 |
| 85.1 | 0.2 | 85.3 | 0 |
| 35.1 | 5.1 | 40.2 | 0 |
| 56.4 | 0 | 56.4 | 0 |
| 58.8 | 0 | 58.8 | 0 |
| 94.5 | 0 | 94.5 | 0 |
| 57.8 | 0 | 57.8 | 0 |
| 72.4 | 0 | 72.4 | 0 |
| 15.7 | 0 | 15.7 | 0 |
| 42.9 | 1.4 | 44.3 | 0 |
| 67.9 | 0 | 67.9 | 0 |
| | | | |
| | | | |
| 45.3 | | 45.3 | |
| 27 | | 27 | |
| 65.5 | | 65.5 | |
| 57 | | 57 | |
| 35.5 | | 35.5 | |
| 90.4 | | 90.4 | |
| 58.5 | | 58.5 | |
| | | 0 | |
| | | 0 | |
| 34.0 | | 34.0 | |
| 21.8 | | 21.8 | |
| 66 | | 66 | |
| 55.2 | | 55.2 | |
| 48.4 | | 48.4 | |
| 92.8 | | 92.8 | |
| 32.2 | | 32.2 | |
| 67 | | 67 | |
| 69.4 | | 69.4 | |
| 36.2 | | 36.2 | |
| 51 | | 51 | |

| June | | | |
|---|---|---|---|
| **Total Rain (mm)** | **Total Snow (cm)** | **Total Precipitation (mm)** | **Snow Ground Last Day (cm)** |
| | | | |
| 75.2 | 0 | 75.2 | 0 |
| 123.2 | 0 | 123.2 | 0 |
| 39.7 | 0 | 39.7 | 0 |
| 72 | 0 | 72 | 0 |
| 87.1 | 0 | 87.1 | 0 |
| 110.1 | 0 | 110.1 | 0 |
| 84.9 | 0 | 84.9 | 0 |
| 31.1 | 0 | 31.1 | 0 |
| 144.5 | 0 | 144.5 | 0 |
| 103.8 | 0 | 103.8 | 0 |
| 90.6 | 0 | 90.6 | 0 |
| 46.1 | 0 | 46.1 | 0 |
| 43.9 | 0 | 43.9 | 0 |
| 64.2 | 0 | 64.2 | 0 |
| 77.6 | 0 | 77.6 | 0 |
| 93.8 | 0 | 93.8 | 0 |
| 88.6 | 0 | 88.6 | 0 |
| 37 | 0 | 37 | 0 |
| 140.2 | 0 | 140.2 | 0 |
| | | | |
| | | | |
| 51.8 | | 51.8 | |
| 67.4 | | 67.4 | |
| 97.8 | | 97.8 | |
| 100.5 | | 100.5 | |
| 111.3 | | 111.3 | |
| 40.3 | | 40.3 | |
| 60.75 | | 60.75 | |
| | | 0 | |
| | | 0 | |
| 41.6 | | 41.6 | |
| 68.0 | | 68.0 | |
| 79.2 | | 79.2 | |
| 42.8 | | 42.8 | |
| 83.6 | | 83.6 | |
| 80.2 | | 80.2 | |
| 118.4 | | 118.4 | |
| 95.8 | | 95.8 | |
| 42.9 | | 42.9 | |
| 48.2 | | 48.2 | |
| | | | |

| July | | | |
|---|---|---|---|
| **Total Rain (mm)** | **Total Snow (cm)** | **Total Precipitation (mm)** | **Snow Ground Last Day (cm)** |
| | | | |
| 36.1 | 0 | 36.1 | 0 |
| 47.5 | 0 | 47.5 | 0 |
| 98 | 0 | 98 | 0 |
| 49.9 | 0 | 49.9 | 0 |
| 15.1 | 0 | 15.1 | 0 |
| 56.2 | 0 | 56.2 | 0 |
| 53.5 | 0 | 53.5 | 0 |
| 216.2 | 0 | 216.2 | 0 |
| 111.4 | 0 | 111.4 | 0 |
| 26.5 | 0 | 26.5 | 0 |
| 5.9 | 0 | 5.9 | 0 |
| 62.5 | 0 | 62.5 | 0 |
| 55.6 | 0 | 55.6 | 0 |
| 49.2 | 0 | 49.2 | 0 |
| 46.5 | 0 | 46.5 | 0 |
| 23.4 | 0 | 23.4 | 0 |
| 83.7 | 0 | 83.7 | 0 |
| 24.4 | 0 | 24.4 | 0 |
| 73 | 0 | 73 | 0 |
| | | | |
| | | | |
| 121.6 | | 121.6 | |
| 43.4 | | 43.4 | |
| 64.3 | | 64.3 | |
| 65.7 | | 65.7 | |
| 115.5 | | 115.5 | |
| 27.8 | | 27.8 | |
| 31.5 | | 31.5 | |
| | | 0 | |
| 65.81 | | 65.81 | |
| 55.81 | | 55.81 | |
| 27.80 | | 27.80 | |
| 56 | | 56 | |
| 38.2 | | 38.2 | |
| 20.6 | | 20.6 | |
| 104.1 | | 104.1 | |
| 40 | | 40 | |
| 3.8 | | 3.8 | |
| 82.1 | | 82.1 | |
| 63.8 | | 63.8 | |
| | | | |

| August | | | |
|---|---|---|---|
| Total Rain (mm) | Total Snow (cm) | Total Precipitation (mm) | Snow Ground Last Day (cm) |
| | | | |
| 102.1 | 0 | 102.1 | 0 |
| 129.5 | 0 | 129.5 | 0 |
| 82.8 | 0 | 82.8 | 0 |
| 74.8 | 0 | 74.8 | 0 |
| 25.7 | 0 | 25.7 | 0 |
| 107.6 | 0 | 107.6 | 0 |
| 18.7 | 0 | 18.7 | 0 |
| 83.4 | 0 | 83.4 | 0 |
| 30.1 | 0 | 30.1 | 0 |
| 77.6 | 0 | 77.6 | 0 |
| 82.4 | 0 | 82.4 | 0 |
| 20.2 | 0 | 20.2 | 0 |
| 32.8 | 0 | 32.8 | 0 |
| 63.7 | 0 | 63.7 | 0 |
| 113.7 | 0 | 113.7 | 0 |
| 44 | 0 | 44 | 0 |
| 66.6 | 0 | 66.6 | 0 |
| 58.8 | 0 | 58.8 | 0 |
| 61.3 | 0 | 61.3 | 0 |
| | | | |
| 63.25 | | 63.25 | |
| 41.6 | | 41.6 | |
| 19 | | 19 | |
| 33 | | 33 | |
| 35.5 | | 35.5 | |
| 59.8 | | 59.8 | |
| 27 | | 27 | |
| 19.5 | | 19.5 | |
| | | 0 | |
| | | 0 | |
| 19.20 | | 19.20 | |
| 16.4 | | 16.4 | |
| 60.6 | | 60.6 | |
| 15 | | 15 | |
| 47.2 | | 47.2 | |
| 63.2 | | 63.2 | |
| 7.2 | | 7.2 | |
| 39.2 | | 39.2 | |
| 32.6 | | 32.6 | |
| 20.8 | | 20.8 | |
| | | | |

| September | | | |
|---|---|---|---|
| Total Rain (mm) | Total Snow (cm) | Total Precipitation (mm) | Snow Ground Last Day (cm) |
| | | | 0 |
| 18.3 | 0 | 18.3 | 0 |
| 20.8 | 0 | 20.8 | 0 |
| 43.9 | 0 | 43.9 | 0 |
| 72.4 | 0 | 72.4 | 0 |
| 52.9 | 0 | 52.9 | 0 |
| 85.8 | 0 | 85.8 | 0 |
| 83.5 | 0 | 83.5 | 0 |
| 76 | 0 | 76 | 0 |
| 54.3 | 0 | 54.3 | 0 |
| 89.3 | 0 | 89.3 | 0 |
| 129.9 | 0 | 129.9 | 0 |
| 56.2 | 0 | 56.2 | 0 |
| 8.4 | 0 | 8.4 | 0 |
| 38.8 | 0 | 38.8 | 0 |
| 24.8 | 0 | 24.8 | 0 |
| 6 | 0 | 6 | 0 |
| 27.4 | 0 | 27.4 | 0 |
| 77.8 | 0.4 | 78.2 | 0 |
| 13.4 | 0 | 13.4 | 0 |
| | | | |
| 89.75 | | 89.75 | |
| 61.3 | | 61.3 | |
| 13.8 | | 13.8 | |
| 68 | | 68 | |
| | | 0 | |
| | | 0 | |
| 46.3 | | 46.3 | |
| 146.5 | | 146.5 | |
| | | 0 | |
| 19 | | 19 | |
| 58.4 | | 58.4 | |
| 2.6 | | 2.6 | |
| 25.2 | | 25.2 | |
| 47.4 | | 47.4 | |
| 69.2 | | 69.2 | |
| 19.4 | | 19.4 | |
| 7.7 | | 7.7 | |
| 59.1 | | 59.1 | |
| 11.1 | | 11.1 | |
| 61.6 | | 61.6 | |
| | | | |

| October | | | |
|---|---|---|---|
| **Total Rain (mm)** | **Total Snow (cm)** | **Total Precipitation (mm)** | **Snow Ground Last Day (cm)** |
| 46.5 | 1.5 | 48 | 0 |
| 131.8 | 12.7 | 144.5 | 0 |
| 30.7 | 0 | 30.7 | 0 |
| 38.2 | 0.3 | 38.5 | |
| 58.2 | 0 | 58.2 | 0 |
| 38.2 | 0.6 | 38.8 | 0 |
| 15.8 | 0 | 15.8 | 0 |
| 67.6 | 0 | 67.6 | 0 |
| 49.4 | 0.4 | 49.8 | 0 |
| | 0 | | 0 |
| 51.2 | 15.8 | 67 | |
| 107.3 | 23.7 | 131 | |
| 24.9 | 0.3 | 25.2 | 0 |
| 25.2 | 0 | 25.2 | 0 |
| 39.4 | 1.2 | 40.6 | 0 |
| 56.9 | 0 | 56.9 | 0 |
| 119.9 | 10.8 | 130.7 | 0 |
| 31.7 | 34.5 | 66.2 | 24 |
| 47 | 6.4 | 53.4 | 0 |
| 39.7 | 0 | 39.7 | |
| 86.5 | | 86.5 | |
| 52.5 | | 52.5 | |
| 81 | | 81 | |
| 94.2 | | 94.2 | |
| 63.3 | | 63.3 | |
| | | 0 | |
| | | 0 | |
| 43.5 | | 43.5 | |
| 208.5 | | 208.5 | |
| | | 0 | |
| 64.2 | | 64.2 | |
| 39.8 | | 39.8 | |
| | | 0 | |
| 28.4 | | 28.4 | |
| 58.4 | | 58.4 | |
| 23.4 | | 23.4 | |
| 35.2 | | 35.2 | |
| 55.6 | | 55.6 | |
| 39.5 | | 39.5 | |
| 71.7 | | 71.7 | |
| 61.5 | | 61.5 | |
| | | | |

| November | | | |
|---|---|---|---|
| **Total Rain (mm)** | **Total Snow (cm)** | **Total Precipitation (mm)** | **Snow Ground Last Day (cm)** |
| 37.8 | 23.1 | 61 | |
| 3 | 41.1 | 44.2 | |
| 26.4 | 6.1 | 32.5 | |
| 16.6 | 35.4 | 52 | 12 |
| 3.4 | 41.9 | 45.3 | 20 |
| 8.7 | 4.9 | 13.6 | |
| 45 | 26.2 | 71.2 | 11 |
| 51.9 | 17.1 | 69 | 12 |
| 25.1 | 14.3 | 39.4 | 3 |
| 49.3 | 12.2 | 61.5 | 8 |
| 15.9 | 65.4 | 81.3 | 21 |
| 3.7 | 14.4 | 18.1 | |
| 44.6 | 51.5 | 96.1 | 21 |
| 31.8 | 20.7 | 52.5 | |
| 46.3 | 10.3 | 56.6 | 4 |
| 75.4 | 26.8 | 102.2 | 2 |
| 19.7 | 86.7 | 106.4 | 34 |
| 37.9 | 44 | 81.9 | 15 |
| 44.8 | 33.5 | 78.3 | |
| 30.6 | 18.1 | 48.7 | |
| 44.5 | | 44.5 | |
| 34.75 | | 34.75 | |
| 35.2 | | 35.2 | |
| 62 | | 62 | |
| 67 | 0 | 67 | 0 |
| | 0 | 0 | 0 |
| 6 | 0 | 6 | 0 |
| 49.5 | 0 | 49.5 | 0 |
| 15.5 | | 15.5 | |
| | 0 | 0 | 0 |
| 35.6 | 0 | 35.6 | |
| 45.2 | 0 | 45.2 | 0 |
| 40.2 | 0 | 40.2 | 0 |
| 62 | 0 | 62 | 0 |
| 43.6 | 0 | 43.6 | 0 |
| 27.4 | 67 | 94.4 | 67 |
| 24 | 0 | 24 | 0 |
| 34 | 0 | 34 | 0 |
| 12.2 | 72 | 84.2 | 72 |
| 38.7 | 65 | 103.7 | 65 |
| 16.8 | 23 | 39.8 | 23 |
| | | | |

| December | | | |
|---|---|---|---|
| **Total Rain (mm)** | **Total Snow (cm)** | **Total Precipitation (mm)** | **Snow Ground Last Day (cm)** |
| 14.7 | 69.3 | 84.1 | |
| 8.4 | 57.9 | 66.3 | |
| 19.3 | 126.5 | 145.8 | |
| 28.2 | 72.8 | 101 | 28 |
| 0 | 52.6 | 52.6 | 41 |
| 28.3 | 58 | 86.3 | 23 |
| 44.5 | 103.3 | 147.8 | 36 |
| 0.2 | 58.7 | 58.9 | 17 |
| 18 | 11 | 29 | 4 |
| 0.3 | 49.8 | 50.1 | 33 |
| 6.8 | 122.2 | 129 | |
| 2.6 | 39.9 | 42.5 | 27 |
| 15 | 22.2 | 37.2 | 28 |
| 2.4 | 28.6 | 31 | 21 |
| 7 | 73.6 | 80.6 | |
| 11 | 51.8 | 62.8 | 27 |
| 1.6 | 128.1 | 129.7 | 80 |
| 15.4 | 53.9 | 69.3 | 20 |
| 0 | 98 | 98 | 52 |
| 14.1 | 31.4 | 45.5 | |
| | | 0 | |
| | | 0 | |
| | 49.6 | 49.6 | 49.6 |
| | 88.8 | 88.8 | 88.8 |
| | 131 | 131 | 131 |
| | 189 | 189 | 189 |
| | 88 | 88 | 88 |
| 15 | 0 | 15 | 0 |
| | | 0 | |
| | 96 | 96 | 96 |
| | 100 | 100 | |
| 0 | 125 | 125 | 125 |
| 0 | 135 | 135 | 135 |
| 0.2 | 196 | 196.2 | 196 |
| 0 | 105 | 105 | 105 |
| 0.6 | 0 | 0.6 | 57 |
| 0 | 105 | 105 | 105 |
| 5.7 | 112 | 117.7 | 112 |
| 17.4 | 72 | 89.4 | 144 |
| 0 | 0 | 0 | 32 |
| 0 | 76 | 76 | 100 |
| | | | |

| | January | | | | |
|---|---|---|---|---|---|
| **Year** | **Mean Maximum Temperature (°C)** | **Mean Min Temp (°C)** | **Mean Temperature (°C)** | **Extreme Maximum Temperature (°C)** | **Extreme Minimum Temperature (°C)** |
| 1974 | | | | | |
| 1975 | -3.2 | -13.8 | -8.5 | 5 | -34.4 |
| 1976 | -0.9 | -10.4 | -5.7 | 9.4 | -21.1 |
| 1977 | -2 | -9.1 | -5.6 | 7.8 | -17.8 |
| 1978 | -7.7 | -15.2 | -11.5 | 2 | -25.5 |
| 1979 | -10.4 | -21.1 | -15.8 | 4 | -34 |
| 1980 | -5.4 | -15.3 | -10.4 | 8.5 | -31 |
| 1981 | 2.4 | -5.3 | -1.5 | 11.5 | -13 |
| 1982 | -7.9 | -18.6 | -13.3 | 5 | -34.5 |
| 1983 | 1.5 | -5.1 | -1.8 | 7.5 | -16.5 |
| 1984 | -1.3 | -7.7 | -4.5 | 4.5 | -24 |
| 1985 | -3.1 | -9 | -6.1 | 4 | -23 |
| 1986 | 1.9 | -6.3 | -2.2 | 10.5 | -24 |
| 1987 | 1.4 | -6.1 | -2.4 | 7 | -16 |
| 1988 | -3.3 | -11.2 | -7.3 | 9 | -26.5 |
| 1989 | -1.7 | -10.9 | -6.3 | 8 | -30 |
| 1990 | -1.2 | -7.9 | -4.6 | 7 | -33 |
| 1991 | -8.2 | -17.3 | -12.7 | 5.5 | -37.5 |
| 1992 | 2.9 | -2.8 | 0 | 10.5 | -8 |
| 1993 | -8.2 | -18.5 | -13.4 | 5 | -30 |
| 1994 | | | | | |
| 1995 | | | | | |
| 1996 | | | -10.41 | 8.7 | -29.5 |
| 1997 | | | | | |
| 1998 | | | -11.64 | 14.1 | -30.6 |
| 1999 | | | | | |
| 2000 | | | -7.65 | 4.5 | -21.9 |
| 2001 | | | | | -9.7 |
| 2002 | | | -5.6 | 5.6 | -24.6 |
| 2003 | | | -3 | 8 | -18.1 |
| 2004 | | | | | |
| 2005 | | | | | |
| 2006 | | | -1.9 | 6.2 | -6.8 |
| 2007 | | | -5.3 | 3.7 | -25.2 |
| 2008 | | | -7.5 | 2.0 | -33.7 |
| 2009 | | | -7.5 | 2.9 | -25.2 |
| 2010 | | | -2.2 | 5.8 | -18.8 |
| 2011 | | | -7.3 | 3.7 | -22.6 |
| 2012 | | | -7.1 | 5.8 | -32.5 |
| 2013 | | | -4.7 | 5.8 | -17.3 |
| 2014 | | | -4.0 | 5.7 | -18.7 |
| 2015 | | | -3.6 | 5.4 | -21.7 |
| 2016 | | | -4.6 | 7.4 | -20.6 |

| February | | | | |
|---|---|---|---|---|
| **Mean Maximum Temperature (°C)** | **Mean Min Temp (°C)** | **Mean Temperature (°C)** | **Extreme Maximum Temperature (°C)** | **Extreme Minimum Temperature (°C)** |
| | | | | |
| -6.4 | -17.6 | -12 | 5.6 | -28.3 |
| 0.5 | -9.5 | -4.5 | 7.2 | -21.7 |
| 5 | -4.4 | 0.3 | 12.2 | -12.2 |
| 2.8 | -9 | -3.1 | 9 | -22.5 |
| -3 | -14.8 | -8.9 | 10 | -34.5 |
| 1.4 | -8.4 | -3.5 | 9.5 | -20 |
| 1.8 | -6.7 | -2.5 | 10.5 | -23.5 |
| -0.5 | -12.9 | -6.7 | 8.5 | -29.5 |
| 4.4 | -3.2 | 0.6 | 11.5 | -13 |
| 4 | -4.4 | -0.2 | 8.5 | -13 |
| -1.2 | -10.7 | -6 | 10 | -23.5 |
| -1.7 | -12.4 | -7.1 | 14.5 | -31 |
| 4.5 | -4.3 | 0.1 | 12 | -12 |
| 0.4 | -8.5 | -4.1 | 7 | -26.5 |
| -6.1 | -17.4 | -11.8 | 6 | -34 |
| -1.6 | -12.6 | -7.1 | 6 | -34 |
| 4.7 | -3.1 | 0.8 | 10.5 | -9.5 |
| 3.9 | -4.6 | -0.3 | 11 | -15 |
| -1.2 | -13.8 | -7.5 | 7 | -28 |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | -0.96 | 11.7 | -11.8 |
| | | | | |
| | | | | -7.3 |
| | | -3.8 | 7.1 | -19.2 |
| | | -4 | 6.3 | -17.7 |
| | | | | |
| | | | | |
| | | -5.2 | 5.4 | -16.7 |
| | | -4.0 | 4.2 | -13.5 |
| | | -3.4 | 7.4 | -20.2 |
| | | -6.1 | 3.7 | -22.6 |
| | | -1.9 | 6.2 | -6.8 |
| | | -9.6 | 3.3 | -26.1 |
| | | -3.3 | 4.5 | -16.7 |
| | | -2.0 | 3.1 | -8.8 |
| | | -10.3 | 1.6 | -28.0 |
| | | -0.7 | 6.9 | -13.2 |
| | | -0.4 | 8.5 | -8.6 |

| March | | | | |
|---|---|---|---|---|
| **Mean Maximum Temperature (°C)** | **Mean Min Temp (°C)** | **Mean Temperature (°C)** | **Extreme Maximum Temperature (°C)** | **Extreme Minimum Temperature (°C)** |
| | | | | |
| 2.1 | -9.7 | -3.8 | 6.7 | -21.7 |
| 2.4 | -8.2 | -2.9 | 13.9 | -31.1 |
| 4.9 | -4.7 | 0.1 | 9.4 | -12.8 |
| 6 | -6.2 | -0.1 | 13.5 | -20 |
| 7.5 | -6.2 | 0.7 | 16 | -14 |
| 3.2 | -7.1 | -2 | 9 | -19 |
| 8.2 | -4.7 | 1.8 | 13 | -11 |
| 4.1 | -10 | -3 | 12.5 | -21.5 |
| 7.2 | -3.6 | 1.8 | 12.5 | -11 |
| 7.5 | -3.5 | 2 | 14 | -9 |
| 5 | -6.8 | -0.9 | 11 | -14 |
| 7.8 | -2.3 | 2.8 | 13.5 | -6 |
| 8.2 | -3.1 | 2.6 | 14.5 | -12.5 |
| 5.7 | -4 | 0.9 | 10.5 | -10 |
| 4.5 | -8 | -1.8 | 10 | -26.5 |
| 5.7 | -6.5 | -0.4 | 10 | -14.5 |
| 3.4 | -10.7 | -3.7 | 12.5 | -28.5 |
| 10.9 | -3.3 | 3.8 | 16 | -8 |
| 6.1 | -6.3 | -0.1 | 11 | -21 |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | 0.13 | 19.9 | -13 |
| | | | | |
| | | 0.5 | 15.9 | -9.7 |
| | | -9.6 | 10.6 | -24.7 |
| | | -2 | 12.8 | -31.5 |
| | | | | |
| | | | | |
| | | -0.5 | 9.8 | -14.1 |
| | | 0.2 | 9.8 | -10.0 |
| | | -1.7 | 6.6 | -12.3 |
| | | -4.2 | 7.4 | -26.1 |
| | | 1.7 | 11.4 | -10.0 |
| | | -1.6 | 8.2 | -23.4 |
| | | -1.4 | 9.8 | -14.1 |
| | | -0.6 | 11.6 | -10.9 |
| | | -4.4 | 8.2 | -22.8 |
| | | 1.9 | 13.2 | -13.3 |
| | | 2.2 | 17.5 | -6.8 |

| April | | | | |
|---|---|---|---|---|
| Mean Maximum Temperature (°C) | Mean Min Temp (°C) | Mean Temperature (°C) | Extreme Maximum Temperature (°C) | Extreme Minimum Temperature (°C) |
| | | | | |
| 10.6 | -4.1 | 3.3 | 17.2 | -13.9 |
| 10.9 | -2.7 | 4.1 | 20.6 | -10.6 |
| 12.7 | -1 | 5.9 | 29.4 | -5 |
| 11.4 | -2.6 | 4.4 | 20.5 | -6 |
| 9.8 | -2.4 | 3.7 | 23 | -11 |
| 13.9 | -2.1 | 5.9 | 24 | -8 |
| 9.5 | -2.4 | 3.6 | 21 | -7 |
| 8.3 | -5.8 | 1.3 | 15.5 | -12.5 |
| 13.1 | -1.6 | 5.8 | 19.5 | -6 |
| 10.8 | -1.6 | 4.6 | 24 | -5.5 |
| 8.8 | -2.8 | 3 | 15 | -7.5 |
| 10 | -1.4 | 4.3 | 22 | -5.5 |
| 13 | -0.7 | 6.2 | 23 | -5.5 |
| 11.9 | -0.8 | 5.6 | 20.5 | -6 |
| 12.9 | -2.5 | 5.2 | 23 | -6 |
| 11.8 | -1.6 | 5.1 | 18 | -6.5 |
| 12.5 | -2.4 | 5.1 | 22 | -5.5 |
| 12.4 | -0.7 | 5.9 | 20 | -9.5 |
| 11.1 | -1.3 | 4.9 | 16.5 | -6.5 |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | 3.76 | 23.1 | -8.6 |
| | | | | |
| | | 1.1 | 19.1 | -7.3 |
| | | | | |
| | | 4.1 | 19.4 | -7.1 |
| | | | | |
| | | | | |
| | | 4.8 | 19.4 | -4.8 |
| | | 2.9 | 18.3 | -14.7 |
| | | 1.0 | 14.1 | -10.6 |
| | | 2.5 | 13.3 | -8.4 |
| | | 4.6 | 22.1 | -5.8 |
| | | 1.1 | 12.6 | -5.8 |
| | | 3.7 | 14.1 | -5.3 |
| | | 2.1 | 15.0 | -8.2 |
| | | 3.1 | 19.0 | -6.5 |
| | | 4.1 | 19.3 | -4.5 |
| | | 8.2 | 23.3 | -1.0 |

| May | | | | |
|---|---|---|---|---|
| **Mean Maximum Temperature (°C)** | **Mean Min Temp (°C)** | **Mean Temperature (°C)** | **Extreme Maximum Temperature (°C)** | **Extreme Minimum Temperature (°C)** |
| | | | | |
| 15.2 | 1.2 | 8.2 | 23.9 | -1.7 |
| 16.5 | 2.7 | 9.6 | 23.9 | -1.1 |
| 14.3 | 2 | 8.2 | 20.6 | -2.2 |
| 14.8 | -0.1 | 7.4 | 25 | -6 |
| 14.5 | 2 | 8.3 | 24 | -2.5 |
| 17.6 | 3.9 | 10.8 | 27.5 | -2 |
| 17.1 | 3.7 | 10.4 | 23 | -1.5 |
| 14.9 | -0.3 | 7.3 | 24.5 | -5 |
| 18.9 | 2.7 | 10.8 | 35 | -2 |
| 12.8 | 1.4 | 7.1 | 20 | -2.5 |
| 17.8 | 2.4 | 10.1 | 27.5 | -3.5 |
| 15.8 | 2.2 | 9 | 29.5 | -3 |
| 16.8 | 2.9 | 9.9 | 27.5 | -2.5 |
| 16.1 | 2.7 | 9.4 | 27.5 | -4 |
| 17 | 2.1 | 9.6 | 25.5 | -2 |
| 15.5 | 3.2 | 9.4 | 25.5 | -2.5 |
| 17.4 | 1.9 | 9.6 | 24.5 | -3 |
| 17.1 | 1.9 | 9.5 | 29 | -3 |
| 20.2 | 4.5 | 12.4 | 29.5 | -3 |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | 16.49 | 31.6 | 7.3 |
| | | 5.91 | 19.4 | -5.4 |
| | | 7.6 | 23.7 | -2.8 |
| | | 6.7 | 25.5 | -2.1 |
| | | | | |
| | | 7.8 | 24.8 | -4.5 |
| | | | | |
| | | | | |
| | | 9.4 | 28.3 | -3.4 |
| | | 9.4 | 24.0 | -0.2 |
| | | | 28.5 | -2.6 |
| | | 7.8 | 23.6 | -1.5 |
| | | 7.6 | 20.6 | -2.9 |
| | | 7.3 | 19.8 | -0.2 |
| | | 8.0 | 21.0 | -1.5 |
| | | 9.9 | 26.5 | -2.8 |
| | | 8.6 | 21.3 | -2.0 |
| | | 11.2 | 22.7 | -1.6 |
| | | 10.0 | 26.8 | -0.5 |

| June | | | | |
|---|---|---|---|---|
| Mean Maximum Temperature (°C) | Mean Min Temp (°C) | Mean Temperature (°C) | Extreme Maximum Temperature (°C) | Extreme Minimum Temperature (°C) |
| | | | | |
| 18.1 | 5.4 | 11.8 | 27.2 | 0 |
| 16.6 | 4.3 | 10.5 | 25 | -0.6 |
| 21 | 5.8 | 13.4 | 28.9 | 0 |
| 22.1 | 5.6 | 13.9 | 30 | -0.5 |
| 18.6 | 4.8 | 11.7 | 28.5 | -0.5 |
| 19.3 | 6.4 | 12.9 | 26.5 | -1.5 |
| 16.9 | 4 | 10.5 | 22.5 | 0 |
| 24.1 | 5.8 | 15 | 31.5 | -3 |
| 18.8 | 7.3 | 13.1 | 25.5 | 3.5 |
| 18.2 | 5.5 | 11.9 | 25.5 | -0.5 |
| 19 | 5.2 | 12.1 | 29.5 | -1.5 |
| 20.8 | 5.9 | 13.4 | 26 | -0.5 |
| 22.2 | 6.9 | 14.6 | 31 | 0 |
| 19.7 | 6.5 | 13.1 | 28 | 1.5 |
| 20.9 | 6.6 | 13.8 | 29.5 | 3 |
| 19.1 | 6.8 | 13 | 28 | 1.5 |
| 18.9 | 6.5 | 12.8 | 26 | 1.5 |
| 24.1 | 7.9 | 16 | 33 | -1 |
| 18.6 | 6.7 | 12.7 | 26.5 | 2 |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | 13.83 | 29.9 | 2.1 |
| | | | | |
| | | 11.95 | 31.7 | 2.6 |
| | | 10.6 | 29.9 | 0.1 |
| | | 14.6 | 33.2 | -0.4 |
| | | 13.8 | 29.1 | 3.2 |
| | | | | |
| | | | | |
| | | 14 | 29.5 | 4.2 |
| | | 11.8 | 29.1 | 3.3 |
| | | | | |
| | | 13.2 | 26.0 | 2.9 |
| | | 11.5 | 22.9 | 2.5 |
| | | 11.1 | 22.5 | 3.7 |
| | | 10.8 | 25.2 | 2.0 |
| | | 12.5 | 27.2 | 3.5 |
| | | 12.5 | 23.8 | 1.9 |
| | | 15.1 | 29.7 | 3.4 |
| | | | | |

| July | | | | |
|---|---|---|---|---|
| Mean Maximum Temperature (°C) | Mean Min Temp (°C) | Mean Temperature (°C) | Extreme Maximum Temperature (°C) | Extreme Minimum Temperature (°C) |
| | | | | |
| 24.6 | 9.6 | 17.1 | 33.9 | 2.8 |
| 20.9 | 7.7 | 14.3 | 26.7 | 2.8 |
| 20.7 | 7.7 | 14.2 | 32.2 | 4.4 |
| 24.7 | 8.8 | 16.8 | 29 | 4 |
| 24.8 | 8.1 | 16.5 | 33 | 3 |
| 21 | 7.5 | 14.3 | 26.5 | 3.5 |
| 22.4 | 7.8 | 15.1 | 27.5 | 3 |
| 21.1 | 8.3 | 14.7 | 30.5 | 4 |
| 21 | 8.2 | 14.6 | 30.5 | 5 |
| 22.9 | 7 | 15 | 31.5 | 2.5 |
| 26.1 | 7.4 | 16.8 | 32 | 2.5 |
| 20.2 | 8.2 | 14.2 | 29 | 4.5 |
| 23.4 | 9.2 | 16.3 | 31.5 | 2.5 |
| 22 | 7.8 | 14.9 | 30.5 | 2.5 |
| 23.5 | 8.5 | 16 | 31 | 4.5 |
| 24.7 | 8.4 | 16.6 | 32 | 4 |
| 22.1 | 8.3 | 15.2 | 31 | 3.5 |
| 24.8 | 8.2 | 16.5 | 34 | 4 |
| 20.3 | 7 | 13.7 | 24.5 | 3 |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | 13.9 | 32.8 | 5 |
| | | 14 | 30.5 | 4.5 |
| | | | | |
| | | 13.6 | 30.7 | 7.6 |
| | | 15.6 | 34.6 | 2.4 |
| | | 12.1 | 23.1 | 4.6 |
| | | | | |
| | | 13.26 | 22.9 | 5.4 |
| | | 11.38 | 32.3 | 6.6 |
| | | 16.99 | 32.3 | 7.4 |
| | | | 33 | |
| | | 17.7 | 31.1 | 7.0 |
| | | 16.0 | 28.3 | 3.7 |
| | | 11.7 | 22.9 | 2.9 |
| | | 16.9 | 27.9 | 5.0 |
| | | 16.5 | 31.1 | 4.9 |
| | | 17.9 | 32.9 | 8 |
| | | 16.8 | 30.7 | 6.0 |
| | | | | |

| August | | | | |
|---|---|---|---|---|
| Mean Maximum Temperature (°C) | Mean Min Temp (°C) | Mean Temperature (°C) | Extreme Maximum Temperature (°C) | Extreme Minimum Temperature (°C) |
| | | | | |
| 18.4 | 6.7 | 12.6 | 25 | 1.7 |
| 19.2 | 9.6 | 14.4 | 25 | 5.6 |
| 23.8 | 8.9 | 16.4 | 31.7 | 5 |
| 21.7 | 7.4 | 14.6 | 31.5 | 3.5 |
| 25.2 | 7.8 | 16.5 | 30.5 | 3 |
| 19.4 | 6.2 | 12.8 | 25 | 1.5 |
| 26 | 8.1 | 17.1 | 33 | 4 |
| 20 | 7.9 | 14 | 27 | 4 |
| 22.8 | 7.6 | 15.2 | 29 | 1 |
| 22.2 | 7.9 | 15.1 | 28 | 1.5 |
| 21.8 | 6.9 | 14.4 | 27.5 | 1.5 |
| 24.6 | 7.8 | 16.2 | 31 | 1.5 |
| 20.9 | 6.7 | 13.8 | 27 | 2 |
| 22 | 8 | 15 | 28.5 | 4 |
| 22 | 8.5 | 15.3 | 29.5 | 3 |
| 24.6 | 8.5 | 16.6 | 34 | 1 |
| 22.9 | 9.4 | 16.2 | 31.5 | 2 |
| 23.5 | 6.9 | 15.2 | 32 | -2.5 |
| 22.6 | 7.3 | 15 | 30.5 | 1.5 |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | 16.89 | 35.1 | 3.7 |
| | | 15.8 | 33.4 | 2.9 |
| | | | | |
| | | 15.3 | 35.6 | 6.2 |
| | | 14.7 | 30.4 | 2.5 |
| | | 13.7 | 26.6 | 6.3 |
| | | | | |
| | | | | |
| | | 14.5 | 26.7 | 4.2 |
| | | 13.5 | 28.3 | 3.7 |
| | | 14.1 | 29.1 | 2.9 |
| | | 16.0 | 31.1 | 5.8 |
| | | 14.7 | 27.9 | 4.2 |
| | | 14.3 | 24.8 | 4.2 |
| | | 15.9 | 29.9 | 4.2 |
| | | 16.8 | 30.3 | 6.8 |
| | | 16.8 | 29.5 | 6.1 |
| | | 15.8 | 27.6 | 5.5 |
| | | | | |

| September | | | | |
|---|---|---|---|---|
| Mean Maximum Temperature (°C) | Mean Min Temp (°C) | Mean Temperature (°C) | Extreme Maximum Temperature (°C) | Extreme Minimum Temperature (°C) |
| | | | 23.3 | -1.7 |
| 18.8 | 3.1 | 11 | 23.9 | -0.6 |
| 18.1 | 4.8 | 11.5 | 23.3 | 0 |
| 15.3 | 3.8 | 9.6 | 20.6 | -1.1 |
| 15.6 | 4.7 | 10.2 | 21 | -2 |
| 19.5 | 5.1 | 12.3 | 28 | 1.5 |
| 16.1 | 5.1 | 10.6 | 23.5 | -1 |
| 18.6 | 4.5 | 11.6 | 31.5 | -2 |
| 17.6 | 6.1 | 11.9 | 25 | -0.5 |
| 14.7 | 3.2 | 9 | 24 | -5.5 |
| 14.9 | 2.4 | 8.7 | 21.5 | -5.5 |
| 14.1 | 2.5 | 8.3 | 22 | -3.5 |
| 15.7 | 3.3 | 9.5 | 24.5 | -2 |
| 20.9 | 4.6 | 12.8 | 28 | -0.5 |
| 17.6 | 3.4 | 10.5 | 34.5 | -2.5 |
| 19.2 | 4.4 | 11.8 | 24.5 | -1.5 |
| 21.3 | 4.5 | 12.9 | 26 | -1.5 |
| 17.8 | 4.2 | 11 | 23.5 | -1 |
| 13.8 | 3.5 | 8.7 | 24 | -3 |
| 19.5 | 2.1 | 10.8 | 26 | -4 |
| | | | | |
| | | | | |
| | | | | |
| | | 12.4 | 31.6 | -0.3 |
| | | 12.62 | 29.5 | 1.2 |
| | | 9.7 | 28.1 | -1.1 |
| | | | | |
| | | | | |
| | | 8.4 | 22.4 | -0.6 |
| | | 10.4 | 28.9 | -1.1 |
| | | | | |
| | | 6.6 | 15.2 | 0.3 |
| | | 11.0 | 28.7 | 0.3 |
| | | 11.1 | 22.5 | 5.0 |
| | | 10.4 | 23.6 | 0.7 |
| | | 12.2 | 27.2 | -0.6 |
| | | 8.5 | 21.7 | 0.3 |
| | | 12.2 | 26.3 | 2.5 |
| | | 12.5 | 26.3 | 0.7 |
| | | 13.1 | 30.7 | 0.2 |
| | | 11.1 | 26.0 | -1.9 |
| | | 8.5 | 24.5 | -0.4 |
| | | | | |

| October | | | | |
|---|---|---|---|---|
| Mean Maximum Temperature (°C) | Mean Min Temp (°C) | Mean Temperature (°C) | Extreme Maximum Temperature (°C) | Extreme Minimum Temperature (°C) |
| 11.1 | 0.9 | 6 | 17.2 | -3.9 |
| 9.3 | 1.3 | 5.3 | 21.7 | -4.4 |
| 9.9 | 0.2 | 5.1 | 17.2 | -5.6 |
| 11.2 | 0.4 | 5.8 | 15.6 | -5 |
| 12.1 | 0.2 | 6.2 | 19.5 | -5.5 |
| 12.3 | 1 | 6.7 | 20.5 | -5 |
| 12.5 | 0 | 6.3 | 23.5 | -6 |
| 10 | -0.4 | 4.8 | 14.5 | -7 |
| 10.3 | 1.3 | 5.8 | 16.5 | -7 |
| 11 | -0.2 | 5.4 | 15 | -4.5 |
| 7.4 | -2.2 | 2.6 | 21 | -25 |
| 8.1 | 0.3 | 4.2 | 14 | -7 |
| 13.1 | 0.2 | 6.7 | 18.5 | -7 |
| 13.2 | -0.7 | 6.3 | 23.5 | -6.5 |
| 12.8 | 1.2 | 7 | 22 | -7 |
| 11.1 | 1.6 | 6.4 | 18.5 | -4.5 |
| 8 | -0.3 | 3.9 | 16.5 | -5.5 |
| 7.4 | -3.1 | 2.2 | 19.5 | -16.5 |
| 11 | -0.4 | 5.2 | 20.5 | -9.5 |
| 11 | 0.1 | 5.4 | 20 | -4.5 |
| | | | | |
| | | 3.13 | 22.5 | -8 |
| | | | | |
| | | 2.9 | 16.3 | -5.6 |
| | | 4.87 | 19.6 | 16.9 |
| | | 3.71 | 18.8 | -6 |
| | | | | |
| | | 2.3 | 17.7 | -4.3 |
| | | 2.9 | 15.9 | -9.4 |
| | | 5.6 | 23.9 | -12.2 |
| | | | | |
| | | 4.2 | 15.6 | -2.9 |
| | | 3.7 | 16.4 | -10.6 |
| | | | | |
| | | 3.9 | 23.6 | -4.8 |
| | | 1.6 | 12.9 | -8.9 |
| | | 5.9 | 22.1 | -2.4 |
| | | 3.8 | 12.9 | -2.0 |
| | | 2.5 | 15.9 | -9.4 |
| | | 4.7 | 16.0 | -4.9 |
| | | 6.6 | 17.7 | -1.6 |
| | | 3.9 | 12.7 | -1.7 |
| | | | | |

| November | | | | |
|---|---|---|---|---|
| Mean Maximum Temperature (°C) | Mean Min Temp (°C) | Mean Temperature (°C) | Extreme Maximum Temperature (°C) | Extreme Minimum Temperature (°C) |
| 3.4 | -3.6 | -0.1 | 9.4 | -12.2 |
| 3.4 | -5.3 | -1 | 16.7 | -20.6 |
| 4.3 | -2.4 | 1 | 11.7 | -11.1 |
| 1.1 | -6.6 | -2.8 | 12.2 | -19.4 |
| -0.7 | -7.6 | -4.2 | 12 | -25 |
| 4 | -5.9 | -1 | 11 | -12 |
| 5.1 | -2.3 | 1.4 | 15.5 | -11 |
| 6.3 | -2.1 | 2.1 | 15 | -7 |
| 0.1 | -6.3 | -3.1 | 9.5 | -16.5 |
| 4.7 | -1.7 | 1.5 | 13 | -11 |
| 1.5 | -6 | -2.3 | 7.5 | -20.5 |
| -8.9 | -15.8 | -12.4 | 7 | -35.5 |
| 1.7 | -5.9 | -2.1 | 7 | -21 |
| 6.1 | -0.6 | 2.8 | 12 | -10 |
| 4.8 | -2.3 | 1.3 | 10.5 | -9 |
| 3.2 | -3.8 | -0.3 | 8.5 | -11 |
| 1.5 | -6.2 | -2.4 | 15 | -20 |
| 3.6 | -3.2 | 0.2 | 9 | -17.5 |
| 2.4 | -3.4 | -0.5 | 6 | -11 |
| 1.3 | -5.8 | -2.3 | 6 | -23 |
| | | | | |
| | | -1.05 | 15.5 | -21.2 |
| | | | | |
| | | -0.35 | 20.2 | 11.5 |
| | | -0.53 | 9.1 | -9 |
| | | 0.29 | 11.2 | -11.9 |
| | | | | |
| | | 0 | 12.3 | -21.9 |
| | | 0.4 | 10 | -10.4 |
| | | -5 | 4.9 | -19.3 |
| | | | | |
| | | -2.0 | 7.4 | -14.7 |
| | | -2.0 | 10.6 | -29.1 |
| | | -2.8 | 6.6 | -16.7 |
| | | 0.7 | 9.8 | -6.31 |
| | | 0.8 | 9.4 | -10.0 |
| | | -4.7 | 13.7 | -25.2 |
| | | -3.7 | 4.6 | -16.7 |
| | | -1.7 | 8.5 | -13.4 |
| | | -1.5 | 5.8 | -8.26 |
| | | -4.5 | 8.6 | -26.7 |
| | | -3.7 | 7.5 | -14.8 |
| | | | | |

| December | | | | |
|---|---|---|---|---|
| Mean Maximum Temperature (°C) | Mean Min Temp (°C) | Mean Temperature (°C) | Extreme Maximum Temperature (°C) | Extreme Minimum Temperature (°C) |
| 2.2 | -5 | -1.4 | 8.3 | -15.6 |
| -0.6 | -8.6 | -4.6 | 5.6 | -20.6 |
| 0.7 | -5.5 | -2.4 | 8.9 | -14.4 |
| -6.8 | -16.4 | -11.6 | 5.5 | -33 |
| -5.1 | -13.5 | -9.3 | 3 | -37 |
| 1.6 | -7.8 | -3.1 | 7 | -31 |
| -3.7 | -11.3 | -7.5 | 11 | -28 |
| -2.6 | -10.5 | -6.6 | 8 | -25 |
| 0.2 | -6.1 | -3 | 7 | -14.5 |
| -9.3 | -15.8 | -12.6 | 1 | -30.5 |
| -7.9 | -15.2 | -11.6 | 5 | -38.5 |
| -3 | -8.5 | -5.8 | 7 | -27 |
| 0.7 | -6.5 | -2.9 | 8.5 | -14 |
| 0.3 | -6 | -2.9 | 10.5 | -14.5 |
| -1.1 | -6.4 | -3.8 | 9 | -20.5 |
| 1 | -4.3 | -1.7 | 9 | -19.5 |
| -5.4 | -13.7 | -9.6 | 7 | -37.5 |
| 2.4 | -4.9 | -1.3 | 8.5 | -13 |
| -5.7 | -13.2 | -9.5 | 3 | -28 |
| 1 | -5.3 | -2.2 | 8.5 | -14.5 |
| | | | | |
| | | -6.12 | 11.3 | -31.8 |
| | | | | |
| | | 2.27 | 16.2 | -13.2 |
| | | -6.25 | 5.1 | -27.4 |
| | | -3.86 | 4.2 | -13.5 |
| | | | | |
| | | -6 | 2.4 | -14.3 |
| | | -3 | 6.3 | -14.5 |
| | | | | |
| | | | | |
| | | -3.4 | 6.2 | -17.4 |
| | | -2.9 | 4.2 | -12.3 |
| | | -12 | 4.5 | -19.5 |
| | | -11.4 | 4.6 | -29.1 |
| | | -10.5 | 2.5 | -29.1 |
| | | -4.2 | 5.0 | -17.4 |
| | | -3.8 | 3.7 | -11.7 |
| | | -5.8 | 6.7 | -18.5 |
| | | -6.6 | 3.8 | -24.4 |
| | | -3.4 | 9.5 | -20.8 |
| | | -4.3 | 6.0 | -14.9 |
| | | | | |

**Monthly Evaporation**

| Month | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| January | | | | | | | | | | | | | | | | | | 4.8 | 8 | 7.6 |
| February | | | | | | | | | | | | | | | | | | 12.8 | 19 | 18 |
| March | | | | | | | | | | | | | | | | | | 36 | 29.9 | 45.2 |
| April | | | | | | | | | | | | | | | | | | 74.6 | 86.9 | 95.8 |
| May | 47 | 40 | 47 | 64.3 | 21.5 | 47 | 47 | | | 55 | 66.9 | 53.4 | 47 | 61.7 | 70 | 46 | 119 | 105.2 | 147.2 | 125.3 |
| June | 71 | 139.9 | 105.8 | 105.5 | 89.9 | 98.3 | 112 | | | 73 | 49.5 | 66.5 | 112 | 77.2 | 98.1 | 71.4 | 133.8 | 140 | 195 | |
| July | 65.7 | 143.4 | 108.9 | 107 | 103.5 | 107 | 145 | | 64.5 | 106 | 65.6 | 81.6 | 107 | 99.19 | 81 | 88.4 | 183.7 | 158.4 | 174.8 | |
| August | 94.2 | 144 | 110 | 92 | 78.8 | 92 | 145 | | 79.6 | 66 | 60.4 | 35.3 | 92 | 81.9 | 60.6 | 65.3 | 136.6 | 128.7 | 118.9 | |
| September | 51.6 | 59 | 49 | 50 | 50 | 43.3 | 50 | | 25.7 | 60 | 21.9 | 76.3 | 50 | 61.6 | 33.9 | 65.8 | 68.4 | 42.5 | 14.3 | |
| October | 14.9 | 16.7 | 26.9 | 15 | 26 | 22.5 | 15 | | 17 | 27 | 18.9 | 5.25 | 15 | 38.7 | 12.9 | 21.3 | 27.9 | 34.6 | 11.8 | |
| November | 2.8 | | | | | | | | | | | | | | | | 2.1 | 7.5 | 6.7 | |
| December | | | | | | | | | | | | | | | | | 4.1 | 7.1 | 5.2 | |