MPMC00109

# Mount Polley Water and Load Balance

**Prepared for**

## Mount Polley Mining Corporation

**Prepared by**

srk consulting

SRK Consulting (Canada) Inc.
1CM017.002
December 2013

# Mount Polley Water and Load Balance

December 2013


**Prepared for**

Mount Polley Mining Corporation
PO Box 12
Likely, BC V0L 1N0
Canada

Tel: +1 250 790 2215
Web: www.imperialmetals.com

**Prepared by**

SRK Consulting (Canada) Inc.
2200–1066 West Hastings Street
Vancouver, BC V6E 3X2
Canada

Tel: +1 604 681 4196
Web: www.srk.com



Project No: 1CM017.002

File Name: Mount Polley Water Management Assessment_1CM017 002FINAL_20131205_SRJ_TRS_SB

# Executive Summary

Mount Polley Mining Corporation (MPMC) retained SRK Consulting (Canada) Inc. (SRK) to prepare a screening level water and load balance for the Mount Polley Mine. This report describes the development and results of the screening level water and load balance model. This model will be used to develop and assess short term (next two years) and long term (beyond two years) water management options for the Mount Polley mine.

The Mount Polley mine discharge is regulated by *Environmental Management Act* Permit 11678 issued in June 2013 by the BC Ministry of Environment. The permit includes limits to water quality and annual discharge volumes. The permit limits the discharge volume to 1.4 $Mm^3$ annually. Receiving water quality objectives also limit the constituent loadings that can be released to Hazeltine Creek, which is dependent on the real-time dilution capacity of Hazeltine Creek.

A screening level water balance model based on annual precipitation, evaporation and runoff was prepared for the Mount Polley Mine site. The water balance model quantifies and forecasts the annual net input of water to the Tailings Management Facility (TMF). Results of the model indicate that the annual site-wide free water volume generated over the last year is approximately 0.8 $Mm^3$. Runoff from progressively larger areas has been diverted to the TMF since it re-opened in 2005, and will increase over next few years as runoff from the northwest portion of the site is diverted to the TMF. The annual site-wide free water volume generated on site is expected to increase to 1.7 $Mm^3$ of water under average hydrologic conditions, or 3.2 $Mm^3$ of water under a wet hydrologic year with similar precipitation as measured in 2008 (621 mm), because of the expanded footprint.

There are no specific sources that contribute a disproportionate quantity of constituent loadings to the TMF.  Rather, waste rock areas, tailings and developed mine areas in general appear to contribute loadings at similar rates. Increases in selenium, molybdenum, nitrate and sulphate have been trending up since the mine operation resumed in 2005. These increases are expected to continue until solubility limits are reached or when mine development and ore processing end.

Copper and uranium concentrations in the TMF do not increase because they precipitate in the milling process. When processing stops after closure, it is possible that the concentrations will increase in the TMF.

In order to discharge 1.4 $Mm^3$ of water during an average precipitation year, treatment will be required for selenium and molybdenum and likely for sulphate and nitrate in the future.

# Table of Contents

# List of Figures



# List of Tables

# 1 Introduction

## 1.1 Background

In June 2013, the BC Ministry of Environment issued an Amended *Environmental Management Act* Permit 11678 to the Mount Polley Mining Corporation (MPMC), which specifies effluent limits and conditions for the Mount Polley Mine. Several of the limits that regulate the release of mine water from site significantly restrict the volume of mine water that can be released to the receiving environment (Hazeltine Creek). The discharge restrictions create challenges because the volume of free mine water that has accumulated on site is stressing the available storage capacity within the tailings management facility (TMF). Expanding the TMF is challenging due to geotechnical considerations.

In September 2013, MPMC retained SRK Consulting (Canada) Inc. (SRK) to prepare a screening level water and load balance for the Mount Polley Mine. SRK visited the site on September 9 and 10, 2013, reviewed available data, and prepared a memo documenting the initial findings (SRK 2013). This report describes the development and results of the screening level water and load balance model. This model will be used to develop and assess short term (next two years) and long term (beyond two years) water management options at Mount Polley.

MPMC short term water management objective is to discharge 6 $Mm^3$ over the next two years. The long term water management objective for the site is to retain enough water volume in the tailings management facility (TMF) to support one year of processing and discharge any site water in excess of this amount.

## 1.2 Report Scope

The scope of this study is to complete the following tasks:

- Prepare a screening level water and load balance for the mine site based on the existing site water balance provided by MPMC. This model uses annual precipitation and evaporation values to estimate the change in water storage in the TMF on an annual basis, based on the contributing catchments and milling rates.
- Review the water quality data across the site in order to understand the loading sources and general trends within the TMF.
- Estimate discharge constraints.
- Prepare preliminary design criteria for developing water management options to meet water management objectives

Section 2 of this report provides a summary of information that was used for the water management assessment. The site water balance and water balance model is discussed in Section 3. Section 4 assesses water quality and the load balance model for the site. Constraints taken into consideration are discussed in Section 5. Conclusions and recommendations are provided in Sections 6 and 7, respectively.

# 2 Supporting Information

## 2.1 *Environmental Management Act* Permit 11678

The *Environmental Management Act* Permit 11678, was amended in June 2013 for MPMC. The permit conditions constrain the volume and quality of the discharge from the site.

The volume of water discharged from the mine site is constrained by two criteria:

1. The total volume of effluent discharged each day must not exceed 35% of flow in Hazeltine Creek for the same day as measured at nearby monitoring station W7.
2. The maximum annual volume of water discharged from the mine site must not exceed 1.4 $Mm^3$ per year.

The permit also states the released water must be dam filtered. However, water can be discharged, if meeting effluent criteria, from any source, given notification of the Ministry.

Water quality limitations are summarized in Table 1. The water quality limits do not apply at the "end-of-pipe" but to the water quality at Station W7 downstream of the discharge to Hazeltine Creek.

**Table 1: Water Quality Limitations as stated in PE 11678 (BC MOE 2013)**

| **Parameter- water sample** | **Units** | **30-day Mean** |
|---|---|---|
| Nitrate | mg/l | 3 |
| Total Copper | mg/l | 0.007 |
| Total Molybdenum | mg/l | 0.05 |
| Total Selenium | mg/l | 0.002 |
| **Parameter –water sample** | **Units** | **Maximum** |
| Sulphate | mg/l | 309 |
| **Parameter –water sample** | **Units** | **Annual Mean** |
| Total Cadmium | mg/l | 0.000025 |
| **Parameter – sediment sample** | **Units** | **Mean** |
| Total Selenium | µg /g dw | 2 |
| **Parameter – Fish Muscle Rainbow Trout** | **Units** | **Mean** |
| Total Selenium | µg /g wet wt | 1 |
| **Parameter – creek substrate** | **Units** | **Maximum** |
| Chlorophyll a | mg/m2 | 100 |
| TSS | mg/l | 25 |

Source: \\VAN-SVR0\Projects\01_SITES\Mt_Polley\1CM017.002_Water and Load Balance Model\!020_Project_Data\010_SRK\Soren's Working Files\ Discharge Strategy WQ 2013 (MTD Only) for Discharge Plan_Rev9_SB.xlsm

Note: Annual mean based on samples taken during the discharge period of April to October

## 2.2 Hydrology

Monthly precipitation and evaporation records from 1998 to 2013 were provided by MPMC. Additional annual precipitation data from the nearby meteorological station at Spokin Lake (Environment Canada, 2013a) were also used.

Hazeltine Creek is the receiving water and has a catchment area of approximately 27.6 $km^2$ and an average elevation of 980 masl (KP, 2009). Knight Piésold Consulting (KP) prepared a hydrograph of monthly average flows for Hazeltine Creek in 2009 using data recorded on site and a regional analysis of nearby gauging stations. MPMC measured flow in the creek from 2010 to 2013 and updated the hydrograph.

A nearby gauging station, Borland Creek below Valley Creek (Environment Canada, 2013b), is similar to those in Hazeltine Creek. The catchment area is 113 $km^2$ and the average elevation is 993 masl. Data from this location was used to estimate the peak flow hydrographs for Hazeltine Creek.

## 2.3 Catchment Delineation

Most catchments at the mine have been delineated by MPMC. MPMC also provided contour information, existing site mapping and infrastructure layout.

## 2.4 Water Quality Data

Historical water quality data were used to develop the load balance model. Water quality monitoring stations are listed in Table 2 and shown on Figure 1.

**Table 2: Water Quality Sampling Locations**

| Station ID | Description and Location |
|---|---|
| LDa | Long Ditch pipeline, south of the confluence with south east rock dump seepage (SERDS) ditch |
| E1 | Tailings Management Facility |
| E10 | Wight Pit |
| E8 | Cariboo Pit |
| JCP | Joe’s Creek Pipeline |
| BP | Boundary Pit |
| E11 | Springer Pit |
| E7 | Perimeter Pond |
| E5 / MTD | Main Embankment Drain |
| W7 | Hazeltine Creek, downstream of the confluence with the mine discharge |

Source: \\VAN-SVR0\Projects\01_SITES\Mt_Polley\1CM017.002_Water and Load Balance Model\!020_Project_Data\010_SRK\Soren's Working Files\ 2013 Compiled Effluent_WQ Data__REV05_SRJ_LCC.xlsm

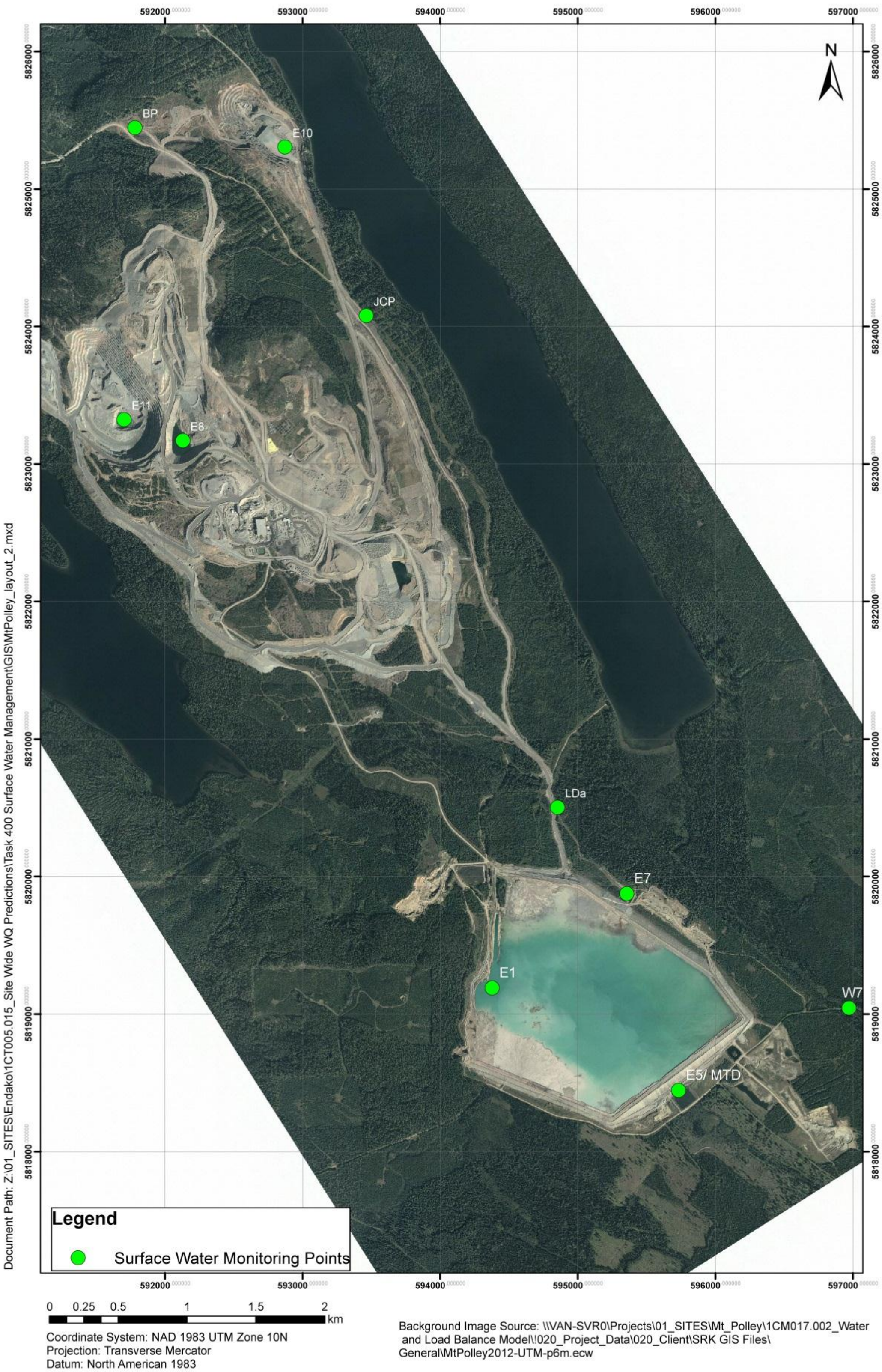



**Figure 1: Water Quality Monitoring Locations**

Water quality samples for total and dissolved metals, nutrients, anions, TSS and physical parameters were collected between December 2008 and April 2013.

## 2.5 Existing Site Water Balance

MPMC prepared a monthly site water balance from May 2012 to June 2013. This water balance estimates the change in storage within the mine water management structures, most notably the TMF, and compares predicted to measured values. Monthly mill throughput, TSF bathymetric surveys, and physical characteristics of the tailings were incorporated into the annual water balance by SRK (Table 3).

**Table 3: MPMC Site Water Balance Values**

| Term | Quantity |
|---|---|
| **Hydrology between May 2012 and April 2013** | |
| Total Precipitation | 690 mm |
| Open Water Evaporation | 480 mm |
| **Tailings Characteristics** | |
| Dry Bulk Density | 1.4 kg/m$^3$ |
| Specific Gravity | 2.65 |
| Moisture Content by Volume | 47 % |
| **Volumes** | |
| Change in Storage in TMF between May 2012 and April 2013 | 7,616,770 m$^3$ |
| Mill Throughput from May 2012 to April 2013 | 3,028,658 tonnes |
| Change in storage in Springer and Cariboo pits between May 2012 and April 2013 | (502,598) m$^3$ |

Source: \\VAN-SVR0\Projects\01_SITES\Mt_Polley\1CM017.002_Water and Load Balance Model\!020_Project_Data\010_SRK\water balance\Site Water Balance 2013_SB_r9.xlsx

MPMC also provided SRK with the estimated annual volume of free water within the TMF (from bathymetric surveys) and Cariboo pit, based on survey, pit modelling and pumping data from 2004 to 2013. This data was later used to verify the revised water balance.

Historical milling rates (Imperial Metals Corporation, 2010) were used to calculate the annual volume of water required for subaqueous deposition of tailings in the TMF from 2007 until 2012.

# 3 Site Water Balance Model

## 3.1 Model Description

A screening level water balance model based on annual precipitation, evaporation and runoff was prepared for the Mount Polley Mine site. The water balance model quantifies and forecasts the annual net input of water to the TMF. Figure 2 shows the site water balance conceptual model.

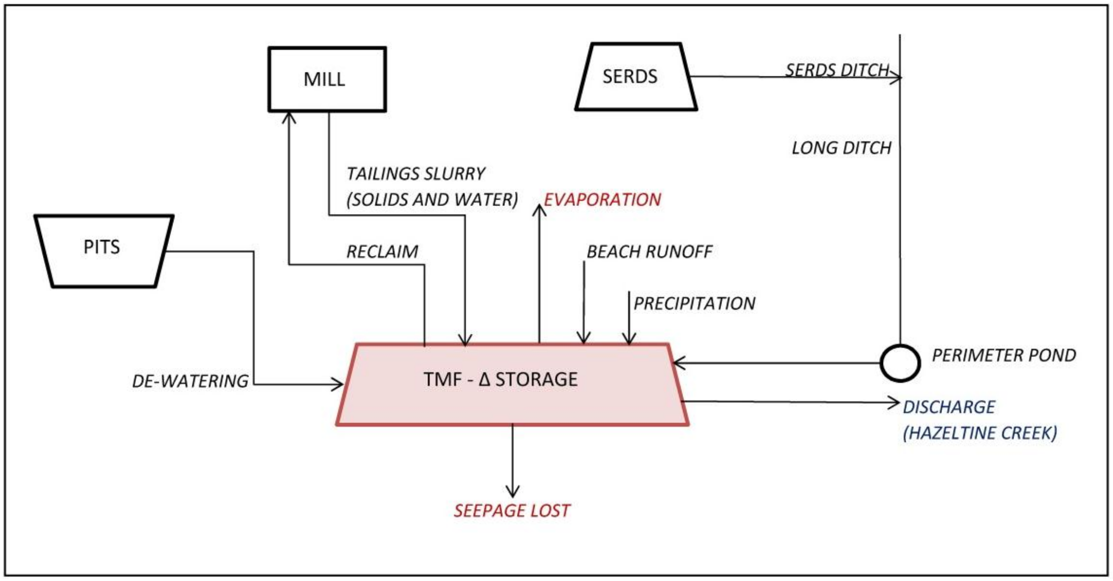
Inputs to the TMF include:

- Tailings slurry from the mill (solids and water),
- Direct precipitation and runoff to the TMF,
- Runoff from developed mine areas,
- Seepage from TMF perimeter drains, and
- Pit de-watering.

Outputs from the TMF include:

- Reclaim water to the mill,
- Evaporation, and
- Seepage losses.

The catchment areas were divided into tailings area and mine area. The tailings area includes the TMF beach and pond. These areas are used to estimate evaporation and direct precipitation to the TMF. The mine area includes all other site catchments that convey water to the TMF (e.g., seepage collection, runoff, or pit water).




Source: \\VAN-SVR0\Projects\01_SITES\Mt_Polley\1CM017.002_Water and Load Balance Model\!020_Project_Data\010_SRK\water balance\Site Water Balance 2013_SB_r9.xlsx

**Figure 2: Schematic of Scoping-level Site Water Balance for the TMF**

## 3.2 Model Inputs

### 3.2.1 Tailings and Reclaim Water

The projected mill throughput is assumed to be 8 million tonnes of ore per year between May 2012 and April 2013. Historical mill rates were used in the verification of the site-wide runoff coefficient.

### 3.2.2 Precipitation, Evaporation

Direct precipitation and evaporation have been measured monthly. However, the precipitation record was not consistent when compared to the record from Spokin Lake. Several of the years of data contained gaps in the monthly record. In order to produce comparable water volumes to those measured on site, the Spokin Lake precipitation record was used in the verification of the site wide runoff coefficient. The evaporation record was more consistent, and was therefore used in the water balance.

### 3.2.3 Storage Capacity of Open Pits

Another unknown in this analysis is how much water was pumped from the pits to the TMF in years past and how much will be pumped in future years. For the purpose of this analysis, it is assumed that the pits will not be used for the long-term storage of mine water.

Groundwater flows into the pits is not included in this analysis, since these flows are assumed to be minor in comparison to the runoff volumes.

It is important to note that the current volume of water in the Cariboo Pit is included in the annual site-wide water volume calculated in the water balance.

### 3.2.4 Runoff

Insufficient data were available to estimate runoff coefficients for individual sub-catchments. A site-wide runoff coefficient was estimated from available data and is used to predict the effect of direct precipitation across the entire mine site.

The site-wide runoff coefficient is defined by Equation 1:

$$\textbf{\textit{Site Wide Runoff Coefficient}} = \frac{\textbf{\textit{Net Annual Runoff Collected}}\ (\textbf{\textit{mm}})}{\textbf{\textit{Total Annual Precipitation}}\ (\textbf{\textit{mm}})} \qquad \text{(Equation 1)}$$

The site wide runoff coefficient was used to calibrate the model.

## 3.3 Model Calibration, Verification and Predictions

Three periods of mine operations were evaluated: operations in 2005 (Figure 3), operations in 2013 (Figure 4) and operations in 2016 (Figure 5). The mine footprint is divided into two areas: the tailings and the mine. The tailings area remains constant and the mine area increases over the three operation periods (Table 4). More runoff from mine areas (contact water) is intercepted by collection ditches (*i.e.,* Long Ditch, SERDS Ditch and the proposed West Ditch) and conveyed to the TMF.

**Table 4: TMF and Mine Areas for each Operation Period**

| Catchment Sub-Section | Type of Area | 2005 ($m^2$) | 2013 ($m^2$) | 2016 ($m^2$) |
|---|---|---|---|---|
| **Tailings Area** | Direct Precipitation | 1,700,000 | 1,700,000 | 1,700,000 |
| | Runoff | 635,000 | 635,000 | 635,000 |
| **Mine Area** | Runoff | 3,350,000 | 6,590,000 | 8,070,000 |

\\VAN-SVR0\Projects\01_SITES\Mt_Polley\1CM017.002_Water and Load Balance Model\!020_Project_Data\010_SRK\water balance\Site Water Balance 2013_SB_r9.xlsx

### 3.3.1 Model Calibration

The water balance model was calibrated by varying the site wide runoff coefficient. Table 5 shows the data used to estimate the runoff coefficient. The change in the TMF water volume and other data (Sections 2.5 and 3) between May 2012 and April 2013 were used to estimate the site-wide runoff coefficient.

**Table 5: TMF Water Balance May 2012 to April 2013**

| Variable | Value | Unit | Data Source |
|---|---|---|---|
| Site-Wide Inventory Increase (Water + Solids) | 7,114,172 | $m^3$ | MPMC |
| Increase in Total Tailings Solids Inventory | 3,028,658 | $m^3$ | Calculated |
| **Change in Water Inventory** | **4,085,515** | $m^3$ | Calculated |
| **Direct TMF Inputs** | | | |
| Direct Precipitation + Beach Runoff | 1,566,989 | $m^3$ | MPMC |
| **Direct TMF Outputs** | | | |
| Evaporation (direct and beach) | (1,054,919) | $m^3$ | MPMC |
| TSF Seepage | (70,080) | $m^3$ | MPMC |
| **Net TMF Direct Inputs** | 441,991 | $m^3$ | |
| **Net TMF Water Inventory Increase** | 3,643,524 | $m^3$ | |
| Catchment Area Upstream of TMF | 6,590,590 | $m^2$ | SRK |
| Yield Upstream of TMF | 552.84 | mm | Calculated |
| Annual Precip (May 2012 - April 2013) | 692.30 | mm | MPMC |
| Annual Evap (May 2012 - April 2013) | 479.50 | mm | MPMC |
| **Site-Wide Runoff Coefficient** | **0.80** | **-** | Calculated |

Source: \\VAN-SVR0\Projects\01_SITES\Mt_Polley\1CM017.002_Water and Load Balance Model\!020_Project_Data\010_SRK\water balance\Site Water Balance 2013_SB_r9.xlsx

The site-wide runoff coefficient was estimated to be approximately 0.80. This value is the fraction of precipitation that eventually accumulates in the TMF.

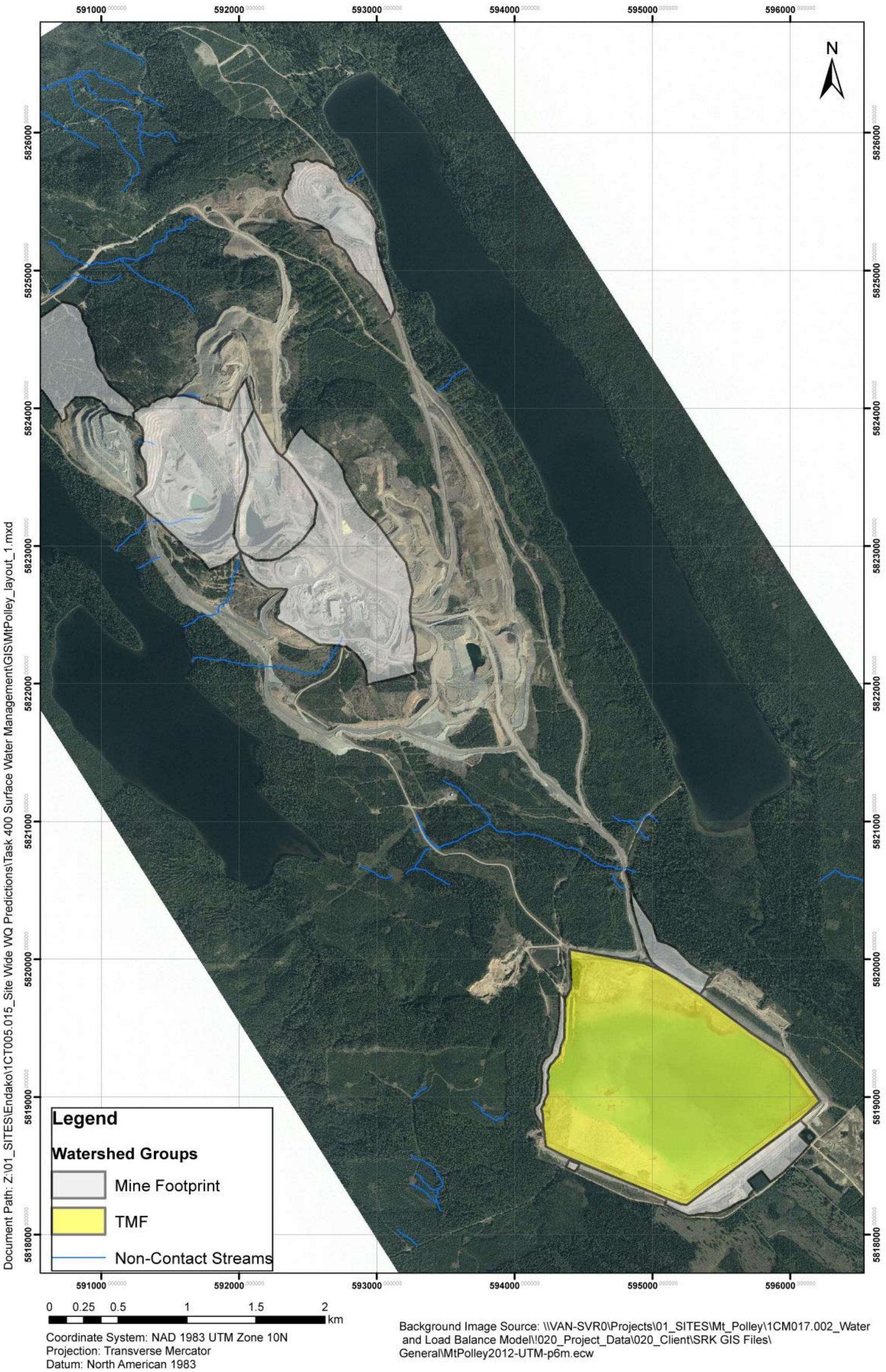



**Figure 3: 2005 Mine Footprint**

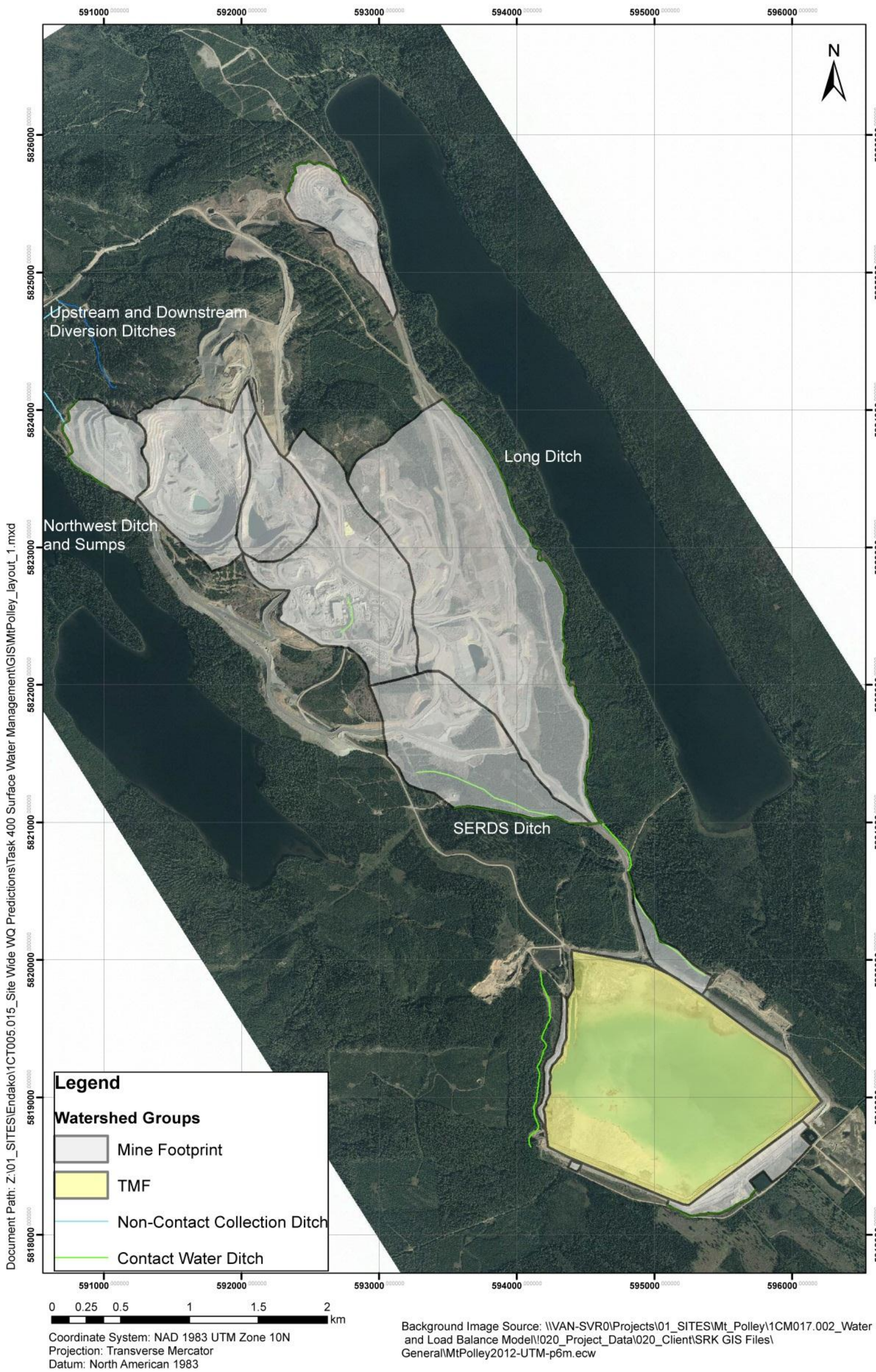
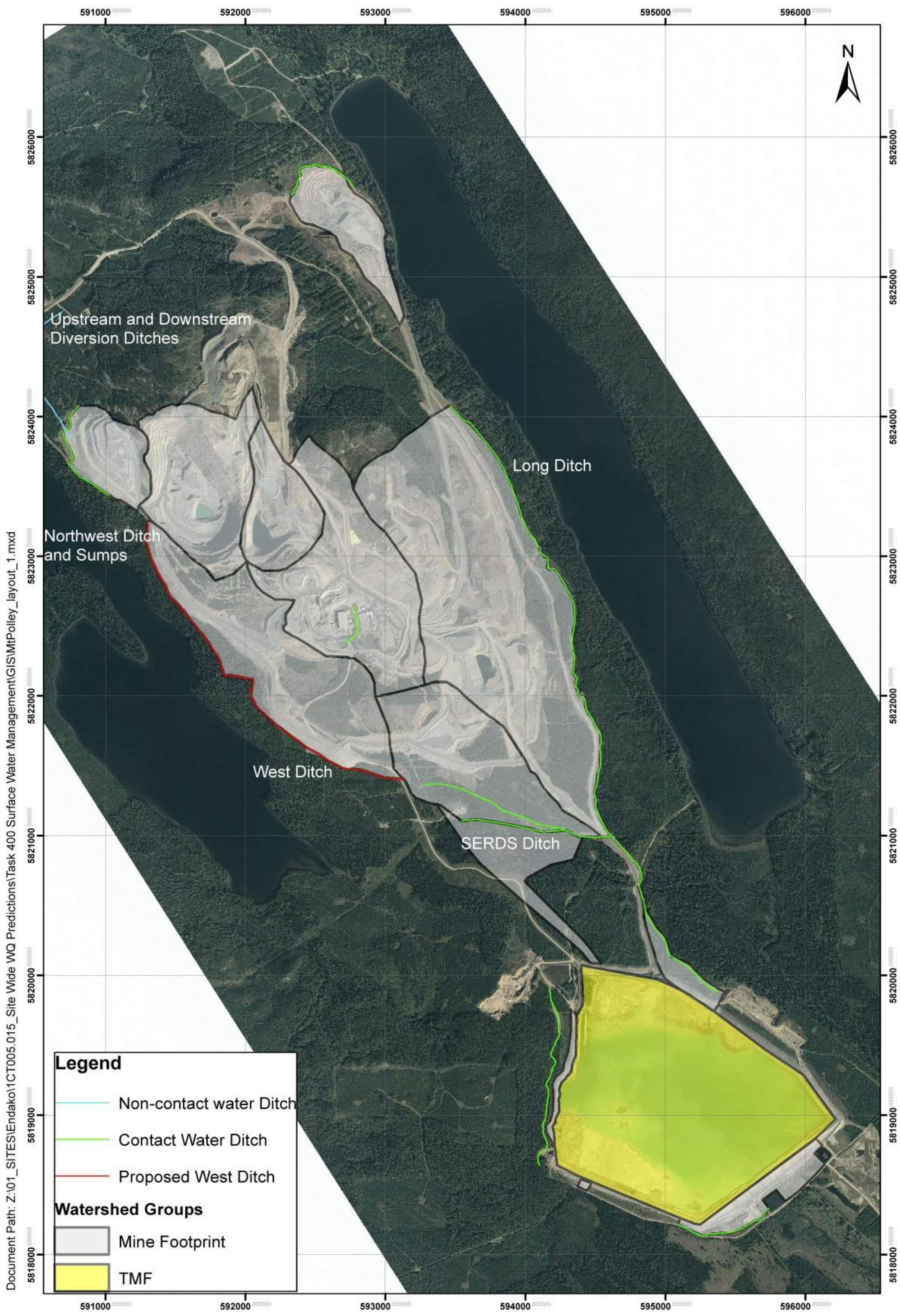



**Figure 4: 2013 Mine Footprint**




Coordinate System: NAD 1983 UTM Zone 10N
Projection: Transverse Mercator
Datum: North American 1983

Background Image Source: \\VAN-SVR0\Projects\01_SITES\Mt_Polley\1CM017.002_Water and Load Balance Model\!020_Project_Data\020_Client\SRK GIS Files\General\MtPolley2012-UTM-p6m.ecw

**Figure 5: 2016 Mine Footprint**

### 3.3.2 Model Verification

The site-wide runoff coefficient, which was calculated to be 0.80, was verified by estimating the water volume in the TMF from 2005 to 2012 using recorded precipitation from Spokin Lake, MPMC evaporation records and milling rates. It was assumed that all mine-related runoff from the site was collected in the TMF, which includes water from the pits.

The initial volume of water in the TMF at the end of 2004 provided by MPMC was approximately 5,000,000 $Mm^3$. A significant loss of water from the TMF of approximately 1.8 $Mm^3$ was observed in August 2008 from the data provided by MPMC. This reduction in TMF volume is included in the water balance to match the observed water volumes.

Table 6 summarizes inputs and predictions for model verification, including site water volumes provided by MPMC, predicted annual water volumes, and cumulative water volumes.

**Table 6: Estimated Annual Site Wide Water Volumes based on Historical Precipitation**

| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013[2] |
|---|---|---|---|---|---|---|---|---|---|
| **Annual Precipitation (mm/year)** | 609 | 468 | 536 | 621 | 532 | 404 | 625 | 565 | 380 |
| **Change in Annual Site-Wide Free Water Volume ($Mm^3$/year)** | (0.8) | 0.3 | (0.1) | 1.7 | (0.2) | (0.6) | 2.3 | 1.2 | 0.8 |
| **Calculated Site-Wide Free Water Volume ($Mm^3$)** | 4.3 | 4.5 | 4.4 | 4.4[1] | 4.2 | 3.7 | 6.0 | 7.2 | 8.1 |
| **MPMC Estimated Site Free Water Volume ($Mm^3$)** | 5.1 | 5.5 | 5.4 | 3.8 | 3.3 | 2.5 | 3.9 | 5.7 | 8.0 |

Source: \\VAN-SVR0\Projects\01_SITES\Mt_Polley\1CM017.002_Water and Load Balance Model\!020_Project_Data\010_SRK\water balance\Site Water Balance 2013_SB_r9.xlsx

Notes:
1. A reduction of 1.8 $Mm^3$ was added in 2008 to match the change in volume in the TMF presented by MPMC.
2. Based on 2013 data until end of June

The model verification indicated that the site-wide runoff coefficient should be adjusted to 0.78, which produced reasonable site-wide free water volume estimates that are comparable to those measured by MPMC.

It is important to note that, from 2005 to 2013, the mine has not been able to discharge water from the TMF, and therefore the accumulated water volume the TMF is the sum of the annual site-wide free water volumes during this period.

### 3.3.3 Model Predictions

The site water balance model was used to predict the annual volume of site-wide water as mining impacted area increases (Table 4). Two scenarios were evaluated. The first scenario assumes average precipitation. The second scenario assumes annual precipitation is the same as in 2008. Table 7 summarizes the annual water volumes for each scenario.

**Table 7: Projected Annual Site-Wide Free Water Volumes, Post-Mine Expansion**

| | Scenario 1: Avg. Precipitation | Scenario 2: 2008 Precipitation |
|---|---|---|
| Annual Precipitation (mm) | 630 | 808 |
| Annual Water Volume ($Mm^3$) | 1.7 | 3.2 |

Source: \\VAN-SVR0\Projects\01_SITES\Mt_Polley\1CM017.002_Water and Load Balance Model\!020_Project_Data\010_SRK\water balance\Site Water Balance 2013_SB_r9.xlsx

These results support the finding that the discharge volume limit or storage capacity must increase to manage free water retained in the TMF. After the mine expands with the West Ditch and the new haul road and waste dumps to the south (Scenario 2), the annual volume of free/excess water is expected to be even greater.

## 3.4 Hazeltine Creek Hydrology and Permitted Discharge

### 3.4.1 Hazeltine Creek Hydrology

The average monthly flow rates in Hazeltine Creek were estimated by KP and improved by MPMC with recorded flow data (Table 8). The majority of the annual flow within Hazeltine Creek occurs in the months of April, May, June and July (approximately 82% of total annual flow). Considering this trend, it is recommended that the 1.4 $Mm^3$ should be discharged over these four months, instead of the full permitted season (April to October) in order to minimize operational costs of discharging.

**Table 8: Monthly Flows for Hazeltine Creek**

| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average Flow ($m^3/s$) | 0.05 | 0.05 | 0.07 | 0.74 | 0.65 | 0.20 | 0.10 | 0.03 | 0.02 | 0.02 | 0.08 | 0.05 |
| % Flow Distribution | 2% | 2% | 3% | 35% | 32% | 10% | 5% | 2% | 1% | 1% | 4% | 2% |

### 3.4.2 Hazeltine Creek Flow Variability and Permitted Discharge

A screening level frequency analysis was prepared for Hazeltine Creek to estimate return periods for annual flow. Flow in Hazeltine Creek affects the volume that can be discharged from the TMF. The discharge flow to Hazeltine Creek cannot exceed 35% of the flow in Hazeltine Creek at the time of discharge. Integrating the flow over the annual hydrograph will produce the total annual volume. The purpose of this analysis is to evaluate how inter-annual variation in Hazeltine Creek flow could affect the TMF discharge rate.

Nearby Environment Canada station Borland Creek below Valley Creek was used because its catchment has a similar average elevation andcatchment area, and has 24 years of complete data (KP, 2009). Eight of the 24 years of data were incomplete or incorrect when compared to the rest of the data set, and were removed from the analysis. A frequency analysis was performed in REGBAY software, using the annual runoff for each of the remaining 16 years of data. REGBAY calculates the various return period annual runoff values by comparing the regression index of different statistical distributions. The distribution with the best fit to the Borland Creek runoff values was the Log Pearson distribution. The annual runoff values are summarized in Table 9. The annual runoff for each return period was then converted into a percentage of the average runoff, which are also shown in Table 9.

**Table 9: Frequency Analysis for Annual Runoff**

| | | Dry | | | | Wet | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Return Period** | Average (KP/MPMC) | 100 | 20 | 10 | 5 | 2 | 5 | 10 | 20 | 100 |
| **Annual Runoff (mm)** | 97.9 | 34.6 | 44.49 | 51.2 | 61.3 | 88.8 | 133.5 | 168.0 | 204.8 | 303.3 |
| **% of Average Annual Runoff** | 100% | 35% | 45% | 52% | 63% | 91% | 136% | 172% | 209% | 310% |
| **Allowable Discharge Volume ($Mm^3$) based on 35% of Hazeltine Creek** | 2.3 | 0.8 | 1.0 | 1.2 | 1.4 | 2.0 | 3.0 | 3.9 | 4.7 | 7.0 |

Percentages of average annual runoff demonstrate inter-annual variability in Hazeltine Creek flow. The allowable discharge volume for each return period is the maximum amount of water that can be discharged annually to Hazeltine Creek from the mine, over the four month discharge period.

The results in Table 9 show that discharge of 1.4 $Mm^3$ is not possible in years that are drier than the 1 in 5 dry year, because the discharge volume exceeds 35% of the annual volume of Hazeltine Creek.

### 3.4.3 Discharge from the Main Toe Drain

The discharge permit states that the discharge water must be dam filtered or only water collected in the Main Toe Drain (MTD). Flow was measured in the MTD infrequently (only two measurements, both during the month of August 2013). Therefore, monthly volumes that report to the MTD cannot be estimated. It is recommended that a flow meter with a totalizer be installed on the pump-back line(s) from the MTD.

# 4 Water Quality and Load Balance

## 4.1 Water Quality Review

Site water quality data were reviewed to assess the effect of mine water and tailings slurry on TMF water quality. Figure 1 shows the locations of sampling stations reviewed.

Figure 6 through Figure 9 show historical concentrations of nitrate, molybdenum, selenium and sulphate for mine water across the Mount Polley mine site, in the TMF and in the MTD. In solution, these parameters are highly soluble anions (i.e., $NO_3^-$, $MoO_4^{2-}$, $SeO_4^{2-}$, $SO_4^{2-}$).

Nitrate is from residual ammonium nitrate fuel oil (ANFO) explosives. Nitrate is also a nutrient and is assimilated by algae and microorganisms. At Mount Polley, the rate of nitrate increase is roughly proportional to the rate of development since 2005. Annual nitrate loading to the TMF each year exceeds the natural degradation rate. Assuming that the ANFO loss rate on site remains as is, the nitrate concentration in the TMF should increase at roughly the same rate as it has since 2005 as long as mine development continues. After closure, the nitrate concentrations are expected to gradually decrease.

Molybdenum, selenium and sulphate concentrations in the TMF have increased over time similar to nitrate. The concentrations of these parameters are expected to continue to increase over the short to medium term of the mine's development. The concentrations of molybdenum, selenium and sulphate in mine water and in the TMF water are similar, which suggests that mine water runoff (pit water, waste rock runoff, etc.) and tailings slurry contribute loadings equally to the TMF. Because loadings originate all over the mine site it is not possible to reduce loadings by targeting a few sources.

Figure 12 and Figure 13 show concentrations of total and dissolved copper at the site. Concentrations of dissolved copper generally are lower in the TMF than in the mine water on site. The lower concentrations in the TMF likely result from increasing the pH in the mill circuit. The increased pH causes copper and other metals such as zinc, nickel, cadmium and lead to precipitate as metal hydroxides. The mill therefore effectively functions as a water treatment plant for metal removal. However, concentrations of dissolved metals are likely to increase during closure when the mill no longer operates.

Figure 13 shows historical concentrations of cadmium. Cadmium concentrations were below the analytical detection limit in most samples collected and the detection limits in many cases are much greater than the downstream standard. It is possible that this can be remedied by requesting that the external laboratory use a lower analytical detection limit, but it is also possible that the samples contain other parameters (such as molybdenum) in concentrations that interfere with the ability to measure low cadmium.

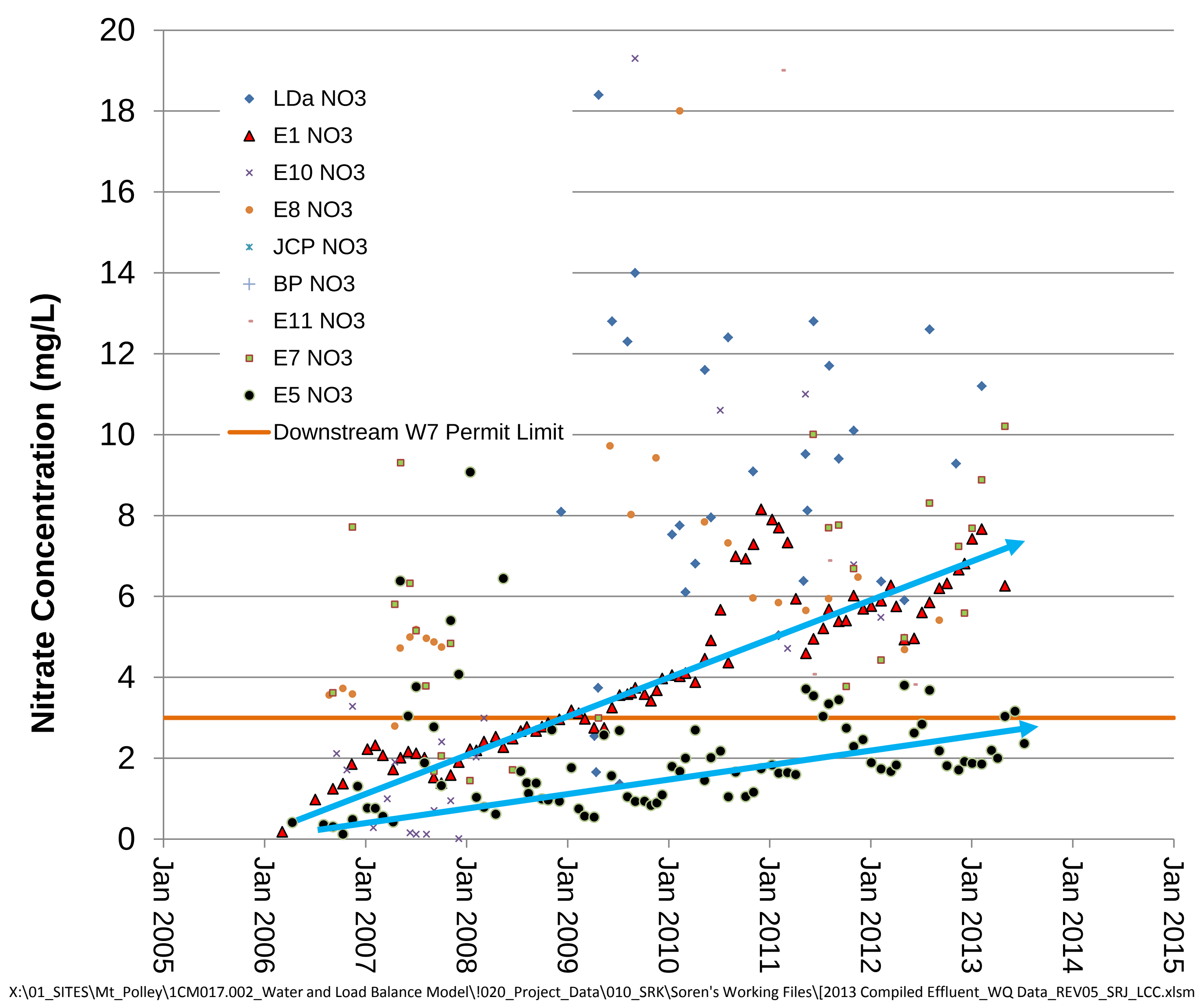
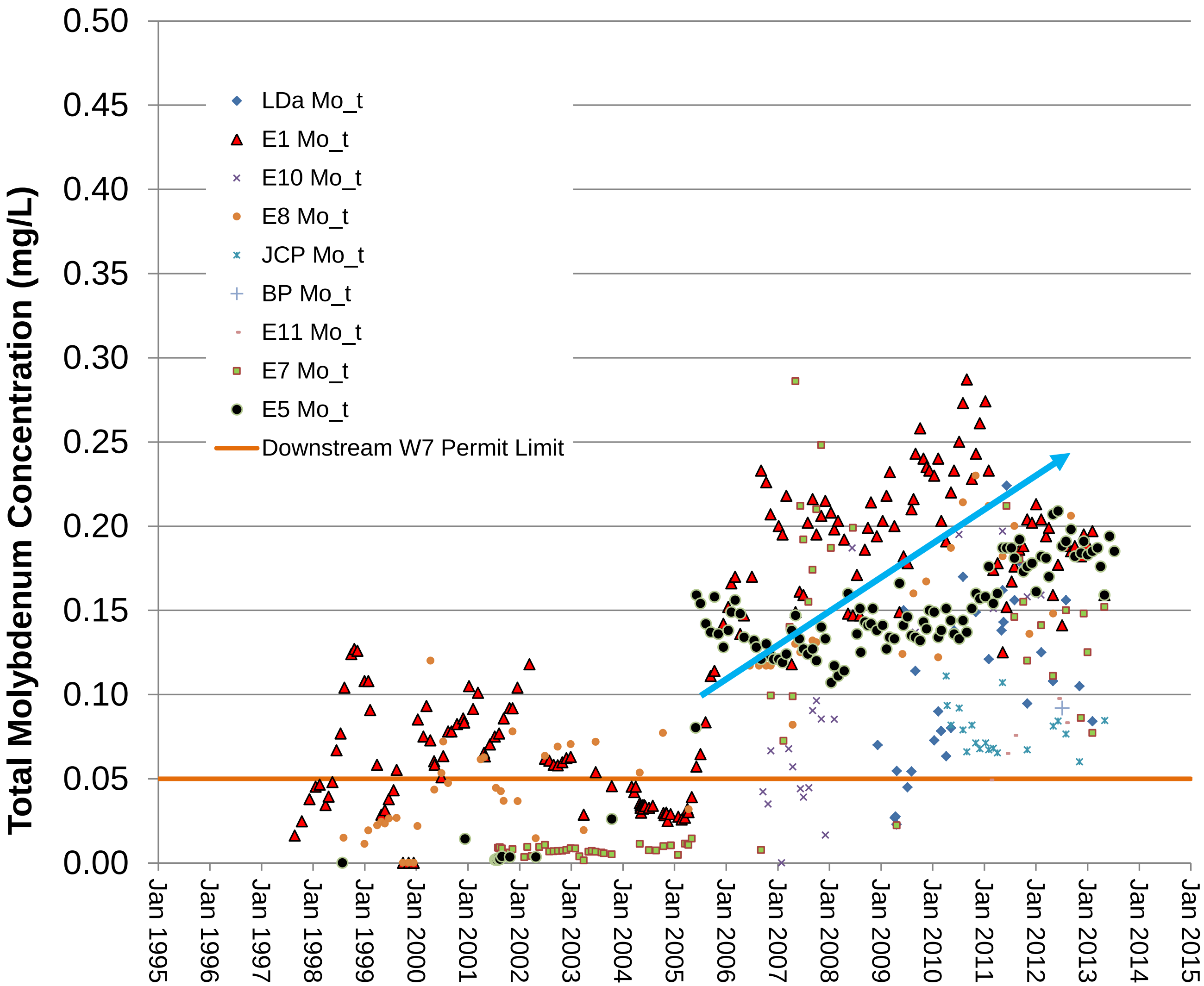
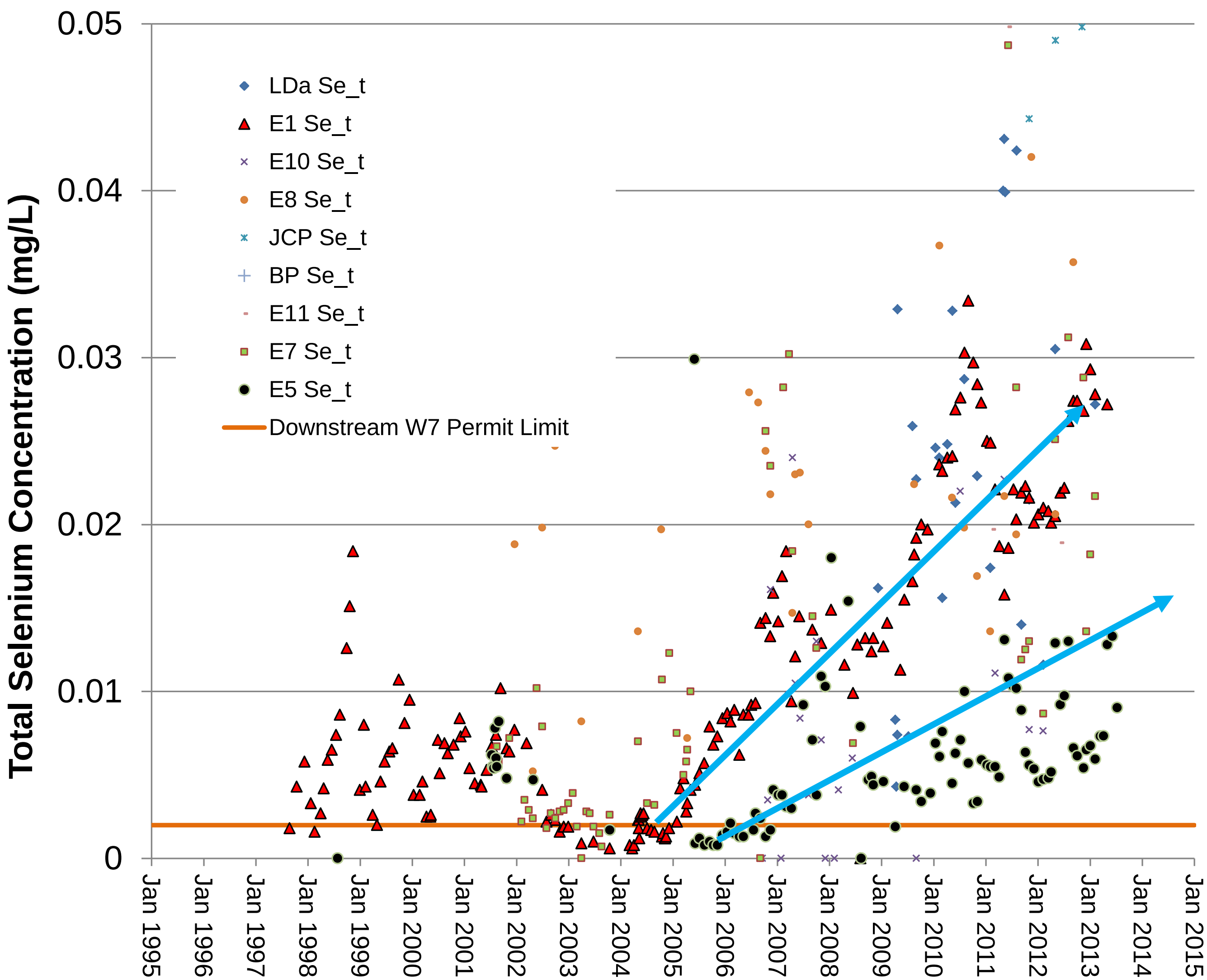



**Figure 6: Nitrate Concentrations in Mount Polley Mine Water**



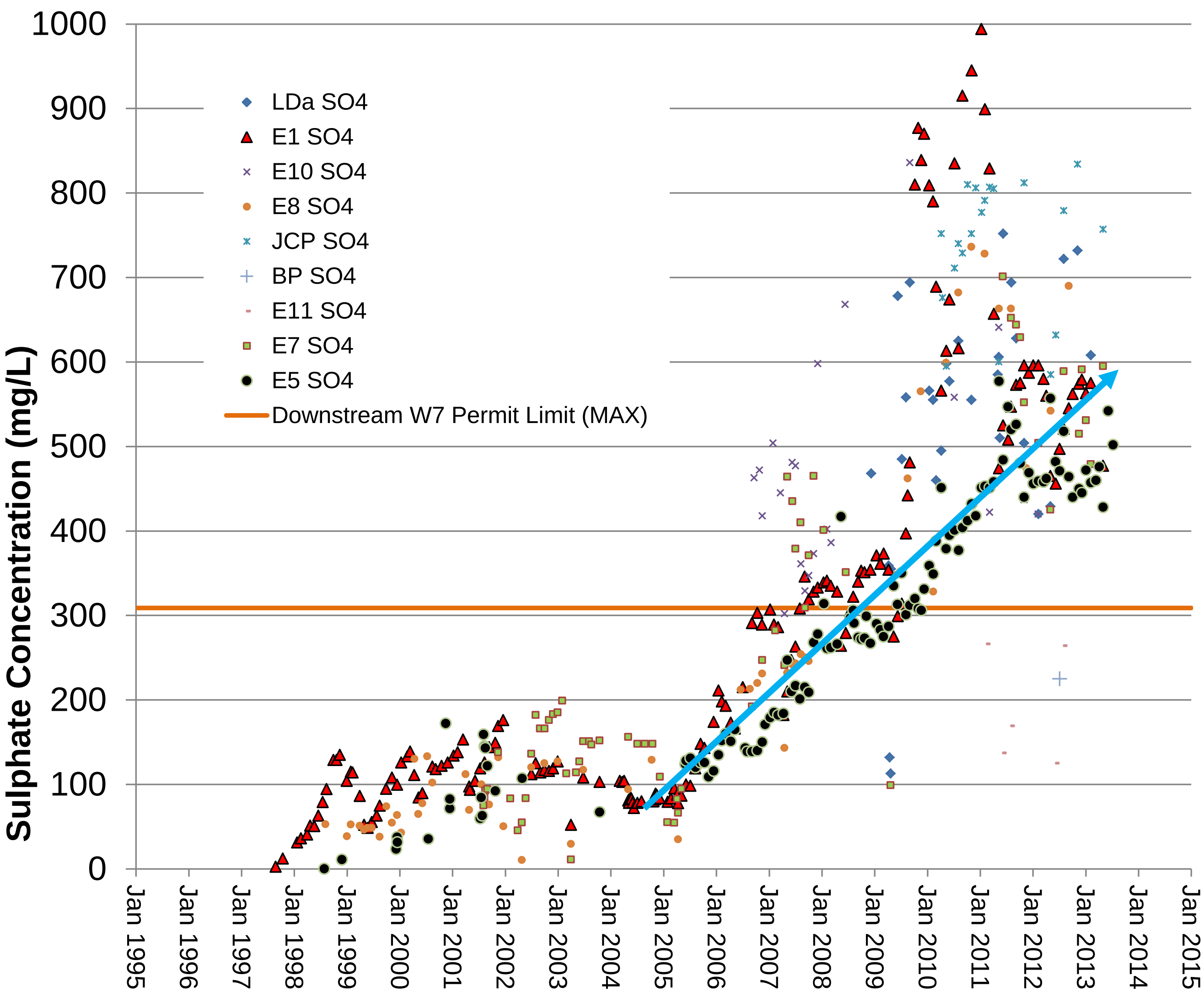

X:\01_SITES\Mt_Polley\1CM017.002_Water and Load Balance Model\!020_Project_Data\010_SRK\Soren's Working Files\[2013 Compiled Effluent_WQ Data_REV05_SRJ_LCC.xlsm

**Figure 7: Total Molybdenum Concentrations in Mount Polley Mine Water**



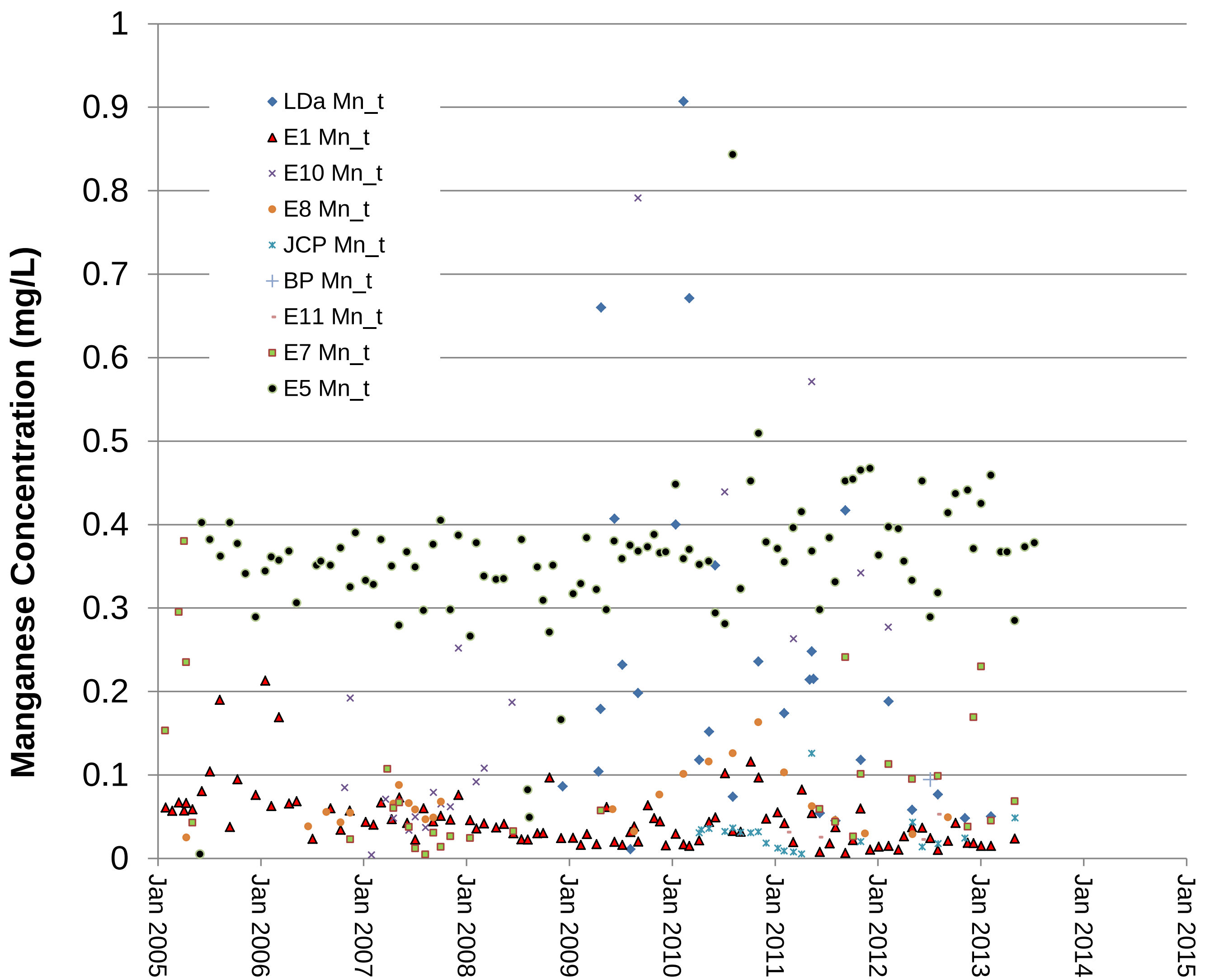

X:\01_SITES\Mt_Polley\1CM017.002_Water and Load Balance Model\!020_Project_Data\010_SRK\Soren's Working Files\[2013 Compiled Effluent_WQ Data_REV05_SRJ_LCC.xlsm

**Figure 8: Total Selenium Concentrations in Mount Polley Mine Water**



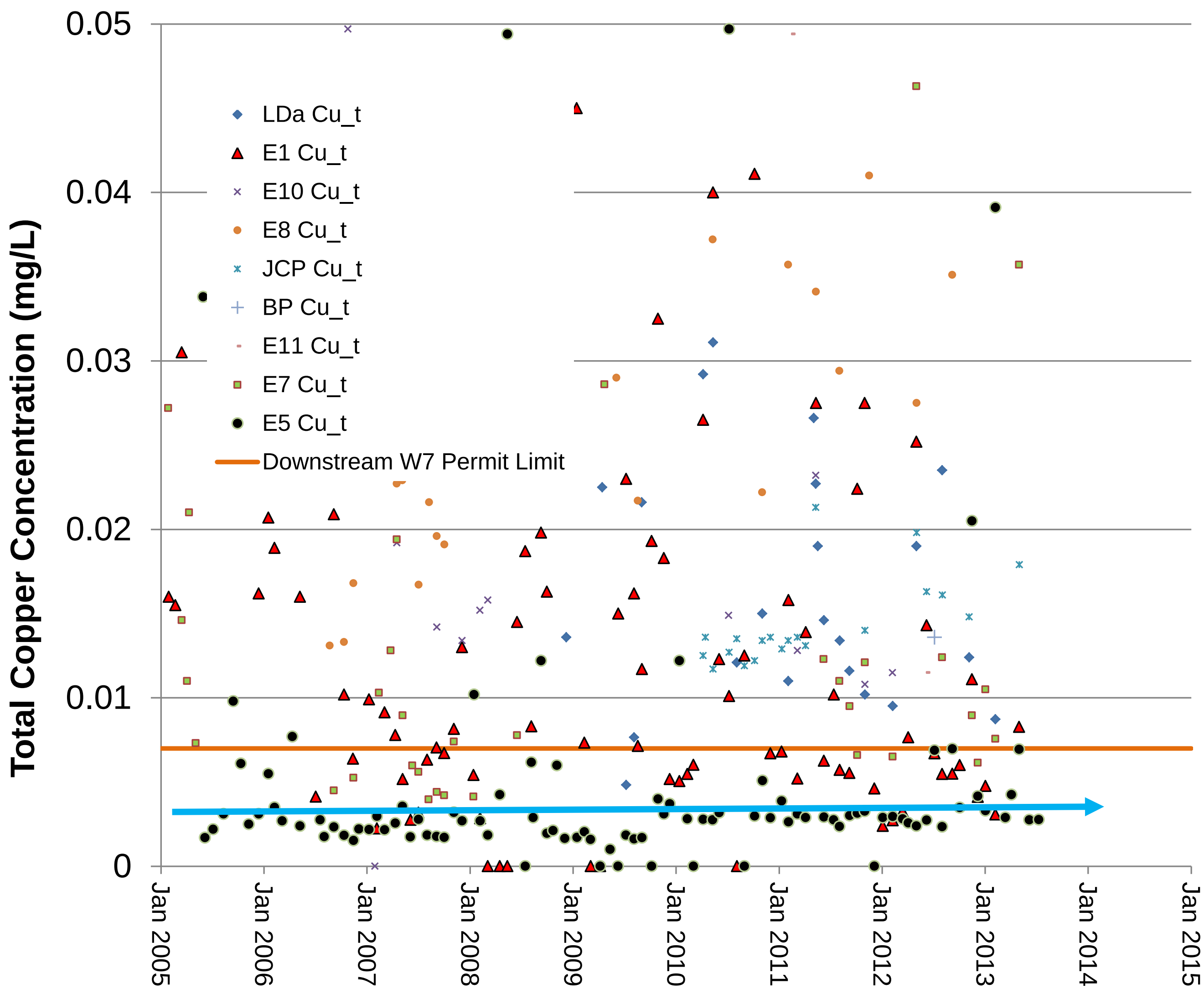

X:\01_SITES\Mt_Polley\1CM017.002_Water and Load Balance Model\!020_Project_Data\010_SRK\Soren's Working Files\[2013 Compiled Effluent_WQ Data_REV05_SRJ_LCC.xlsm

**Figure 9 Sulphate Concentrations in Mount Polley Mine Water**



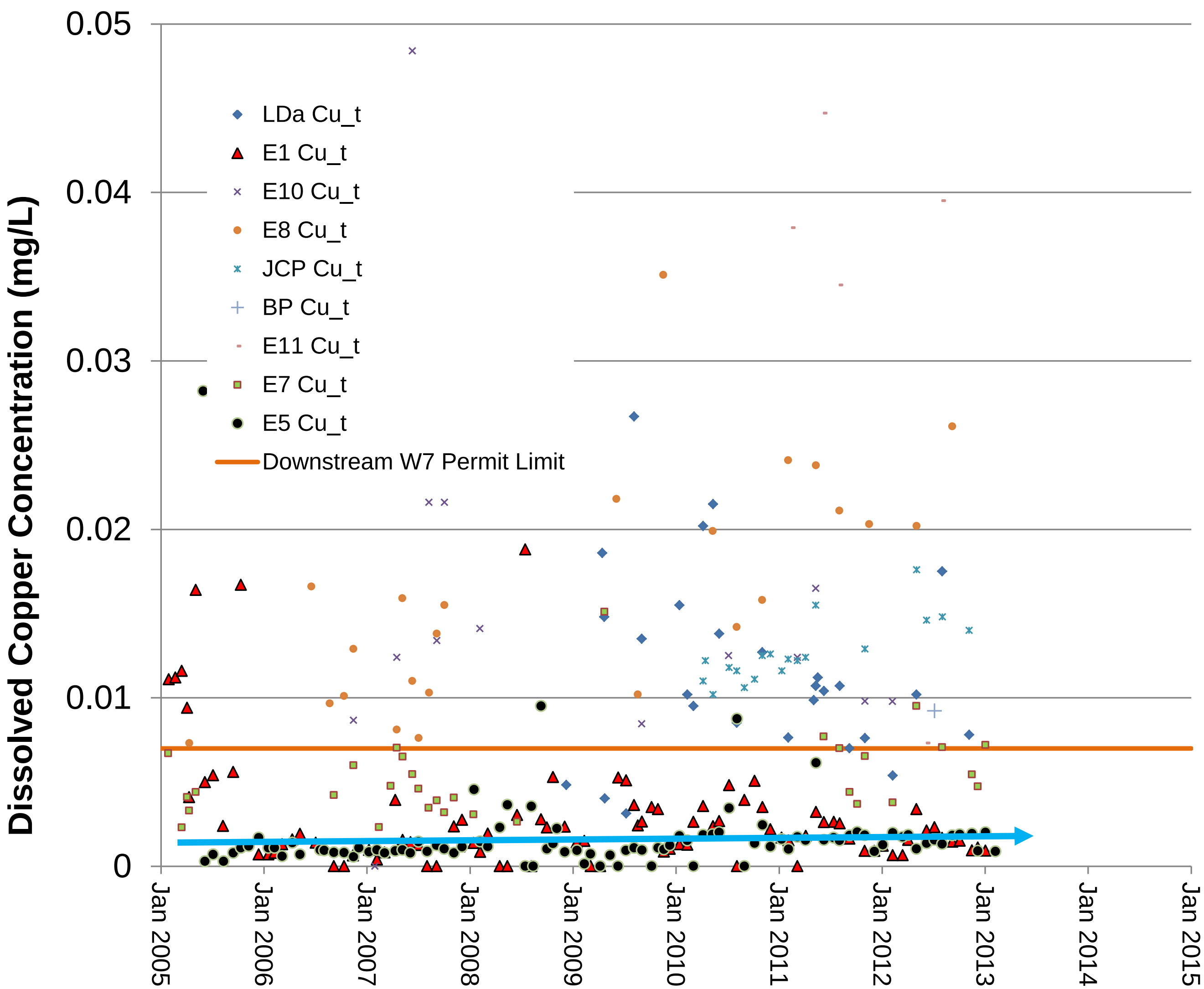

X:\01_SITES\Mt_Polley\1CM017.002_Water and Load Balance Model\!020_Project_Data\010_SRK\Soren's Working Files\[2013 Compiled Effluent_WQ Data_REV05_SRJ_LCC.xlsm

**Figure 10: Manganese Concentrations in Mount Polley Mine Water**



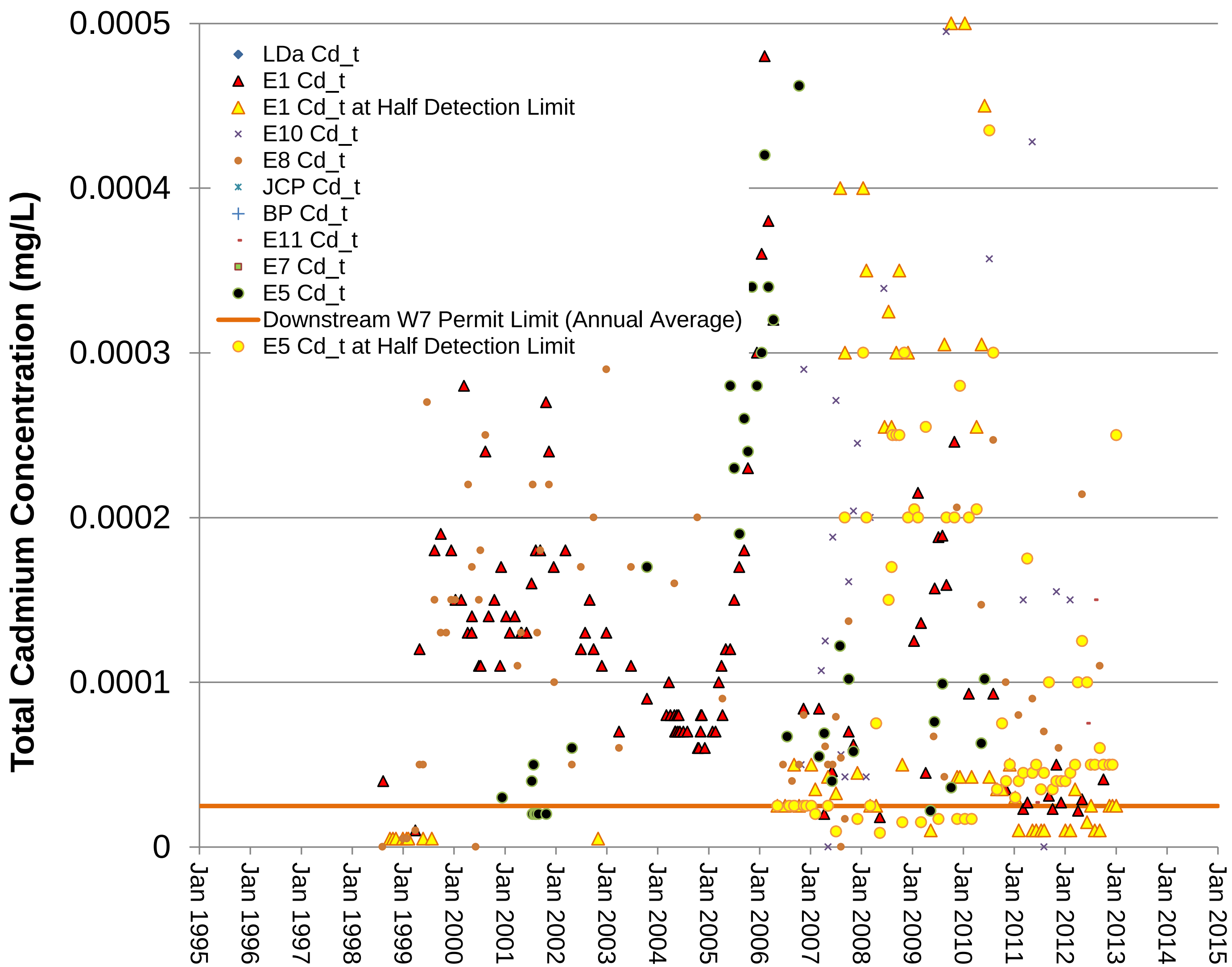

X:\01_SITES\Mt_Polley\1CM017.002_Water and Load Balance Model\!020_Project_Data\010_SRK\Soren's Working Files\[2013 Compiled Effluent_WQ Data_REV05_SRJ_LCC.xlsm

**Figure 11: Total Copper Concentrations in Mount Polley Mine Water**




X:\01_SITES\Mt_Polley\1CM017.002_Water and Load Balance Model\!020_Project_Data\010_SRK\Soren's Working Files\[2013 Compiled Effluent_WQ Data_REV05_SRJ_LCC.xlsm

**Figure 12: Dissolved Copper Concentrations in Mount Polley Mine Water**




X:\01_SITES\Mt_Polley\1CM017.002_Water and Load Balance Model\!020_Project_Data\010_SRK\Soren's Working Files\[2013 Compiled Effluent_WQ Data_REV05_SRJ_LCC.xlsm

**Figure 13: Total Cadmium Concentrations in Mount Polley Mine Water**

# 5 Discharge Constraints

## 5.1 Hazeltine Creek Water Quality

A mass balance was used to estimate monthly allowable discharge rates, from the MTD or TMF into Hazeltine Creek using the following equation:

$$Discharge\ Flow\ \left(\frac{m^3}{s}\right) = \frac{\left(Backgr.Conc\left(\frac{mg}{L}\right) - Permit\ Conc\left(\frac{mg}{L}\right)\right) Upstream\ flow\left(\frac{m3}{s}\right)}{Permit\ Conc\left(\frac{mg}{L}\right) - Effluent\ Conc.\left(\frac{mg}{L}\right)} \qquad \text{(Equation 2)}$$

Current concentrations of nitrate, copper, molybdenum, selenium and sulphate from the TMF, MTD and Hazeltine Creek and monthly average flows were used in the mass balance (Table 10).

**Table 10: Constituent concentrations used to estimate discharge limits. Units are mg/L**

| Location | Nitrate | Total Copper | Total Molybdenum | Total Selenium | Sulphate |
|---|---|---|---|---|---|
| Hazeltine Creek | 0.0014 | 0.0029 | 0.0018 | 0.00058 | 24 |
| MTD | 1.09 | 0.0038 | 0.179 | 0.016 | 455 |
| TMF | 6.2 | 0.009 | 0.179 | 0.03 | 539 |

Source: Z:\01_SITES\Mt_Polley\1CM017.002_Water and Load Balance Model\!020_Project_Data\010_SRK\Soren's Working Files\Discharge Strategy WQ 2013 (MTD Only) for Discharge Plan_Rev9_SB.xlsm

Table 11 presents the maximum allowable annual discharge volumes from the TMF and MTD based on the current concentrations of nitrate, copper, molybdenum, selenium and sulphate within Hazeltine Creek. These estimates are based on average Hazeltine Creek hydrologic conditions, and assume that discharge only occurs between April and July.

**Table 11: Maximum Discharge of Untreated Water from the TMF or MTD during an average runoff year in Hazeltine Creek.**

| Parameter | Max Untreated Discharge From: | |
|---|---|---|
| | TMF ($Mm^3$/year) | MTD ($Mm^3$/year) |
| Nitrate | 4.2 | Not limited |
| Total Copper | 6.6 | Not limited |
| Total Molybdenum | 0.7 | 1.7 |
| Total Selenium | 0.2 | 0.4 |
| Sulphate | 5.5 | 2.4 |

Source: \\VAN-SVR0\Projects\01_SITES\Mt_Polley\1CM017.002_Water and Load Balance Model\!020_Project_Data\010_SRK\Soren's Working Files\ Discharge Strategy WQ 2013 (MTD Only) for Discharge Plan_Rev9_SB.xlsm

Note: Red shading indicates constituents already exceed discharge loading limit.

Selenium and molybdenum are currently the only two parameters that limit the allowable discharge of untreated water from the TMF (Table 11). Nitrate, total copper and sulphate concentrations do not restrain the TMF discharge volume below the annual volume limit. Selenium limits the discharge volume from the MTD. Nitrate and copper concentrations within the MTD are currently below the permitted discharge limit in the MTD. Under current conditions, the available volume of water discharged from either the TMF or MTD is much less than the maximum amount permitted, due to quality constraints.

The current sediment selenium concentrations in Hazeltine Creek exceed the permit limit (2 mg/kg). SRK understands that MPMC can discharge water on the condition that sediment concentrations are monitored, and remain below 5 mg/kg.

## 5.2 Discharging Treated Water from the TMF

### 5.2.1 Approach and Assumptions

The current discharge load of selenium and molybdenum must be reduced to discharge the maximum permitted volume (1.4 $Mm^3$) to Hazeltine Creek. Treatment will reduce the load of these constituents. In the future, nitrate and/or sulphate treatment may also be needed. Treatment targets for selenium, molybdenum, nitrate and sulphate (in mg/L) were estimated for discharging from 1.4 $Mm^3$ to 4.0 $Mm^3$ of treated water annually. This assumes the current permit limits in Hazeltine Creek (W7) would remain in effect and TMF water is treated.

TMF concentrations of selenium, molybdenum, nitrate-N and sulphate between May 2012 and May 2013 were averaged. As a contingency, average concentrations and hydrologic inputs were increased by 25%.

### 5.2.2 Results

The treatment targets for selenium, molybdenum, sulphate, and nitrate were calculated. Table 12 presents the water treatment target concentration ranges on an average annual basis, as well as the current TMF concentrations and the limit for each parameter set in the discharge permit. Two treatment and discharge options were evaluated. For Option 1 treatment rate would be constant. For Option 2 the treatment rate would vary to match the hydrograph of Hazeltine Creek to take advantage of the maximum dilution capacity in Hazeltine Creek.

Table 12 shows the target concentration for the annual discharge volumes for each treatment option. The target concentrations decrease with increasing discharge volumes because the dilution capacity in Hazeltine Creek remains constant.

**Table 12: Water Treatment Target Ranges for TMF water**

| Condition | Annual Discharge Volume ($Mm^3$) | Target Effluent Concentration from TMF (mg/l) | | | |
|---|---|---|---|---|---|
| | | Selenium | Molybdenum | Sulphate | Nitrate |
| **TMF Current Concentration** | - | 0.03 | 0.2 | 539 | 6.2 |
| **W7 Permit Concentration** | - | 0.002 | 0.05 | 309 | 3 |
| **Option 1**<br>**Water Treatment at Constant Rate** | 1.4 | 0.003 | 0.08 | 473 | 5 |
| | 2 | 0.0026 | 0.07 | 424 | 4 |
| | 3 | 0.0024 | 0.06 | 386 | 4 |
| | 4 | 0.0023 | 0.06 | 366 | 4 |
| **Option 2**<br>**Water Treatment Variable According to Hydrograph** | 1.4 | 0.005 | 0.17 | 1028 | 11 |
| | 2 | 0.004 | 0.13 | 813 | 8 |
| | 3 | 0.004 | 0.12 | 731 | 7 |
| | 4 | 0.004 | 0.12 | 731 | 7 |

\\VAN-SVR0\Projects\01_SITES\Mt_Polley\1CM017.002_Water and Load Balance Model\!020_Project_Data\010_SRK\Soren's Working Files\ Discharge Strategy WQ 2013 (MTD Only) for Discharge Plan_Rev9_SB.xlsm

# 6 Conclusions

Mount Polley Mine Corporation requested SRK prepare a screening level site wide water and load balance to assess the discharge requirements from the TMF against the permit requirements specified in Permit 11678. This analysis included an annual water balance around the TMF, a hydrologic analysis on the variability of flow within Hazeltine Creek, an assessment of the water quality across the site, and an estimation of allowable discharge volumes as well as treatment requirements.

The following conclusions were made based on this analysis:

- With the expected increase in total mine catchment area, the 1.4 $Mm^3$ will be exceeded on an average basis (1.7 $Mm^{3)}$ in an average precipitation year and 3.2 $Mm^3$ in a year with 808 mm precipitation).
- The 35% maximum discharge criteria becomes limiting during to a 1 in 5 dry year or drier years.
- There are no "hot spot" loading sources that contribute a disproportionate amount of constituent loadings to the TMF.
- Increases in selenium, molybdenum, nitrate and sulphate have been trending up since the mine operation resumed in 2005. These increases are expected to continue until their solubility limits are reached or until the end of the milling and mining process.
- Some metals, including copper and uranium, show no change in concentrations in the TMF due to precipitation in the milling process. After closure of the mine, when the milling process is no longer operational, it is possible that the concentrations will increase in the TMF.
- In order to achieve the desired 1.4 $Mm^3$ of annual mine water discharge, treatment will be required to reduce the concentrations of selenium and molybdenum and likely for sulphate and nitrate depending on the water treatment capacity.

# 7 Recommendations

Based on the site wide water balance and water quality review SRK recommends the following:

- Develop a strategy for obtaining permission to increase the volume of allowable discharge from site.
- Implement flow monitoring for the MTD flow.
- Request that the external laboratory use a lower analytical detection limit for cadmium.
- Evaluate short- and long-term water treatment options.

This report, *"Mount Polley Water Management Assessment - DRAFT"*, was prepared by

*This signature was scanned with the author's approval for exclusive use in this document; any other use is not authorized.*

Samantha Barnes, EIT
Staff Consultant

*This signature was scanned with the author's approval for exclusive use in this document; any other use is not authorized.*

Soren Jensen, PEng
Senior Consultant

and reviewed by

*This signature was scanned with the author's approval for exclusive use in this document; any other use is not authorized.*

Tom Sharp, PhD, PEng
Principal Consultant

All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

**Disclaimer**—SRK Consulting (Canada) Inc. has prepared this document for Mount Polley Mining Corporation. Any use or decisions by which a third party makes of this document are the responsibility of such third parties. In no circumstance does SRK accept any consequential liability arising from commercial decisions or actions resulting from the use of this report by a third party.

The opinions expressed in this report have been based on the information available to SRK at the time of preparation. SRK has exercised all due care in reviewing information supplied by others for use on this project. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information, except to the extent that SRK was hired to verify the data.

# 8 References

British Columbia Ministry of Environment [ BC MOE]. 2013. Amended Permit 11678. Issued to Mount Polley Mining Corp. Authorization No.: 11678. June 2013.

Environment Canada [EC]. 2013a. Spokin Lake

Environment Canada [EC]. 2013b. Borland Creek

Knight Piésold Consulting [KP]. 2009. Assessment of Hazeltine Creek flows. Letter prepared for Mount Polley Mining Corporation. Project Reference: VA101-1/25-A.01. April 2009.

Knight Piésold Consulting [KP]. 2011. 2010 Flows in Hazeltine Creek. Letter prepared for Mount Polley Mining Corporation. File No.: VA101-1/30-A.01. February 2011

Imperial Metals. 2010. Annual Information Form for the Year Ended December 31, 2009. Vancouver.

Mount Polley Mining Corporation. 2013. 2012 Environmental and Reclamation Report. Prepared for Ministry of Energy and Mines (Mines Act Permit M-200), and Ministry of Environment. March 2013.

SRK Consulting (Canada) Inc., 2013. Water Management Strategy, Mount Polley Mine – DRAFT. Prepared for Mount Polley Mining Corporation. Project No.: September 23, 2013.