Mount Nansen Closure Alternatives Water Balance/Water Quality Model

Description of Model Configuration and Water Quality Predictions (Updated Final Draft)

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1 Introduction

The overall objective of the modeling work was to develop an integrated water balance/water quality model to support the ongoing assessment of closure alternatives for the Mount Nansen Mine Site. The model was developed in Goldsim, a Monte Carlo simulator commonly used for water balance and water quality modeling at mine sites. This work built upon previous modeling efforts completed in 2009/2010 and incorporated additional information developed in 2010 and 2011 to further develop and characterize closure options for the site. The model was then used to assess the long-term performance of the closure options being evaluated with respect to predicted water quality in the downstream receiving environment in Victoria Creek. The six closure options evaluated as part of this work were:

- Option 1A – Tailings Dam Upgrade with Water Cover and Waste Rock in Place;
- Option 1B – Tailings Dam Upgrade with Water Cover and Waste Rock Backfill into Pit;
- Option 2A – Tailings Dam Upgrade with Saturated Soil Cover and Waste Rock in Place;
- Option 2B – Tailings Dam Upgrade with Saturated Soil Cover and Waste Rock Backfill into Pit;
- Option 3 – Tailings Backfill into Pit with High Infiltration Cover and Waste Rock in Place; and
- Option 4 – Tailings and Waste Rock Backfill into Pit with Low-Infiltration Cover.

The model incorporated various water balance and geochemical inputs developed by others including:

- Characterization of site hydrology and climatic conditions (AECOM 2010a);
- Definition of physical and geotechnical characteristics of each closure option (AECOM 2010b);
- Source term chemistry (Lorax 2010a);
- Hydrogeological characterization of the tailings and pit (AECOM 2010c);
- One-dimensional water balance modeling of tailings cover options (Golder 2010a);
- One-dimensional water balance modeling of waste rock backfill (Golder 2010a); and
- Low-Infiltration cover assessment and modeling (Golder 2010b)

For each closure option, the water quality model was run using monthly time steps. This time interval of the model output was selected as it is consistent with the quality of the input data and allows for the assessment of seasonal variations in water quality. For each option, two sets of source terms were developed and incorporated in to the model: Best Estimate and Upper Estimate. In addition, three different climatic conditions were evaluated for each source term scenario: dry, average and wet precipitation condition. Specific details for the model configuration, assumptions and results are discussed in the following sections.

2 Site Climate, Hydrology and Water Quality Model Assumptions

2.1 Climate

2.1.1 Precipitation

A historical climate record for precipitation was generated for the site for the period 1964 to 2006 based on climate data collected at the Environment Canada station at Carmacks (AECOM 2010a). The following provides an overview of this analysis. Specific details are provided in *Development of a Mount Nansen Precipitation, Temperature, and Evaporation Data Record and Pit and Tailings Pond Inflow Volume Estimation* (AECOM 2010a).

For summer precipitation, or rainfall, a relationship was developed using monthly precipitation data from the Carmacks climate station and the climate station at Mount Nansen for the overlapping period between 2000 and 2006. Using this relationship, the historical daily rainfall data from the Carmack's station were used to generate a proxy historical daily precipitation record for Mount Nansen. Based on this synthetic record, dry, wet and average precipitation conditions were selected. The year 1976 was selected as the dry year, 2000 was selected as the wet year, and 2003 was selected s a typical or average year. Monthly precipitation for each precipitation condition is presented in Table 2-1.

Table 2-1 Monthly Precipitation for Dry, Average and Wet Year Condition (mm)

Month	Dry Year	Average Year	Wet Year
April	57.0	46.1	63.3
May	31.4	34.1	61.9
June	31.1	68.0	47.0
July	46.9	61.0	88.0
August	7.9	38.0	117.0
September	0.5	13.0	85.0
October	5.2	23.0	10.0
Total	180.0	283.2	472.2

For snowfall and the calculation of end of March snow water equivalents (SWE), a regression formula was developed using accumulated snow at Carmacks from November 1 through March, in conjunction with the end of March SWE measured at Mount Nansen as part of the annual snow survey program. An additional correlation was then developed to account for any additional snowfall during the month of April based on April precipitation at site and Carmacks for the period of 2000 to 2006. For snowmelt it is assumed that 82% of the annual snow accumulation melts between April 15th and April 30th and 18% between from May 1st and May 7th.

2.1.2 Evaporation

There are no direct evaporation data available for the Mount Nansen site. Lake evaporation rates estimated for the Pelly Ranch Environment Canada Meteorological gauging station were used to estimate evaporation at Mount Nansen (AECOM 2010a). Mean annual lake evaporation for the site was estimated to be 369 mm occurring from May to September, with the majority occurring in June and July. Monthly mean lake evaporation rates are provided in Table 2-2.

Table 2-2 Monthly Evaporation (mm)

Month	Evaporation (mm)
May	85
June	98
July	90
August	65
September	31
Total	369

2.2 Hydrology

Using the annual precipitation for dry, average and wet year conditions, monthly flows were calculated for each precipitation condition at various locations in the mine site catchment including Dome Creek (AECOM 2010a). For the months with measurable rainfall and snowmelt (April through October) the total volume of surface flow for each month was calculated according to the following:

Monthly volume of surface flow = monthly precipitation x runoff coefficient x catchment area

A runoff coefficient of 0.6 was used for the summer months and a spring runoff coefficient of 0.8 was used for the months of April and May. Runoff coefficient estimates provided in AECOM (2010a) were not derived from site or local measurements, but were based on professional judgment.

Attempts to measure flow in winter showed that Dome Creek and Pony Creek were frozen to the substrate. As a result, zero flow was assumed for Dome Creek during the winter months (November through March).

In contrast to Dome Creek, Victoria Creek experiences some flow during the winter period, as revealed by on-site monitoring. For the Victoria Creek catchment, a different approach was adopted to calculate monthly stream flows based on the monthly distribution of annual flow as measured at the Water Survey Gauging Station on the Nordenskiold River (Table 2-3).

Table 2-3 Monthly Steam Flow Distribution for Victoria Creek

Month	Monthly Flow Distribution (%)
January	1.2
February	0.6
March	0.7
April	5
May	25.9
June	18.7
July	12.8
August	11.3
September	11.2
October	7.2
November	3.4
December	2

2.3 Water Quality

2.3.1 Summary of Existing Conditions

The Mount Nansen site is shown in relation to the receiving environment and the water quality monitoring stations in Figure 2-1. The Upper Dome Creek monitoring site is situated downstream of the tailings facility, just downstream of where tailings seepage water enters Dome Creek. Upstream of the tailings facility on Dome Creek, there are two water quality monitoring locations, DX and D1. The mill complex is situated in between these two stations. Flow at the Upper Dome Creek monitoring site is a combination of flow through the diversion channel and flow from the continuous discharge from the seepage pond. The receiving environment site for Victoria Creek is represented by the sampling location Vic @ Road. This location is downstream of inputs from both Dome Creek and Back Creek, and includes all potential mine site related inputs to the receiving environment. In contrast to Dome Creek, Victoria Creek is known to support fish and fish habitat.

A large amount of baseline water quality data were collected over the past ten years at the Mount Nansen site. Surface water quality sampling began in 1999 by the Department of Indian and Northern Affairs (DIAND). The Government of Yukon took over the sampling program in 2003, and in 2005 contracted this work to Environmental Dynamics (EDI), who continue to oversee site monitoring. In 2009, AECOM prepared a comprehensive compilation of the available site water quality data up to October 2009 (AECOM 2010d). Review of the compiled water quality data indicated a marked improvement in parameter detection limits after December 2007. Since 2007, water quality samples have been consistently analyzed at one laboratory at suitable detection limits to allow comparison to CCME Guidelines for the Protection of Aquatic Life. In consideration of this change in 2007, water quality data for modeling purposes was limited to data collected between December 2007 and July 2010.

In general, the water quality data for Victoria Creek upstream of the Dome Creek confluence (Victoria Upstream and Victoria Reference) show comparable water quality compositions (Figure 2-2). In contrast, inspection of the water quality data for Victoria Creek downstream of the Dome Creek confluence (Vic @ Road) shows a clear mine-related influence. For example, sulfate concentrations in Victoria Creek downstream of Dome Creek (mean = 28.5 mg/L) exhibit a pronounced increase in comparison to levels upstream of Back Creek (Victoria Reference mean = 12.3 mg/L) and downstream of Back Creek (Upper Victoria mean = 13.4 mg/L) (Figure 2-2). Despite the mine-related loadings from Dome Creek, sulfate concentrations in Victoria Creek remain below the working sulfate guideline (British Columbia Approved Water Quality Guideline of 100 mg/L) for all stations and time periods.

Inter-station comparisons on Victoria Creek were also conducted for the main trace elements of concern (arsenic, zinc and cadmium) (Figure 2-2). Dissolved metals, as opposed to total concentrations, were selected for the spatial comparison in order to isolate mine-related influences, and to specifically rule out the interfering effects of suspended solids contributed by both natural and anthropogenic sources (e.g., placer mining activity). In general, metal concentrations upstream of the Dome Creek confluence (Victoria Upstream and Victoria Reference) are low and show good between-station consistency. Downstream of Dome Creek, the concentrations of dissolved arsenic show well defined increases, reflecting the contribution of mine-related inputs. Dissolved arsenic concentrations in Victoria Creek increase by almost an order of magnitude from upstream values of ~0.0004 mg/L to mean levels downstream of Dome Creek of 0.003 mg/L (Figure 2-2). At all sites, dissolved arsenic values remain below the water quality guideline of 0.005 mg/L.

The downstream trends for dissolved zinc and dissolved cadmium are less pronounced than those observed for sulfate and dissolved arsenic. Mean values for dissolved zinc below the Dome Creek confluence (0.0041 mg/L) show only a minor increase in concentration in comparison to levels observed upstream (mean = 0.0027 mg/L). Similarly, inputs from Dome Creek have only a minor influence on dissolved cadmium concentration in Victoria Creek. Dissolved cadmium concentrations upstream of Dome Creek (mean = 0.000023 mg/L) are only marginally lower than those values reported downstream of the Dome Creek confluence (mean = 0.000027 mg/L).

Collectively, the water quality data for Victoria Creek demonstrate that inputs from Dome Creek have a marked effect on water quality with respect to sulfate and arsenic. Minor mine-related signatures from Dome Creek with respect to zinc and cadmium are also observed; however, the effect on these parameters is far less pronounced. In consideration to the conditions currently observed in Victoria Creek, the existing levels of sulfate, arsenic, zinc and cadmium are not anticipated to have adverse effects on aquatic communities. This conclusion relates to the absolute concentrations currently observed, principles of metal bioavailability (i.e., toxicity dependent on free ion activity), as well as to the hardness-dependent toxicity characteristics of sulfate, cadmium and zinc.

2.3.2 Background Water Quality Assumptions

2.3.2.1 Use of Median Value

The primary objective of this document is to provide the technical information necessary from which to evaluate the merits of each closure alternative by stakeholders, including local communities, as well as federal, Yukon and First Nation governments. In order to best illustrate the differences between the closure options with regards to water quality, background conditions were assigned median values for "total" metals in the model. The rationale for the use of total metals, and the use of annual median values as opposed to monthly values, is as follows:

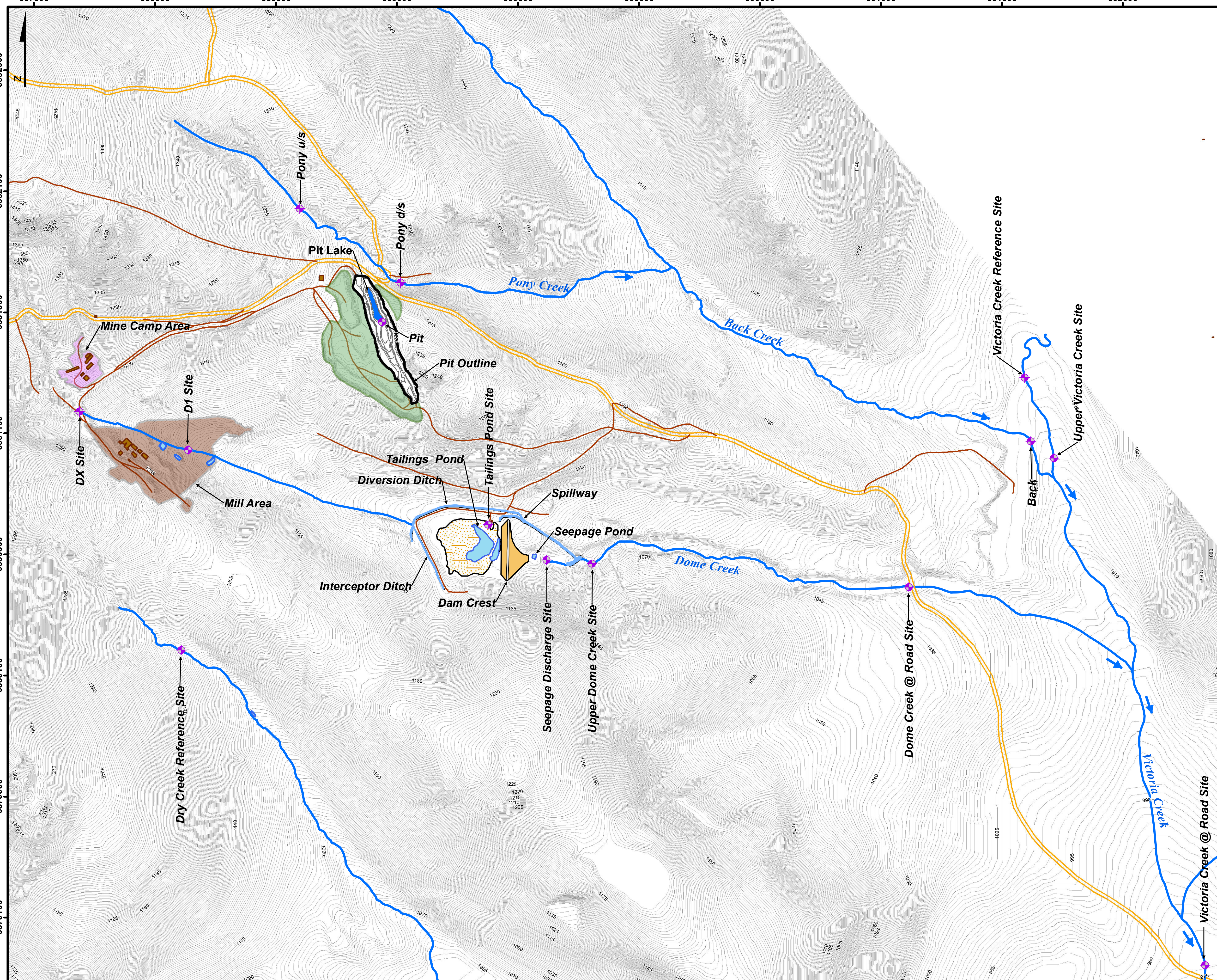
1. Inclusion of the full range in seasonal total metal levels will generate very high values for some metals at the downstream sites. This will act to overwhelm the mine-related signature and prevent adequate differentiation of the various closure options;
2. Metal levels in Victoria Creek and Back Creek are governed predominantly by particulate fractions, with maximum metal levels occurring commensurately with elevated TSS. However, there are no consistent seasonal trends in the data, which imply TSS events are governed by variables other than freshet flows, such as storm events and placer mining activities. Accordingly, it is difficult to assign defensible monthly total metal values;
3. From the perspective of metal bioavailability, it is now widely accepted that the toxicity of metals in natural waters is greatly dependent on their chemical form, and that the total metal concentration is generally a poor predictor of its biological impact. Specifically, it is recognized that for most trace elements, biologically availability and hence toxicity is governed by the concentration of the free metal-ion (or free ion activity). Accordingly, given that the median "total" background values include a high proportion of particulate species, the model will overestimate the biologically-available fraction. This adds an element of conservatism into the model;
4. Background concentrations for the winter months were assigned median values based largely on samples collected during the ice-free months. Given that samples collected during the ice-free months contain a significant proportion of particulate metals, it is likely that the median values overestimate the values observed during the winter months. This adds a further element of conservatism into the model;
5. Worst-case parameter concentrations are predicted for the low flow months, and therefore these months will be the focus of the options comparison. TSS concentrations, and hence particulate metal levels, are predicted to be low during the winter months, and hence the considerations with regards to the use of total metals has less relevance during these critical periods; and
6. The use of dissolved metal values was also avoided, given the questionable reliability of the data with regards to the lack of field filtration and the long holding times between sample collection and filtration at the laboratory.

2.3.2.2 Removal of Mill Area Influence

Assessment of all existing water quality at site (AECOM, 2010d) indicated that the mill site area is a source of contaminants to Dome Creek upstream of the tailings area. Review of the baseline data at D1 and DX indicates that the mill area has an influence on the water quality at D1 for arsenic, cadmium, manganese, zinc, sulfate, calcium, magnesium and hardness (Table 2-4). Given that reclamation of the mill area is common closure element to all six options being evaluated, the background concentrations (median) for arsenic, cadmium, zinc, sulfate, calcium, and magnesium in Dome Creek were assigned those values for Station DX. Selection of the DX water quality as input into the mass loading model allows for more effective differentiation of the performance of the various closure options.

Table 2-4 Summary of Water Quality at D1 and DX in Dome Creek (Median of 2007 to 2010 dataset)

	Median Concentration (mg/L) (2007 to 2010)	
	DX	**D1**
Sulfate	156	412
Total Arsenic	0.005	0.015
Total Cadmium	0.00004	0.00179
Total Manganese	0.064	0.252
Total Zinc	0.009	0.397
Total Calcium	65.9	170.5
Total Magnesium	16.7	54.7
Hardness	233	652



CLIENT::

Yukon Government

Legend

- Surface Water Quality Stations
- Mine Road
- Public Road
- Mill Area
- Mine Camp Area
- Tailings Dam
- Ponds
- Tailings
- Mine Infrastructure
- Pit Outline
- Waste Rock Area

Topography (Except Pit)

- Index (5m)
- Interm. (1m)

Meters 0 250 500 1,000

Data courtesy of AECOM

Figure for illustrative purposes only

SCALE:	1:15,000
DATE:	NOV 2nd, 2010
PROJECTION:	NAD_1983_UTM_Zone_8N
PROJECT MANAGER:	J.S.

PROJECT:

Mount Nansen Water Balance and Water Quality Predictions

TITLE: **Mount Nansen Mine Site Current Conditions and Surface Water Quality Monitoring Stations**

PROJECT No:	FIGURE No:
J907-4	**2-1**

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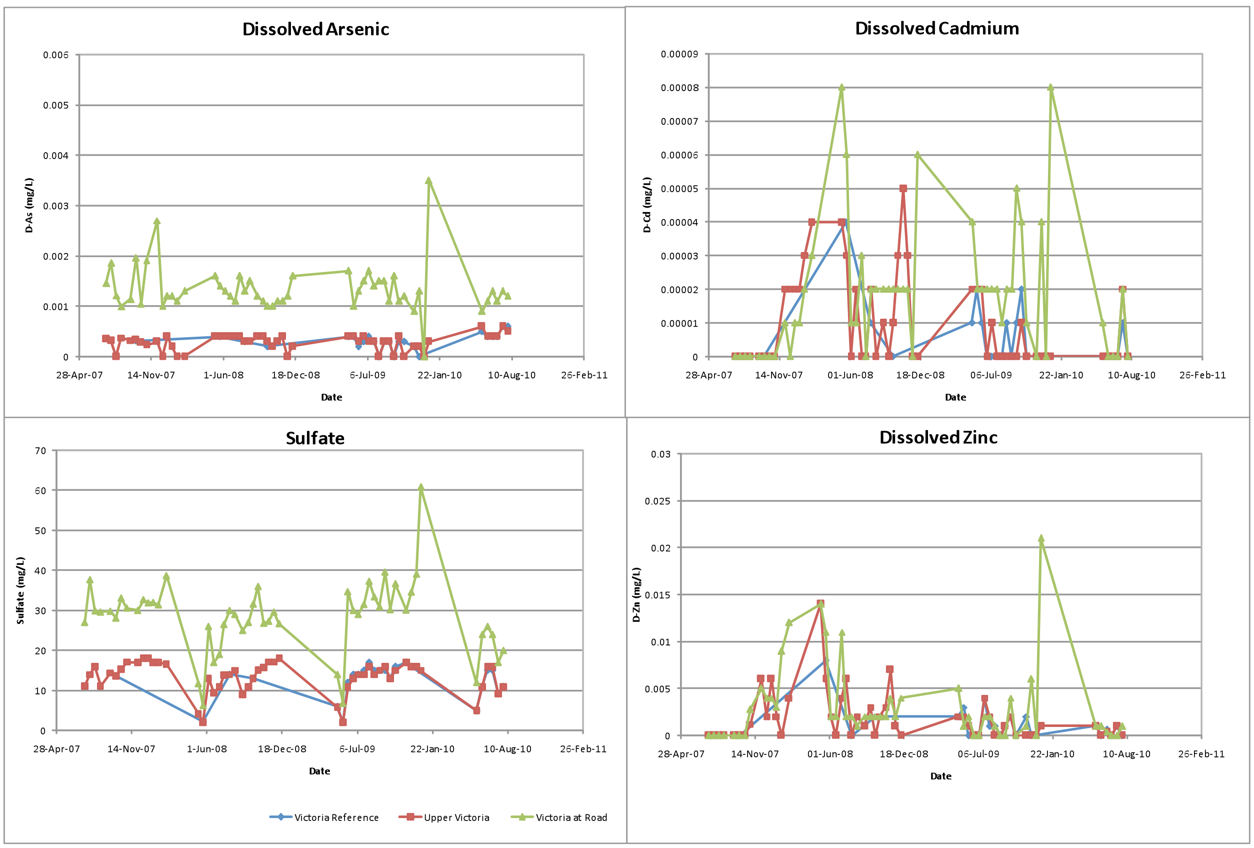


Figure 2-2 Time Series Profiles of Dissolved Arsenic, Cadmium, Zinc and Sulfate for Victoria Creek Upstream of the Back Creek Confluence (Victoria Reference), Upstream of the Dome Creek Confluence (Upper Victoria) and Downstream of Dome Creek (Victoria at Road)(existing conditions)

3 Pit and Tailings Area Water Balance Assumptions

The following sections summarize the groundwater flow regime for the Tailings Management Area and the Brown-McDade Pit presented in detail in *Hydrogeological Characterization of the Mt. Nansen Mine Site* (AECOM (2010c). The key water balance assumptions carried forward into the model are discussed, specifically, the assumed long-term discharge rates to the downstream receiving environment.

3.1 Brown-McDade Pit

As part of the earlier modeling work carried out by AECOM in 2009/2010 (AECOM 2010e) a pit water balance model was developed to simulate historical pit water levels. The pit lake was modeled as a reservoir or lake and the surface runoff coefficients were adjusted such that the predicted pit water levels matched the historical pit water levels. Results of this water balance indicated that relatively little groundwater makes up the water balance inflows into the pit, and that the pit water balance is dominated by surface water inflows. Since the development of the pit lake water balance model in 2009, additional field data has become available which resulted in a revision in the thinking around the pit water balance, and specifically the interactions between the pit and shallow and deep groundwater systems (AECOM 2010c).

As discussed in *Hydrogeological Characterization of the Mt. Nansen Mine Site* (AECOM (2010c), the pit lake is inferred to be a surface expression of the regional groundwater table and the water levels in the pit being hydraulically connected to the regional water table elevation. In the winter, the regional water table drops below the elevation of the water in the pit, resulting in a downward movement of water from the pit to the underlying groundwater system. During the open water season and periods of snowmelt and precipitation, the regional ground water table rises and there is an upward movement of water from the underlying groundwater system into the pit. Compared to the surrounding regional groundwater system, the pit water levels show relatively minimal changes in response to snowmelt and precipitation events. Given that the seasonal variations in the pit water level elevations mimic those observed in the underlying groundwater system, it appears that the water level in the pit is primarily controlled by the regional groundwater system rather than surface runoff.

In addition to the vertical fluctuations of water due to seasonal variations in the groundwater table, there is a horizontal component of groundwater flow in and out of the pit (AECOM 2010c). Based on the revised conceptual hydrogeological model, horizontal inflows into the pit consist of contributions from both the shallow and deep groundwater system while outflows from the pit to the receiving environment are solely associated with the deep groundwater system. The following summarizes the various components of groundwater inflows and outflow from the pit, although only the deep groundwater discharge from the pit to Dome Creek was used in the model.

- The shallow groundwater discharges to the north end of the pit, conveying water from Pony Creek within the active zone in the shallow fractured bedrock unit. This active zone flow is active during two periods of the year: during snowmelt and spring freshet in May and June and in late fall/early winter prior to active layer freeze back (October through December). For the remainder of the year, this shallow groundwater pathway is assumed to be either frozen (January to April) or unsaturated (July to September). Estimated shallow groundwater inflows into the pit ranged from 90 m^3/year to 750 m^3/year.

- The deep groundwater system is inferred to discharge to the north end of the pit from the regional bedrock aquifer. Estimated monthly groundwater inflows from the deep groundwater system range from 0.9 m^3/month to 48.2 m^3/month, for an estimated total of 298 m^3/year.

- Groundwater is thought to discharge from the south end of the pit towards Dome Creek via the deep groundwater system. The rate of groundwater discharge from the pit to Dome Creek was estimated using Darcy's Law for a range of hydraulic conductivity values and porosity and the long-term average gradient (2001 to 2010). Groundwater discharge from the pit was estimated to be on order of 4,249 m^3/year (0.13 L/s), but could be as low as 157 m^3/year (0.005 L/s) if permeability is lower. The discharge from the pit to Dome Creek was conservatively set to 0.13 L/s in the model.

3.2 Tailings Management Area

The tailings area is underlain by a shallow aquifer overlying permafrost. The shallow aquifer receives groundwater contributions primarily from the upstream valley bottom aquifer and the south-facing slopes of the Dome Creek catchment (AECOM 2010c). Onset precipitation and runoff infiltrates through the tailings and ultimately reports to the shallow unfrozen aquifer. The water level of the tailings pond rises each spring in response to runoff and snow melt from the tailings catchment. Below the permafrost, is a deeper groundwater system that is inferred to report to the deeper parts of the Dome Creek valley.

The tailings are in tension saturation. Tailings porewater and water in the tailings pond slowly infiltrates through the tailings and enters the underlying shallow aquifer. It then flows downgradient through the remnant organics and tailings dam fill and reports to the seepage collection pond. Groundwater flow into the seepage pond is primarily comprised of two components: 1) seepage through the dam, and 2) groundwater flow from the terrace north of the seepage collection pond. Based on measured groundwater gradients, a portion of the groundwater flowing within the terrace is likely recharge from the overlying diversion channel. Water collected in the seepage collection pond is pumped over the frozen seepage dyke and into Dome Creek above its confluence with the diversion channel. Review of the historical seepage data indicates that pumping rates fluctuate seasonally in response to changes in tailings and seepage pond levels as a result of precipitation and snowmelt.

A critical input to the model is the estimated long-term seepage from the tailings area for Option 1 and 2. The following summarizes the assessment of long-term seepage rates from the tailings area that was carried out by AECOM (AECOM 2010c).

- Two-dimensional groundwater flow through the tailings dam was conducted as part of the geotechnical investigation (AECOM, 2010b) to estimate the amount of groundwater seepage through the tailings dam in its current condition. A unit width seepage rate of 1.1×10^{-5} m^2/s was estimated for the cross-section through the centreline of the tailings dam or an overall steady-state seepage rate of 2.8 L/s.

- Historical seepage collection pond pumping data, specifically low flow or winter season data, was reviewed to confirm the results of two-dimensional seepage modeling through the dam (AECOM, 2010c). Estimates of seepage reporting to the seepage collection pond were made based on time-series analysis, correlation analysis with precipitation and catchment recharge analysis and compared to the results of two-dimensional seepage modeling (AECOM 2010c).

- Recent pumping records from the seepage collection pond that indicate minimum winter pumping rates were on the order of 3.5 L/s with an average pumping rate was 5.11 L/s. The results of the time series analysis (3.5 L/s), correlation analysis (2.9 L/s), catchment based calculations (2.9 L/s) and numerical seepage modeling (2.8 L/s) indicate groundwater reporting to the seepage collection pond is between 2.8 L/s and 3.5 L/s. For modeling purposes for the tailings-in-place options the long-term seepage from the tailing facility to the receiving environment is conservatively set at the maximum of the estimated seepage rates: 3.5 L/s.

- For the existing dam configuration, mass loading calculations using groundwater chemistry data indicated that approximately 66% of the groundwater reporting to the seepage pond originated from the tailings area, with the remaining 34% originating from the terrace north of the seepage collection pond, effectively diluting seepage reporting to the seepage collection pond (AECOM 2010c).

4 Description of Model for Closure Alternatives

AECOM (2010b) and Lorax (2010b) provide detailed descriptions of each of the closure options evaluated. Table 4-1 summarizes the key components of each option with respect to general design, water management and water quality.

4.1 Overview of Model Configuration

Simplified schematics of the water balance/water quality model for each closure option are shown in Figures 4-1 to 4-6. For each option, the model integrates the mine-related loadings and flows in the receiving environment. The mine site related sources that may contribute contaminant loadings to the receiving environment for each option are summarized below, and discussed in further detail in the following sections.

- Option 1A and 2A – Tailings Dam Upgrade with Water Cover or Saturated Soil Cover and Waste Rock in Place
    1. Year-round seepage from tailings storage area;
    2. Seasonal, shallow seepage from portions of waste rock on surface;
    3. Year-round deep groundwater seepage from the low-grade ore;
    4. Year-round deep groundwater seepage from portions of waste rock on surface; and
    5. Year-round deep groundwater seepage from the pit.

- Options 1B and 2B – Tailings Dam Upgrade with Water Cover or Saturated Soil Cover and Waste Rock Backfill into Pit
    1. Year-round seepage from tailings storage area;
    2. Year-round deep groundwater seepage from the low-grade ore; and
    3. Year-round deep groundwater seepage from the backfilled pit.

- Option 3 – Tailings Backfill into Pit with High Infiltration Cover and Waste Rock in Place
    1. Year-round deep groundwater seepage from low-grade ore;
    2. Year-round deep groundwater seepage from waste rock on surface; and
    3. Year-round deep groundwater seepage from the backfilled pit.

- Option 4 – Tailings and Waste Rock Backfill into Pit with Low-Infiltration Cover
    1. Year-round deep groundwater seepage from low-grade ore;
    2. Year-round deep groundwater seepage from the backfilled pit.

For each option, a total of six different model scenarios were run, including combinations of two different source term chemistry estimates (Best Estimate and Upper Estimate) and three precipitation conditions (dry, average and wet year). The model was run on a monthly time step for a calendar year (12 months).

On a monthly basis (time-step), the contaminant loading from each source for each option was calculated as follows:

Load = source concentration X source flow or seepage rate.

The total load to the receiving environment at the Victoria Creek model point was then calculated for each parameter as the sum of the loads from all the contributing sources. For example for Option 1A, the total load to the receiving environment was calculated as follows:

Total Load = Load from Waste Rock (both shallow and deep seepage) + load from Tailings + Load from Pit + Load from Low-grade Ore + Load from Residual Upstream Catchment.

The residual upstream catchment area is the component of the Victoria Creek catchment area contributing flow to the Victoria Creek model point that is not mine-impacted.

Similarly, the total flow at the Victoria Creek model point was calculated as the sum of all the contributing inflows. For Option 1A, at each time step the total flow at Victoria Creek was calculated as:

Total Flow = Inflow from Waste Rock + Inflow from Tailings + Inflow from Pit + Inflow from Low-grade Ore + Inflow from Residual Upstream Catchment.

The contaminant concentration in the receiving environment at the Victoria Creek model point was then calculated as follows for each time step:

Concentration = Total Load / Total Flow

The suite of parameters included in the model are sulfate, arsenic, cadmium, copper, iron, manganese zinc, ammonia-N, nitrate-N, nitrite-N, total cyanide, WAD-cyanide, cyanate, calcium and magnesium. For modeling purposes, it is assumed that all constituents behave conservatively and all metals are modeled as total metals. In addition, hardness was calculated based on modeled calcium and magnesium concentrations.

Details regarding the specific assumptions for the modeled inflows and source chemistry for each closure option are discussed in the following sections.

Table 4-1 Summary of Closure Options Key Components

Option 1 (a and b)	Option 2 (a and b)	Option 3	Option 4
Tailings			
• Stabilized in place with dam upgrade • Water cover – 0.7 m water and 0.3 m soil diffusion layer • Tailings Elevation – 1097.75 mASL • Diffusion Layer Elevation – 1098.05 mASL • Water Cover Elevation and Spillway Invert– 1098.75 mASL • Includes a soil cover beach to keep water from crest of dam	• Stabilized in place with dam upgrade • Saturated soil cover • Tailings Elevation – 1097.75 mASL • Soil Cover Elevation – 1098.75 mASL • Spillway invert – 1099.0 mASL • Includes a soil cover beach to keep water from crest of dam	• Relocate tailings to pit with high infiltration cover to maximize tailings saturation • Tailings dam is breached and valley reclaimed	• Relocation of tailings and waste rock to the pit with low infiltration cover to maintain tailings in a dry condition • Tailings dam is breached and valley reclaimed
Dome Creek Diversion			
• Dome Creek Diversion removed and Dome Creek routed through Tailings Impoundment	• Dome Creek Diversion removed and Dome Creek routed through Tailings Impoundment	• Dome Creek Diversion removed and creek returned to original channel through tailings area	• Dome Creek Diversion removed and creek returned to original channel through tailings area
Waste Rock			
Option 1A • All waste rock is left in place Option 1B • All waste rock relocated to pit	Option 2A • All waste rock is left in place Option 2B • All waste rock relocated to pit	• All waste rock is left in place with the exception of 23,200 m^3 for tailings cover	• 44,000 m^3 of waste rock is relocated to bottom of pit and 300,000 m^3 on top of tailings • Remaining is left in place as is
Pit			
Option 1A • Pit remains as is with anticipated long-term water elevation stabilizing at 1182.3 mASL Option 1B • All waste rock relocated to pit	Option 2A • Pit remains as is with anticipated long-term water elevation stabilizing at 1182.3 mASL Option 2B • All waste rock relocated to pit	• Tailings relocated to pit and kept in a saturated state • Tailings covered with 1.0 m waste rock • All runoff from surrounding pit catchment is routed to covered tailings area to maximize infiltration	• Relocation of tailings to pit and storage in a dry condition • 44,000 m^3 of waste rock is relocated to bottom of pit and 300,000 m^3 on top of tailings • Waste rock then covered with a multi-layer vegetated, store-release soil cover • Runoff from onset precipitation routed away from pit area to either the Dome Creek or Pony Creek Catchments to minimize infiltration into tailings.

4.2 Option 1A – Tailings Dam Upgrade with Water Cover/Waste Rock in Place

4.2.1 Tailings Area Water Balance Model Assumptions

For Option 1A, the tailings area was modeled as a reservoir or pond with inflows from onset precipitation and runoff from the surrounding area, including Dome Creek. Outflows from the system include discharge via the spillway, evaporation from the pond surface area, and infiltration from the tailings pond through the tailings and the tailings dam. The soil beach area was assumed to be relatively impermeable and any onset precipitation on the soil beach area reports to the tailings pond. The physical characteristics of the pond used in the model are summarized in Table 4-2.

Table 4-2 Model Inputs for Option 1A Tailings Area

Model Inputs	Value
Tailings Elevation (mASL)	1097.75
Diffusion Layer Elevation (mASL)	1098.05
Spillway Invert Elevation (mASL)	1098.75
Maximum Depth of Water Cover (m)	0.70
Pond Surface Area (m^2)	60,000
Soil Beach Surface Area (m^2)	12,600
Soil Beach Elevation (mASL)	1099.4
Soil Beach Area Runoff Coefficient	1.0
Proportion of Dome Creek Routed to Pond (%)	100

4.2.1.1 Infiltration/Seepage through Tailings and Dam

Two separate analyses were carried out to evaluate the potential infiltration from the tailings area. Golder carried out an assessment of the cover water balance using a 1-dimensional numerical model to estimate the cover water balance fluxes (Golder 2010a). As a separate analysis, AECOM also carried out a two-dimensional analysis of seepage rates in the tailings, dam and soil foundations (AECOM 2010b).

The one-dimensional modeling carried out by Golder encompassed the open water season between April 15 and October 31 for mean, dry and wet precipitation conditions. The computed fluxes included evaporation, runoff, surface infiltration, and infiltration through the top and bottom of the tailings. Details of this work are provided in Lorax (2010b), Appendix C2. Table 4-3 summarizes the cumulative flux values computed for the cover water balance for Option 1.

Table 4-3 Summary of Option 1 One-Dimensional Cumulative Fluxes (April 15 to October 31)

	Dry Year (m^3/m^2)	Mean Year (m^3/m^2)	Wet Year (m^3/m^2)
Top of Cover	-	-	-
Top of Tailings	0.21	0.21	0.21
Bottom of Tailings	0.21	0.21	0.21

The results of one-dimensional modeling indicate that the tailings would remain saturated at all times for Option 1A/B. Furthermore, the fluxes through the tailings are independent of climatic conditions as long as there is sufficient water from the surrounding catchment to maintain the water cover. Based on a tailings surface area of 60,000 m^2, the one-dimensional flux over the period of April 15 to October 31 (200 days) is 12,600 m^3 or 0.7 L/s.

The 2-D analysis carried out by AECOM focused on providing an understanding of how the design of the two tailings-in-place options (Option 1A/B and Option 2A/B) will affect the pore water pressure conditions and seepage rates in the tailings, dam and foundation soils. The analysis for Option 1 looked at two scenarios. The first scenario had a wedge of coarse tailings against the dam and the second replaced the coarse tailings with fine tailings. The modeled seepage rates per metre width are:

- With "wedge" of coarse tailings against dam face – 6.5×10^{-6} m^2/s; and
- With coarse tailings replaced with fine tailings – 4.5×10^{-6} m^2/s.

The design carried forward for the assessment includes the replacement of the coarse tailings with fine tailings. The resultant seepage rate for this option, based on a dam length of 256 m is 1.18 L/s. As expected, this two-dimensional seepage rate is larger than that predicted using the one-dimensional model, and better represents the potential seepage out of the tailings pond area. Therefore, for the model a seepage rate of 1.18 L/s was adopted to characterize the seepage from the tailings pond through the tailings, dam and foundation soils.

4.2.1.2 Discharge from Tailings Area

An assessment of the seepage collection pond pumping rates was carried out by AECOM (AECOM 2010c) to determine the most appropriate long-term seepage rate to be used in the model for Options 1 and 2. Four methods were used to estimate long-term seepage from the tailings area:

- Times series analysis of historical data (2006 to 2010) specifically targeting periods of low flow;
- Correlation analysis with precipitation events;
- 2-D numerical modeling; and
- Catchment-based calculations.

The results of each of these analyses are presented in Table 4-4.

Table 4-4 Summary of Tailings Area Seepage Rates

Method	Estimated Seepage Rate (L/s)
Time Series	3.5
Precipitation Correlation	2.9
2-D Numerical Modeling	2.8
Catchment Based	2.86

Based on the results of these analyses, the long-term seepage rate for Options 1 and 2 was conservatively set to 3.5 L/s (based on time series of historical data).

4.2.2 Pit Water Balance Model Assumptions

For Option 1A, the pit is left as is and the critical input to the model is the flux of water out of the pit to the receiving environment, specifically Dome Creek. As outlined in the *Hydrogeological Characterization of the Mt. Nansen Mine Site* (AECOM 2010c), the pit lake is a surface expression of the regional groundwater system. In this system, groundwater discharges from the south end of the pit lake to the deep regional groundwater system and ultimately Dome Creek. The rate of groundwater discharge from the pit to Dome Creek was estimated using Darcy's Law for a range of hydraulic conductivities (K) and is summarized in Table 4-5 along with the corresponding travel times.

Table 4-5 Summary of Pit Discharge Rates to Dome Creek

Hydraulic Conductivity	Estimated Discharge Rate (L/s)	Travel Times (years) 1% Porosity	Travel Times (years) 10% Porosity
Low ($K=1.00 \times 10^{-7}$)	0.005	26	262
Intermediate ($K=1.50 \times 10^{-6}$)	0.0749	1.75	17.47
High ($K=2.70 \times 10^{-6}$)	0.1347	0.97	9.71

Based on the results of this analysis, the discharge from the pit to Dome Creek was conservatively set to 0.13 L/s in the model.

4.2.3 Waste Rock Water Balance Model Assumptions

For Option 1A, all waste rock is left on surface as is. Table 4-6 provides a summary of the waste rock catchment groupings and Table 4-7 provides a summary of the waste rock catchment areas used for the water balance component of the model.

Table 4-6 Summary of Waste Rock Catchment Groupings

ID	Waste Rock Sub-Catchment	Area (m^2)	Waste Rock Catchment Label	Seepage Classification	Receiving Environment
A	None	26,425	WR-DC1	Seepage - shallow groundwater	Dome Creek
B	NW Pile	12,750	WR-DC2	Seepage – deep groundwater	Dome Creek
	Mid-Sector	21,325	WR-DC2	Seepage – deep groundwater	Dome Creek
	S-SW Pile	38,225	WR-DC2	Seepage – deep groundwater	Dome Creek
	Total	72,300			
B	Ore Backfill	4,200	ORE-DC	Seepage – deep groundwater	Dome Creek
C	NW Pile	7,025	WR-PC1	Seepage – shallow groundwater	Pony Creek
	East Pile	5,800	WR-PC1	Seepage – shallow groundwater	Pony Creek
	Total	12,825			

Table 4-7 Summary of Waste Rock Water Balance Areas

Waste Rock Catchment	Area (m^2)	Seepage Classification	Receiving Environment
WR-DC1	26,425	Seepage - shallow groundwater	Dome Creek
WR-DC2	72,300	Seepage – deep groundwater	Dome Creek
ORE-DC	4,200	Seepage – deep groundwater	Dome Creek
WR-PC1	12,825	Seepage – shallow groundwater	Pony Creek

For the waste rock water balance, a key assumption is that there is no net surface water runoff. Snowmelt and onset precipitation either evaporates or infiltrates into the waste rock dumps. Monthly infiltration (mm) for each precipitation condition were based on the results of the water balance work carried out by Golder for Options 1B and 2B (Golder 2010a). Monthly infiltration rates (mm) were calculated from the daily net infiltration results for each of the average, dry and wet year condition and are summarized in

Table 4-8.

Table 4-8 Summary of Monthly Waste Rock Infiltration (mm)

Month	Monthly Waste Rock Infiltration (mm)		
	Dry Year	Average Year	Wet Year
April	55.62	44.95	61.71
May	5.47	6.31	14.86
June	0.94	22.38	3.09
July	12.46	13.71	31.47
August	0	6.57	62.26
September	0	0	60.38
October	5.17	23.35	10.57
Total	79.66	117.27	244.34

For seepage reporting as shallow groundwater to either Dome Creek or Pony Creek, the waste rock dump seepage outflow is attenuated as it flows through the dumps. For these dumps the shallow groundwater seepage outflow for each month was distributed according to the following:

- 80% of current month's net infiltration plus 20% of previous month's net infiltration.

For waste rock seepage reporting as deep groundwater to Dome Creek, the total annual infiltration was distributed evenly throughout the entire year. Since the groundwater flow system acts to dampen variations in infiltration resulting from variable precipitation conditions, it was assumed that the average year infiltration (117.27 mm) applied to all modeled precipitation conditions.

4.2.4 Water Balance Considerations for Option 1A

A critical assumption for the tailings area as part of Option 1A/B, is the ability of the contributing catchment to provide sufficient water supply to maintain a water cover of 0.7 m, particularly during the open water, non-frozen period. An assessment of the available water supply to the tailings area was carried out by AECOM (AECOM 2010a) for dry, average and wet precipitation conditions. A summary of the monthly inflows to the tailings area for each precipitation condition is provided in Table 4-9. For the Dome Creek and tailings area catchments, the inflow volumes were based on a runoff coefficient of 0.6 in the summer months and a spring runoff coefficient of 0.8 for the months of April and May. A runoff coefficient of 1.0 was assumed for the soil beach area. Monthly outflows from the tailings area included evaporation from the pond area surface and seepage through the tailings and dam. Monthly outflow volumes are presented in Table 4-9 along with the calculated deficit/surplus for each open water season month.

Based on this assessment, the inflows to the tailings area are sufficient to maintain the 0.7 m water cover over the open water season for average and wet precipitation conditions. Although for the dry precipitation condition there is a deficit in September of 3,950 m^3, this only corresponds to a minimal drop in water cover depth of 0.07 m (based on a pond area of 60,000 m^2). In the following month (October) there is sufficient surplus to bring the water cover depth back to 0.7 m.

These proposed runoff coefficients of 0.8 (spring months) and 0.6 (remaining months) are not backed up quantitatively using site data or findings from other studies and therefore may not be adequately representative of runoff conditions at the site for all locations and conditions. Carey and Woo (2001) found runoff coefficients as high as 0.8 in the nearby Wolf Creek basin, however, they also found that hillslopes in the watershed had runoff coefficients during snowmelt that varied considerably. No runoff was observed on the south-facing slopes, but 155 mm, 50 mm and 19 mm of water were discharged from the north, east and west-slopes, giving runoff ratios of 0.8, 0.6 and 0.25 respectively. Factors such as aspect, snow redistribution, presence/absence of ice lenses, soil type/development and infiltration potential were identified as key determinants of runoff generation at different times of year. Therefore a sensitivity analysis was completed for the dry precipitation conditions assuming a lower runoff coefficient of 0.4 for all the open water season months.

The results of this assessment are presented Table 4-10. Again, there is a deficit in September of 4,250.8 m^3 which corresponds to a drop in water cover depth of 0.071 m. The following month (October) provides an estimated surplus of 3,654.1 m^3 which will result in an overall increase in the water cover depth by 0.06 m to a total water depth of 0.6 m.

Table 4-9 Summary of Monthly Inflows and Outflows to Tailings Pond – Option 1A/B

Dry Precipitation Conditions									
Month	Inflows (m^3)					Outflows (m^3)			
	Dome Creek	Tailings Catchment	Soil Beach	Pond Area	Total	Evap.	Seepage	Total	Surplus/ Deficit
April	123,915	17,857	719	3,422	145,912	0	3,059	3,059	142,854
May	68,269	9,838	396	1,885	80,389	5,100	3,161	8,261	72,128
June	50,615	7,294	391	1,864	60,165	5,880	3,059	8,939	51,226
July	76,445	11,016	591	2,815	90,867	5,400	3,161	8,561	82,306
August	12,939	1,865	100	476	15,380	3,900	3,161	7,061	8,319
September	815	117	6	30	969	1,860	3,059	4,919	-3,950
October	8,441	1,217	65	311	10,034	0	3,161	3,161	6,873
Total					403,714				359,757
Average Precipitation Conditions									
Month	Inflows (m^3)					Outflows (m^3)			
	Dome Creek	Tailings Catchment	Soil Beach	Pond Area	Total	Evap.	Seepage	Total	Surplus/ Deficit
April	100,210	14,441	581	2,767	117,999	0	3,059	3,059	114,940
May	74,136	10,684	430	2,047	87,297	5,100	3,161	8,261	79,036
June	110,813	15,969	857	4,080	131,719	5,880	3,059	8,939	122,780
July	99,406	14325	769	3,660	118,159	5,400	3,161	8,561	109,599
August	61,925	8,924	479	2,280	73608	3,900	3,161	7,061	66,547
September	21,185	3,053	164	780	25182	1,860	3,059	4,919	20,263
October	37,481	5,401	290	1,380	44552	0	3,161	3,161	41,391
Total					598515				554,557
Wet Precipitation Conditions									
Month	Inflows (m^3)					Outflows (m^3)			
	Dome Creek	Tailings Catchment	Soil Beach	Pond Area	Total	Evap.	Seepage	Total	Surplus/ Deficit
April	137,451	19,808	797	3,796	161,852	0	3,059	3,059	158,793
May	134,475	19,379	780	3,713	158,347	5,100	3,161	8,261	150,086
June	76,591	11,038	592	2,820	91,041	5,880	3,059	8,939	82,102
July	143,405	20,666	1,109	5,280	170,460	5,400	3,161	8,561	161,899
August	190,663	27,476	1,474	7,020	226,634	3,900	3,161	7,061	219,573
September	138,516	19,961	1,071	5,100	164,648	1,860	3,059	4,919	159,730
October	16,296	2,348	126	600	19,370	0	3,161	3,161	16,210
Total					992,352				948,394

Table 4-10 Summary of Monthly Inflows and Outflows to Tailings Pond – Option 1A/B – Runoff Coefficient = 0.4

Dry Precipitation Conditions									
Month	**Inflows (m^3)**					**Outflows (m^3)**			
	Dome Creek	**Tailings Catchment**	**Soil Beach**	**Pond Area**	**Total**	**Evap.**	**Seepage**	**Total**	**Surplus/ Deficit**
April	61,957	8,929	719	3,422	75,026	0	3,059	3,059	71,968
May	34,135	4,919	396	1,885	41,335	5,100	3,161	8,261	33,074
June	33,744	4,863	391	1,864	40,861	5,880	3,059	8,939	31,923
July	50,963	7,344	591	2,815	61,713	5,400	3,161	8,561	53,152
August	8,626	1,243	100	476	10,446	3,900	3,161	7,061	3,385
September	543	78	6	30	658	1,860	3,059	4,919	-4,261
October	5,628	811	65	311	6,815	0	3,161	3,161	3,654
Total					236,853				192,896

4.2.5 Geochemical/Source Term Assumptions

The source term estimates for both the Best Estimate and the Upper Estimate are presented in Table 4-11 for Option 1A.

Table 4-11 Summary Source Term Chemistry for Option 1A (all values in mg/L)

	Best Estimate				Upper Estimate			
Parameter	Tailings	Pit Lake	Waste Rock Pile	Ore	Tailings	Pit Lake	Waste Rock Pile	Ore
Arsenic	0.04	0.02	0.0068	0.026	0.3	0.08	0.0227	0.041
Cadmium	0.00089	0.02	0.033	0.09	0.0015	0.03	0.184	0.201
Copper	0.0087	0.03	0.039	0.015	0.015	0.09	0.225	0.036
Iron	12.8	0.5	0.01	0.03	40	2.97	0.06	0.05
Manganese	7.75	2.91	4.8	49	10	6.9	28.6	97.4
Zinc	0.02	1.76	5.14	10.4	0.1	2.92	34.2	31.2
Sulfate	663	1230	1530	2265	1380	1690	2940	2680
Ammonia	6.4	0.18	0.03	0.03	12	0.4	0.12	0.093
Nitrate	3.1	1.71	2	0.33	10	3.85	9.96	0.85
Nitrite	0.25	0.06	0.023	0.08	0.6	0.3	0.36	0.1
Cyanide – T	0.7	n/a	n/a	n/a	0.5	n/a	n/a	n/a
WAD – CN	0.025	n/a	n/a	n/a	0.15	n/a	n/a	n/a
Cyanate	1.6	n/a	n/a	n/a	18	n/a	n/a	n/a
Calcium	241	385	368	431	24	470	346	431
Magnesium	32.5	124	92.7	297	4.6	163	90.5	297

The following provides a summary of the rationale for the source term chemistry for each modeled component. Full descriptions of the source terms estimate are provided in Lorax (2010a).

Waste Rock (Subaerial, Unsaturated)

- The evaluation of the waste rock source terms for Option 1A (subaerial unsaturated waste rock) utilized data acquired from seeps, lysimeters and unsaturated field bin.
- Of these data sources, water quality for the natural seeps were used to generate source term estimates. This relates to the fact that the seeps, which have been active for up to 10 years, are implicitly representative of on-site weathering conditions.
- A statistical evaluation was performed on the seepage dataset and the most appropriate mean or median value was selected as the conservative best estimate source term.
- Upper Estimate values for all parameters were derived from the maximum drainage quality values.

Low-Grade Ore (Unsaturated)

- Conservative Best Estimate source term values were determined using the higher of the median or mean concentrations from the unsaturated ore field bin drainage.
- Upper Estimate values for all parameters, except arsenic, were derived from the maximum drainage quality data obtained from the unsaturated ore field bin.
- Concentrations of arsenic measured in shake flask extraction (SFE) leachate were applied in order to provide a more conservative Upper Estimate estimate.

Pit Lake

- Pit lake water quality collected by EDI from the pit bottom, middle, and bottom were statistically analyzed.
- The median values for each layer were calculated and the most conservative value was selected as the conservative Best Estimate source term.
- The Upper Estimate source terms were determined by averaging all data that is greater than or equal to the value for the 90th percentile.

Tailings in Place

- The conservative Best Estimate tailings source terms were derived by averaging the concentration of each parameter in the seepage collection pond for data collected since November 2007. Poor detection limits present a limitation on data collected prior to November 2007,
- Upper Estimate source terms were developed using two approaches with the following assumptions: 1) infrequent yet consistent spikes observed in seepage pond data since January 1999 represent mechanisms that may dominate in the long-term; and 2) groundwater quality from well MW09-08 is a proxy for groundwater that bypasses the seepage collection pond and may report to Dome Creek in the future. There are numerous exceptions to these approaches which are outlined in detail in Lorax (2010a).
- The use of a sand diffusion layer is included as part of the design of the tailings cover system in Option 1A/B to serve two purposes:
  - Maintain the physical stability of the tailings; and
  - Reduce diffusion of constituents from the tailings pore water into the water cover.
- This upward diffusion of constituents from the tailings into the water cover is of relevance for arsenic, manganese and sulfate (Lorax 2010a). To account for the potential loading to the water cover, and ultimately Dome Creek, the diffusive flux terms presented in Table 4-12 were incorporated into the model for arsenic, manganese and sulfate (based on a water cover area of 60,000 m^2).

Table 4-12 Summary of Diffusive Flux Rate

Parameter	Diffusive Flux Rate (g/day)
Arsenic	8.6
Manganese	7.4
Sulfate	2,967

4.3 Option 1B – Tailings Dam Upgrade with Water Cover/Waste Rock Backfill into Pit

4.3.1 Tailings Area Water Balance Model Assumptions

The tailings area model assumptions for Option 1B are the same as those described in Section 4.2.1 for Option 1A.

4.3.2 Pit / Backfilled Waste Rock Water Balance Model Assumptions

Golder conducted a one-dimensional water balance model to describe the relocation and long-term storage of waste rock in the pit (Golder 2010a). The one-dimensional model covered the open water season between April 15 and October 31 for mean, dry and wet precipitation conditions. The computed fluxes included evaporation, runoff, surface infiltration, and infiltration through the top and bottom of the waste. Details of this work are provided in Lorax (2010b), Appendix C2. For Options 1B and 2B, the model results indicate that it would take over 12 years for water to reach the bottom of the 30 m of waste rock placed in the pit. Once water reaches the bottom of the waste rock, the flux would reach steady state conditions. The steady state cumulative annual fluxes are presented in Table 4-13 along with the steady state flux rate based on a waste rock surface area in the pit of 36,000 m^2.

Table 4-13 Summary of Option 1B and 2B 1-D Cumulative Fluxes (April 15 to October 31)

	Dry Year	Average Year	Wet Year
Cumulative Annual Flux (m^3/m^2)	0.08	0.12	0.24
Flux Rate (L/s)	0.09	0.137	0.27

Given the time to reach steady state conditions in the waste rock placed in the pit, in conjunction with the overall dampening effect on the flow imposed by the 30 m of waste rock, an average annual flux rate of 0.137 L/s was selected for all precipitation conditions in the model. Although the average annual flux rate through the waste rock and the estimated groundwater discharge rate to Dome Creek (0.1347 L/s) are similar, the higher value of 0.137 L/s was adopted as the long-term pit discharge rate to Dome Creek for Options 1b and 2b.

4.3.3 Waste Rock Water Balance Assumptions

In Option 1B, the low-grade ore remains in place and the water balance assumptions for the low-grade ore in Option 1B are the same as those described in Section 4.2.3 for Option 1A.

4.3.4 Water Balance Considerations for Option 1B

The water balance consideration for Option 1B are the same as those described in Section 4.2.4 for Option 1A.

4.3.5 Geochemical/Source Term Assumptions

The source term estimates for both the Best Estimate and the Upper Estimate are presented in Table 4-14 for Option 1B. With the exception of the backfilled waste rock, the rationale for the source term chemistry for each modeled component are the same as those presented in Section 4.2.5 for Option 1A. Full descriptions of the source terms derivations are provided in Lorax (2010a).

Backfilled Waste Rock

- Option 1B dictates that a portion of the waste rock will be saturated (below the water table) and a portion of the waste rock will be unsaturated (above the water table). Therefore, the chemistry of the drainage from the pit is dictated by a combination of geochemical processes occurring within both unsaturated and saturated waste rock.
- Source terms for these backfill options were derived by selecting the most conservative values from the unsaturated/subaerially exposed waste rock source terms and the saturated waste rock source terms.
- Saturated waste rock source terms were derived using drainage data from the saturated field bin.
    - A statistical evaluation was performed on the datasets and the most appropriate mean or median value was selected as the conservative best estimate source term.
    - Arsenic, whose mobility should be greatly increased under suboxic conditions, was approached differently. The conservative Best Estimate value for arsenic release under saturated conditions was derived from the highest value from the pit bottom water quality samples (0.12 mg/L). The sample

from which the value was derived contained depressed nitrate, elevated ammonia and manganese, and slightly elevated iron compared to other samples, suggesting the presence of suboxic conditions in Brown-McDade pit bottom waters.

- Upper Estimate values for all parameters except nitrate, nitrite and copper were derived from the maximum drainage quality data obtained from the saturated waste rock field bin. Concentrations of nitrate, nitrite, and copper measured in pit bottom waters were applied in order to provide more conservative Upper Estimate estimates.
- The Upper Estimate value for dissolved arsenic under saturated conditions was derived from taking the Upper Estimate drainage value from the saturated tailings field bin and scaling it based on the median solid phase concentration of arsenic in Mount Nansen tailings (3,027 mg/L) and the median solid phase concentration in Mount Nansen waste rock (239 mg/L) to derive a value of 1.2 mg/L. This is based on the assumption that arsenic in both waste rock and tailings is primarily associated with iron-oxides and will be released under suboxic conditions.

Table 4-14 Summary Source Term Chemistry for Option 1B (all values in mg/L)

	Best Estimate				Upper Estimate			
Parameter	**Tailings**	**Pit – Waste Rock**	**Waste Rock Pile**	**Ore**	**Tailings**	**Pit – Waste Rock**	**Waste Rock Pile**	**Ore**
Arsenic	0.04	0.12	n/a	0.026	0.3	1.2	n/a	0.041
Cadmium	0.00089	0.027	n/a	0.09	0.0015	0.184	n/a	0.201
Copper	0.0087	0.04	n/a	0.015	0.015	0.225	n/a	0.036
Iron	12.8	2.15	n/a	0.03	40	5.28	n/a	0.05
Manganese	7.75	143	n/a	49	10	181	n/a	97.4
Zinc	0.02	5.14	n/a	10.4	0.1	34.2	n/a	31.2
Sulfate	663	2040	n/a	2265	1380	2940	n/a	2680
Ammonia	6.4	1.25	n/a	0.03	12	1.54	n/a	0.093
Nitrate	3.1	0.32	n/a	0.33	10	1.371	n/a	0.85
Nitrite	0.25	0.1	n/a	0.08	0.6	0.396	n/a	0.1
Cyanide – T	0.67	0	n/a	0	0.5	0	n/a	0
WAD – CN	0.025	0	n/a	0	0.15	0	n/a	0
Cyanate	1.6	0	n/a	0	18	0	n/a	0
Calcium	241	368	n/a	431	24	346	n/a	431
Magnesium	32.5	93	n/a	297	4.6	91	n/a	297

4.4 Option 2A – Tailings Dam Upgrade with Saturated Soil Cover/Waste Rock in Place

4.4.1 Tailings Area Water Balance Model Assumptions

For Option 2A, the tailings area was modeled as a very shallow reservoir or pond with inflows from onset precipitation and runoff from the surrounding area, including Dome Creek. Outflows from the system include discharge via the spillway, evaporation from the pond surface area, and infiltration from the tailings pond through the tailings and the tailings dam. In addition, the soil beach area was assumed to be relatively impermeable and any onset precipitation on the soil beach area reports to the tailings pond. The physical characteristics of the pond used in the model are summarized in Table 4-15.

Table 4-15 Model Inputs for Option 2A Tailings Area

Model Inputs	Value
Tailings Elevation (mASL)	1097.75
Soil Cover Elevation (mASL)	1098.75
Spillway Invert Elevation (mASL)	1099
Maximum Depth of Water Cover (m)	0.25
Pond Surface Area (m^2)	60,000
Soil Beach Surface Area (m^2)	12,600
Soil Beach Elevation (mASL)	1099.4
Soil Beach Area Runoff Coefficient	1.0
Proportion of Dome Creek Routed to Pond (%)	100

4.4.1.1 Infiltration/Seepage through Tailings and Dam

As outlined in Section 4.2.1.1, two separate analyses were carried out to evaluate the potential infiltration from the tailings area. Golder carried out an assessment of the cover water balance using a one-dimensional numerical model to estimate the cover water balance fluxes (Golder 2010a). AECOM carried out a two-dimensional analysis of seepage rates in the tailings, dam and soil foundations (AECOM 2010c).

The 1-D modeling carried out by Golder covered the open water season between April 15 and October 31 for mean, dry and wet precipitation conditions. The computed fluxes included evaporation, runoff, surface infiltration, and infiltration through the top and bottom of the tailings. Details of this work are provided in Appendix A. Table 4-16 summarizes the cumulative flux values computed for the cover water balance for Option 2.

Table 4-16 Summary of Option 2 1-D Cumulative Fluxes (April 15 to October 31)

	Dry Year (m^3/m^2)	Mean Year (m^3/m^2)	Wet Year (m^3/m^2)
Top of Cover	-	-	-
Top of Tailings	0.21	0.21	0.21
Bottom of Tailings	0.21	0.21	0.21

The results of one-dimensional modeling indicate that the tailings would remain saturated for all flow conditions for Option 2. Furthermore, the fluxes through the tailings are independent of climatic conditions as long as there is sufficient water from the surrounding catchment to maintain the water level within the soil cover. Based on a tailings surface area of 60,000 m^2, the one-dimensional flux over the period April 15 to October 31 (200 days) is 12,600 m^3 or 0.7 L/s.

The two-dimensional analysis carried out by AECOM focused on providing an understanding of how the design of the two tailings-in-place options (Option 1 and Option 2) will affect the pore water pressure conditions and seepage rates in the tailings, dam and foundation soils. The modeled 2-D seepage rate per metre width for the saturated soil cover is 6.7×10^{-6} m^2/s.

The resultant seepage rate for this option, based on a dam length of 256 m is 1.7 L/s. As expected, the two-dimensional seepage rate is larger than that predicted using the 1-D modeling, and better represents the potential seepage out of the tailings pond area. Therefore, for the model a seepage rate of 1.7 L/s was adopted to characterize the seepage from the tailings pond through the tailings, dam and foundation soils.

4.4.1.2 Discharge from Tailings Area

The long-term seepage rate from the tailings area to Dome Creek for Option 2A is the same as that for Option 1A presented in Section 4.2.1.2: 3.5 L/s.

4.4.2 Pit Water Balance Model Assumptions

The pit model assumptions for Option 2A are the same as those for Option 1A presented in Sections 4.2.2.

4.4.3 Waste Rock Water Balance Model Assumptions

The waste rock model assumptions for Option 2A are the same as those for Option 1A presented in Sections 4.2.3.

4.4.4 Water Balance Considerations for Option 2A

Similar to Option 2A/B, a critical assumption for Option 1A/B is the ability of the contributing catchment area to provide sufficient water supply to maintain the water elevation within the 1 m soil cover, particularly during the open water, non-frozen period. As discussed in Section 4.4.1.1, this option was modeled as a shallow pond with a maximum water cover depth of 0.25 m. The results of the assessment of available water supply to the tailings area for Option 2A/2B are presented in Table 4-17.

Similar to Option 1A/B, the inflows from the tailings area catchment are sufficient to maintain the 0.25 m water cover through open water season for average and wet precipitation conditions. For the dry precipitation conditions there is a predicted deficit in September of 5,205 m^3. However, this corresponds to a minimal drop in water cover depth of 0.09 m to a depth of 0.16 cm above the soil cover. In the following month (October) there is sufficient surplus to bring the water cover depth back to 0.25 m.

Similar to Option 1A/B, the sensitivity of the tailings area water balance to the assumed runoff coefficients was assessed for the dry precipitation condition assuming a runoff coefficient of 0.4 for all open water season months. The results of this assessment are presented in Table 4-18. Again, there is a deficit in September of 5515 m^3, corresponding to a drop in water cover depth of 0.09 m. The following month there is only an estimated surplus of 2,358m^3 which increases the water cover depth by 0.04 m, resulting in a final depth of 0.20 m. In either case the water cover is maintained.

Table 4-17 Summary of Monthly Inflows and Outflows to Tailings Pond – Option 2A/B

Dry Precipitation Conditions									
Month	**Inflows (m^3)**					**Outflows (m^3)**			
	Dome Creek	**Tailings Catchment**	**Soil Beach**	**Pond Area**	**Total**	**Evap.**	**Seepage**	**Total**	**Surplus/ Deficit**
April	123,915	17,857	719	3,422	145,912	0	4,313	4,313	141,599
May	68,269	9,838	396	1,885	80,389	5,100	4,457	9,557	70,832
June	50,615	7,294	391	1,864	60,165	5,880	4,313	10,193	49,971
July	76,445	11,016	591	2,815	90,867	5,400	4,457	9,857	81,010
August	12,939	1,865	100	476	15,380	3,900	4,457	8,357	7,023
September	815	117	6	30	969	1,860	4,313	6,173	-5,205
October	8,441	1,217	65	311	10,034	0	4,457	4,457	5,577
Total					403,714				350,808
Average Precipitation Conditions									
Month	**Inflows (m^3)**					**Outflows (m^3)**			
	Dome Creek	**Surplus/ Deficit**	**Soil Beach**	**Pond Area**	**Total**	**Evap.**	**Seepage**	**Total**	**Surplus/ Deficit**
April	100,210	14,441	581	2,767	117,999	0	4,313	4,313	113,686
May	74,136	10,684	430	2,047	87,297	5,100	4,457	9,557	77,740
June	110,813	15,969	857	4,080	131,719	5,880	4,313	10,193	121,526
July	99,406	14,325	769	3,660	118,159	5,400	4,457	9,857	108,303
August	61,925	8,924	479	2,280	73,608	3,900	4,457	8,357	65,251
September	21,185	3,053	164	780	25,182	1,860	4,313	6,173	19,008
October	37,481	5,401	290	1,380	44,552	0	4,457	4,457	40,095
Total					598,515				545,608
Wet Precipitation Conditions									
Month	**Inflows (m^3)**					**Outflows (m^3)**			
	Dome Creek	**Surplus/ Deficit**	**Soil Beach**	**Pond Area**	**Total**	**Evap.**	**Seepage**	**Total**	**Surplus/ Deficit**
April	137,451	19,808	797	3,796	161,852	0	4,313	4,313	157,539
May	134,475	19,379	780	3,713	158,347	5,100	4,457	9,557	148,790
June	76,591	11,038	592	2,820	91,041	5,880	4,313	10,193	80,848
July	143,405	20,666	1,109	5,280	170,460	5,400	4,457	9,857	160,603
August	190,663	27,476	1,474	7,020	226,634	3,900	4,457	8,357	218,277
September	138,516	19,961	1,071	5,100	164,648	1,860	4,313	6,173	158,475
October	16,296	2,348	126	600	19,370	0	4,457	4,457	14,914
Total					992,352				939,445

Table 4-18 Summary of Monthly Inflows and Outflows to Tailings Pond – Option 2A/B – Runoff Coefficient = 0.4

Dry Precipitation Conditions									
Month	Inflows (m^3)					Outflows (m^3)			
	Dome Creek	Tailings Catchment	Soil Beach	Pond Area	Total	Evap.	Seepage	Total	Surplus/ Deficit
April	61,957	8,929	719	3,422	75,026	0	4,313	4,313	70,713
May	34,135	4,919	396	1,885	41,335	5,100	4,457	9,557	31,778
June	33,744	4,863	391	1,864	40,861	5,880	4,313	10,193	30,668
July	50,963	7,344	591	2,815	61,713	5,400	4,457	9,857	51,856
August	8,626	1,243	100	476	10,446	3,900	4,457	8,357	2,089
September	543	78	6	30	658	1,860	4,313	6,173	-5,515
October	5,628	811	65	311	6,815	0	4,457	4,457	2,358
Total					236,853				183,947

4.4.5 Geochemical/Source Term Assumptions

The source term estimates for Option 2A are the same as those for Option 1A presented in Section 4.2.5 with the exception that there is no diffusion of arsenic, manganese and sulfate through the cover. Full descriptions of the source term derivations are provided in Lorax (2010a).

4.5 Option 2B – Tailings Dam Upgrade wit Saturated Soil Cover/Waste Rock Backfill into Pit

4.5.1 Tailings Area Water Balance Model Assumptions

The tailings area model assumptions for Option 2B are the same as those described in Section 4.4.1 for Option 2A.

4.5.2 Pit / Backfilled Waste Rock Water Balance Model Assumptions

The pit and backfill waste rock model assumptions for Option 2B are the same as those for Option 1B presented in Sections 4.3.2.

4.5.3 Waste Rock Water Balance Model Assumptions

The waste rock model assumptions for Option 2B for the low-grade ore are the same as those for Option 1B presented in Sections 4.3.3.

4.5.4 Water Balance Considerations for Option 2B

The water balance considerations for Option 2B are the same as those described for in Section 4.4.4 for Option 2A.

4.5.5 Geochemical/Source Term Assumptions

The source term estimates for Option 2B are the same as those for Option 1B presented in Sections 4.3.5 with the exception that there is no diffusion of arsenic, manganese and sulfate through the cover. Full descriptions of the source term derivations are provided in Lorax (2010a).

4.6 Option 3 – Tailings Backfill into Pit with High Infiltration Cover/Waste Rock in Place

4.6.1 Tailings Area Water Balance Model Assumptions

In Option 3, all the tailings are relocated to the pit, the tailings dam is breached and the valley is reclaimed. For modeling purposes, it was assumed that the flow from Dome Creek catchment upstream of the dam and associated breach is returned to natural conditions. For each precipitation condition modeled, the contributing flow from this area is defined by the catchment area at the Upper Dome Creek model point and monthly flows were determined using the methods outlined in Section 2.

4.6.2 Pit/Backfilled Tailings Water Balance Model Assumptions

Golder constructed a one-dimensional water balance model to describe the long-term storage of tailings in the pit in support of Option 3 (Golder 2010a). Once relocated to the pit, the tailings will be covered by waste rock to minimize evaporation and maximize infiltration. Critical to the success of this option is the ability to keep the tailings saturated in the long-term (85% saturation or greater) to limit the ingress of oxygen and development of acid generating conditions. The modeling carried out by Golder for this option evaluated the potential for the tailings to de-saturate to levels below the target saturation level of

85%. The computed fluxes included evaporation, surface infiltration, and infiltration through the top and bottom of the waste. The model was conducted in one-dimension, and did not consider surface inflows from other areas in the pit catchment. In this manner, the only source of water considered was direct precipitation to the tailings footprint (details of this work are provided in Lorax (2010b), Appendix C2).

A critical physical property of the tailings in the pit is the hydraulic conductivity of the combined tailings (fine and coarse tailings). The estimated range of hydraulic conductivity of the combined tailings is between 1 x 10^{-8} m/s and 5 x 10^{-9} m/s. This range was used in the modeling carried out by Golder to assess the sensitivity of the system to the potential for tailings de-saturation. As part of the work completed by Golder, laboratory test work was performed on samples of combined tailings to support the assumptions of hydraulic conductivity. The results of this test work yielded an average conductivity value of 1 x 10^{-8} m/s for the combined tailings. This value is identical to the upper limit of the estimated range provided above.

A key component of the work completed by Golder was to assess the potential for the de-saturation of tailings relocated to the pit. For this work, two climate data sets were modeled including dry and mean year conditions. The results indicate that with an average combined hydraulic conductivity of 1 x 10^{-8} m/s, the tailings de-saturate over time for both precipitation conditions. Although the degree of saturation remains above the 85% threshold for the time period modeled for mean year conditions (15 years), there is a clear trend towards tailings de-saturation in the long-term. This de-saturation would be faster during periods of prolonged drought or dry conditions. For mean and dry conditions, the modeling indicates that there is a deficit of water at a hydraulic conductivity of 1 x 10^{-8} m/s. Model results for a combined tailings average hydraulic conductivity of 5 x 10^{-9} m/s, indicate that the tailings will maintain saturation levels above the target of 85% in the long-term. However, the feasibility of attaining this degree of tailings saturation in the pit is highly uncertain. As discussed in AECOM (2010b), there is a high level of uncertainty with regards to the feasibility of blending the tailings sufficiently to achieve a desired bulk hydraulic conductivity.

A second component of the 1-D modeling involved estimating the water balance fluxes for mean, dry and wet precipitation conditions for incorporation into the site water balance and water quality model. An average hydraulic conductivity of 1 x 10^{-8} m/s was used for the in-pit tailings. Table 4-19 summarizes the cumulative fluxes through the top of the cover, top of the tailings and bottom of the tailings for each precipitation condition.

Table 4-19 Summary of Option 3 1-D Cumulative Fluxes (April 15 to October 31)

	Cumulative Flux (m^3/m^2)			
	Top of Cover	**Top of Tailings**	**Bottom of Tailings**	**Deficit**
Dry Year	0.02	0.13	0.15	0.02
Average Year	0.06	0.14	0.16	0.02
Wet Year	0.18	0.16	0.16	0

The model results indicate that for Option 3, taking into consideration only direct onset precipitation, there would be a deficit of water during dry and mean precipitation conditions. For these cases, unless additional water can be routed to the tailings area to make up the deficit, the tailings would be predicted to de-saturate progressively over time under the conditions modeled.

Table 4-20 summarizes the steady state flux rate out of the bottom of the tailings and annual deficit for each precipitation conditions based on the proposed tailings surface area of 21,000 m^2.

Table 4-20 Summary of Option 3 Steady State Flux and Annual Deficit

	Steady State Flux (L/s)	Deficit (m^3)
Dry Year	0.099	420
Average Year	0.104	420
Wet Year	0.104	0

To ensure that the target saturation level of 85% is achieved during all precipitation conditions, the one-dimensional model predicts that an additional 420 m^3 of water would be required on an annual basis, above that provided by direct onset precipitation and snow melt. The ability of the proposed design for Option 3 to provide this quantity of water is discussed in Section 4.6.4.

Based on the steady state fluxes summarized in

Table 4-20, a flux rate though the bottom of the tails of 0.104 L/s was adopted for all precipitation conditions. For the long-term discharge rate from the pit to Dome Creek, an estimated groundwater discharge rate of 0.1347 L/s was assumed.

4.6.3 Waste Rock Water Balance Model Assumptions

The waste rock model assumptions for Option 3 for waste rock remaining on the surface are the same as those for Option 1A presented in Section 4.2.3 except for the relocation of the East Pile to the pit for use as cover material for the tailings. Table 4-21 and

Table 4-22 summarize the remaining waste rock storage areas on surface for Option 3 that are incorporated into the model.

Table 4-21 Summary of Waste Rock Storage Areas for Option 3

ID	Waste Rock Sub-Catchment	Area (m^2)	Waste Rock Catchment Label	Seepage Classification	Receiving Environment
A	None	26,425	WR-DC1	Seepage - shallow groundwater	Dome Creek
B	NW Pile	12,750	WR-DC2	Seepage – deep groundwater	Dome Creek
	Mid-Sector	21,325	WR-DC2	Seepage – deep groundwater	Dome Creek
	S-SW Pile	38,225	WR-DC2	Seepage – deep groundwater	Dome Creek
	Total	72,300			
B	Ore Backfill	4,200	ORE-DC	Seepage – deep groundwater	Dome Creek
C	NW Pile	7,025	WR-PC1	Seepage – shallow groundwater	Pony Creek
	East Pile	0	WR-PC1	Seepage – shallow groundwater	Pony Creek
	Total	12,825			

Table 4-22 Summary of Waste Rock Water Balance Areas for Option 3

Waste Rock Catchment	Area (m^2)	Seepage Classification	Receiving Environment
WR-DC1	26,425	Seepage - shallow groundwater	Dome Creek
WR-DC2	72,300	Seepage – deep groundwater	Dome Creek
ORE-DC	4,200	Seepage – deep groundwater	Dome Creek
WR-PC1	7,025	Seepage – shallow groundwater	Pony Creek

4.6.4 Water Balance Considerations for Option 3

As discussed in section 4.6.2 for average and dry precipitation conditions, a minimum of an additional 420 m^3 would be required to ensure tailings saturation levels are maintained at 85% or higher. The surface area of the tailings placed in the pit is 21,000 m^2, while the entire pit catchment for Option 3 is 33,930 m^2, resulting in a residual pit catchment area of 12,930 m^2.Table 4-23 summarizes the monthly and total supplemental water volume that could be provided by snowmelt and precipitation from the residual pit catchment assuming a runoff coefficient for the residual drainage area of 0.4. For both the dry and average precipitation conditions there is sufficient runoff from the surrounding catchment to provide the supplemental water required to offset the identified deficit of 420 m^3.

Table 4-23 Assessment of Residual Drainage Water Supply for Option 3

Month	Dry Year			Average Year		
	Precipitation (mm)	Precipitation (m^3)	Runoff (m3)	Precipitation (mm)	Precipitation (m^3)	Runoff (m3)
April	57.0	737.4	295.0	46.1	596.3	238.5
May	31.4	406.3	162.5	34.1	441.2	176.5
June	31.1	401.6	160.6	68.0	879.2	351.7
July	46.9	606.5	242.6	61.0	788.7	315.5
August	7.9	102.7	41.1	38.0	491.3	196.5
September	0.5	6.5	2.6	13.0	168.1	67.2
October	5.2	67.0	26.8	23.0	297.4	119.0
Total	180.0	2327.9	931.2	283.2	3662.3	1464.9

4.6.5 Geochemical/Source Term Assumptions

The source term estimates for both the Best Estimate and the Upper Estimate are presented in Table 4-24 for Option 3. The source term estimates for waste rock and low-grade ore in Option 3 are the same as those for Option 1A presented in Sections 4.2.5. For the saturated backfilled tailings, the following summarizes the rationale behind the source term derivation. Full descriptions of the source term estimates are provided in Lorax (2010a).

Tailings Backfill (Saturated)

- Loading reduction factors of 50% for arsenic were applied to the model to account for attenuation along groundwater flowpaths between the pit and receiving water courses. Some degree of arsenic attenuation in the subsurface environment can be expected through adsorption/co-precipitation mechanisms. Specific removal mechanisms for dissolved arsenic include sorption to Fe oxides (Bowel, 1994), sorption to clay minerals (Violante and Pigna, 2002), and arsenic precipitation as secondary sulphide minerals (Martin and Pedersen, 2002). The presence of silt-clay facies in the underlying deposits in the area certainly suggests that the sorption of arsenic to clay minerals may play a dominant role. Further, the ore-body surrounding the open pit is defined as an iron-oxide deposit. The oxidized, iron-rich nature of the bedrock is also expected to provide some attenuation of arsenic, as described by Bowell (1994). The magnitude of the ascribed loading reductions (~50%) is based on experience at other mine operations (unpublished data) which have monitored arsenic removal in groundwater downgradient of tailings facilities. At these sites in northwestern Ontario and British Columbia arsenic loading reductions of greater than 90% have been documented.

- Either mild (Best Estimate) or strongly (Upper Estimate) suboxic conditions will persist in tailings porewater. Groundwater monitoring data for wells screened in tailings materials were used to derive source term estimates.

Table 4-24 Summary Source Term Chemistry for Option 3 (all values in mg/L)

	Best Estimate			Upper Estimate		
Parameter	**Pit – Tailings**	**Waste Rock Pile**	**Ore**	**Pit – Tailings**	**Waste Rock Pile**	**Ore**
Arsenic	9.3	0.0068	0.026	15	0.0227	0.041
Cadmium	0.001	0.033	0.09	0.001	0.184	0.201
Copper	0.002	0.039	0.015	0.002	0.225	0.036
Iron	3.2	0.01	0.03	15	0.06	0.05
Manganese	5	4.8	49	24	28.6	97.4
Zinc	0.045	5.14	10.4	0.45	34.2	31.2
Sulfate	1700	1530	2265	2000	2940	2680
Ammonia	15	0.03	0.03	15	0.12	0.093
Nitrate	0.1	2	0.33	0.1	9.96	0.85
Nitrite	0.085	0.023	0.08	0.085	0.36	0.1
Cyanide – T	0.04	*n/a*	*n/a*	0.9	*n/a*	*n/a*
WAD – CN	0.03	*n/a*	*n/a*	0.2	*n/a*	*n/a*
Cyanate	6	*n/a*	*n/a*	6	*n/a*	*n/a*
Calcium	*136*	368	431	470	346	431
Magnesium	*50*	92.7	297	45	90.5	297

4.7 Option 4 – Tailings and Waste Rock Backfill into Pit with Low Infiltration Cover

4.7.1 Tailings Area Water Balance Model Assumptions

Similar to Option 3, Option 4 includes tailings relocation to the pit, breaching of the tailings dam and reclamation of the Dome Creek valley. For modeling purposes, it was assumed that flow from the Dome Creek catchment upstream of the dam and associated breach is returned to natural conditions. For each precipitation condition modeled, the contributing flow from this area is defined by the catchment area at the Upper Dome Creek model point and monthly flows were determined using the methods outlined in Section 2.

4.7.2 Pit/Backfilled Tailings and Waste Rock Water Balance Model Assumptions

Option 4 consists of relocating the tailings to the pit following partial backfill with waste rock, and subsequently overlain by waste rock and a synthetic barrier cover system to minimize infiltration. The use of a synthetic cover system is more suitable to the climatic conditions at the site and is not reliant on a viable vegetative cover. Golder was commissioned to identify potential designs of low-infiltration covers and conduct a conceptual assessment of the cover performance for the various cover options (Golder 2010b). In addition, Golder carried out preliminary infiltration modeling of one of the cover options, specifically a store-release-divert soil cover. Details of the dry cover assessment and modeling are presented in Lorax (2010b), Appendix C3. Results of the dry cover assessment indicate that the typical range of infiltration rates for synthetic barrier cover systems is 1% to 3%. To account for possible reduction in long-term cover performance, a long-term infiltration rate of 5% of average annual precipitation was selected for modeling purposes.

In addition to the actual footprint of the relocated tailings (24,800 m^2), the pit catchment also includes an additional covered area of 9,600 m^2. For modeling purposes, it was assumed that the water infiltrating from this additional area eventually infiltrates through the tailings. The annual volume infiltrating through the tailings and the long-term infiltration rate adopted in the model are presented in Table 4-25. In summary, a long-term infiltration rate through the tailings of 0.015 L/s was selected for modeling Option 4.

Table 4-25 Summary of Infiltration through Tailings for Option 4

Contributing Area	Area (m^2)	Precipitation (mm)	Annual Infiltration Volume (m^3)	Infiltration Rate (L/s)
Tailings	24,800	283.2	351.2	-
Surrounding Catchment	9,600	283.2	135.9	-
Total			487.1	0.015

In addition to the vertical flow through the tailings of 0.015 L/s, there is a component of horizontal flow through the waste rock under laying the tailings. Given that the long-term groundwater discharge rate from the pit to Dome Creek is assumed to be 0.13 L/s, the horizontal flow rate through the waste rock was assumed to be the difference between the total pit discharge rate and the vertical infiltration rate through the tailings or 0.119 L/s.

4.7.3 Waste Rock Model Assumptions

The waste rock model assumptions for Option 4 for waste rock remaining on the surface are the same as those for Option 1A presented in Section 4.2.3 except for the relocation of approximately 344,000 m^3 of waste rock to the pit and placement of the low infiltration cover over the low-grade ore. Table 4-26 summarizes the remaining waste rock storage areas on surface for Option 4 that are incorporated into the model.

Table 4-26 Summary of Waste Rock Water Balance Areas for Option 4

Waste Rock Catchment	Area (m^2)	Seepage Classification	Receiving Environment
WR-DC1	0	Seepage - shallow groundwater	Dome Creek
WR-DC2	23,495	Seepage – deep groundwater	Dome Creek
ORE-DC	4,200	Seepage – deep groundwater	Dome Creek
WR-PC1	0	Seepage – shallow groundwater	Pony Creek

As part of the cover for the tailings in the pit, the low-grade ore pile is also incorporated into the store-release-divert cover. In addition to the footprint of the low-grade ore pile of 4,200 m^2, an additional surface area of 4,200 m^2 is also incorporated into the cover with subsequent infiltrating waters routing through the low-grade ore.

4.7.4 Geochemical/Source Term Assumptions

The source term estimates for both the Best Estimate and the Upper Estimate are presented in Table 4-27 for Option 4.

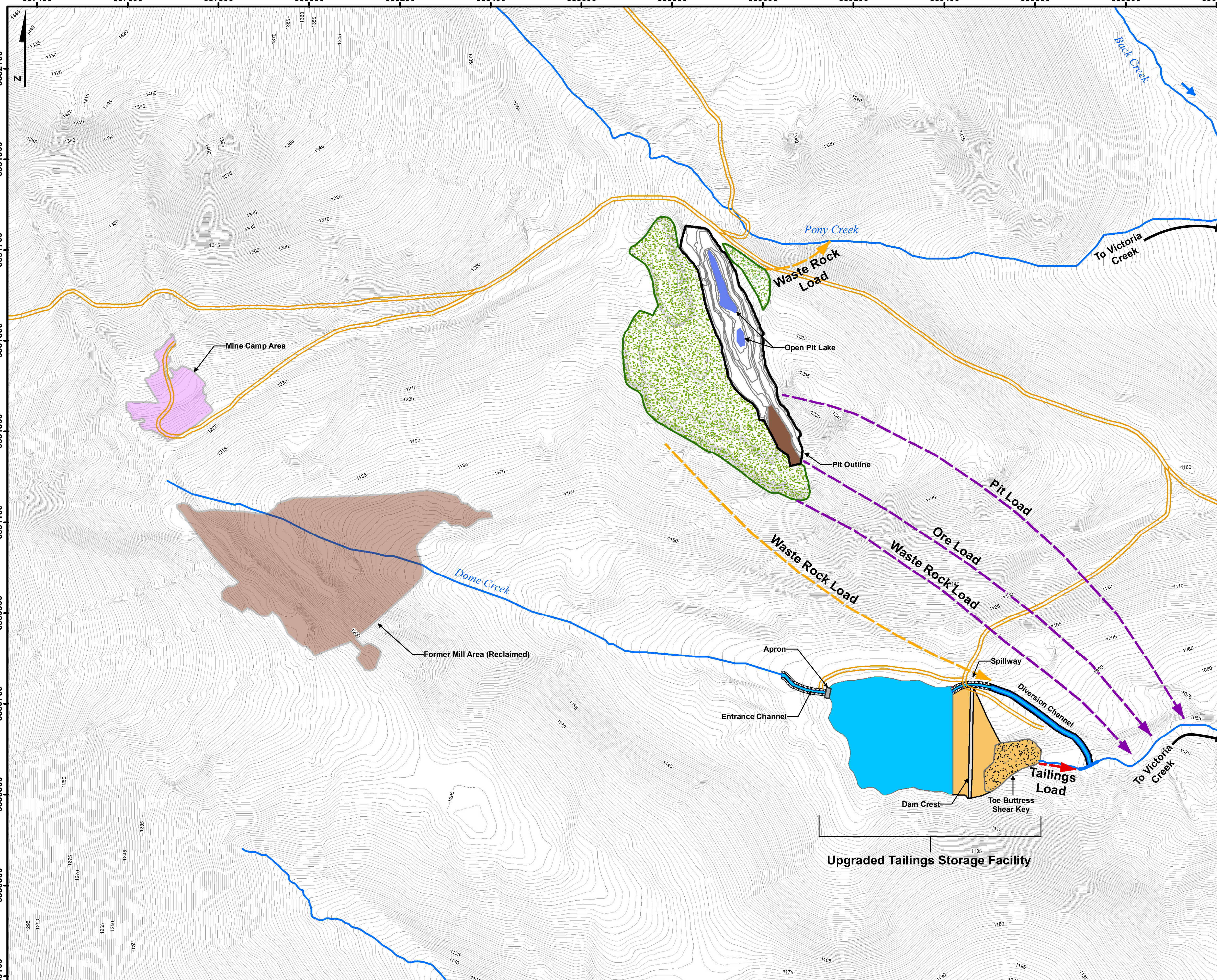
Table 4-27 Summary Source Term Chemistry for Option 4 (all values in mg/L)

Parameter	Best Estimate				Upper Estimate			
	Pit – Waste Rock	Pit – Tailings	Waste Rock Pile	Ore	Pit – Waste Rock	Pit – Waste Rock	Waste Rock Pile	Ore
Arsenic	0.12	28.4	0.0068	0.026	1.2	28.4	0.0227	0.041
Cadmium	0.027	0.184	0.033	0.09	0.184	0.184	0.184	0.201
Copper	0.04	1.4	0.039	0.015	0.225	1.4	0.225	0.036
Iron	2.15	574	0.01	0.03	5.28	574	0.06	0.05
Manganese	143	28.6	4.8	49	181	28.6	28.6	97.4
Zinc	5.14	26.2	5.14	10.4	34.2	26.2	34.2	31.2
Sulfate	2040	2500	1530	2265	2940	2500	2940	2680
Ammonia	1.25	6.5	0.03	0.03	1.54	6.5	0.12	0.093
Nitrate	0.32	3	2	0.33	1.371	3	9.96	0.85
Nitrite	0.1	0.3	0.023	0.08	0.396	0.3	0.36	0.1
Cyanide – T	n/a	0.07	n/a	n/a	n/a	0.07	n/a	n/a
WAD – CN	n/a	0.03	n/a	n/a	n/a	0.03	n/a	n/a
Cyanate	n/a	2	n/a	n/a	n/a	2	n/a	n/a
Calcium	368	250	368	431	346	250	346	431
Magnesium	93	60	92.7	297	91	60	90.5	297

The source term estimates for waste rock (subaerial) and low-grade ore in Option 4 are the same as those for Option 1A presented in Sections 4.2.5. The source term estimates for the backfilled waste rock are the same as those presented in Section 4.3.5 for Option 1B. For the backfilled tailings, which are assumed to be in an un-saturated state, the following summarizes the rationale behind the source term derivation. Full descriptions of the source terms estimate are provided in Lorax (2010a).

Tailings Backfill (Un-saturated)

- Tailings will produce acidic drainage.
- Arctic Gold and Silver tailings were used as a geochemical analogue. Values for this mine were compared to humidity cell drainage data from the three cells that went acid.
- Similar to Option 3, loading reduction factors of 50% for arsenic were applied to the model to account for attenuation along groundwater flowpaths between the pit and receiving water courses.
- Upper Estimate source terms were not developed for Option 4 due to a lack of suitable data.



CLIENT::

Yukon Government

Legend

- Roads
- Watercourse
- Former Mill Area (Reclaimed)
- Mine Camp Area
- Dam Area
- Pit Outline
- Reclaimed Ore Area
- Reclaimed Waste Rock Dump
- Upgraded Tailings Impoundment (Water Cover)
- Shallow Groundwater Seepage
- Tailings Seepage
- Deep Groundwater Seepage

Topography

- Index (5m)
- Interm (1m)

Meters: 0, 150, 300, 600

Data courtesy of AECOM

Figure for illustrative purposes only

SCALE:	1:8,000
DATE:	OCT 22nd, 2010
PROJECTION:	NAD_1983_UTM_Zone_8N
PROJECT MANAGER:	J.S.

PROJECT:

Mount Nansen Water Balance and Water Quality Predictions

TITLE:

Closure Option 1A Water Model Schematic

PROJECT No:	FIGURE No:
J907-4	**4.1**

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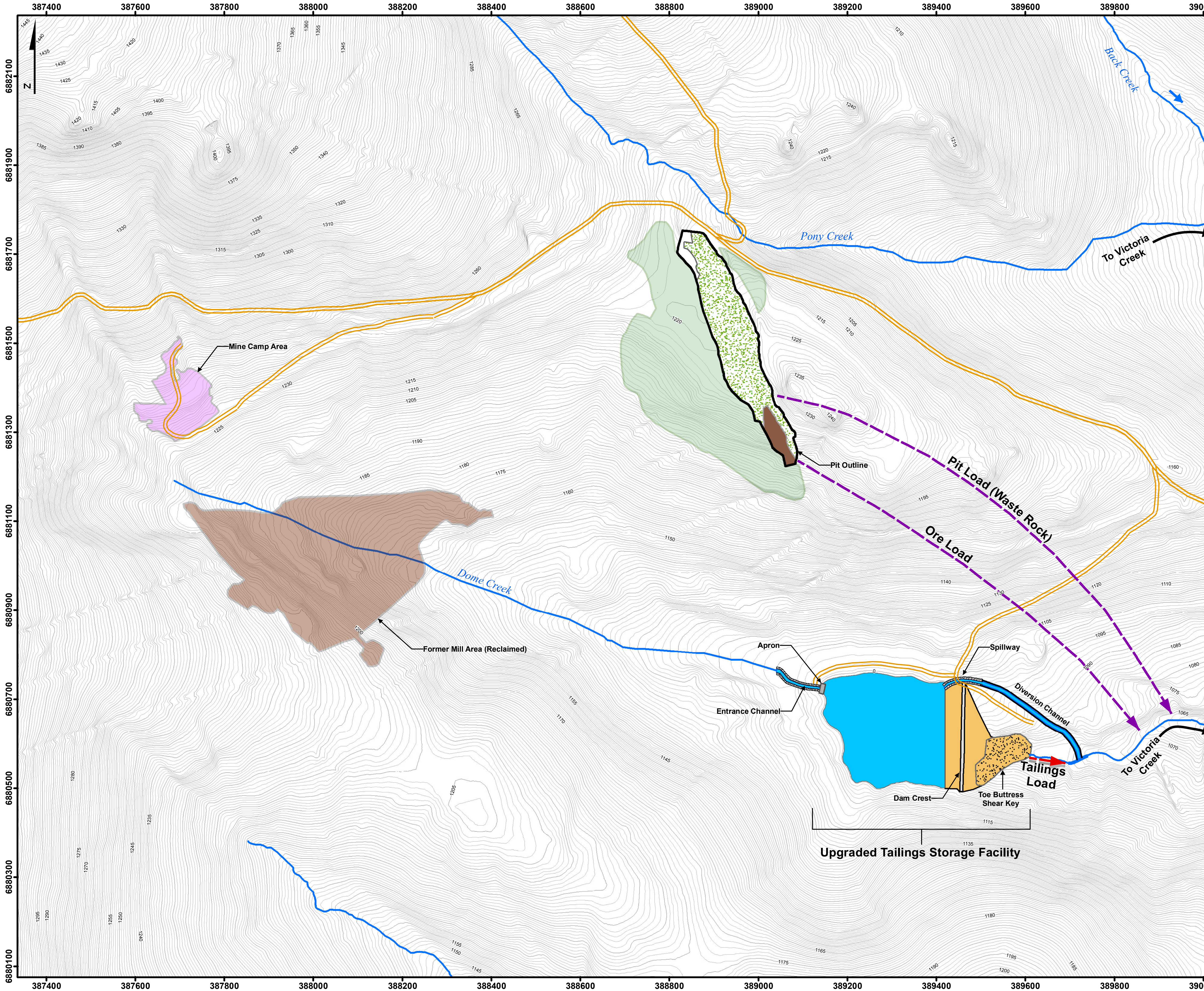

CLIENT:: Yukon Government

Legend

- Mine Roads
- Watercourse
- Former Mill Area (Reclaimed)
- Mine Camp Area
- Dam Area
- Former Waste Rock Dump Area (Reclaimed)
- Pit_Outline
- Reclaimed Ore Area
- Reclaimed Pit Backfill (Waste Rock)
- Upgraded Tailings Impoundment (Water Cover)
- Tailings Seepage
- Deep Groundwater Seepage

Topography

- Index (5m)
- Interm (1m)

Meters: 0 150 300 600

Data courtesy of AECOM

Figure for illustrative purposes only

SCALE:	1:8,000
DATE:	OCT 22nd, 2010
PROJECTION:	NAD_1983_UTM_Zone_8N
PROJECT MANAGER:	J.S.

PROJECT:

Mount Nansen Water Balance and Water Quality Predictions

TITLE:

Closure Option 1B Water Model Schematic

PROJECT No:	FIGURE No:
J907-4	4.2

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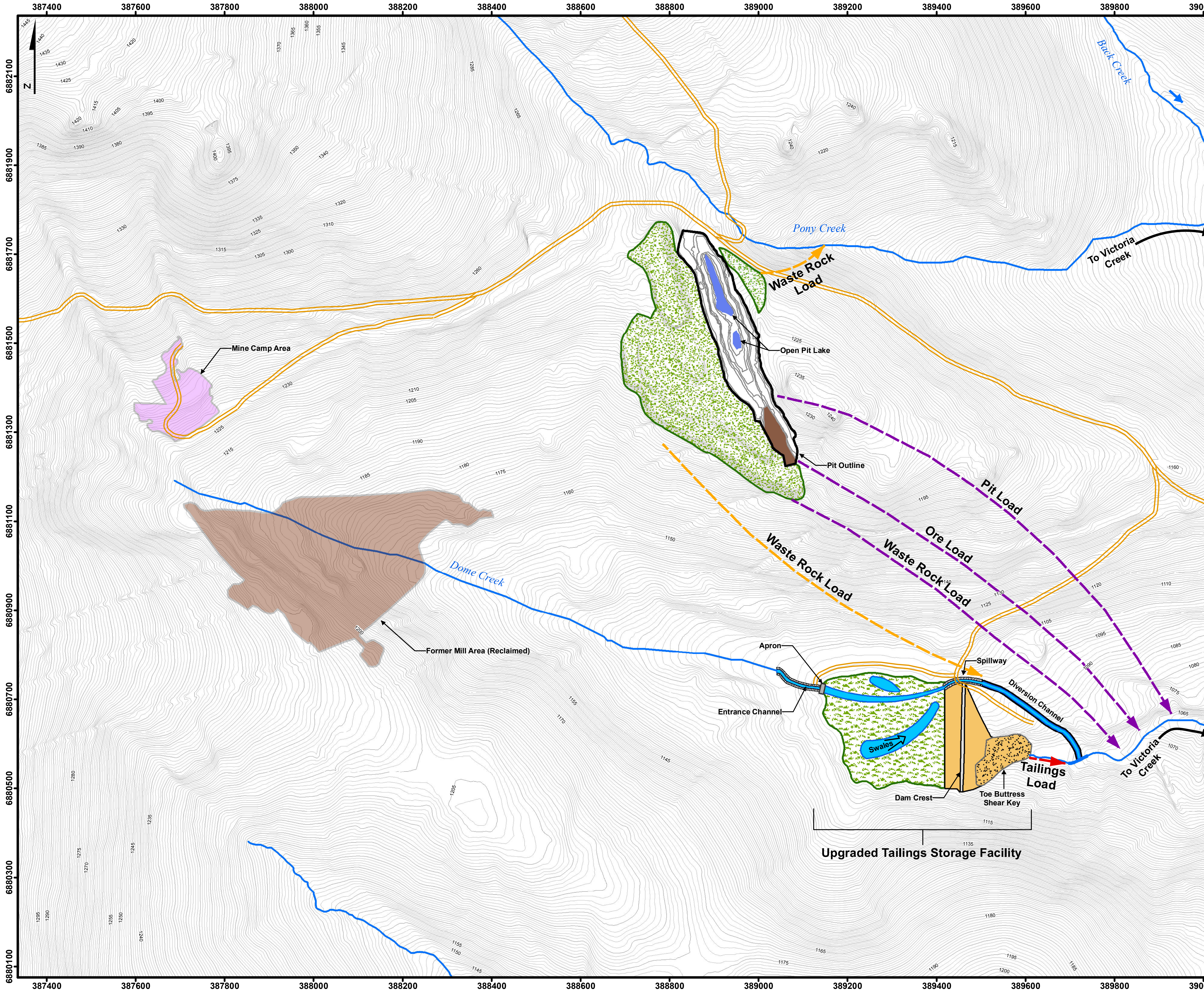

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Legend

- Roads
- Watercourse
- Former Mill Area (Reclaimed)
- Mine Camp Area
- Dam Area
- Pit Outline
- Reclaimed Ore Area
- Reclaimed Waste Rock Dump
- Upgraded Tailings Impoundment (Saturated Soil Cover)
- Shallow Groundwater Seepage
- Tailings Seepage
- Deep Groundwater Seepage

Topography

- Index (5m)
- Interm (1m)

Meters: 0, 150, 300, 600

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PROJECTION:	NAD_1983_UTM_Zone_8N
PROJECT MANAGER:	J.S.

PROJECT:
Mount Nansen Water Balance and Water Quality Predictions

TITLE:
Closure Option 2A Water Model Schematic

PROJECT No:	FIGURE No:
J907-4	4.3

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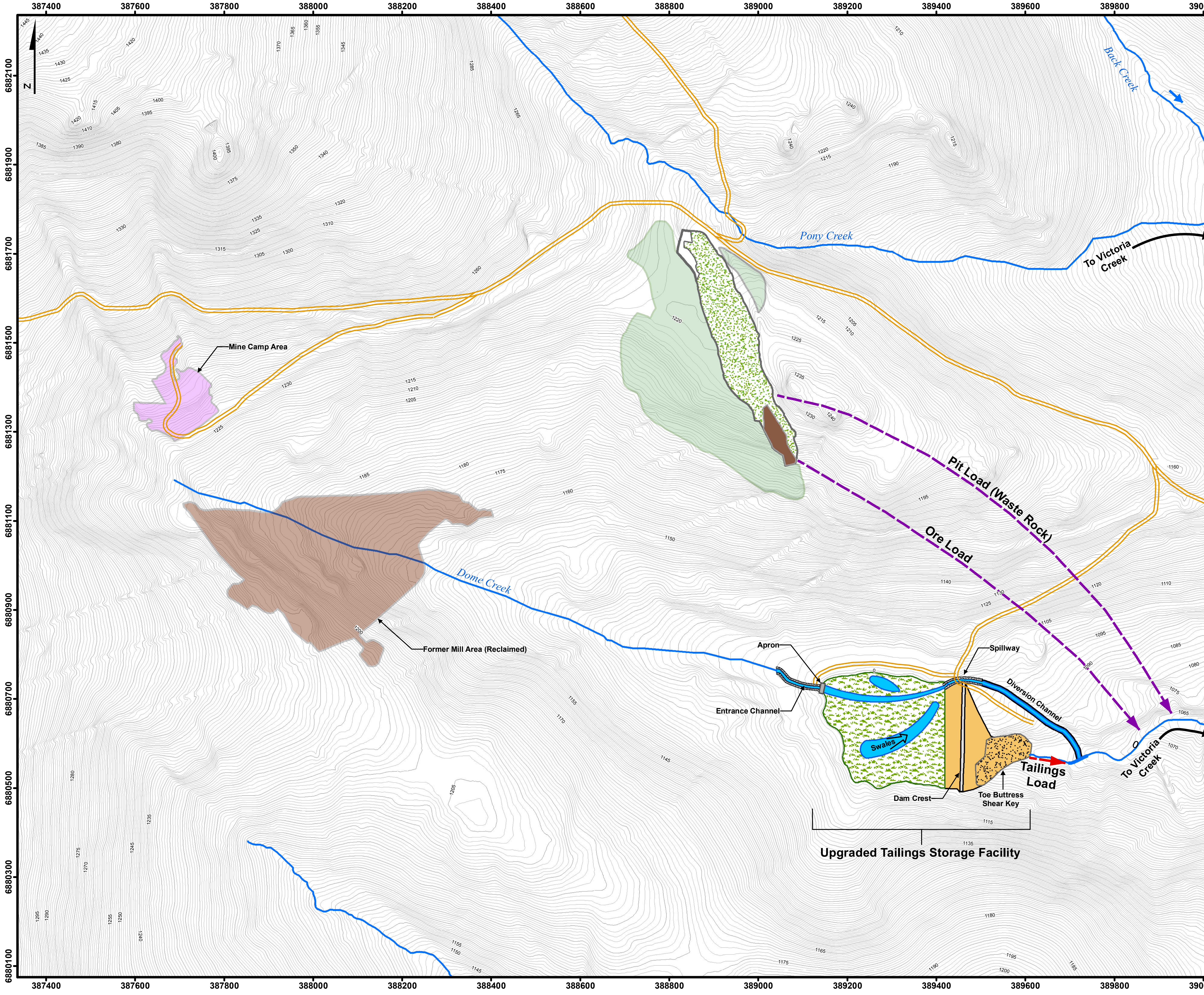

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Legend

- Roads
- Watercourse
- Dam Area
- Former Mill Area (Reclaimed)
- Mine Camp Area
- Former Waste Rock Dump Area (Reclaimed)
- Pit Outline
- Reclaimed Ore Area
- Reclaimed Pit Backfill (Waste Rock)
- Upgraded Tailings Impoundment (Saturated Soil Cover)
- Deep Groundwater Seepage
- Tailings Seepage

Topography

- Index (5m)
- Interm (1m)

Meters: 0 150 300 600

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SCALE: 1:8,000

DATE: OCT 22th, 2010

PROJECTION: NAD_1983_UTM_Zone_8N

PROJECT MANAGER: J.S.

PROJECT: **Mount Nansen Water Balance and Water Quality Predictions**

TITLE: **Closure Option 2B Water Model Schematic**

PROJECT No:	FIGURE No:
J907-4	4.4

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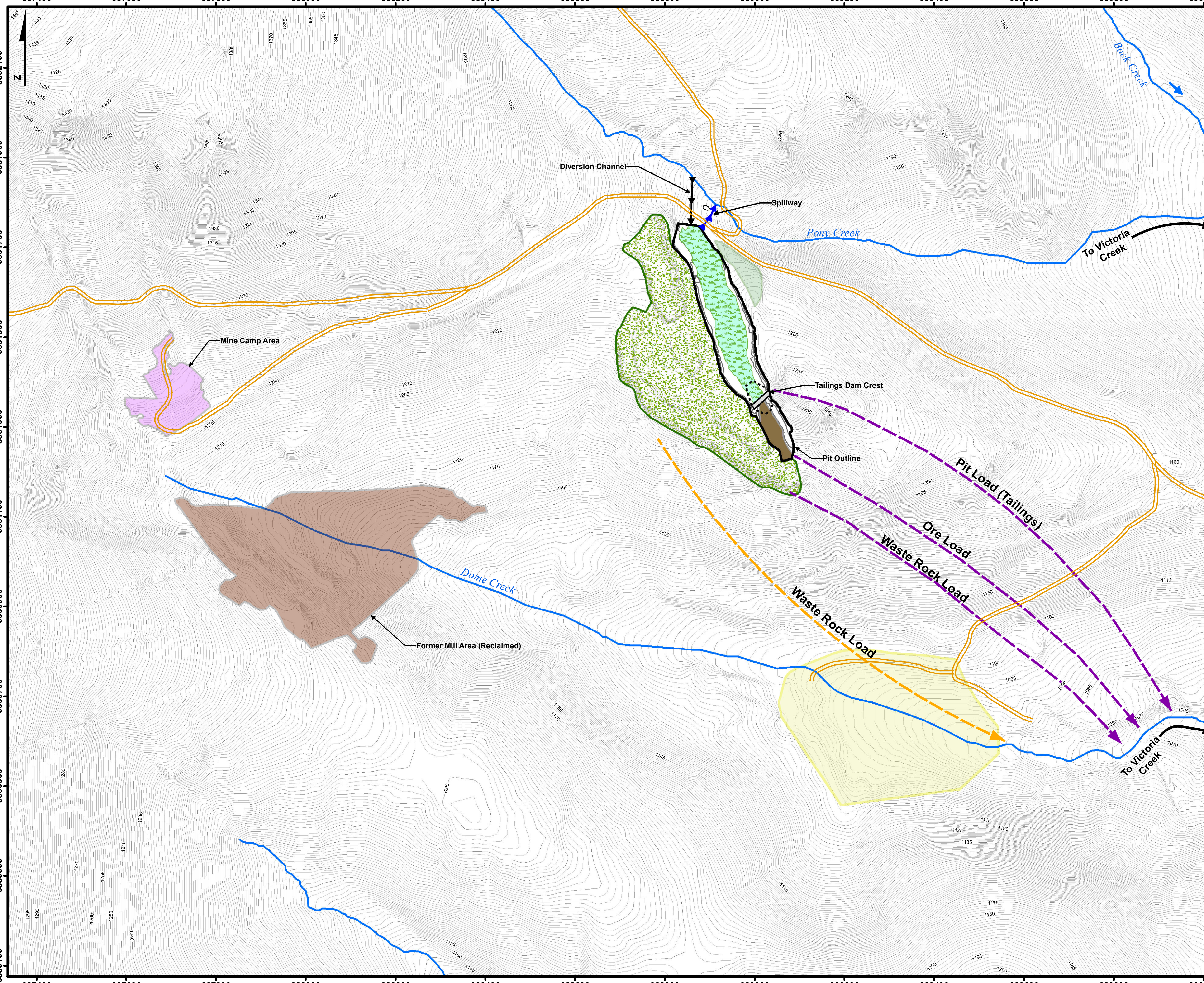

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Legend

- Roads
- Watercourse
- Former Mill Area (Reclaimed)
- Mine Camp Area
- Former Waste Rock Dump Area (Reclaimed)
- Former Tailings Impoundment Footprint (Valley Restoration)
- Pit Outline
- Tailings Dam Footprint
- Reclaimed Ore Area
- Reclaimed Waste Rock Dump
- Reclaimed Backfilled Pit (Tailings with High Infiltration Cover)
- Shallow Groundwater Seepage
- Deep Groundwater Seepage

Topography

- Index (5m)
- Interm (1m)

Meters 0 150 300 600

Data courtesy of AECOM

Figure for illustrative purposes only

SCALE:	1:8,000
DATE:	OCT 22nd, 2010
PROJECTION:	NAD_1983_UTM_Zone_8N
DATA SOURCE:	J.S.

PROJECT:

Mount Nansen Water Balance and Water Quality Predictions

TITLE:

Closure Option 3 Water Model Schematic

PROJECT No:	FIGURE No:
J907-4	**4.5**

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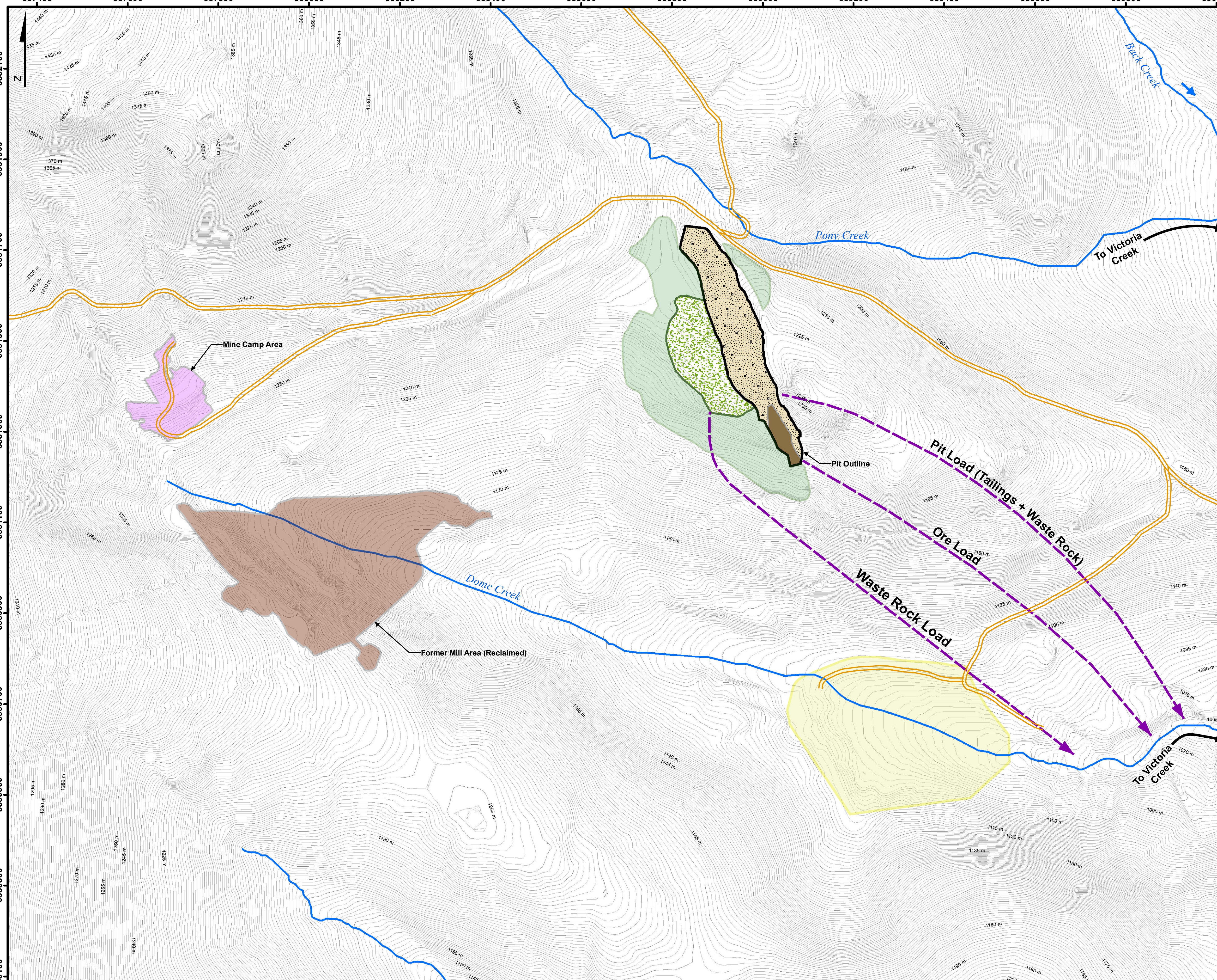

CLIENT:: Yukon Government

Legend

- Roads
- Watercourse
- Former Mill Area (Reclaimed)
- Mine Camp Area
- Former Waste Rock Dump Area (Reclaimed)
- Former Tailings Impoundment Footprint (Valley Restoration)
- Pit Outline
- Reclaimed Ore Area
- Reclaimed Waste Rock Dump
- Reclaimed Backfilled Pit (Tailings + Waste Rock with Low Infiltration Cover)
- Deep Groundwater Seepage

Topography

- Index (5m)
- Interm (1m)

Meters: 0, 150, 300, 600

Data courtesy of AECOMM

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SCALE: 1:8,000

DATE: OCT 22nd, 2010

PROJECTION: NAD_1983_UTM_Zone_8N

PROJECT MANAGER: J.S.

PROJECT: **Mount Nansen Water Balance and Water Quality Predictions**

TITLE: **Closure Option 4 Water Model Schematic**

PROJECT No: **J907-4**

FIGURE No: **4.6**

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5 Water Quality Predictions

A water balance and water quality model was used to support the assessment of each of the proposed closure alternatives. The results of the model, specifically predicted water quality in the receiving environment at Victoria Creek, were used to assess the overall performance of the proposed alternatives.

For each option, a total of six different model scenarios were run, including combinations of two different source term chemistry estimates (Best Estimate and Upper Estimate) and three precipitation conditions (dry, average and wet year). The Best Estimate and Upper Estimate predictions reflect the range in source concentrations used in the model (Lorax 2010). For each scenario, the model was run on a monthly time step for a calendar year (12 months). The model output included concentrations for a suite of major ions and trace elements in Victoria Creek downstream of all surface water and groundwater inputs. However, in order to illustrate the predicted performance of the various options, emphasis was placed on arsenic, sulfate, cadmium and zinc, since these constituents are the primary parameters of concern. Full results are available in Appendix A.

In addition to the six model scenarios, the following sensitivity runs were carried out to assess the implications on water quality of key uncertainties identified for various aspects of the closure options.

- Options 1 and 2 – Loss of attenuation of arsenic in tailings seepage along the flow path to the receiving environment;
- Options 3 and 4 – Loss of attenuation of arsenic along the groundwater flow path between the pit and the receiving environment; and
- Option 4 – Increased infiltration rate of 15% of annual precipitation through the low-infiltration cover.

5.1 Water Quality and Water Balance Model Results - Option 1A

5.1.1 Performance

Water quality predictions for each of the six model runs were used to assess the performance of Option 1A through comparison to existing water quality in the downstream receiving environment in Victoria Creek and to CCME Guidelines for the Protection of Aquatic Life. For cadmium, the recently updated draft chronic guideline was used (Environment Canada, 2008). The draft updated cadmium guideline for long-term exposure is:

$$CWQG = e^{(0.7409[\ln(hardness)] - 4.796)}$$

where the CWQG is in µg/L and hardness is measured as $CaCO_3$ equivalents in mg/L.

A summary of the Best Estimate water quality predictions (average year) for sulfate, arsenic, cadmium and zinc in Victoria Creek for Option 1A is presented in Table 5-1. Presented for comparison are the existing minimum, median and maximum winter concentrations in Victoria Creek and the applicable CCME guidelines.

Existing metal levels in Victoria Creek are governed predominantly by particulate fractions, and show elevated levels in conjunction with TSS. However, there are no consistent seasonal trends in the data, which implies TSS events are governed by variables other than freshet flows, including storm events and upstream placer mining activities. Accordingly, maximum winter concentrations were used for the comparison as they most accurately reflect the range of current water quality conditions during the more sensitive winter low flow period when higher parameters concentrations are predicted to occur. It should be noted that the winter dataset is limited to samples collected from November to January and likely does not capture the full range of current variability observed during the winter low-flow period. Time series of the predicted concentrations are also presented graphically in Figures 5-1 through 5-4 for each of the source chemistry and precipitation conditions. Source loading distributions of arsenic, cadmium and zinc are presented in Figure 5-9 for the Best Estimate/Average Flow Scenario.

Option 1 and Option 2 (tailings in place with dam upgrade) are designed to maintain saturated tailings conditions as a means to prevent the development of acidic conditions, thereby sustaining circum-neutral pH drainages from the tailings storage facility. This pH neutrality is expected to persist over the long-term. Further, the attenuation mechanisms currently observed in the existing tailings storage facility can also be expected to persist in the long-term (Lorax 2010a). Option 1A maintains waste rock and the Brown McDade Pit in their current configurations. Dumps will be re-graded; however their footprint will remain the same. Therefore, Option 1A (and Option 2A) is analogous to the existing status quo condition. In this regard, comparison of the predicted results for Option 1A to existing water quality for Victoria Creek can be used to assess the overall conservatism that has been built into the model, particularly given that the mill site area contaminant load has been removed in the model predictions. The performance of the other options may also be measured against Option 1A, since it most closely represents modeled status quo conditions.

Key highlights (for Best Estimate/Average Flow Scenario) of the water quality predictions for Option 1A are:

- For all modeled parameters, peak concentrations are predicted to occur during the winter low flow period due to ongoing loadings from the site during periods of minimal flow and available dilution. This disproportionate load is emphasized by the assumptions for seepage rate from the tailings and discharge rate from the deep groundwater system, which are assumed to remain constant throughout the year despite varying flows in Victoria Creek.

- Sulfate
  - In general, the predicted concentrations for sulfate (median = 36 mg/L) are similar to existing sulfate concentrations (median = 29.6 mg/L) in Victoria Creek, except for winter low flow periods. During this period, the predicted maximum concentration of 106 mg/L is significantly higher than the maximum observed winter sulfate concentration (60.9 mg/L).
  - The primary source of the higher predicted sulfate concentrations in the winter low flow period is the invariant discharge of tailings seepage to the receiving environment at constant rate of 3.5 L/s. In reality, it would be anticipated that the seepage discharge would decrease over the winter period. In this manner, the winter predictions likely represent over estimates.

- Arsenic
  - Predicted concentrations of arsenic (median = 0.0020 mg/L) are comparable to existing arsenic concentrations in Victoria Creek (median = 0.0016 mg/L) and are well below the CCME guideline of 0.005 mg/L.
  - Maximum concentrations of arsenic are predicted to occur during winter low flow (peaking at 0.0055 mg/L). This value marginally exceeds the CCME guideline, although is within the range of the existing maximum winter concentrations (maximum = 0.0075 mg/L).
  - The predicted loading associated with tailings seepage is the dominant source of arsenic to the receiving environment (95% of a total predicted annual loading of 4.6 kg).

- Cadmium

  - Predicted cadmium concentrations are higher than the existing values currently observed in Victoria Creek.
  - The predicted median cadmium concentration (0.00012 mg/L) is approximately 4 times higher than the existing median concentration in Victoria Creek data (0.00003 mg/L) but well below the CCME guideline.
  - Maximum concentrations of cadmium are predicted to occur in winter (January to March) at concentrations above the draft CCME guideline.
  - The predicted maximum cadmium concentration of 0.00055 mg/L is approximately twice the existing maximum winter concentration 0.0003 mg/L.
  - The predicted loading from seepage from the waste rock dumps is the dominant source of cadmium to the receiving environment (72% of a total predicted annual loading of 0.7 kg).

- Zinc
  - The predicted median zinc concentration (0.018 mg/L) is approximately twice the existing median concentration (0.009 mg/L) but below the CCME guideline of 0.03 mg/L.
  - Maximum concentrations of zinc are predicted to occur in winter (December to April) at concentrations above the CCME guideline.
  - The predicted maximum zinc concentration (0.062 mg/L) is 3 times the existing winter maximum concentration (0.02 mg/L).
  - The predicted loading from seepage from the waste rock dumps is the dominant source of zinc to the receiving environment (88% of a total predicted annual loading of 82.1 kg).

For both cadmium and zinc, the over estimation of concentrations in Victoria Creek is primarily due to the overly conservative assumptions for seepage from the waste rock dumps to the receiving environment. Observations on site and elsewhere (e.g., Faro) suggest that south facing slopes will not produce much seepage due to evaporation. Despite numerous attempts to collect seepage, seeps have not been found from south facing dumps southwest of the pit. As a result, seepage rates from these areas are likely overestimated. Further, seepage from portions of the dumps is assumed to infiltrate into the bedrock aquifer and discharge to Victoria Creek via Dome Creek at a constant rate throughout the year. This assumption likely overestimates loadings in the winter and underestimates loadings during the active flow period. A further aspect contributing to model conservatism is that the model does not take into account any attenuation of species along the flow path to the receiving environment. Some degree of cadmium and zinc attenuation in the subsurface environment can be expected through adsorption/precipitation processes. Attenuation of cadmium and zinc appears to be currently occurring in the vicinity of the mill area in upper Dome Creek and below the tailings impoundment in lower Dome Creek. The persistence and long-term performance of these mechanisms is uncertain.

Table 5-1 Summary of Predicted Concentrations (mg/L) in Victoria Creek for Option 1A – Best Estimate Source Terms and Average Precipitation Conditions (all values in mg/L)

		Existing Water Quality[c]			Predicted Water Quality	
	CCME Guideline	Minimum	Median	Winter Maximum[c]	Median	Maximum
Arsenic	0.005	0.001	0.0016	0.0075	0.0020	0.0055
Cadmium	0.00034[a]	0.000005	0.00003	0.0003	0.00012	0.00051
Zinc	0.03	0.0005	0.009	0.02	0.018	0.062
Sulfate		6.2	29.6	60.9	36	106

Notes:

a. Draft CCME Guideline for Cadmium (Environment Canada 2008) at Hardness = 150 mg/L as $CaCO_3$.
b. Existing water quality data for Victoria Creek at Road (2007 to 2010).
c. Maximum winter concentration from the existing water quality data set for Victoria Creek (November to February, 2007 to 2010).

Overall, the Best Estimate Average Precipitation model results for Option 1A are comparable to existing water quality conditions in Victoria Creek and can be used to best represent current conditions at the site. The predicted higher winter concentrations are due to the disproportionate winter loadings from the tailings area and deep groundwater pathways which are assumed to remain constant throughout the year. The limited data set for the winter period does not likely encompass the entire range of observed water quality conditions. This presents a limitation of the comparison between predicted concentrations and existing winter values.

5.1.2 Uncertainty

As with all predictive models, there are uncertainties related to the various inputs and assumptions that form the basis of the model. Some of these uncertainties are general in nature and apply to all of the options such as monthly flow rates, annual precipitation, evaporation and background or upstream water quality. Others are unique to the specific closure options such as source term chemistry and source discharge or flow rates. Where there is more understanding and/or historical data to support the model assumptions, there is less uncertainty associated with the predicted results. The following provides a summary of the key uncertainties associated with the modeling results for Option 1A.

- For the tailings area, Option 1A has less overall uncertainty associated with the water quality predictions in comparison to the other options primarily due to the long-term flow and water quality records for the seepage collection pond. Specifically, the performance of the existing tailings facility with regards to seepage rates and water quality is predicted to provide a defensible proxy for the performance of Option 1 over the long-term. This provides a reasonable amount of confidence in the predictions. Accordingly, predictions that exceed observed water quality conditions in Victoria Creek are considered a metric of the model's conservatism.

- A significant amount of conservatism has been incorporated into the model to account for various uncertainties. One key component of this conservatism is the assumption of constant seepage rate from both the tailings area and the deep groundwater pathways conveying contaminants from the pit and surrounding waste rock areas. This conservatism is reflected in the higher predicted winter concentrations which generally exceed historical winter maximum concentrations. In reality, the tailings seepage and deep groundwater flows will exhibit some seasonal variability with a reduction in flows during the winter months. In addition, the use of the assumed constant seepage rate of 3.5 L/s is also conservative as it is based on the current dam condition is and therefore does not include the estimated reduction in seepage through the dam as a result of the dam upgrade (~1.6 L/s reduction).

- Precipitation conditions were evaluated for three precipitation conditions (average year, dry year and wet year) to account for the uncertainty associated with climate variability. Overall, the impact of varying precipitation, and subsequently flow in the receiving environment, is reflected in the predicted water quality for each precipitation condition presented in Figures 5-5 through 5-8. As expected, during dryer years, there is less dilution capacity in the receiving environment and therefore higher predicted concentrations. Conversely, during wet precipitation years, the additional flow in the receiving environment results in lower predicted concentrations.

- As outlined in AECOM (2010b), the groundwater discharge rate from the pit to Dome Creek was estimated for three different hydraulic conductivities which range over approximately 4 orders of magnitude. This uncertainty in the range of hydraulic conductivities and associated pit discharge rates has the potential to significantly impact the pit loading to the receiving environment. In the absence of the appropriate level of hydrogeological information required to refine the range of estimated hydraulic conductivities, the pit discharge rate in the model was conservatively set to the maximum estimated value of 0.13 L/s.

- A comparison of Best Estimate and Upper Estimate results provide an overall indication of the implication of the uncertainty associated with source term chemistry (Lorax 2010). This is best illustrated in the winter low flow months (January to March) where the predicted Upper Estimate concentrations are significantly higher in relation to maximum winter baseline concentrations (Figures 5-1 to 5-4). Although applying the Upper Estimate source chemistry provides an additional layer of conservatism into the model, the associated predicted downstream water quality is not consistent with the observed current range in water quality conditions. Therefore, the Upper Estimate model output is not considered to be representative of the anticipated performance of Option 1A.

- One of the key considerations for the Tailings in Place Options (Options 1 and 2) is whether the attenuation process reducing arsenic concentrations will continue in the long-term. An Upper estimate arsenic source term has been provided for seepage from the tailings mass, as represented by closure Option 1 and 2. The Upper estimate is based on elevated arsenic concentrations measured in a shallow monitoring well downgradient of the seepage collection pond. The upper estimate value (0.30 mg/L arsenic) is also supported by observed total and dissolved arsenic concentrations within the tailings pond. Maximum total and dissolved arsenic concentrations measured in the pond since October 2007 (since method detection limits improved) are 0.27 and 0.17 mg/L, respectively. The Upper Estimate for arsenic is considered a reasonable proxy for tailings seepage that does not undergo attenuation. This is supported by the tailings pond water quality, which is assumed to be representative of average seepage from the tailings mass in its current configuration. Predicted Upper Estimate arsenic concentrations in Victoria Creek range from 0.002 mg/L to 0.033 mg/L with a median concentration of 0.005 mg/L and are higher than the Best Estimate results and existing concentrations in Victoria Creek. As outlined above, although the Upper Estimate source term provides for an assessment of the impact of the loss of attenuation along the tailing seepage pathway, these predicted concentrations are not considered to be representative of the anticipate performance of Options 1 and 2.

- With respect to the tailings area water balance for Option 1A, one of the key considerations is whether there is sufficient water supply in the catchment upstream of the tailings area to maintain a water cover of 0.7 m, particularly during the open water, non-frozen period. A two-part assessment of the available water supply was carried out for this option as part of the water balance modeling. The first assessment was carried out assuming a runoff coefficient of 0.8 for spring runoff (April and May) and a runoff coefficient of 0.6 for the remaining open water season months as per AECOM (2010c). It is unclear if these proposed coefficients adequately represent runoff conditions at the site for all locations and conditions.

- Some clarification of the topic above is provided in Carey and Woo (2001), who found runoff coefficients as high as 0.8 in the nearby Wolf Creek basin; however, they also found that hillslopes in the watershed had runoff coefficients during snowmelt that varied considerably. No runoff was observed on the south-facing slopes, but 155 mm, 50 mm and 19 mm of water was discharged from the north, east and west-slopes, giving runoff ratios of 0.8, 0.6 and 0.25 respectively. Factors such as aspect, snow redistribution, presence/absence of ice lenses, soil type/development and infiltration potential were identified as key determinants of runoff generation at different times of year. In order to account for these findings, a sensitivity analysis was completed for Option 1A assuming a lower runoff coefficient of 0.4 for all the open water season months. Results of this assessment indicate that inflows to the tailings area are generally sufficient to maintain a 0.7 m water cover during the open water season. During dry conditions, a minimal drop in water cover would occur, although not significant enough to impact the ability of the water cover to maintain the tailings in a saturated state.

In summary, taking into consideration the uncertainties outlined above, the Best Estimate Average Precipitation results are considered to be representative of current conditions and best represent the anticipated performance of Option 1A. A considerable degree of confidence is associated with the water quality predictions. Where appropriate, conservative assumptions were incorporated into the model to offset uncertainty associated with specific model assumptions. These results, while specific to Option 1A, are representative of current site conditions and can be used as a bench mark from which to assess the performance of the other closure options.

5.2 Water Quality and Water Balance Model Results - Option 1B

The predicted water quality for each of the model runs was used to assess the performance of the other closure options. Specifically, the results of the model were compared to the Best Estimate Average Precipitation results for Option 1A, which provides a proxy for current site conditions. For each option, the predicted minimum, mean and maximum concentrations for each source term chemistry and precipitation condition are presented in Figures 5-5 through 5-8 along with the results for Option 1A. Time series profiles of the predicted concentrations for sulfate, arsenic, cadmium and zinc are presented in Figures 5-1 through 5-4. Where appropriate, CCME guidelines are provided for reference. Source loading distributions of arsenic, cadmium and zinc are presented in Figure 5-9 for the Best Estimate/Average Flow Scenario.

5.2.1 Performance

Key highlights (for Best Estimate/Average Flow Scenario) of the assessment for Option 1B are:

- Similar to Option 1A, for all modeled parameters, peak predicted concentrations occur during the winter low flow period due to continuous loadings from the site during periods of minimal flow and available dilution. This disproportionate load is emphasized by the seepage rate from the tailings and discharge rate from the deep groundwater system, which are assumed to remain constant throughout the year during.

- Sulfate
  - In general, the predicted concentrations of sulfate for Option 1B (median = 35 mg/L; maximum = 98 mg/L) are comparable lower than those for Option 1A (median = 36 mg/L, maximum = 106 mg/L).
  - Similar to Option 1A, the primary source of predicted sulfate concentrations in the winter low flow period is the year round discharge of tailings seepage to the receiving environment at constant rate of 3.5 L/s.

- Arsenic
  - Predicted concentrations of arsenic for Option 1B (median = 0.002 mg/L, maximum = 0.0059 mg/L) are comparable to those for Option 1A (median = 0.002 mg/L, maximum = 0.0055 mg/L) indicating no overall change in performance from current conditions.
  - The predicted loading from tailings seepage is the dominant source of arsenic to the receiving environment (89% of a total predicted annual loading of 4.9 kg) with the backfilled waste rock contributing a higher loading compared to waste rock storage on surface in Option 1A.

- Cadmium
  - The predicted cadmium concentrations for Option 1B (median = 0.00006 mg/L, maximum = 0.00028 mg/L) are lower than those predicted for Option 1A (median = 0.00012 mg/L, maximum = 0.00051 mg/L) and well below CCME guidelines.
  - Comparison of the predicted cadmium concentrations for Option 1B in Victoria Creek to those for Option 1A indicate an improvement in performance.
  - The improvement in water quality relates to a decrease in loading from waste rock. Although still the dominant source of cadmium to the receiving environment, the waste rock contributes significantly less loading primarily due to the overall reduction of the waste rock footprint as a result of backfilling (62% of a total predicted annual loading of 0.3 kg).

- Zinc
  - The predicted zinc concentrations for Option 1B (median= 0.010 mg/L, maximum = 0.035 mg/L) are lower than those predicted for Option 1A (median = 0.018 mg/L, maximum = 0.062 mg/L) and generally below the CCME guideline, except during winter low flow conditions.
  - Comparison of the predicted zinc concentrations for Option 1B in Victoria Creek to those for Option 1A indicate an improvement in performance.
  - Similar to cadmium, the water quality improvements associated with zinc can be attributed to a decrease in the loading from waste rock primarily due to the overall reduction of the waste rock footprint (92% of a total predicted annual loading of 30 kg).

Overall, the Best Estimate Average Precipitation model results for Option 1B are comparable to Option 1A and current conditions for sulfate and arsenic. For cadmium and zinc, the predicted water quality for Option 1B indicates an overall improvement compared to current conditions and those predicted for Option 1A. The predicted reductions in cadmium and zinc concentrations in the receiving environment are due to the reduction in loading from waste rock due to the reduction in the waste rock footprint after backfilling.

5.2.2 Uncertainty

The key uncertainties associated with the modeling results for Option 1B are the same as those outlined in Section 5.1.2 for Option 1A.

5.3 Water Quality and Water Balance Model Results - Option 2A

5.3.1 Performance

Key highlights (for Best Estimate/Average Flow Scenario) of the assessment for Option 2A are:

- Similar to Option 1A, for all modeled parameters peak concentrations occur during the winter low flow period due to ongoing discharge of mine-related loadings during periods of minimal flow and available dilution. This disproportionate load is emphasized by the seepage rate from the tailings and discharge rate from the deep groundwater system, which are assumed to remain constant throughout the year during.

- Sulfate
  - The predicted concentrations of sulfate (median = 36 mg/L, maximum = 106 mg/L) are the same as those for Option 1A.
  - Similar to Option 1, the primary source of predicted sulfate concentrations in the winter low flow period is the year round discharge of tailings seepage to the receiving environment at constant rate of 3.5 L/s.

- Arsenic
  - Predicted concentrations of arsenic for Option 2A (median = 0.0019 mg/L, maximum = 0.0055 mg/L) are similar to those for Option 1A indicating no overall change in performance with respect to current conditions.
  - The predicted loading from tailings seepage, similar to Option 1A, is the dominant source of arsenic to the receiving environment.

- Cadmium
  - The predicted cadmium concentrations for Option 2A (median = 0.00012mg/L, maximum = 0.00051 mg/L) are the same as those predicted for Option 1A indicating no overall change in performance with respect to current conditions.
  - The predicted loading from seepage from the waste rock dumps, similar to Option 1A, is the dominant source of cadmium to the receiving environment.

- Zinc
  - The predicted zinc concentrations for Option 2A (median = 0.018 mg/L, maximum = 0.062 mg/L) are similar to those predicted for Option 1A, indicating no overall change in performance with respect to current conditions.
  - The predicted loading from seepage from the waste rock dumps, similar to Option 1A, is the dominant source of zinc to the receiving environment.

Overall, the Best Estimate Average Precipitation model results for Option 2A are comparable to Option 1A and current conditions.

5.3.2 Uncertainty

The key uncertainties associated with the modeling results for Option 2A are similar to those outlined in Section 5.1.2 for Option 1A. As outlined above for Option 1A, one of the key considerations is whether there is sufficient water supply in the catchment upstream of the tailings area to maintain the tailings in a saturated state, and specifically, if the proposed runoff coefficients are representative of runoff conditions at the site for all locations and conditions. Results of a sensitivity analysis indicate that inflows to the tailings area are generally sufficient to maintain the assumed 0.25 m water cover during the open water season. During dry conditions, a minimal drop in water cover would occur, although not significant enough to impact the ability of the saturated soil cover to maintain the tailings in a saturated state.

5.4 Water Quality and Water Balance Model Results - Option 2B

5.4.1 Performance

Key highlights (for Best Estimate/Average Flow Scenario) of the assessment for Option 2B are:

- Similar to Option 1A, concentrations for all modeled parameters are predicted to peak during the winter low flow period due to the ongoing discharge of mine-related loadings during periods of minimal flow and available dilution. This disproportionate load is emphasized by the seepage rate from the tailings and discharge rate from the deep groundwater system, which are assumed to remain constant throughout the year.

- Sulfate
  - In general, the predicted concentrations of sulfate (median = 35 mg/L, maximum = 98 mg/L) for Option 2B are similar to Option 1B and than those for Option 1A (median = 36 mg/L, maximum = 106 mg/L).
  - Similar to Option 1B, the primary source of predicted sulfate concentrations in the winter low flow period is the year round discharge of tailings seepage to the receiving environment at constant rate of 3.5 L/s.

- Arsenic
  - Predicted concentrations of arsenic for Option 2B (median = 0.0019 mg/L, maximum = 0.0059 mg/L) are comparable to those for Option 1A (median = 0.002 mg/L, maximum = 0.0055 mg/L) indicating no change in performance from current conditions.
  - The predicted loading from tailings seepage, similar to Option 1B, is the dominant source of arsenic to the receiving environment.

- Cadmium
  - The predicted cadmium concentrations for Option 2B (median = 0.00006 mg/L, maximum = 0.00028 mg/L) are lower than those predicted for Option 1A (median = 0.00012 mg/L, maximum = 0.00051 mg/L) and well below CCME guidelines.
  - Comparison of the predicted cadmium concentrations for Option 2B in Victoria Creek to those for Option 1A indicate an improvement in performance from current conditions.
  - Similar to Option 1B, the backfilled waste rock, although still the dominant source of cadmium to the receiving environment, contributes significantly less loading primarily due to the overall reduction of the waste rock footprint.

- Zinc
  - The predicted zinc concentrations for Option 2B (median = 0.010 mg/L, maximum = 0.035 mg/L) are lower than those predicted for Option 1A (median = 0.018 mg/L, maximum = 0.062 mg/L) and generally below the CCME guideline, except during winter low flow conditions.
  - Comparison of the predicted zinc concentrations for Option 1B in Victoria Creek to those for Option 1A indicate an improvement in performance from current conditions.
  - Similar to cadmium, the water quality improvements associated with zinc can be attributed to a decrease in the loading from waste rock primarily due to the overall reduction of the waste rock footprint.

Similar to Option 1B, the Best Estimate Average Precipitation model results for Option 2B are comparable to Option 1A and current conditions for sulfate and arsenic. For cadmium and zinc, the predicted water quality for Option 2B (and 1B) indicates an overall improvement compared to current conditions and those predicted for Option 1A. The predicted reductions in cadmium and zinc concentrations in the receiving environment can be attributed to the reduction in loading from waste rock associated with the reduction in waste rock footprint after backfilling.

5.4.2 Uncertainty

The key uncertainties associated with the modeling results for Option 2B are similar to those outlined in Section 5.3.2 for Option 2A.

5.5 Water Quality and Water Balance Model Results - Option 3

5.5.1 Performance

Key highlights (for Best Estimate/Average Flow Scenario) of the assessment for Option 3 are:

- Similar to Option 1A, peak concentrations for all parameters occur during the winter low flow period due to the ongoing discharge of mine-related loadings during periods of minimal flow and available dilution. This disproportionate load is emphasized by discharges from the deep groundwater system (pit and waste rock) which are assumed to remain constant throughout the year during.

- Sulfate
  - In general, predicted concentrations of sulfate (median = 30 mg/L, maximum = 44 mg/L) are lower than those for Option 1A (median = 36 mg/L, maximum = 106 mg/L). The lower sulfate concentrations predicted for Option 3 reflect the removal of seepage from the tailings area which represents the primary source of sulfate to Victoria Creek.

- Arsenic
  - Predicted concentrations of arsenic for Option 3 (median = 0.0034 mg/L, maximum = 0.022 mg/L) are higher than those for Option 1A (median = 0.002 mg/L, maximum = 0.0055 mg/L) and current conditions.
  - The predicted loading from saturated tailings stored in the pit is the dominant source of arsenic to the receiving environment (99% of a total predicted annual loading of 20 kg).
  - The predicted annual loading from the saturated tailings in the pit is approximately 4 times higher that from the tailings in Option 1A and current conditions.

- Cadmium
  - The predicted cadmium concentrations for Option 3 (median = 0.00009 mg/L, maximum = 0.00038 mg/L) are marginally lower than those predicted for Option 1A (median = 0.00012 mg/L, maximum = 0.00051 mg/L) and well below the CCME guideline.
  - Comparison of the predicted cadmium concentrations for Option 3 in Victoria Creek to those for Option 1A indicates a marginal improvement in performance from current conditions.
  - The predicted loading from waste rock is the dominant source of cadmium to the receiving environment (99% of a total predicted annual loading of 0.5 kg).
  - The predicted total annual loading for cadmium is lower than that for Option 1A and current conditions due to a reduction in source loading from the saturated tailings, as well as the removal of the pit lake as a source of cadmium.

- Zinc
  - The predicted zinc concentrations for Option 3 (median = 0.017 mg/L, maximum = 0.059 mg/L) are similar than those predicted for Option 1A (median = 0.018 mg/L, maximum = 0.062 mg/L) and generally below the CCME guideline, except during winter low flow conditions.
  - Comparison of the predicted zinc concentrations for Option 3 in Victoria Creek to those for Option 1A indicates no improvement in performance from current conditions.
  - Similar to cadmium, the predicted loading from waste rock is the dominant source of zinc to the receiving environment (99% of a total predicted annual loading of 69 kg).
  - The predicted total annual loading for zinc is lower than that for Option 1A and current conditions due to a reduction in source loading from the saturated tailings as well as the removal of the pit lake as a source of zinc.

Overall, the Best Estimate Average Precipitation model results for Option 3 show comparable values for cadmium and zinc and in comparison to Option 1A and current conditions. For sulfate, the removal of the tailings from the Dome Creek valley results in a reduction in concentration in Victoria Creek compared to current conditions and those predicted for Option 1A. This largely relates to a decrease in the water flux associated with in-pit tailings placement. For arsenic, the predicted concentrations for Option 3 are higher than those predicted for Option 1A and current conditions. The increase in arsenic largely reflects the higher residual arsenic source loading from the backfilled tailings, which incorporates a 50% reduction of arsenic loading along the groundwater flow path due to attenuation.

5.5.2 Uncertainty

With the exception of those uncertainties outlined in Section 5.1.2 for Option 1A for the tailings area, the uncertainties associated with the modeling results for Option 3 are similar to those outlined for Option 1A, specifically:

- A significant amount of conservatism has been incorporated into the model to account for various uncertainties. One key component of this conservatism is the assumption of constant seepage rate from both the tailings area and the deep groundwater pathways conveying contaminants from the pit and surrounding waste rock areas. This conservatism is reflected in the higher predicted winter concentrations which generally exceed historical winter maximum concentrations. In reality, the tailings seepage and deep groundwater flows will exhibit some seasonal variability with a reduction in flows during the winter months.
- Precipitation conditions were evaluated for three precipitation conditions (average year, dry year and wet year) to account for the uncertainty associated with climate variability. Overall, the impact of varying precipitation, and subsequently flow in the receiving environment, is reflected in the predicted water quality for each precipitation condition presented in Figures 5-5 through 5-8. As expected, during dryer years, there is less dilution capacity in the receiving environment and therefore higher predicted concentrations. Conversely, during wet precipitation years, the additional flow in the receiving environment results in lower predicted concentrations.
- As outlined in AECOM (2010b), the groundwater discharge rate from the pit to Dome Creek was estimated for three different hydraulic conductivities which range over approximately 4 orders of magnitude. This uncertainty in the range of hydraulic conductivities and associated pit discharge rates has the potential to significantly impact the pit loading to the receiving environment. In the absence of the appropriate level of hydrogeological information required to refine the range of estimated hydraulic

conductivities, the pit discharge rate in the model was conservatively set to the maximum estimated value of 0.13 L/s.

In addition, the following uncertainties are associated with the water balance and water quality predictions for Option 3:

- A critical uncertainty associated with Option 3 is related to the feasibility of attaining a desired level (85%) of tailings saturation in the pit. As discussed in the 2010 geotechnical analysis (AECOM 2010b), there is a high level of uncertainty with regards to the feasibility of blending the tailings sufficiently to achieve a desired bulk hydraulic conductivity. The water balance and water quality model for Option 3 assumed that the tailings are well mixed with a uniform hydraulic conductivity. In reality, some degree of incomplete mixing will occur, resulting in spatial heterogeneity in the water holding properties of the tailings.

- As discussed in Section 4.6.4, the results of one-dimensional modeling indicate that a minimum annual addition of 420 m^3 of water is required to ensure tailings saturation levels are maintained at 85% or higher (i.e., water that must come from outside the tailings footprint). The water quality modeling for this option assumed that the surrounding catchment of the pit area can provide the water to offset this deficit. To ensure sufficient water is available, a water balance assessment was carried out for dry and average conditions. Assuming the surface area of the tailings placed in the pit is 21,000 m^2 and the entire pit catchment for Option 3 is 33,930 m^2, the residual pit catchment area is 12,930 m^2. Based on this assessment, this residual catchment area can provide an additional 2,328 m^3/year of potential inflow during a dry year and 3,663 m^3/year during an average year. Assuming a runoff coefficient of 0.4, these water volumes translate to 931 m^3 and 1,465 m^3 during dry and average conditions, respectively. Such volumes are sufficient to offset the assumed deficit, and therefore maintain tailings saturation.

- A relevant uncertainty is the potential for the attenuation of contaminants along groundwater flow paths from the pit. The loading model for tailings placement in the open pit (Options 3 and 4) incorporates a reduction in arsenic loading of 50% due to attenuation along the groundwater flow path between the pit and Dome Creek and/or Victoria Creek. In this context, attenuation refers to adsorption and/or precipitation processes that result in the removal of dissolved arsenic from solution. As discussed in Section 4.6.3 some degree of arsenic attenuation in the subsurface environment can be expected through adsorption/co-precipitation mechanisms. The magnitude of the ascribed loading reductions (~50%) is based on experience at other mine operations (unpublished data) which have monitored arsenic removal in groundwater downgradient of tailings facilities. At these sites in northwestern Ontario and British Columbia arsenic loading reductions of greater than 90% have been documented. Therefore the assumption of 50% reduction of arsenic loading in the model is considered to impart considerable conservatism into the model predictions.

- A sensitivity analysis was run to assess the impacts of zero attenuation of arsenic from the tailings along the groundwater flow paths from the pit. Loss of the anticipated attenuation of arsenic results in higher predicted concentrations in Victoria Creek (median = 0.005 mg/L and maximum = 0.043 mg/L), well above for Option 1A and current conditions.

5.6 Water Quality and Water Balance Model Results - Option 4

5.6.1 Performance

Key highlights (for Best Estimate/Average Flow Scenario) of the assessment for Option 4 are:

- Similar to Option 1A, peak concentrations for all modeled parameters are predicted to occur during the winter low flow period due to ongoing discharge of mine-related loadings during periods of minimal flow and available dilution. This disproportionate load is emphasized by discharges from the deep groundwater system (pit and waste rock), which are assumed to remain constant throughout the year.

- Sulfate
  - In general, the predicted concentrations of sulfate (median = 30 mg/L, maximum = 40 mg/L) are lower than those for Option 1A (median = 36 mg/L, maximum = 106 mg/L). The lower sulfate concentrations predicted for Option 4 largely relate to a decrease in the water flux associated with in-pit tailings placement..

- Arsenic
  - Predicted concentrations of arsenic for Option 4 (median = 0.0023 mg/L, maximum = 0.009 mg/L) are similar to those for Option 1A (median = 0.002 mg/L, maximum = 0.0055 mg/L) and current conditions, except for marginally higher predicted winter low flow concentrations.
  - The predicted loading from tailings stored in the pit is the dominant source of arsenic to the receiving environment (94% of a total predicted annual loading of 7 kg).
  - The predicted annual loading from the tailings in the pit is approximately 1.5 times higher that from the tailings in Option 1A and current conditions.

- Cadmium
  - The predicted cadmium concentrations for Option 4 (median = 0.00006 mg/L, maximum = 0.00035 mg/L) are slightly lower than those predicted for Option 1A (median = 0.00012 mg/L, maximum = 0.00051 mg/L) and well below the CCME guideline.
  - Comparison of the predicted cadmium concentrations for Option 4 in Victoria Creek to those for Option 1A indicates a minor improvement in performance from current conditions.
  - The predicted loading from waste rock is the dominant source of cadmium to the receiving environment (69% of a total predicted annual loading of 0.3 kg).
  - The predicted total annual loading for cadmium is lower than that for Option 1A and current conditions due to a reduction in source loading from waste rock as a result of the partial backfill of waste rock to the pit and the inclusion of the ore stockpile in the low-infiltration cover area.

- Zinc
  - The predicted zinc concentrations for Option 4 (median = 0.012 mg/L, maximum = 0.058 mg/L) are similar to those predicted for Option 1A (median = 0.018 mg/L, maximum = 0.062 mg/L) and generally below the CCME guideline, except during winter low flow conditions.
  - Comparison of the predicted zinc concentrations for Option 4 in Victoria Creek to those for Option 1A indicates no improvement in performance from current conditions.
  - Similar to cadmium, the predicted loading from waste rock is the dominant source of zinc to the receiving environment (73% of a total predicted annual loading of 48 kg).
  - Although the predicted annual loading from the backfilled tailings in Option 4 is lower than that for Option 1A and current conditions, the annual loading from tailings is approximately 5 times higher than that for Option 1A. The overall reduction in zinc loading is, similar to cadmium, due to a reduction in source loading from waste rock as a result of the partial backfill of waste rock to the pit inclusion of the ore stockpile in the low-infiltration cover area.

Overall, the Best Estimate Average Precipitation model results for Option 4 are comparable to Option 1A and current conditions with respect to zinc and show a marginal improvement with respect to cadmium. For sulfate, the removal of the tailings from the Dome Creek valley results in a reduction in concentrations compared to current conditions owing to a decrease in the water flux associated with in-pit tailings placement. For arsenic, the predicted concentrations for Option 4 are similar those predicted for Option 1A and current conditions, except for marginally higher concentrations during the winter low flow conditions. The results for Option 4 also demonstrate that despite the assumption that acidic conditions develop within in-pit tailings, such conditions do not have a marked effect on increasing contaminant loadings when compared to Option 3. This can be related to the low water flux through the tailings cover which offsets the higher source term concentrations in the loading calculations.

5.6.2 Uncertainty

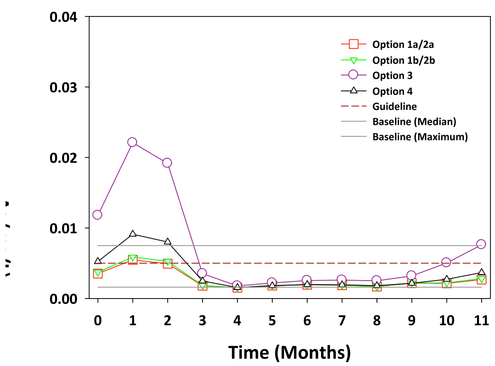
With the exception of those uncertainties outlined in Section 5.5.2 for Option 3 for the high-infiltration tailings cover, the uncertainties associated with the modeling results for Option 4 are similar to those outlined for Option 3. In addition, the following uncertainties are associated with the water balance and water quality predictions for Option 4:

- As discussed in Section 4.7.2, the typical range of infiltration rates for the synthetic barrier cover system is 1% to 3% of annual precipitation. For the loading model, an infiltration rate of 5% of average annual precipitation was conservatively assumed to account for cover degradation and the anticipated decrease in performance in the long-term. This type of cover was selected as it is the most appropriate for the site's climatic conditions and is not reliant on a viable vegetative cover. The implications of using a cover design with a higher infiltration rate of 15% was assessed as part of the sensitivity analysis, specifically on predicted arsenic concentrations in Victoria Creek. Increasing the cover infiltration rate to 15% of annual precipitation results in higher predicted concentrations in Victoria Creek (median = 0.004 mg/L and maximum = 0.023 mg/L), above those predicted for Option 1A and current conditions.

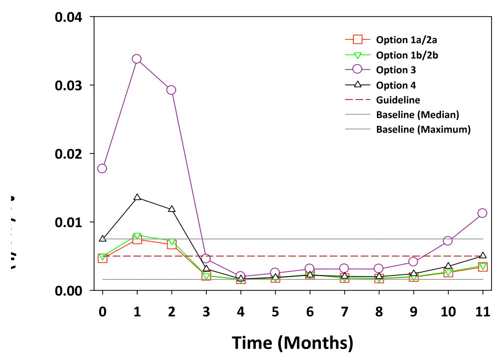
- The uncertainty with regards to potential for the attenuation of arsenic along the groundwater flow path also has direct relevance to Option 4. This topic is discussed in detail in Section 5.5.2. A sensitivity analysis was run to assess the impacts of zero attenuation of arsenic from the tailings along the groundwater flow paths from the pit. Loss of the anticipated attenuation of arsenic results in slightly higher predicted concentrations in Victoria Creek (median = 0.003 mg/L and maximum = 0.016 mg/L), marginally above for Option 1A and current conditions.

Average Flow

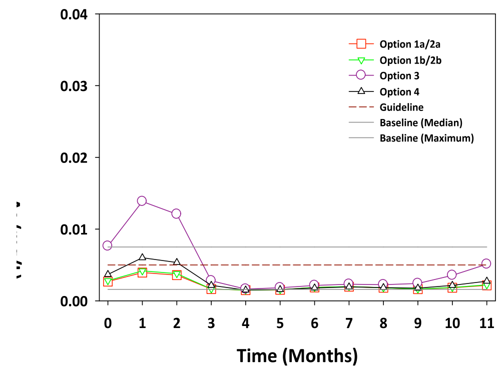
Best Estimate Scenario



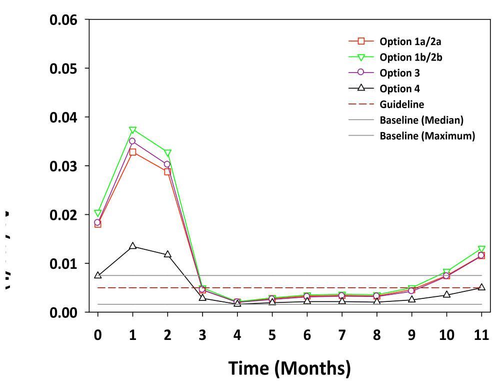
Low Flow

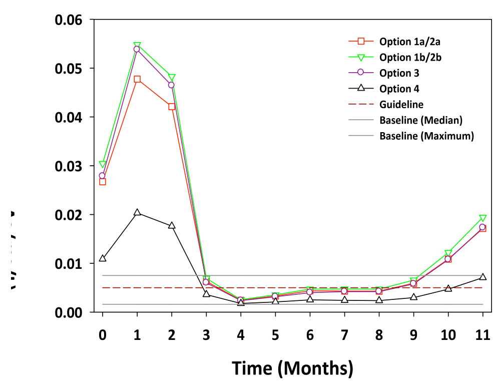


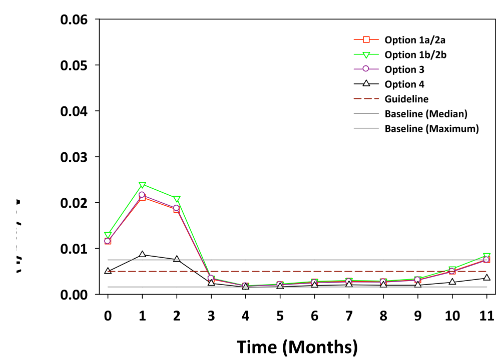
High Flow



Upper Estimate Scenario







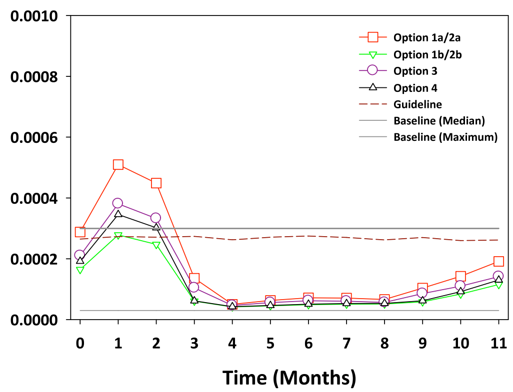
Notes: 1. Baseline (Maximum) is equivelant to the Winter Maximum measured at Victoria Creek

2. Axes for Best Estimate Scenario and Upper Estimate Scenario are different

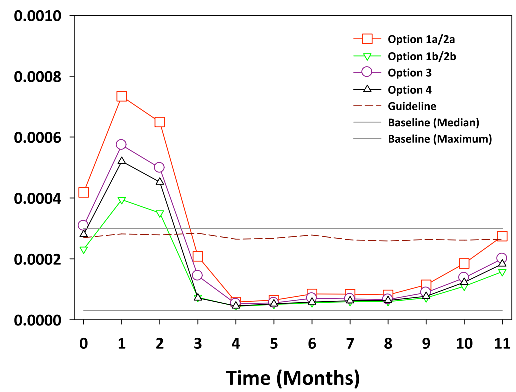
Figure 5-1 Time Series Plots of Predicted Arsenic Concentrations in Victoria Creek

Average Flow

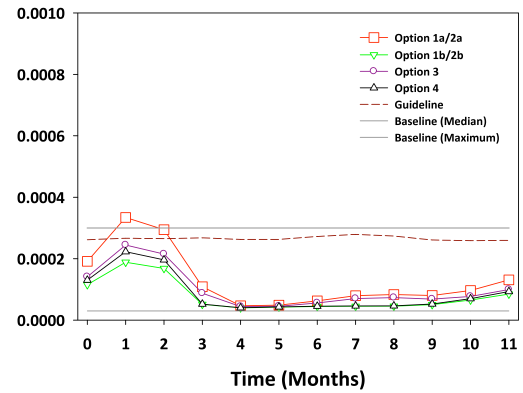
Best Estimate Scenario



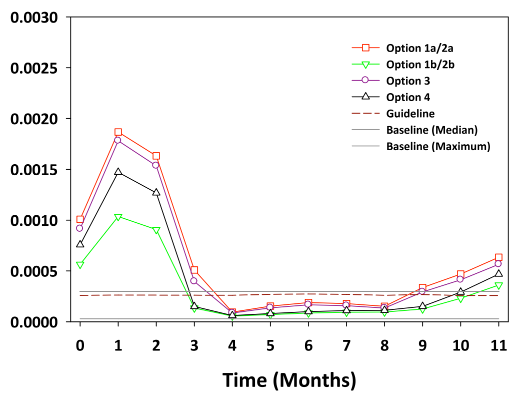
Low Flow

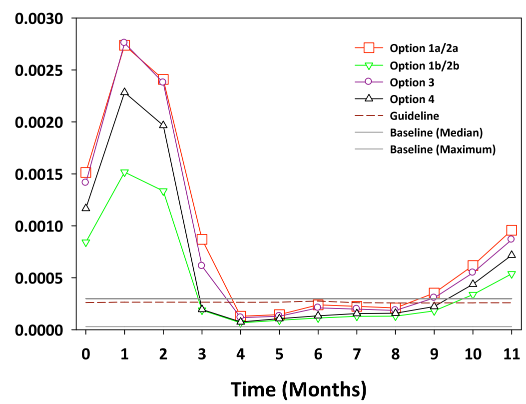


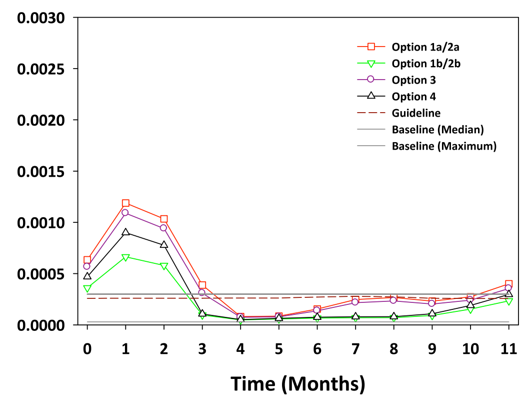
High Flow



Upper Estimate Scenario



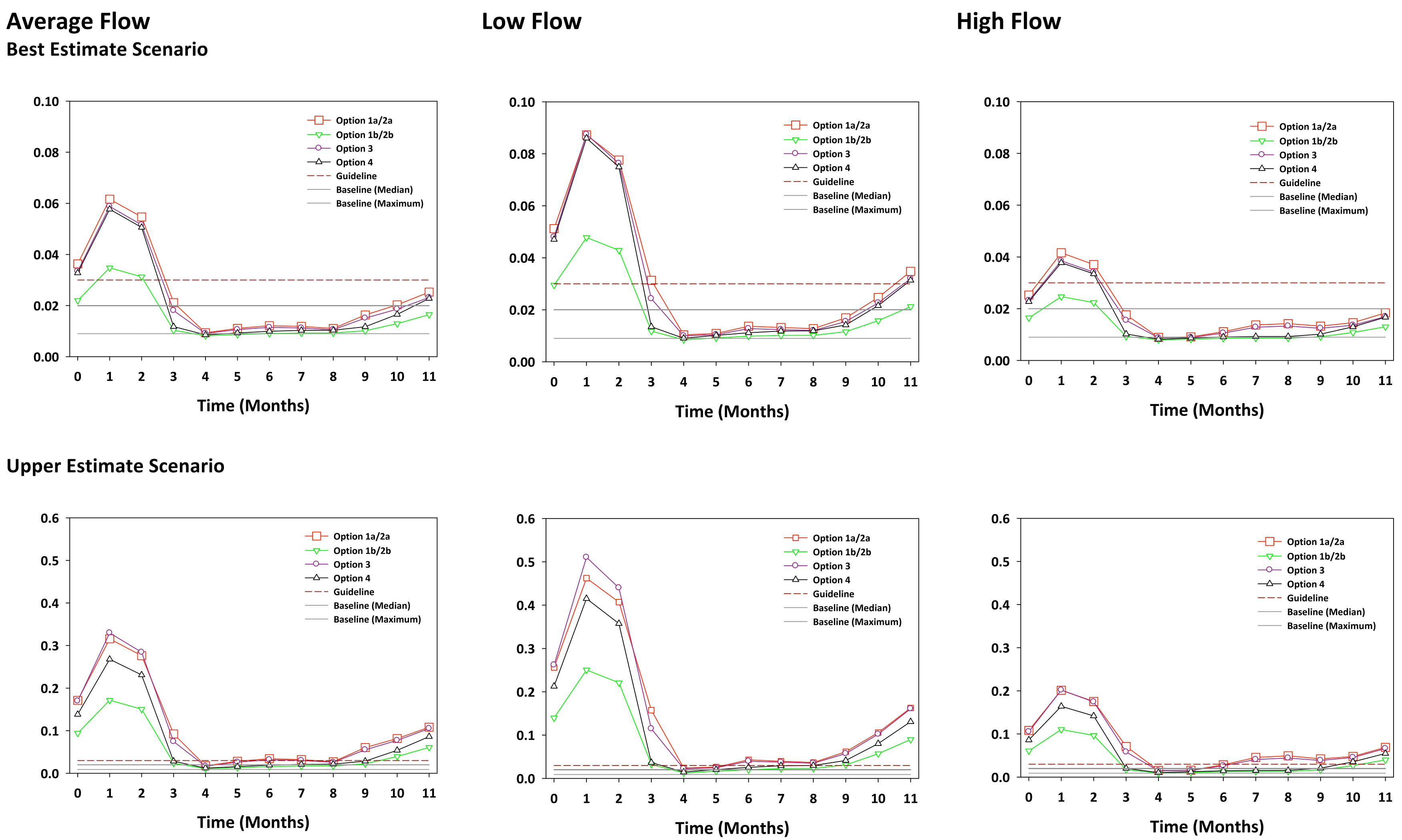




Notes: 1. Baseline (Maximum) is equivelant to the Winter Maximum measured at Victoria Creek

2. Axes for Best Estimate Scenario and Upper Estimate Scenario are different

Figure 5-2 Time Series Plots of Predicted Cadmium Concentrations in Victoria Creek

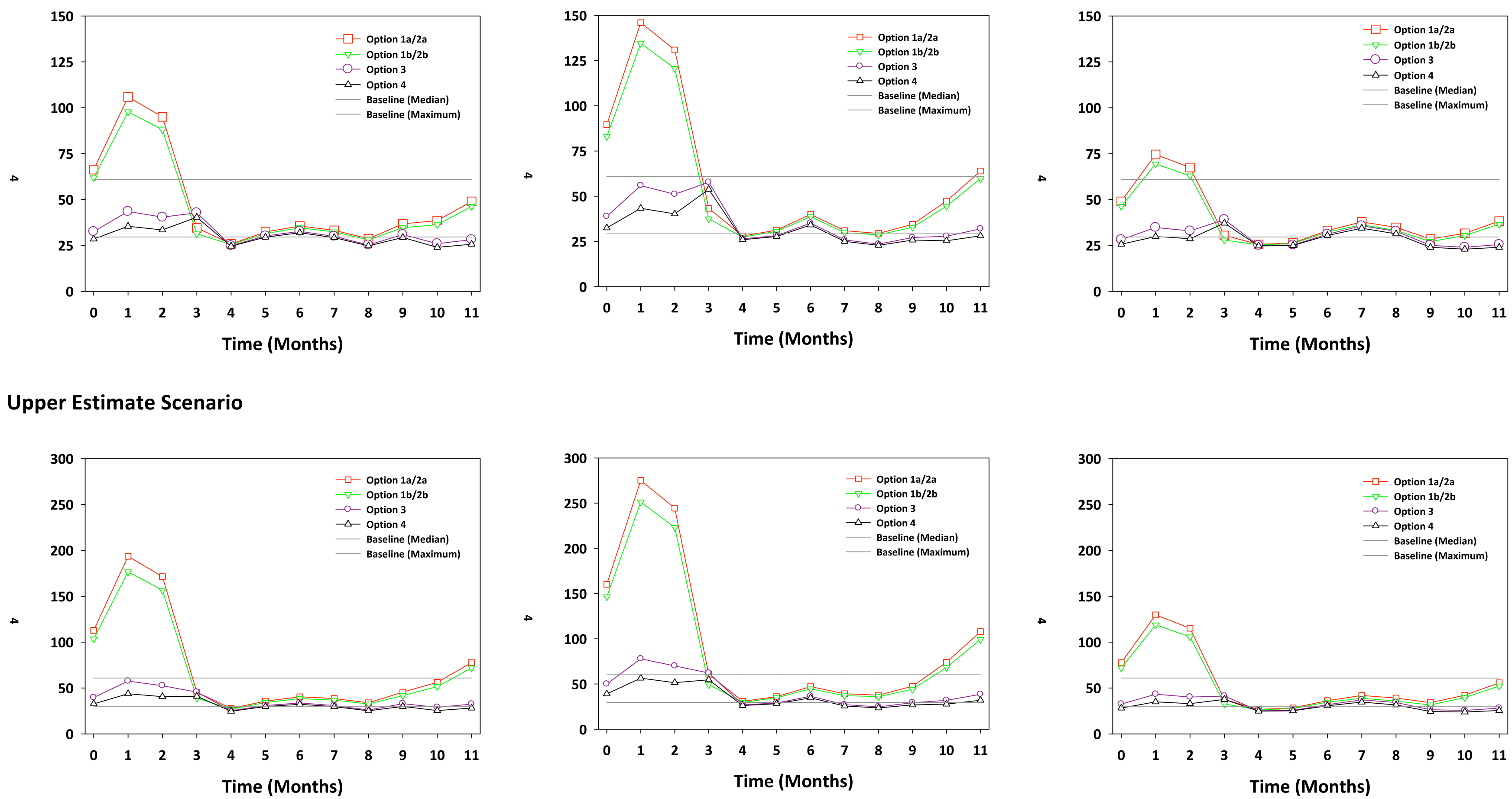


Notes: 1. Baseline (Maximum) is equivelant to the Winter Maximum measured at Victoria Creek
2. Axes for Best Estimate Scenario and Upper Estimate Scenario are different

Figure 5-3 Time Series Plots of Predicted Zinc Concentrations in Victoria Creek

Average Flow **Low Flow** **High Flow**

Best Estimate Scenario



Notes: 1. Baseline (Maximum) is equivelant to the Winter Maximum measured at Victoria Creek
2. Axes for Best Estimate Scenario and Upper Estimate Scenario are different

Figure 5-4 Time Series Plots of Predicted Sulphate Concentrations in Victoria Creek

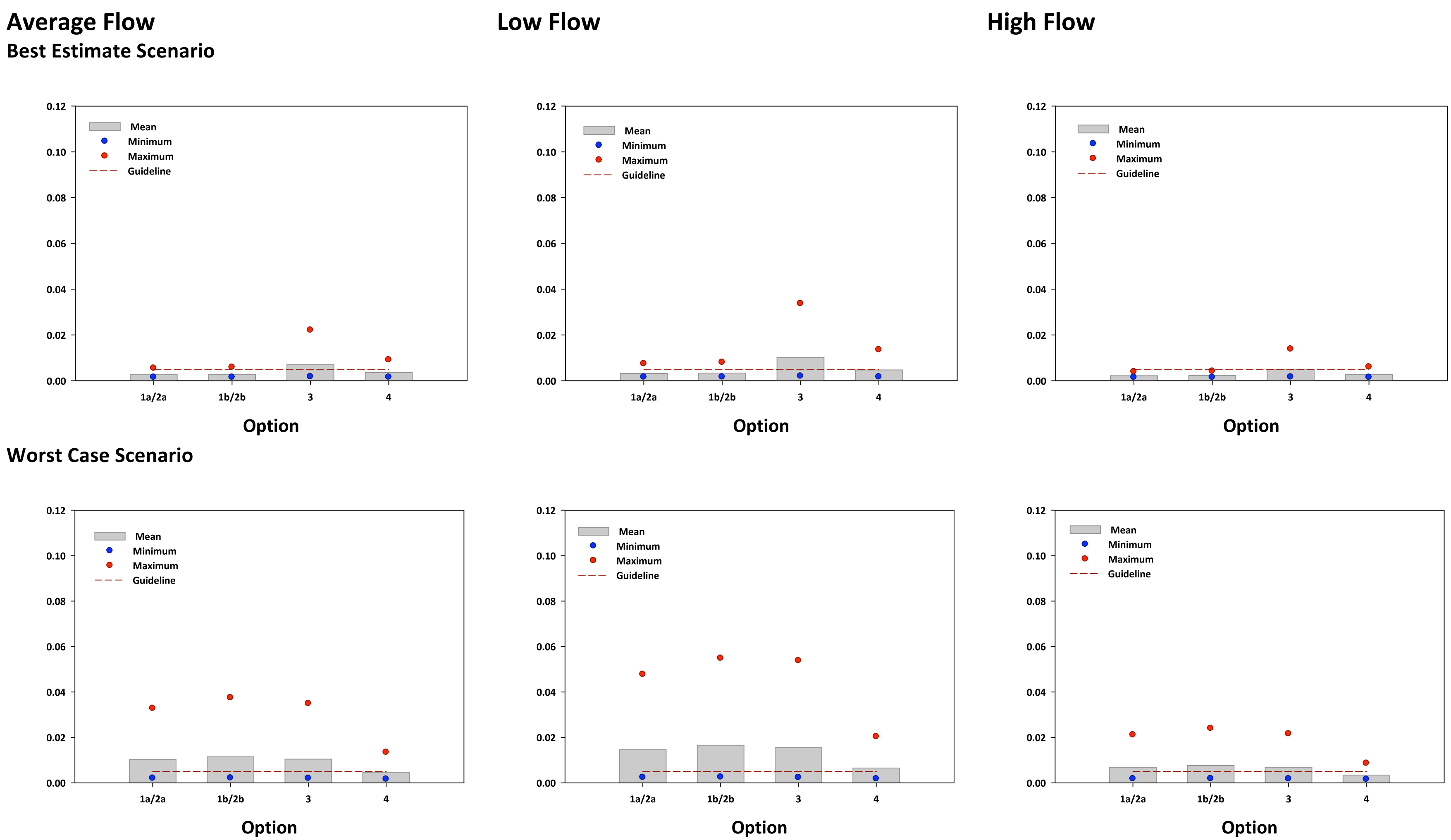


Figure 5-5 Box Plots of Predicted Mean, Minimum and Maximum Arsenic Concentrations in Victoria Creek

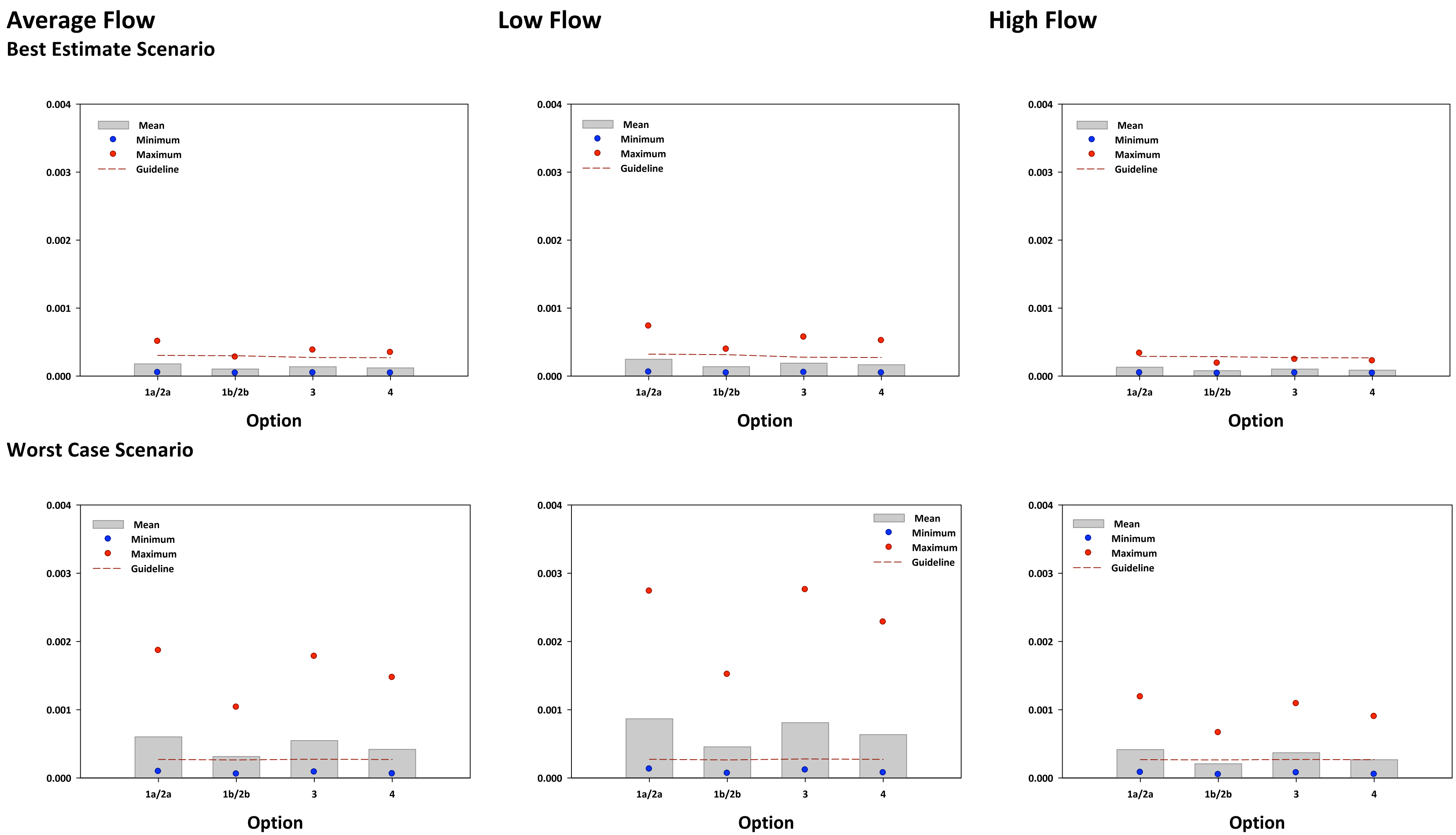


Figure 5-6 Box Plots of Predicted Mean, Minimum and Maximum Cadmium Concentrations in Victoria Creek

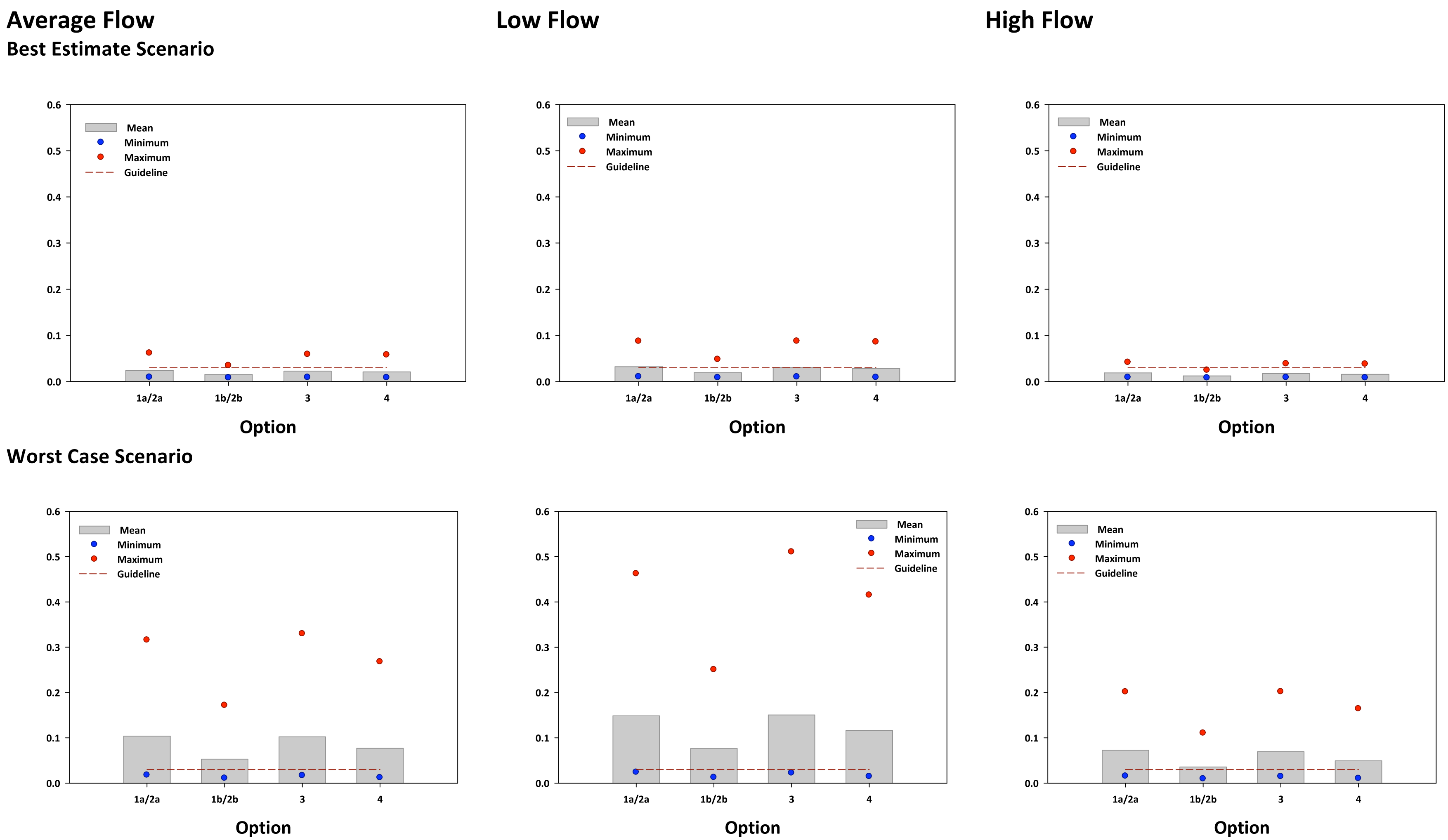


Figure 5-7 Box Plots of Predicted Mean, Minimum and Maximum Zinc Concentrations in Victoria Creek

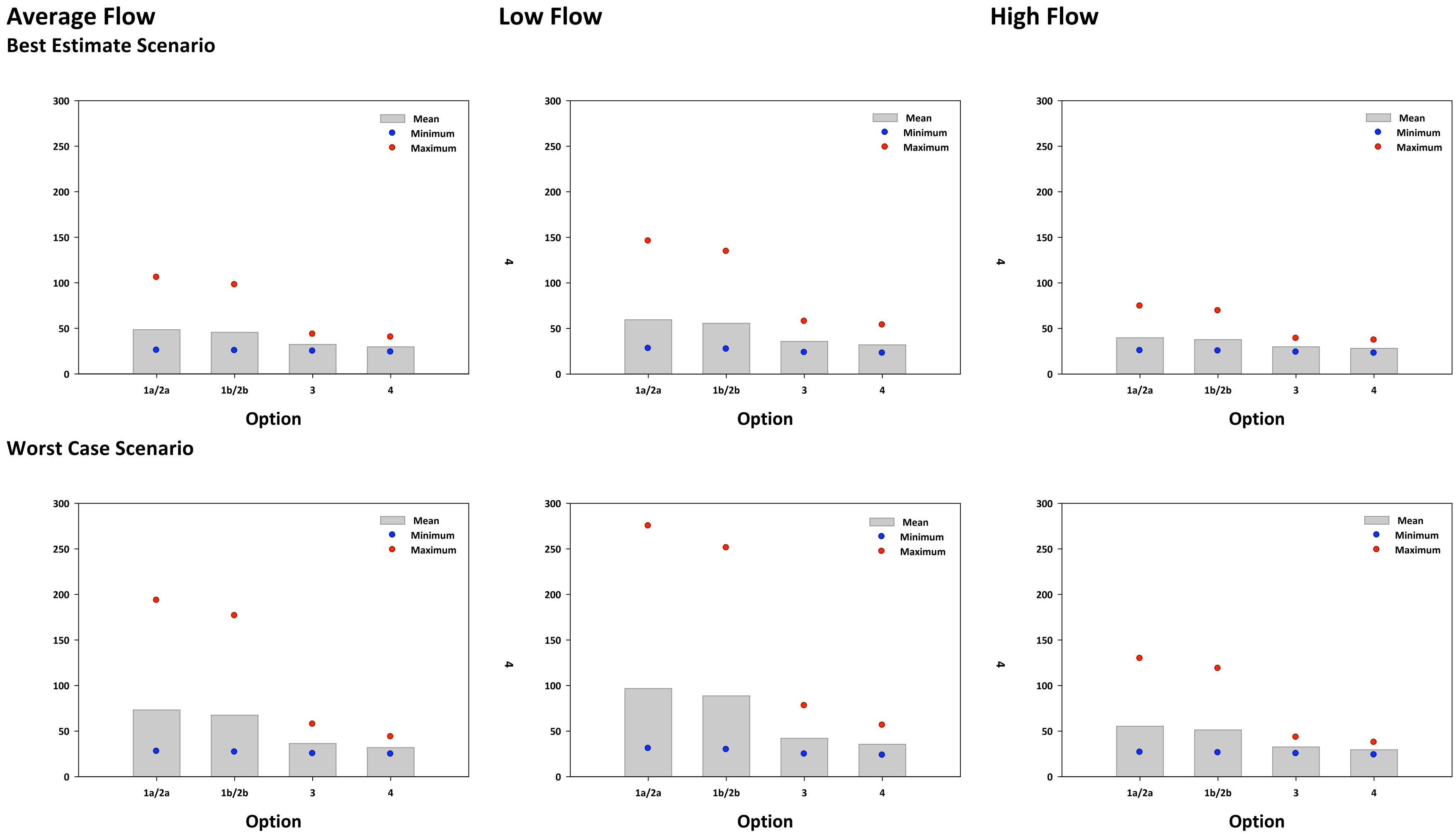
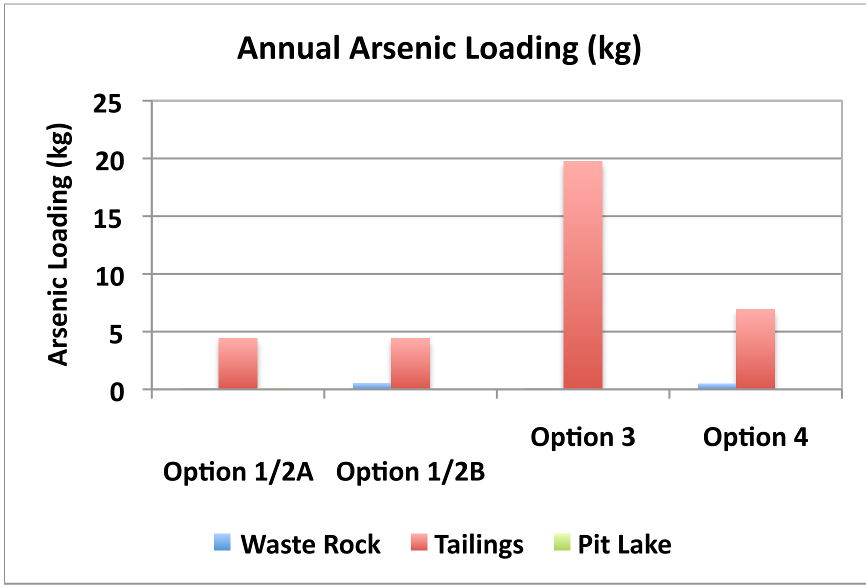
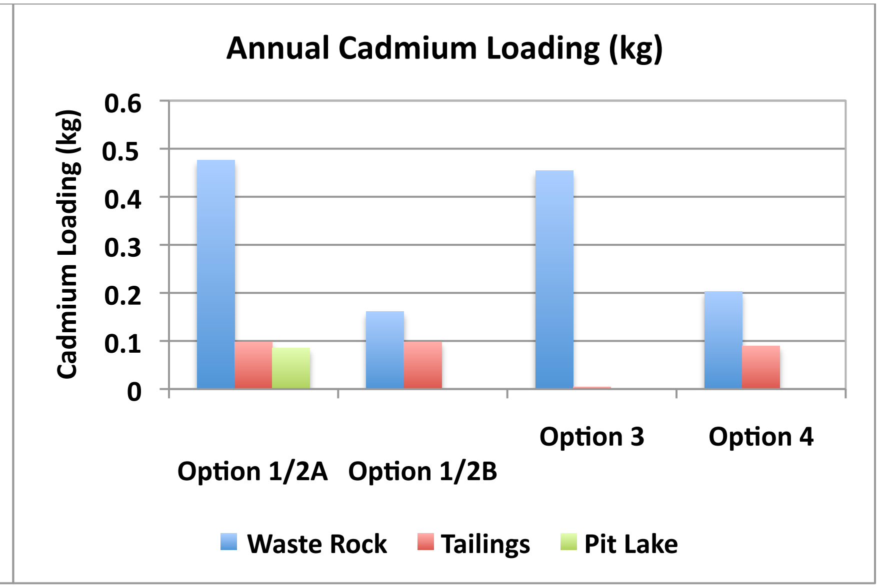


Figure 5-5 Box Plots of Predicted Mean, Minimum and Maximum Sulphate Concentrations in Victoria Creek





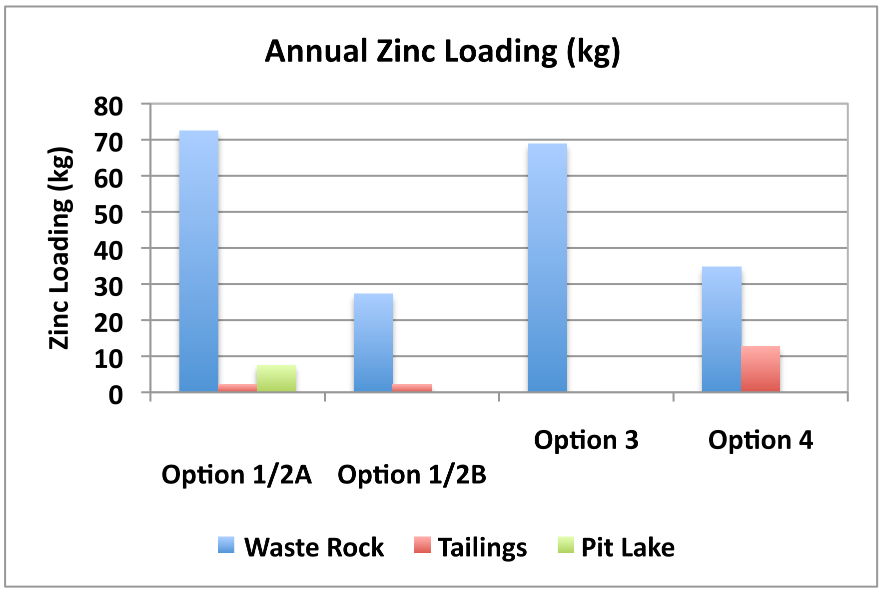


Figure 5 9 Distribution of Average Flow Scenario Arsenic, Cadmium and Zinc Annual Loading (kg)

6 Summary

The predicted water quality for each of the model runs was used to assess the performance of the closure options. Water quality predictions for each of the six model runs were used to assess the performance of Option 1A through comparison to existing water quality in the downstream receiving environment in Victoria Creek and to CCME Guidelines for the Protection of Aquatic Life. These results, while specific to Option 1A, were considered to be representative of current site conditions and were then used as a bench mark from which to assess the performance of the other closure options.

The following summarizes the key findings of the assessment of the six closure options, including sensitivity runs, from the perspective of performance related to predicted water quality in the receiving environment at Victoria Creek.

- For all options, peak concentrations are predicted to occur during the winter low flow period due to ongoing loadings from the site during periods of minimal flow and available dilution. This disproportionate load is emphasized by the assumptions for seepage rate from the tailings and discharge rate from the deep groundwater system, which are assumed to remain constant throughout the year despite varying flows in Victoria Creek.
- Overall, the Best Estimate Average Precipitation model results for Option 1A are comparable to existing water quality conditions in Victoria Creek and can be used to best represent current conditions at the site.
- For the tailings area, Options 1and 2 have less overall uncertainty associated with the water quality predictions in comparison to the other options primarily due to the long-term flow and water quality records for the seepage collection pond. Specifically, the performance of the existing tailings facility with regards to seepage rates and water quality is predicted to provide a defensible proxy for the performance of these options over the long-term.
- Overall, the Best Estimate Average Precipitation model results for Option 2A are comparable to Option 1A and current conditions.
- The Best Estimate Average Precipitation model results for Options 1B and 2B are comparable to Option 1A and current conditions for sulfate and arsenic. For cadmium and zinc, the predicted water quality for Option 1B and 2B indicates an overall improvement compared to current conditions. The predicted reductions in cadmium and zinc concentrations in the receiving environment are due to the reduction in loading from waste rock due to the reduction in the waste rock footprint after backfilling.
- One of the key considerations for the Tailings In Place Options (Options 1A, 1B, 2A and 2B) is whether there is sufficient water supply in the catchment upstream of the tailings area to maintain the tailings in a saturated state, and specifically, if the proposed runoff coefficients are representative of runoff conditions at the site for all locations and conditions. Results of the water balance analysis for both the 0.7 m water cover and the 1 m saturated soil cover indicate that inflows to the tailings area are generally sufficient to maintain the tailings in a saturated state, even during dry conditions.
- One of the key considerations for the Tailings in Place Options (Options 1 and 2) is whether the attenuation process reducing arsenic concentrations will continue in the long-term. An Upper estimate arsenic source term has been provided for seepage from the tailings mass, as represented by closure Option 1 and 2. The Upper Estimate for arsenic is considered a reasonable proxy for tailings seepage

that does not undergo attenuation. Although, the Upper Estimate source term provides for an assessment of the impact of the loss of attenuation along the tailing seepage pathway, these predicted concentrations are not considered to be representative of the anticipate performance of Options 1 and 2.

- The Best Estimate Average Precipitation model results for Option 3 showed a marginal improvement for cadmium and comparable values for zinc in comparison to Option 1A and current conditions. For sulfate, the removal of the tailings from the Dome Creek valley results in a reduction in concentration in Victoria Creek compared to current conditions and those predicted for Option 1A. This largely relates to a decrease in the water flux associated with in-pit tailings placement. For arsenic, the predicted concentrations for Option 3 are significantly higher than those predicted for Option 1A and current conditions. The increase in arsenic largely reflects the higher residual arsenic source loading from the backfilled tailings, which incorporates a 50% reduction of arsenic loading along the groundwater flow path due to attenuation.

- A critical uncertainty associated with Option 3 is related to the feasibility of attaining a desired level (85%) of tailings saturation in the pit. As discussed in the 2010 geotechnical analysis (AECOM 2010b), there is a high level of uncertainty with regards to the feasibility of blending the tailings sufficiently to achieve a desired bulk hydraulic conductivity. The water balance and water quality model for Option 3 assumed that the tailings are well mixed with a uniform hydraulic conductivity. In reality, some degree of incomplete mixing will occur, resulting in spatial heterogeneity in the water holding properties of the tailings.

- Another relevant uncertainty related to Options 3 and 4 is the potential for the attenuation of contaminants along groundwater flow paths from the pit. The loading model for tailings placement in the open pit (Options 3 and 4) incorporates a reduction in arsenic loading of 50% due to attenuation along the groundwater flow path between the pit and Dome Creek and/or Victoria Creek. Another relevant uncertainty related to Option 3 is the potential for the attenuation of contaminants along groundwater flow paths from the pit. The magnitude of the ascribed loading reductions (~50%) is based on experience at other mine operations (unpublished data) which have monitored arsenic removal in groundwater downgradient of tailings facilities. At these sites in northwestern Ontario and British Columbia arsenic loading reductions of greater than 90% have been documented. Therefore the assumption of 50% reduction of arsenic loading in the model is considered to impart considerable conservatism into the model predictions. An increase in the level of attenuation would result in further improvement of the performance of these options with respect to arsenic concentrations in the receiving environment. Conversely, a reduction in the level of assumed attenuation would result in significantly higher predicted concentrations in the downstream receiving environment.

- The Best Estimate Average Precipitation model results for Option 4 are comparable to Option 1A and current conditions with respect to cadmium and zinc. For sulfate, the removal of the tailings from the Dome Creek valley results in a reduction in concentrations compared to current conditions owing to a decrease in the water flux associated with in-pit tailings placement. For arsenic, the predicted concentrations for Option 4 are similar those predicted for Option 1A and current conditions, except for marginally higher concentrations during the winter low flow conditions. The results for Option 4 also demonstrate that despite the assumption that acidic conditions develop within in-pit tailings, such conditions do not have a marked effect on increasing contaminant loadings when compared to Option 3. This can be related to the low water flux through the tailings cover which offsets the higher source term concentrations in the loading calculations.

- For the loading model for Option 4, an infiltration rate of 5% of average annual precipitation was conservatively assumed for the low-infiltration cover (synthetic barrier cover system) to account for cover degradation and the anticipated decrease in performance in the long-term. Results of the dry cover assessment indicate that the typical range of infiltration rates for synthetic barrier cover systems is 1% to 3%. To account for possible reduction in long-term cover performance, a conservative long-term infiltration rate of 5% of average annual precipitation was selected for modeling purposes.

7 References

AECOM (2010a). Development of a Mount Nansen Precipitation, Temperature, and Evaporation Data Record and Pit and Tailings Pond Inflow Volume Estimation. Prepared for Assessment and Abandoned Mines Branch, Department of Energy, Mines and Resources, Government of Yukon, November 2010.

AECOM (2010b). Geotechnical Assessment and Costing of the Mt. Nansen Mine Closure Alternatives (Draft for Discussion). Prepared for Assessment and Abandoned Mines Branch, Department of Energy, Mines and Resources, Government of Yukon, November 2010.

AECOM (2010c). Hydrogeological Characterization of the Mt. Nansen Mine Site (Draft for Discussion). Prepared for Assessment and Abandoned Mines Branch, Department of Energy, Mines and Resources, Government of Yukon, November 2010.

AECOM (2010d). Mt. Nansen Surface Water Quality Baseline Characterization. Prepared for Assessment and Abandoned Mines Branch, Department of Energy, Mines and Resources, Government of Yukon, February 2010.

AECOM (2010e). Mt Nansen Water Quality Model for the Alternatives Assessment. Prepared for Assessment and Abandoned Mines Branch, Department of Energy, Mines and Resources, Government of Yukon, February 2010.

Bowell R. J. (1994). Sorption of arsenic by iron oxides and oxyhydroxides in soils. Appl. Geochem. 9, 279-286.

Carey, S.K. and M.K. Woo (2001). Spatial variability of hillslope water balance, Wolf Creek basin, subarctic Yukon. Hydrol. Process. 15, 3113–3132.

Environment Canada (2008). Canadian Water Quality Guideline: Cadmium. Scientific Supporting Document (draft September 2008). Ecosystem Health: Science-based Solutions. National Guidelines and Standards Office, Environment Canada, Ottawa.

Golder (2010a). Assessment of Closure Options and Cover Water Balance for the Mt. Nansen Project, Yukon. Technical Memorandum prepared for Lorax Environmental Services Ltd., October 2010.

Golder (2010b). Conceptual Assessment of Low Infiltration Cover Options for the Mt. Nansen Project, Yukon. Technical Memorandum prepared for Lorax Environmental Services Ltd., October 2010.

Lorax (2010a). Mount Nansen Mine Geochemical Assessment in Support of Evaluation of Closure Plant Options (DRAFT). Prepared for Assessment and Abandoned Mines Branch, Department of Energy, Mines and Resources, Government of Yukon, October 2010.

Lorax (2010b). Mount Nansen Options for Closure. Prepared for Assessment and Abandoned Mines Branch, Department of Energy, Mines and Resources, Government of Yukon, November 2010.

Manning, B. A. and Goldberg, S. (1997). Adsorption and Stability of Arsenic (III) at the Clay Mineral - Water Interface. Environ. Sci. Technol. 31, 2005-2011.

Martin A. J. and Pedersen T. F. (2002). Seasonal and interannual mobility of arsenic in a lake impacted by metal-mining. Env. Sci. Tech. 36, 1516-1523.

Violante A. and Pigna M. (2002). Competitive Sorption of Arsenate and Phosphate on Different Clay Minerals and Soils. Soil Sci. Soc. Am. J. 66 (1788-1796).

Appendix A

Predicted Water Quality Results – Victoria Creek

Table A1 Option 1A Predicted Water Quality in Victoria Creek (mg/L) - Best Estimate Source Terms

Average Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0035	0.00029	0.0027	0.93	0.600	0.036	66.3	0.36	0.24	0.019	0.039	0.0033	0.182	41.5	10.5	146.6
Feb	0.0055	0.00051	0.0032	1.54	1.003	0.062	105.9	0.67	0.40	0.031	0.073	0.0044	0.254	53.9	12.2	184.9
March	0.0049	0.00045	0.0031	1.37	0.892	0.055	95.0	0.59	0.36	0.027	0.063	0.0041	0.234	50.5	11.7	174.4
April	0.0018	0.00014	0.0023	0.37	0.234	0.021	34.5	0.07	0.10	0.008	0.007	0.0022	0.115	31.2	9.1	115.5
May	0.0015	0.00005	0.0021	0.26	0.159	0.009	25.9	0.02	0.07	0.005	0.001	0.0020	0.103	28.7	8.7	107.5
June	0.0018	0.00006	0.0021	0.28	0.170	0.011	32.3	0.03	0.07	0.006	0.002	0.0021	0.105	30.6	9.1	113.7
July	0.0020	0.00007	0.0021	0.30	0.182	0.012	35.6	0.04	0.08	0.006	0.004	0.0021	0.108	31.5	9.3	116.9
August	0.0019	0.00007	0.0021	0.31	0.189	0.012	33.3	0.05	0.08	0.006	0.004	0.0021	0.109	30.9	9.1	114.6
September	0.0017	0.00007	0.0022	0.32	0.193	0.011	28.7	0.05	0.08	0.007	0.004	0.0021	0.109	29.6	8.8	110.3
October	0.0022	0.00010	0.0022	0.35	0.220	0.016	36.7	0.07	0.09	0.007	0.006	0.0022	0.114	31.9	9.3	117.9
November	0.0021	0.00014	0.0024	0.49	0.313	0.020	38.5	0.14	0.13	0.010	0.014	0.0025	0.130	32.7	9.2	119.7
December	0.0027	0.00019	0.0025	0.66	0.424	0.025	49.0	0.22	0.17	0.013	0.024	0.0028	0.150	36.1	9.7	129.9

Dry Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0047	0.00042	0.0030	1.29	0.837	0.051	89.5	0.54	0.34	0.026	0.059	0.0039	0.224	48.8	11.5	169.1
Feb	0.0074	0.00073	0.0037	2.16	1.411	0.087	146.0	0.99	0.56	0.043	0.107	0.0055	0.328	66.5	14.0	223.6
March	0.0067	0.00065	0.0035	1.93	1.257	0.078	130.9	0.87	0.50	0.038	0.094	0.0051	0.300	61.7	13.3	209.0
April	0.0021	0.00021	0.0024	0.43	0.285	0.031	43.3	0.11	0.12	0.009	0.011	0.0024	0.123	33.7	9.6	123.6
May	0.0016	0.00006	0.0021	0.28	0.168	0.010	28.0	0.03	0.07	0.006	0.002	0.0021	0.105	29.3	8.8	109.5
June	0.0018	0.00006	0.0022	0.31	0.188	0.011	31.2	0.04	0.08	0.006	0.004	0.0021	0.109	30.3	9.0	112.7
July	0.0023	0.00008	0.0021	0.34	0.204	0.014	40.0	0.06	0.09	0.007	0.006	0.0022	0.112	32.9	9.5	121.3
August	0.0018	0.00008	0.0022	0.36	0.222	0.013	30.9	0.07	0.09	0.007	0.007	0.0022	0.114	30.3	8.9	112.4
September	0.0017	0.00008	0.0022	0.36	0.224	0.013	29.4	0.07	0.10	0.007	0.007	0.0022	0.115	29.9	8.8	111.0
October	0.0019	0.00011	0.0023	0.43	0.269	0.017	34.4	0.10	0.11	0.009	0.011	0.0023	0.122	31.4	9.1	115.8
November	0.0026	0.00018	0.0025	0.63	0.404	0.025	47.3	0.21	0.17	0.013	0.022	0.0027	0.147	35.5	9.6	128.2
December	0.0034	0.00027	0.0027	0.89	0.575	0.035	63.9	0.34	0.23	0.018	0.036	0.0032	0.178	40.7	10.4	144.3

Wet Precipitaiton

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0027	0.00019	0.0025	0.66	0.424	0.025	49.0	0.22	0.17	0.013	0.024	0.0028	0.150	36.0	9.7	129.9
Feb	0.0039	0.00033	0.0028	1.06	0.684	0.042	74.6	0.43	0.28	0.021	0.046	0.0035	0.197	44.1	10.8	154.6
March	0.0036	0.00029	0.0027	0.95	0.612	0.037	67.4	0.37	0.25	0.019	0.040	0.0033	0.184	41.8	10.5	147.7
April	0.0016	0.00011	0.0022	0.32	0.200	0.018	30.4	0.05	0.09	0.007	0.004	0.0021	0.109	30.0	8.9	111.6
May	0.0015	0.00005	0.0021	0.25	0.152	0.009	25.6	0.02	0.07	0.005	0.001	0.0020	0.102	28.6	8.7	107.2
June	0.0015	0.00005	0.0021	0.27	0.160	0.009	26.4	0.02	0.07	0.006	0.002	0.0021	0.103	28.9	8.7	108.0
July	0.0019	0.00006	0.0021	0.28	0.166	0.011	33.1	0.03	0.07	0.006	0.002	0.0021	0.105	30.8	9.1	114.5
August	0.0020	0.00008	0.0021	0.28	0.168	0.014	37.8	0.03	0.07	0.006	0.002	0.0021	0.105	32.1	9.4	118.9
September	0.0018	0.00008	0.0021	0.28	0.171	0.014	34.8	0.03	0.07	0.006	0.002	0.0021	0.105	31.2	9.2	115.9
October	0.0016	0.00008	0.0022	0.31	0.192	0.013	28.5	0.04	0.08	0.006	0.004	0.0021	0.108	29.5	8.8	109.9
November	0.0018	0.00010	0.0023	0.39	0.245	0.015	31.6	0.09	0.10	0.008	0.009	0.0023	0.118	30.6	8.9	113.1
December	0.0022	0.00013	0.0023	0.50	0.314	0.018	38.2	0.14	0.13	0.010	0.014	0.0025	0.131	32.7	9.2	119.5

Table A2 Option 1B Predicted Water Quality in Victoria Creek (mg/L) - Best Estimate Source Terms

Average Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0037	0.00016	0.0026	0.94	0.885	0.022	61.8	0.36	0.23	0.019	0.037	0.0033	0.183	40.0	10.0	141.4
Feb	0.0059	0.00028	0.0030	1.56	1.546	0.035	97.8	0.68	0.38	0.031	0.070	0.0044	0.256	51.3	11.5	175.3
March	0.0053	0.00025	0.0029	1.39	1.364	0.031	87.9	0.59	0.34	0.028	0.061	0.0041	0.236	48.2	11.1	166.0
April	0.0018	0.00006	0.0022	0.37	0.280	0.010	31.3	0.07	0.09	0.008	0.007	0.0022	0.115	30.4	8.9	112.6
May	0.0015	0.00004	0.0021	0.26	0.169	0.008	25.5	0.02	0.07	0.005	0.001	0.0020	0.103	28.6	8.7	107.1
June	0.0018	0.00005	0.0021	0.28	0.187	0.009	31.5	0.03	0.07	0.006	0.002	0.0021	0.105	30.4	9.0	113.0
July	0.0020	0.00005	0.0021	0.30	0.206	0.009	34.6	0.04	0.08	0.006	0.003	0.0021	0.108	31.3	9.2	115.9
August	0.0019	0.00005	0.0021	0.31	0.219	0.009	32.4	0.05	0.08	0.006	0.004	0.0021	0.109	30.6	9.0	113.7
September	0.0017	0.00005	0.0022	0.32	0.225	0.009	28.0	0.05	0.08	0.007	0.004	0.0021	0.109	29.4	8.8	109.5
October	0.0022	0.00006	0.0022	0.35	0.264	0.010	34.7	0.07	0.09	0.007	0.006	0.0022	0.114	31.4	9.1	115.9
November	0.0022	0.00008	0.0023	0.50	0.415	0.013	36.3	0.14	0.13	0.010	0.014	0.0025	0.130	32.0	9.0	117.2
December	0.0028	0.00012	0.0024	0.67	0.599	0.016	46.3	0.23	0.17	0.013	0.023	0.0028	0.151	35.2	9.4	126.7

Dry Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0050	0.00023	0.0028	1.30	1.273	0.030	83.0	0.55	0.32	0.026	0.056	0.0039	0.226	46.7	10.9	161.3
Feb	0.0080	0.00039	0.0034	2.19	2.220	0.048	134.5	1.00	0.54	0.044	0.104	0.0055	0.331	62.8	12.9	209.9
March	0.0072	0.00035	0.0032	1.96	1.965	0.043	120.7	0.88	0.48	0.039	0.091	0.0051	0.303	58.5	12.4	196.8
April	0.0021	0.00007	0.0022	0.44	0.352	0.012	37.5	0.11	0.11	0.009	0.011	0.0024	0.124	32.3	9.2	118.5
May	0.0016	0.00004	0.0021	0.28	0.183	0.008	27.4	0.03	0.07	0.006	0.002	0.0021	0.105	29.1	8.8	108.9
June	0.0018	0.00005	0.0021	0.31	0.217	0.009	30.6	0.04	0.08	0.006	0.004	0.0021	0.109	30.1	8.9	112.0
July	0.0023	0.00006	0.0021	0.34	0.243	0.010	38.7	0.06	0.08	0.007	0.005	0.0022	0.112	32.5	9.4	120.0
August	0.0018	0.00006	0.0022	0.36	0.271	0.010	29.8	0.07	0.09	0.007	0.006	0.0022	0.114	30.0	8.8	111.2
September	0.0018	0.00006	0.0022	0.36	0.275	0.010	28.6	0.07	0.09	0.007	0.007	0.0022	0.115	29.6	8.7	110.0
October	0.0020	0.00007	0.0023	0.43	0.346	0.012	32.8	0.10	0.11	0.009	0.010	0.0023	0.123	30.9	8.9	114.0
November	0.0027	0.00011	0.0024	0.64	0.566	0.016	44.5	0.21	0.16	0.013	0.021	0.0027	0.147	34.6	9.4	125.0
December	0.0036	0.00016	0.0026	0.90	0.846	0.021	59.7	0.34	0.22	0.018	0.035	0.0032	0.178	39.4	10.0	139.3

Wet Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0028	0.00012	0.0024	0.67	0.599	0.016	46.3	0.23	0.17	0.013	0.023	0.0028	0.151	35.2	9.4	126.7
Feb	0.0042	0.00019	0.0027	1.07	1.023	0.025	69.3	0.43	0.26	0.021	0.044	0.0035	0.198	42.4	10.3	148.4
March	0.0038	0.00017	0.0026	0.96	0.904	0.022	62.9	0.37	0.24	0.019	0.038	0.0033	0.185	40.4	10.1	142.4
April	0.0017	0.00005	0.0022	0.32	0.225	0.009	27.9	0.05	0.08	0.007	0.004	0.0021	0.109	29.4	8.8	109.4
May	0.0015	0.00004	0.0021	0.25	0.158	0.008	25.2	0.02	0.07	0.005	0.001	0.0020	0.102	28.5	8.7	106.9
June	0.0015	0.00004	0.0021	0.27	0.171	0.008	26.1	0.02	0.07	0.006	0.001	0.0021	0.103	28.8	8.7	107.7
July	0.0019	0.00004	0.0021	0.28	0.180	0.009	32.3	0.03	0.07	0.006	0.002	0.0021	0.105	30.6	9.1	113.8
August	0.0020	0.00005	0.0021	0.28	0.182	0.009	36.3	0.03	0.07	0.006	0.002	0.0021	0.105	31.7	9.3	117.5
September	0.0018	0.00005	0.0021	0.28	0.185	0.009	33.1	0.03	0.07	0.006	0.002	0.0021	0.105	30.8	9.1	114.4
October	0.0016	0.00005	0.0022	0.31	0.220	0.009	27.1	0.04	0.08	0.006	0.004	0.0021	0.109	29.1	8.7	108.6
November	0.0019	0.00007	0.0022	0.39	0.308	0.011	30.4	0.09	0.10	0.008	0.008	0.0023	0.118	30.2	8.8	111.7
December	0.0022	0.00008	0.0023	0.50	0.420	0.013	36.6	0.14	0.13	0.010	0.014	0.0025	0.131	32.1	9.1	117.5

Table A3 Option 2A Predicted Water Quality in Victoria Creek (mg/L) - Best Estimate Source Terms

Average Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0035	0.00029	0.0027	0.93	0.600	0.036	66.3	0.36	0.24	0.019	0.039	0.0033	0.182	41.5	10.5	146.6
Feb	0.0055	0.00051	0.0032	1.54	1.003	0.062	105.9	0.67	0.40	0.031	0.073	0.0044	0.254	53.9	12.2	184.9
March	0.0049	0.00045	0.0031	1.37	0.892	0.055	95.0	0.59	0.36	0.027	0.063	0.0041	0.234	50.5	11.7	174.4
April	0.0018	0.00014	0.0023	0.37	0.234	0.021	34.5	0.07	0.10	0.008	0.007	0.0022	0.115	31.2	9.1	115.5
May	0.0015	0.00005	0.0021	0.26	0.159	0.009	25.9	0.02	0.07	0.005	0.001	0.0020	0.103	28.7	8.7	107.5
June	0.0017	0.00006	0.0021	0.28	0.170	0.011	32.0	0.03	0.07	0.006	0.002	0.0021	0.105	30.5	9.1	113.4
July	0.0018	0.00007	0.0021	0.30	0.182	0.012	35.3	0.04	0.08	0.006	0.004	0.0021	0.108	31.5	9.2	116.6
August	0.0018	0.00007	0.0021	0.31	0.189	0.012	33.0	0.05	0.08	0.006	0.004	0.0021	0.109	30.8	9.1	114.4
September	0.0016	0.00007	0.0022	0.32	0.193	0.011	28.5	0.05	0.08	0.007	0.004	0.0021	0.109	29.6	8.8	110.1
October	0.0019	0.00010	0.0022	0.35	0.219	0.016	36.3	0.07	0.09	0.007	0.006	0.0022	0.114	31.8	9.2	117.4
November	0.0021	0.00014	0.0024	0.49	0.313	0.020	38.5	0.14	0.13	0.010	0.014	0.0025	0.130	32.7	9.2	119.7
December	0.0027	0.00019	0.0025	0.66	0.424	0.025	49.0	0.22	0.17	0.013	0.024	0.0028	0.150	36.1	9.7	129.9

Dry Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0047	0.00042	0.0030	1.29	0.837	0.051	89.5	0.54	0.34	0.026	0.059	0.0039	0.224	48.8	11.5	169.1
Feb	0.0074	0.00073	0.0037	2.16	1.411	0.087	146.0	0.99	0.56	0.043	0.107	0.0055	0.328	66.5	14.0	223.6
March	0.0067	0.00065	0.0035	1.93	1.257	0.078	130.9	0.87	0.50	0.038	0.094	0.0051	0.300	61.7	13.3	209.0
April	0.0021	0.00021	0.0024	0.43	0.285	0.031	43.3	0.11	0.12	0.009	0.011	0.0024	0.123	33.7	9.6	123.6
May	0.0016	0.00006	0.0021	0.28	0.168	0.010	28.0	0.03	0.07	0.006	0.002	0.0021	0.105	29.3	8.8	109.6
June	0.0017	0.00006	0.0022	0.31	0.188	0.011	30.9	0.04	0.08	0.006	0.004	0.0021	0.108	30.2	9.0	112.4
July	0.0020	0.00008	0.0021	0.33	0.204	0.014	39.1	0.06	0.09	0.007	0.006	0.0022	0.112	32.6	9.4	120.3
August	0.0018	0.00008	0.0022	0.36	0.223	0.013	30.7	0.07	0.09	0.007	0.007	0.0022	0.114	30.3	8.9	112.2
September	0.0017	0.00008	0.0022	0.36	0.224	0.013	29.4	0.07	0.10	0.007	0.007	0.0022	0.115	29.9	8.8	111.0
October	0.0019	0.00011	0.0023	0.43	0.269	0.017	34.4	0.10	0.11	0.009	0.011	0.0023	0.122	31.4	9.1	115.8
November	0.0026	0.00018	0.0025	0.63	0.404	0.025	47.3	0.21	0.17	0.013	0.022	0.0027	0.147	35.5	9.6	128.2
December	0.0034	0.00027	0.0027	0.89	0.575	0.035	63.9	0.34	0.23	0.018	0.036	0.0032	0.178	40.7	10.4	144.3

Wet Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0027	0.00019	0.0025	0.66	0.424	0.025	49.0	0.22	0.17	0.013	0.024	0.0028	0.150	36.0	9.7	129.9
Feb	0.0039	0.00033	0.0028	1.06	0.684	0.042	74.6	0.43	0.28	0.021	0.046	0.0035	0.197	44.1	10.8	154.6
March	0.0036	0.00029	0.0027	0.95	0.612	0.037	67.4	0.37	0.25	0.019	0.040	0.0033	0.184	41.8	10.5	147.7
April	0.0016	0.00011	0.0022	0.32	0.200	0.018	30.4	0.05	0.09	0.007	0.004	0.0021	0.109	30.0	8.9	111.6
May	0.0015	0.00005	0.0021	0.25	0.152	0.009	25.6	0.02	0.07	0.005	0.001	0.0020	0.102	28.6	8.7	107.2
June	0.0015	0.00005	0.0021	0.27	0.160	0.009	26.3	0.02	0.07	0.006	0.002	0.0021	0.103	28.8	8.7	108.0
July	0.0017	0.00006	0.0021	0.28	0.166	0.011	32.7	0.03	0.07	0.006	0.002	0.0021	0.105	30.7	9.1	114.1
August	0.0018	0.00008	0.0021	0.28	0.168	0.014	37.7	0.03	0.07	0.006	0.002	0.0021	0.105	32.1	9.4	118.8
September	0.0018	0.00008	0.0021	0.28	0.171	0.014	34.9	0.03	0.07	0.006	0.002	0.0021	0.105	31.2	9.2	116.0
October	0.0016	0.00008	0.0022	0.31	0.193	0.013	28.4	0.04	0.08	0.006	0.004	0.0021	0.109	29.5	8.8	109.9
November	0.0018	0.00010	0.0023	0.39	0.245	0.015	31.6	0.09	0.10	0.008	0.009	0.0023	0.118	30.6	8.9	113.1
December	0.0022	0.00013	0.0023	0.50	0.314	0.018	38.2	0.14	0.13	0.010	0.014	0.0025	0.131	32.7	9.2	119.5

Table A4 Option 2B Predicted Water Quality in Victoria Creek (mg/L) - Best Estimate Source Terms

Average Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0037	0.00016	0.0026	0.94	0.885	0.022	61.8	0.36	0.23	0.019	0.037	0.0033	0.183	40.0	10.0	141.4
Feb	0.0059	0.00028	0.0030	1.56	1.546	0.035	97.8	0.68	0.38	0.031	0.070	0.0044	0.256	51.3	11.5	175.3
March	0.0053	0.00025	0.0029	1.39	1.364	0.031	87.9	0.59	0.34	0.028	0.061	0.0041	0.236	48.2	11.1	166.0
April	0.0018	0.00006	0.0022	0.37	0.280	0.010	31.3	0.07	0.09	0.008	0.007	0.0022	0.115	30.4	8.9	112.6
May	0.0015	0.00004	0.0021	0.26	0.169	0.008	25.5	0.02	0.07	0.005	0.001	0.0020	0.103	28.6	8.7	107.2
June	0.0017	0.00005	0.0021	0.28	0.187	0.009	31.3	0.03	0.07	0.006	0.002	0.0021	0.105	30.3	9.0	112.7
July	0.0018	0.00005	0.0021	0.30	0.206	0.009	34.4	0.04	0.08	0.006	0.003	0.0021	0.108	31.2	9.2	115.7
August	0.0018	0.00005	0.0021	0.31	0.219	0.009	32.2	0.05	0.08	0.006	0.004	0.0021	0.109	30.6	9.0	113.6
September	0.0017	0.00005	0.0022	0.32	0.225	0.009	28.0	0.05	0.08	0.007	0.004	0.0021	0.109	29.4	8.8	109.5
October	0.0019	0.00006	0.0022	0.35	0.263	0.010	34.4	0.07	0.09	0.007	0.006	0.0022	0.114	31.3	9.1	115.6
November	0.0022	0.00008	0.0023	0.50	0.415	0.013	36.3	0.14	0.13	0.010	0.014	0.0025	0.130	32.0	9.0	117.2
December	0.0028	0.00012	0.0024	0.67	0.599	0.016	46.3	0.23	0.17	0.013	0.023	0.0028	0.151	35.2	9.4	126.7

Dry Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0050	0.00023	0.0028	1.30	1.273	0.030	83.0	0.55	0.32	0.026	0.056	0.0039	0.226	46.7	10.9	161.3
Feb	0.0080	0.00039	0.0034	2.19	2.220	0.048	134.5	1.00	0.54	0.044	0.104	0.0055	0.331	62.8	12.9	209.9
March	0.0072	0.00035	0.0032	1.96	1.965	0.043	120.7	0.88	0.48	0.039	0.091	0.0051	0.303	58.5	12.4	196.8
April	0.0021	0.00007	0.0022	0.44	0.352	0.012	37.5	0.11	0.11	0.009	0.011	0.0024	0.124	32.3	9.2	118.5
May	0.0016	0.00004	0.0021	0.28	0.183	0.008	27.4	0.03	0.07	0.006	0.002	0.0021	0.105	29.2	8.8	109.0
June	0.0017	0.00005	0.0021	0.31	0.217	0.009	30.4	0.04	0.08	0.006	0.004	0.0021	0.108	30.1	8.9	111.8
July	0.0020	0.00006	0.0021	0.34	0.243	0.010	38.0	0.06	0.08	0.007	0.005	0.0022	0.112	32.3	9.3	119.1
August	0.0018	0.00006	0.0022	0.36	0.271	0.010	29.8	0.07	0.09	0.007	0.006	0.0022	0.114	30.0	8.8	111.1
September	0.0018	0.00006	0.0022	0.36	0.275	0.010	28.6	0.07	0.09	0.007	0.007	0.0022	0.115	29.6	8.7	110.0
October	0.0020	0.00007	0.0023	0.43	0.346	0.012	32.8	0.10	0.11	0.009	0.010	0.0023	0.123	30.9	8.9	114.0
November	0.0027	0.00011	0.0024	0.64	0.566	0.016	44.5	0.21	0.16	0.013	0.021	0.0027	0.147	34.6	9.4	125.0
December	0.0036	0.00016	0.0026	0.90	0.846	0.021	59.7	0.34	0.22	0.018	0.035	0.0032	0.178	39.4	10.0	139.3

Wet Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0028	0.00012	0.0024	0.67	0.599	0.016	46.3	0.23	0.17	0.013	0.023	0.0028	0.151	35.2	9.4	126.7
Feb	0.0042	0.00019	0.0027	1.07	1.023	0.025	69.3	0.43	0.26	0.021	0.044	0.0035	0.198	42.4	10.3	148.4
March	0.0038	0.00017	0.0026	0.96	0.904	0.022	62.9	0.37	0.24	0.019	0.038	0.0033	0.185	40.4	10.1	142.4
April	0.0017	0.00005	0.0022	0.32	0.225	0.009	27.9	0.05	0.08	0.007	0.004	0.0021	0.109	29.4	8.8	109.4
May	0.0015	0.00004	0.0021	0.25	0.158	0.008	25.3	0.02	0.07	0.005	0.001	0.0020	0.102	28.5	8.7	107.0
June	0.0015	0.00004	0.0021	0.27	0.171	0.008	26.1	0.02	0.07	0.006	0.001	0.0021	0.103	28.8	8.7	107.7
July	0.0017	0.00004	0.0021	0.28	0.180	0.009	32.0	0.03	0.07	0.006	0.002	0.0021	0.105	30.5	9.1	113.4
August	0.0018	0.00005	0.0021	0.28	0.181	0.009	36.2	0.03	0.07	0.006	0.002	0.0021	0.105	31.7	9.3	117.5
September	0.0018	0.00005	0.0021	0.28	0.185	0.009	33.2	0.03	0.07	0.006	0.002	0.0021	0.105	30.8	9.1	114.6
October	0.0016	0.00005	0.0022	0.31	0.220	0.009	27.2	0.04	0.08	0.006	0.004	0.0021	0.109	29.1	8.7	108.7
November	0.0019	0.00007	0.0022	0.39	0.308	0.011	30.4	0.09	0.10	0.008	0.008	0.0023	0.118	30.2	8.8	111.7
December	0.0022	0.00008	0.0023	0.50	0.420	0.013	36.6	0.14	0.13	0.010	0.014	0.0025	0.131	32.1	9.1	117.5

Table A5 Option 3 Predicted Water Quality in Victoria Creek (mg/L) - Best Estimate Source Terms

Average Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0118	0.00021	0.0023	0.25	0.188	0.033	32.6	0.04	0.07	0.005	0.000	0.0021	0.113	29.3	9.0	110.2
Feb	0.0221	0.00038	0.0025	0.25	0.232	0.059	43.5	0.07	0.08	0.006	0.000	0.0021	0.125	31.1	9.6	117.0
March	0.0192	0.00033	0.0024	0.25	0.219	0.052	40.4	0.07	0.08	0.005	0.000	0.0021	0.122	30.6	9.4	115.1
April	0.0035	0.00010	0.0021	0.23	0.145	0.018	42.8	0.01	0.06	0.005	0.000	0.0020	0.102	33.2	9.7	123.0
May	0.0018	0.00005	0.0021	0.24	0.144	0.009	24.9	0.01	0.06	0.005	0.000	0.0020	0.100	28.3	8.7	106.4
June	0.0022	0.00006	0.0021	0.24	0.143	0.011	30.1	0.01	0.06	0.005	0.000	0.0020	0.101	29.8	9.0	111.4
July	0.0025	0.00006	0.0021	0.24	0.143	0.011	32.7	0.01	0.06	0.005	0.000	0.0020	0.101	30.5	9.1	113.7
August	0.0026	0.00006	0.0021	0.24	0.144	0.011	29.9	0.01	0.06	0.005	0.000	0.0020	0.101	29.7	9.0	111.0
September	0.0025	0.00006	0.0021	0.24	0.147	0.011	25.2	0.01	0.06	0.005	0.000	0.0020	0.101	28.3	8.7	106.5
October	0.0032	0.00009	0.0021	0.24	0.149	0.015	30.9	0.01	0.06	0.005	0.000	0.0020	0.102	29.8	9.0	111.7
November	0.0050	0.00011	0.0022	0.24	0.161	0.019	25.9	0.02	0.07	0.005	0.000	0.0020	0.104	28.2	8.7	106.2
December	0.0076	0.00014	0.0022	0.24	0.170	0.023	28.1	0.03	0.07	0.005	0.000	0.0020	0.108	28.5	8.8	107.5

Dry Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0177	0.00031	0.0024	0.25	0.213	0.048	38.9	0.06	0.08	0.005	0.000	0.0021	0.120	30.3	9.3	114.1
Feb	0.0337	0.00057	0.0027	0.26	0.281	0.088	55.9	0.11	0.09	0.006	0.000	0.0022	0.140	33.2	10.2	124.7
March	0.0292	0.00050	0.0026	0.25	0.262	0.076	51.0	0.10	0.09	0.006	0.000	0.0021	0.134	32.4	9.9	121.7
April	0.0046	0.00014	0.0020	0.23	0.145	0.024	57.7	0.01	0.06	0.005	0.000	0.0020	0.103	37.3	10.6	136.9
May	0.0020	0.00005	0.0021	0.24	0.144	0.010	26.4	0.01	0.06	0.005	0.000	0.0020	0.101	28.7	8.8	107.8
June	0.0025	0.00006	0.0021	0.24	0.145	0.010	28.2	0.01	0.06	0.005	0.000	0.0020	0.101	29.2	8.9	109.4
July	0.0031	0.00007	0.0021	0.24	0.144	0.013	35.1	0.01	0.06	0.005	0.000	0.0020	0.102	31.1	9.3	115.9
August	0.0031	0.00007	0.0021	0.24	0.150	0.012	25.8	0.01	0.06	0.005	0.000	0.0020	0.102	28.4	8.7	106.9
September	0.0031	0.00007	0.0022	0.24	0.151	0.012	23.5	0.01	0.06	0.005	0.000	0.0020	0.102	27.8	8.6	104.6
October	0.0041	0.00009	0.0022	0.24	0.154	0.016	27.2	0.02	0.07	0.005	0.000	0.0020	0.103	28.7	8.8	107.7
November	0.0071	0.00014	0.0022	0.24	0.169	0.023	27.8	0.03	0.07	0.005	0.000	0.0020	0.107	28.5	8.8	107.3
December	0.0112	0.00020	0.0023	0.24	0.185	0.032	31.9	0.04	0.07	0.005	0.000	0.0021	0.112	29.2	9.0	109.8

Wet Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0076	0.00014	0.0022	0.24	0.170	0.023	28.1	0.03	0.07	0.005	0.000	0.0020	0.108	28.5	8.8	107.5
Feb	0.0138	0.00024	0.0023	0.25	0.197	0.039	34.8	0.05	0.07	0.005	0.000	0.0021	0.115	29.6	9.1	111.6
March	0.0121	0.00021	0.0023	0.25	0.189	0.034	32.9	0.04	0.07	0.005	0.000	0.0021	0.113	29.3	9.0	110.4
April	0.0028	0.00009	0.0021	0.23	0.143	0.015	39.0	0.01	0.06	0.005	0.000	0.0020	0.101	32.2	9.5	119.6
May	0.0016	0.00004	0.0021	0.24	0.143	0.009	25.0	0.01	0.06	0.005	0.000	0.0020	0.100	28.4	8.7	106.6
June	0.0018	0.00005	0.0021	0.24	0.143	0.009	25.2	0.01	0.06	0.005	0.000	0.0020	0.100	28.4	8.7	106.8
July	0.0021	0.00006	0.0021	0.24	0.142	0.011	31.1	0.01	0.06	0.005	0.000	0.0020	0.101	30.1	9.0	112.3
August	0.0023	0.00007	0.0021	0.24	0.142	0.013	35.7	0.01	0.06	0.005	0.000	0.0020	0.101	31.3	9.3	116.6
September	0.0022	0.00007	0.0021	0.24	0.144	0.013	32.7	0.01	0.06	0.005	0.000	0.0020	0.101	30.5	9.1	113.7
October	0.0024	0.00007	0.0021	0.24	0.149	0.012	25.0	0.01	0.06	0.005	0.000	0.0020	0.101	28.3	8.7	106.3
November	0.0036	0.00008	0.0022	0.24	0.153	0.014	24.0	0.01	0.07	0.005	0.000	0.0020	0.103	27.8	8.6	104.9
December	0.0051	0.00010	0.0022	0.24	0.159	0.017	25.5	0.02	0.07	0.005	0.000	0.0020	0.105	28.1	8.7	105.8

Table A6 Option 4 Predicted Water Quality in Victoria Creek (mg/L) - Best Estimate Source Terms

Average Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0052	0.00019	0.0026	0.39	0.445	0.033	28.5	0.01	0.07	0.005	0.000	0.0020	0.100	28.7	8.8	107.8
Feb	0.0091	0.00035	0.0031	0.54	0.744	0.058	35.4	0.02	0.07	0.006	0.000	0.0020	0.100	29.9	9.1	112.2
March	0.0080	0.00030	0.0030	0.50	0.659	0.051	33.4	0.01	0.07	0.006	0.000	0.0020	0.100	29.6	9.0	110.9
April	0.0025	0.00006	0.0021	0.26	0.180	0.012	40.3	0.01	0.06	0.005	0.000	0.0020	0.100	32.7	9.6	121.2
May	0.0015	0.00004	0.0021	0.24	0.152	0.009	24.6	0.01	0.06	0.005	0.000	0.0020	0.100	28.3	8.7	106.2
June	0.0018	0.00005	0.0021	0.25	0.157	0.009	29.5	0.01	0.06	0.005	0.000	0.0020	0.100	29.7	9.0	110.9
July	0.0020	0.00005	0.0021	0.25	0.164	0.010	31.9	0.01	0.06	0.005	0.000	0.0020	0.100	30.3	9.1	113.2
August	0.0019	0.00005	0.0021	0.25	0.170	0.010	29.3	0.01	0.06	0.005	0.000	0.0020	0.100	29.6	8.9	110.6
September	0.0018	0.00005	0.0022	0.25	0.174	0.010	24.7	0.01	0.06	0.005	0.000	0.0020	0.100	28.3	8.7	106.2
October	0.0022	0.00006	0.0022	0.26	0.187	0.012	29.3	0.01	0.06	0.005	0.000	0.0020	0.100	29.5	8.9	110.5
November	0.0027	0.00009	0.0023	0.29	0.250	0.017	23.9	0.01	0.06	0.005	0.000	0.0020	0.100	27.8	8.6	104.9
December	0.0037	0.00013	0.0024	0.33	0.325	0.023	25.7	0.01	0.07	0.005	0.000	0.0020	0.100	28.2	8.7	106.0

Dry Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0075	0.00028	0.0029	0.48	0.617	0.047	32.5	0.01	0.07	0.005	0.000	0.0020	0.100	29.4	9.0	110.3
Feb	0.0135	0.00052	0.0037	0.71	1.085	0.086	43.3	0.02	0.08	0.006	0.000	0.0020	0.100	31.3	9.5	117.2
March	0.0118	0.00045	0.0034	0.65	0.952	0.075	40.2	0.02	0.07	0.006	0.000	0.0020	0.100	30.8	9.3	115.3
April	0.0031	0.00007	0.0020	0.26	0.191	0.013	53.7	0.01	0.05	0.005	0.000	0.0020	0.100	36.5	10.4	134.0
May	0.0017	0.00005	0.0021	0.25	0.157	0.009	25.9	0.01	0.06	0.005	0.000	0.0020	0.100	28.6	8.7	107.5
June	0.0019	0.00005	0.0021	0.25	0.169	0.010	27.7	0.01	0.06	0.005	0.000	0.0020	0.100	29.1	8.8	109.1
July	0.0022	0.00006	0.0021	0.26	0.177	0.011	34.1	0.01	0.06	0.005	0.000	0.0020	0.100	30.9	9.2	115.2
August	0.0020	0.00006	0.0022	0.26	0.192	0.012	25.0	0.01	0.06	0.005	0.000	0.0020	0.100	28.3	8.7	106.3
September	0.0020	0.00006	0.0022	0.27	0.194	0.012	22.8	0.01	0.06	0.005	0.000	0.0020	0.100	27.7	8.5	104.2
October	0.0024	0.00008	0.0022	0.28	0.220	0.014	25.7	0.01	0.06	0.005	0.000	0.0020	0.100	28.4	8.7	106.8
November	0.0035	0.00012	0.0024	0.32	0.311	0.022	25.4	0.01	0.07	0.005	0.000	0.0020	0.100	28.1	8.6	105.8
December	0.0050	0.00018	0.0026	0.38	0.428	0.031	28.1	0.01	0.07	0.005	0.000	0.0020	0.100	28.6	8.8	107.5

Wet Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0037	0.00013	0.0024	0.33	0.324	0.023	25.7	0.01	0.07	0.005	0.000	0.0020	0.100	28.2	8.7	106.0
Feb	0.0060	0.00022	0.0027	0.42	0.505	0.038	29.9	0.01	0.07	0.005	0.000	0.0020	0.100	28.9	8.9	108.6
March	0.0053	0.00020	0.0026	0.40	0.453	0.033	28.7	0.01	0.07	0.005	0.000	0.0020	0.100	28.7	8.8	107.9
April	0.0022	0.00005	0.0021	0.25	0.163	0.010	37.1	0.01	0.06	0.005	0.000	0.0020	0.100	31.8	9.4	118.2
May	0.0015	0.00004	0.0021	0.24	0.148	0.008	24.7	0.01	0.06	0.005	0.000	0.0020	0.100	28.3	8.7	106.4
June	0.0016	0.00004	0.0021	0.24	0.153	0.009	25.0	0.01	0.06	0.005	0.000	0.0020	0.100	28.4	8.7	106.6
July	0.0018	0.00005	0.0021	0.24	0.154	0.009	30.4	0.01	0.06	0.005	0.000	0.0020	0.100	29.9	9.0	111.8
August	0.0019	0.00005	0.0021	0.24	0.153	0.009	34.4	0.01	0.06	0.005	0.000	0.0020	0.100	31.1	9.3	115.7
September	0.0018	0.00005	0.0021	0.25	0.156	0.009	31.3	0.01	0.06	0.005	0.000	0.0020	0.100	30.2	9.1	112.7
October	0.0018	0.00005	0.0022	0.25	0.172	0.010	24.0	0.01	0.06	0.005	0.000	0.0020	0.100	28.1	8.6	105.5
November	0.0022	0.00007	0.0022	0.27	0.207	0.013	22.9	0.01	0.06	0.005	0.000	0.0020	0.100	27.7	8.5	104.2
December	0.0027	0.00009	0.0023	0.29	0.252	0.017	24.0	0.01	0.06	0.005	0.000	0.0020	0.100	27.9	8.6	104.9

Table A7 Summary of Predicted Concentrations (mg/L) in Victoria Creek - Best Case Source Terms

Summary of Predicted Concentrations (mg/L) in Victoria Creek for the Best Estimate Source Terms and Dry Precipitation Scenario

		Existing Water Quality[c]			Option 1a					Option 1b					Option 2a					Option 2b					Option 3					Option 4				
	CCME Guideline	Minimum	Median	Winter Maximum[d]	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances
Arsenic	0.005	0.001	0.0016	0.0075	0.0016	0.0022	0.0032	0.0074	2	0.0016	0.0022	0.0033	0.0080	2	0.0016	0.0020	0.0031	0.0074	2	0.0016	0.0021	0.0033	0.0080	2	0.0020	0.0043	0.0101	0.0337	5	0.0017	0.0028	0.0047	0.0135	4
Cadmium	0.00034[a]	0.000005	0.00003	0.0003	0.00006	0.00015	0.00025	0.00073	3	0.00004	0.00007	0.00014	0.00039	0	0.00006	0.00015	0.00025	0.00073	3	0.00004	0.00007	0.00014	0.00039	0	0.00005	0.00011	0.00019	0.00057	3	0.00005	0.00007	0.00017	0.00052	3
Copper	0.002 - 0.004[b]	0.0005	0.002	0.003	0.0021	0.0023	0.0026	0.0037	6	0.0021	0.0022	0.0025	0.0034	6	0.0021	0.0023	0.0026	0.0037	6	0.0021	0.0022	0.0025	0.0034	7	0.0020	0.0022	0.0022	0.0027	9	0.0020	0.0022	0.0025	0.0037	11
Iron	0.3	0.044	0.25	0.3	0.28	0.43	0.78	2.16	11	0.28	0.43	0.79	2.19	11	0.28	0.43	0.78	2.16	11	0.28	0.43	0.79	2.19	11	0.23	0.24	0.24	0.26	0	0.25	0.27	0.36	0.71	5
Manganese		0.0025	0.0396	0.0401	0.17	0.28	0.50	1.41		0.18	0.35	0.73	2.22		0.17	0.28	0.50	1.41		0.18	0.35	0.73	2.22		0.14	0.15	0.18	0.28		0.16	0.21	0.39	1.08	
Zinc	0.03	0.0005	0.009	0.02	0.010	0.021	0.032	0.087	5	0.008	0.012	0.019	0.048	2	0.010	0.021	0.032	0.087	5	0.008	0.012	0.019	0.048	2	0.010	0.019	0.030	0.088	4	0.009	0.014	0.029	0.086	4
Sulphate		6.23	29.6	60.9	27.99	41.62	59.57	145.97		27.37	38.08	55.64	134.52		28.01	41.18	59.45	145.97		27.44	37.71	55.56	134.52		23.50	30.06	35.79	57.70		22.80	27.90	32.04	53.75	
Ammonia-N	0.832	0.005	0.005	0.01	0.03	0.11	0.29	0.99	2	0.03	0.11	0.29	1.00	2	0.03	0.11	0.29	0.99	2	0.03	0.11	0.29	1.00	2	0.01	0.02	0.04	0.11	0	0.01	0.01	0.01	0.02	0
Nitrate-N	2.9	0.005	0.1	0.24	0.072	0.116	0.204	0.561	0	0.071	0.110	0.196	0.535	0	0.072	0.116	0.205	0.561	0	0.071	0.110	0.196	0.535	0	0.057	0.065	0.069	0.091	0	0.052	0.064	0.065	0.076	0
Nitrite-N	0.06	0.0025	0.005	0.05	0.006	0.009	0.016	0.043	0	0.006	0.009	0.016	0.044	0	0.006	0.009	0.016	0.043	0	0.006	0.009	0.016	0.044	0	0.005	0.005	0.005	0.006	0	0.005	0.005	0.005	0.006	0
Cyanide-T				0	0.002	0.011	0.030	0.107		0.002	0.010	0.029	0.104		0.002	0.011	0.030	0.107		0.002	0.010	0.029	0.104		0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	
CN_WAD		0.002	0.002	0.002	0.002	0.002	0.003	0.005		0.002	0.002	0.003	0.006		0.002	0.002	0.003	0.005		0.002	0.002	0.003	0.006		0.002	0.002	0.002	0.002		0.002	0.002	0.002	0.002	
Cyanate		0.2	0.1	0.1	0.105	0.123	0.165	0.328		0.105	0.123	0.166	0.331		0.105	0.123	0.165	0.328		0.105	0.123	0.165	0.331		0.101	0.103	0.111	0.140		0.100	0.100	0.100	0.100	
Calcium		7.4	27.3	47.3	29.3	33.3	39.3	66.5		29.1	32.4	38.1	62.8		29.3	33.2	39.2	66.5		29.2	32.3	38.0	62.8		27.8	29.2	30.4	37.3		27.7	28.9	29.8	36.5	
Magnesium		2	8.75	16	8.8	9.5	10.2	14.0		8.7	9.3	9.9	12.9		8.8	9.5	10.2	14.0		8.7	9.3	9.9	12.9		8.6	8.9	9.2	10.6		8.5	8.8	9.0	10.4	
Hardness		26.7	103	182	109.5	122.5	140.0	223.6		108.9	119.3	135.6	209.9		109.6	121.9	139.9	223.6		109.0	118.8	135.5	209.9		104.6	109.6	113.9	136.9		104.2	108.3	111.6	134.0	

Summary of Predicted Concentrations (mg/L) in Victoria Creek for the Best Estimate Source Terms and Average Precipitation Scenario

		Existing Water Quality[c]			Option 1a					Option 1b					Option 2a					Option 2b					Option 3					Option 4				
	CCME Guideline	Minimum	Median	Winter Maximum[d]	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances
Arsenic	0.005	0.001	0.0016	0.0075	0.0015	0.0020	0.0026	0.0055	2	0.0015	0.0021	0.0027	0.0059	2	0.0015	0.0019	0.0026	0.0055	1	0.0015	0.0019	0.0027	0.0059	2	0.0018	0.0034	0.0070	0.0221	5	0.0015	0.0023	0.0035	0.0091	3
Cadmium	0.00034[a]	0.000005	0.00003	0.0003	0.00005	0.00012	0.00018	0.00051	3	0.00004	0.00006	0.00010	0.00028	0	0.00005	0.00012	0.00018	0.00051	2	0.00004	0.00006	0.00010	0.00028	0	0.00005	0.00009	0.00014	0.00038	2	0.00004	0.00006	0.00012	0.00035	2
Copper	0.002 - 0.004[b]	0.0005	0.002	0.003	0.0021	0.0022	0.0024	0.0032	6	0.0021	0.0022	0.0023	0.0030	8	0.0021	0.0022	0.0024	0.0032	9	0.0021	0.0022	0.0023	0.0030	8	0.0021	0.0021	0.0022	0.0025	11	0.0021	0.0022	0.0024	0.0031	11
Iron	0.3	0.044	0.25	0.3	0.26	0.36	0.60	1.54	11	0.26	0.36	0.60	1.56	10	0.26	0.36	0.60	1.54	9	0.26	0.36	0.60	1.56	10	0.23	0.24	0.24	0.25	0	0.24	0.26	0.32	0.54	4
Manganese		0.0025	0.0396	0.0401	0.16	0.23	0.38	1.00		0.17	0.27	0.53	1.55		0.16	0.23	0.38	1.00		0.17	0.27	0.53	1.55		0.14	0.15	0.17	0.23		0.15	0.18	0.30	0.74	
Zinc	0.03	0.0005	0.009	0.02	0.009	0.018	0.024	0.062	5	0.008	0.010	0.015	0.035	2	0.009	0.018	0.024	0.062	3	0.008	0.010	0.015	0.035	2	0.009	0.017	0.023	0.059	3	0.009	0.012	0.021	0.058	3
Sulphate		6.23	29.6	60.9	25.86	36.17	48.47	105.87		25.48	34.65	45.67	97.82		25.87	35.81	48.36	105.87		25.52	34.41	45.60	97.82		24.86	30.53	32.26	43.51		23.94	29.29	29.71	40.35	
Ammonia-N	0.832	0.005	0.005	0.01	0.02	0.07	0.19	0.67	2	0.02	0.07	0.19	0.68	0	0.02	0.07	0.19	0.67	0	0.02	0.07	0.19	0.68	0	0.01	0.01	0.03	0.07	0	0.01	0.01	0.01	0.02	0
Nitrate-N	2.9	0.005	0.1	0.24	0.069	0.096	0.156	0.400	0	0.069	0.091	0.150	0.382	0	0.069	0.096	0.156	0.400	0	0.069	0.091	0.150	0.382	0	0.060	0.063	0.067	0.081	0	0.057	0.063	0.064	0.072	0
Nitrite-N	0.06	0.0025	0.005	0.05	0.005	0.007	0.012	0.031	0	0.005	0.007	0.012	0.031	0	0.005	0.007	0.012	0.031	0	0.005	0.007	0.012	0.031	0	0.005	0.005	0.005	0.006	0	0.005	0.005	0.005	0.006	0
Cyanide-T				0	0.001	0.007	0.020	0.073		0.001	0.007	0.019	0.070		0.001	0.007	0.020	0.073		0.001	0.007	0.019	0.070		0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	
CN_WAD		0.002	0.002	0.002	0.002	0.002	0.003	0.004		0.002	0.002	0.003	0.004		0.002	0.002	0.003	0.004		0.002	0.002	0.003	0.004		0.002	0.002	0.002	0.002		0.002	0.002	0.002	0.002	
Cyanate		0.2	0.1	0.1	0.103	0.114	0.143	0.254		0.103	0.115	0.143	0.256		0.103	0.114	0.143	0.254		0.103	0.115	0.143	0.256		0.100	0.102	0.107	0.125		0.100	0.100	0.100	0.100	
Calcium		7.4	27.3	47.3	28.7	31.7	35.8	53.9		28.6	31.3	34.9	51.3		28.7	31.6	35.7	53.9		28.6	31.3	34.9	51.3		28.2	29.7	29.8	33.2		27.8	29.5	29.4	32.7	
Magnesium		2	8.75	16	8.7	9.2	9.7	12.2		8.7	9.1	9.5	11.5		8.7	9.2	9.7	12.2		8.7	9.1	9.5	11.5		8.7	9.0	9.1	9.7		8.6	8.9	8.9	9.6	
Hardness		26.7	103	182	107.5	117.4	129.3	184.9		107.1	115.9	126.2	175.3		107.5	117.0	129.2	184.9		107.2	115.7	126.1	175.3		106.2	111.2	111.6	123.0		104.9	110.6	110.0	121.2	

Summary of Predicted Concentrations (mg/L) in Victoria Creek for the Best Estimate Source Terms and Wet Precipitation Scenario

		Existing Water Quality[c]			Option 1a					Option 1b					Option 2a					Option 2b					Option 3					Option 4				
	CCME Guideline	Minimum	Median	Winter Maximum[d]	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances
Arsenic	0.005	0.001	0.0016	0.0075	0.0015	0.0018	0.0022	0.0039	0	0.0015	0.0019	0.0022	0.0042	0	0.0015	0.0018	0.0021	0.0039	0	0.0015	0.0018	0.0022	0.0042	0	0.0016	0.0026	0.0048	0.0138	4	0.0015	0.0020	0.0027	0.0060	2
Cadmium	0.00034[a]	0.000005	0.00003	0.0003	0.00005	0.00009	0.00013	0.00033	0	0.00004	0.00005	0.00008	0.00019	0	0.00005	0.00009	0.00013	0.00033	0	0.00004	0.00005	0.00008	0.00019	0	0.00004	0.00008	0.00010	0.00024	0	0.00004	0.00005	0.00009	0.00022	0
Copper	0.002 - 0.004[b]	0.0005	0.002	0.003	0.0021	0.0022	0.0023	0.0028	9	0.0021	0.0022	0.0022	0.0027	9	0.0021	0.0022	0.0023	0.0028	9	0.0021	0.0022	0.0022	0.0027	9	0.0021	0.0021	0.0022	0.0023	12	0.0021	0.0021	0.0022	0.0027	12
Iron	0.3	0.044	0.25	0.3	0.25	0.31	0.46	1.06	7	0.25	0.31	0.46	1.07	7	0.25	0.31	0.46	1.06	7	0.25	0.31	0.46	1.07	7	0.23	0.24	0.24	0.25	0	0.24	0.25	0.29	0.42	3
Manganese		0.0025	0.0396	0.0401	0.15	0.20	0.29	0.68		0.16	0.22	0.38	1.02		0.15	0.20	0.29	0.68		0.16	0.22	0.38	1.02		0.14	0.15	0.16	0.20		0.15	0.17	0.24	0.50	
Zinc	0.03	0.0005	0.009	0.02	0.009	0.014	0.019	0.042	2	0.008	0.009	0.012	0.025	0	0.009	0.014	0.019	0.042	2	0.008	0.009	0.012	0.025	0	0.009	0.013	0.017	0.039	2	0.008	0.010	0.016	0.038	2
Sulphate		6.23	29.6	60.9	25.55	33.97	39.79	74.55		25.24	32.70	37.80	69.35		25.59	33.81	39.74	74.55		25.30	32.60	37.78	69.35		23.97	29.61	29.91	39.05		22.95	27.16	28.17	37.14	
Ammonia-N	0.832	0.005	0.005	0.01	0.02	0.05	0.12	0.43	0	0.02	0.05	0.12	0.43	0	0.02	0.05	0.12	0.43	0	0.02	0.05	0.12	0.43	0	0.01	0.01	0.02	0.05	0	0.01	0.01	0.01	0.01	0
Nitrate-N	2.9	0.005	0.1	0.24	0.066	0.084	0.121	0.275	0	0.066	0.081	0.117	0.263	0	0.066	0.084	0.121	0.275	0	0.066	0.081	0.117	0.263	0	0.060	0.064	0.065	0.074	0	0.058	0.063	0.063	0.068	0
Nitrite-N	0.06	0.0025	0.005	0.05	0.005	0.007	0.009	0.021	0	0.005	0.006	0.009	0.021	0	0.005	0.007	0.009	0.021	0	0.005	0.006	0.009	0.021	0	0.005	0.005	0.005	0.005	0	0.005	0.005	0.005	0.005	0
Cyanide-T				0	0.001	0.004	0.012	0.046		0.001	0.004	0.012	0.044		0.001	0.004	0.012	0.046		0.001	0.004	0.012	0.044		0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	
CN_WAD		0.002	0.002	0.002	0.002	0.002	0.002	0.003		0.002	0.002	0.002	0.004		0.002	0.002	0.002	0.003		0.002	0.002	0.002	0.004		0.002	0.002	0.002	0.002		0.002	0.002	0.002	0.002	
Cyanate		0.2	0.1	0.1	0.102	0.109	0.126	0.197		0.102	0.109	0.127	0.198		0.102	0.109	0.126	0.197		0.102	0.109	0.127	0.198		0.100	0.101	0.104	0.115		0.100	0.100	0.100	0.100	
Calcium		7.4	27.3	47.3	28.6	31.0	33.0	44.1		28.5	30.7	32.4	42.4		28.6	31.0	33.0	44.1		28.5	30.7	32.4	42.4		27.8	28.9	29.4	32.2		27.7	28.5	29.1	31.8	
Magnesium		2	8.75	16	8.7	9.2	9.3	10.8		8.7	9.1	9.2	10.3		8.7	9.2	9.3	10.8		8.7	9.1	9.2	10.3		8.6	8.9	8.9	9.5		8.5	8.7	8.8	9.4	
Hardness		26.7	103	182	107.2	115.2	120.9	154.6		106.9	114.1	118.8	148.4		107.2	115.1	120.9	154.6		107.0	114.0	118.7	148.4		104.9	108.9	110.2	119.6		104.2	107.3	109.0	118.2	

Notes:

a. At Hardness = 150 mg/L as $CaCO_3$ - hardness dependent

b. 0.002 mg/L at hardness of 0 - 120 mg/L as $CaCO_3$, 0.003 mg/L at hardness of 120 - 180 mg/L as $CaCO_3$, and 0.004 mg/L at hardness of > 180 mg/L as $CaCO_3$

c. Existing water quality data set for Victoria Creek at Road (2007 to 2010)

d. Maximum of available winter water quality data (2007 to 2010) collected in November, December, January and February.

Table A8 Option 1A Predicted Water Quality in Victoria Creek (mg/L) - Worst Case Source Terms

Average Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0180	0.00101	0.0040	2.43	0.844	0.171	112.8	0.67	0.66	0.040	0.028	0.0101	1.085	29.6	9.0	111.0
Feb	0.0328	0.00187	0.0056	4.37	1.464	0.316	193.5	1.25	1.19	0.071	0.052	0.0173	1.955	31.5	9.5	117.8
March	0.0288	0.00163	0.0052	3.84	1.294	0.276	171.4	1.09	1.04	0.062	0.045	0.0154	1.717	31.0	9.3	115.9
April	0.0045	0.00051	0.0028	0.65	0.317	0.092	45.4	0.13	0.19	0.012	0.005	0.0035	0.283	29.0	8.8	108.8
May	0.0020	0.00009	0.0022	0.32	0.171	0.018	27.7	0.03	0.09	0.006	0.001	0.0023	0.136	28.3	8.7	106.2
June	0.0028	0.00015	0.0023	0.38	0.193	0.028	35.7	0.05	0.10	0.007	0.002	0.0025	0.164	29.8	9.0	111.4
July	0.0033	0.00019	0.0023	0.44	0.212	0.034	40.4	0.07	0.12	0.008	0.003	0.0028	0.191	30.4	9.1	113.6
August	0.0034	0.00018	0.0023	0.47	0.220	0.032	38.5	0.08	0.13	0.009	0.003	0.0029	0.205	29.6	9.0	110.8
September	0.0033	0.00015	0.0023	0.48	0.221	0.027	33.9	0.08	0.13	0.009	0.003	0.0029	0.210	28.3	8.7	106.3
October	0.0046	0.00034	0.0026	0.60	0.278	0.060	45.6	0.12	0.17	0.011	0.005	0.0034	0.265	29.9	9.0	111.9
November	0.0075	0.00047	0.0029	1.05	0.412	0.082	56.2	0.25	0.29	0.018	0.010	0.0050	0.462	28.3	8.7	106.6
December	0.0116	0.00063	0.0033	1.59	0.575	0.108	77.6	0.41	0.43	0.026	0.017	0.0070	0.706	28.8	8.8	108.0

Dry Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0267	0.00151	0.0049	3.57	1.209	0.256	160.2	1.01	0.97	0.058	0.042	0.0144	1.596	30.7	9.3	115.0
Feb	0.0478	0.00274	0.0073	6.33	2.092	0.462	275.2	1.85	1.72	0.102	0.076	0.0246	2.836	33.5	9.9	124.6
March	0.0421	0.00241	0.0066	5.60	1.855	0.407	244.4	1.62	1.52	0.090	0.067	0.0219	2.504	32.8	9.8	122.0
April	0.0063	0.00087	0.0033	0.86	0.427	0.158	60.8	0.20	0.26	0.016	0.008	0.0043	0.381	30.3	9.1	113.2
May	0.0024	0.00013	0.0022	0.36	0.187	0.024	30.9	0.04	0.10	0.007	0.002	0.0025	0.155	28.6	8.7	107.5
June	0.0033	0.00015	0.0023	0.46	0.214	0.026	36.1	0.08	0.12	0.009	0.003	0.0028	0.201	29.1	8.8	109.1
July	0.0044	0.00024	0.0024	0.55	0.248	0.043	47.1	0.10	0.15	0.010	0.004	0.0032	0.241	31.2	9.3	116.2
August	0.0043	0.00023	0.0025	0.62	0.268	0.040	39.2	0.12	0.17	0.011	0.005	0.0034	0.272	28.3	8.7	106.2
September	0.0043	0.00021	0.0025	0.63	0.268	0.037	37.7	0.13	0.17	0.011	0.005	0.0034	0.275	27.8	8.6	104.7
October	0.0059	0.00035	0.0027	0.84	0.343	0.062	47.6	0.19	0.23	0.015	0.008	0.0042	0.370	28.2	8.7	106.0
November	0.0109	0.00062	0.0032	1.49	0.547	0.106	74.0	0.39	0.41	0.025	0.016	0.0066	0.662	28.7	8.8	107.8
December	0.0172	0.00096	0.0039	2.32	0.807	0.163	108.0	0.63	0.63	0.038	0.026	0.0097	1.033	29.5	9.0	110.6

Wet Precipitaiton

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0116	0.00063	0.0033	1.59	0.574	0.108	77.6	0.41	0.43	0.026	0.017	0.0070	0.705	28.8	8.8	108.0
Feb	0.0211	0.00119	0.0043	2.84	0.974	0.201	129.7	0.79	0.77	0.046	0.033	0.0116	1.267	30.0	9.1	112.4
March	0.0185	0.00103	0.0040	2.49	0.863	0.176	115.2	0.69	0.68	0.041	0.028	0.0103	1.111	29.7	9.0	111.2
April	0.0033	0.00039	0.0026	0.49	0.258	0.071	37.5	0.08	0.14	0.009	0.003	0.0029	0.211	28.6	8.8	107.5
May	0.0018	0.00008	0.0022	0.29	0.160	0.015	26.7	0.02	0.08	0.006	0.001	0.0022	0.121	28.3	8.7	106.4
June	0.0021	0.00009	0.0022	0.33	0.171	0.016	28.3	0.03	0.09	0.006	0.001	0.0023	0.139	28.4	8.7	106.6
July	0.0027	0.00015	0.0022	0.36	0.188	0.029	36.2	0.04	0.10	0.007	0.002	0.0025	0.155	30.1	9.1	112.5
August	0.0029	0.00025	0.0023	0.37	0.202	0.046	41.8	0.05	0.10	0.007	0.002	0.0025	0.160	31.3	9.3	116.6
September	0.0028	0.00027	0.0024	0.37	0.208	0.049	39.1	0.05	0.11	0.008	0.002	0.0025	0.162	30.4	9.1	113.6
October	0.0031	0.00023	0.0024	0.47	0.230	0.042	34.1	0.08	0.13	0.009	0.003	0.0028	0.203	28.2	8.7	106.2
November	0.0050	0.00027	0.0026	0.73	0.302	0.048	42.1	0.15	0.20	0.013	0.006	0.0038	0.319	27.9	8.6	105.1
December	0.0076	0.00040	0.0028	1.06	0.406	0.069	55.7	0.26	0.29	0.018	0.010	0.0050	0.469	28.2	8.7	106.2

Table A9 Option 1B Predicted Water Quality in Victoria Creek (mg/L) - Worst Case Source Terms

Average Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0204	0.00057	0.0033	2.45	1.103	0.094	103.5	0.67	0.62	0.039	0.028	0.0102	1.089	28.0	8.5	104.9
Feb	0.0375	0.00104	0.0044	4.42	1.959	0.172	176.6	1.27	1.11	0.069	0.052	0.0175	1.970	28.5	8.5	106.4
March	0.0328	0.00091	0.0041	3.88	1.724	0.151	156.6	1.10	0.97	0.061	0.046	0.0155	1.729	28.4	8.5	106.0
April	0.0049	0.00014	0.0023	0.65	0.320	0.024	39.0	0.13	0.17	0.011	0.005	0.0035	0.284	28.2	8.6	105.9
May	0.0021	0.00006	0.0022	0.32	0.176	0.011	27.0	0.03	0.08	0.006	0.001	0.0023	0.136	28.1	8.6	105.8
June	0.0029	0.00007	0.0021	0.38	0.201	0.013	34.2	0.05	0.10	0.007	0.002	0.0025	0.164	29.6	8.9	110.6
July	0.0035	0.00009	0.0022	0.44	0.226	0.016	38.4	0.07	0.11	0.008	0.003	0.0028	0.191	30.2	9.1	112.6
August	0.0037	0.00009	0.0022	0.47	0.242	0.017	36.8	0.08	0.12	0.009	0.003	0.0029	0.205	29.4	8.9	109.9
September	0.0036	0.00010	0.0022	0.48	0.249	0.017	32.7	0.08	0.12	0.009	0.003	0.0029	0.210	28.1	8.6	105.5
October	0.0050	0.00013	0.0023	0.61	0.300	0.022	41.7	0.12	0.15	0.011	0.005	0.0034	0.265	29.4	8.9	109.9
November	0.0083	0.00023	0.0026	1.05	0.495	0.039	51.5	0.25	0.27	0.017	0.010	0.0050	0.463	27.6	8.5	103.9
December	0.0131	0.00036	0.0029	1.60	0.733	0.061	71.9	0.42	0.40	0.026	0.017	0.0070	0.707	27.8	8.5	104.3

Dry Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0304	0.00084	0.0040	3.60	1.605	0.140	146.4	1.02	0.90	0.056	0.042	0.0145	1.606	28.3	8.5	105.8
Feb	0.0548	0.00152	0.0055	6.42	2.831	0.251	251.2	1.87	1.61	0.100	0.077	0.0249	2.870	29.1	8.6	107.9
March	0.0483	0.00134	0.0051	5.66	2.502	0.221	223.1	1.64	1.42	0.088	0.068	0.0221	2.530	28.9	8.6	107.3
April	0.0069	0.00019	0.0024	0.87	0.415	0.032	49.4	0.20	0.22	0.015	0.008	0.0043	0.383	28.9	8.8	108.1
May	0.0026	0.00007	0.0022	0.36	0.195	0.013	29.7	0.05	0.09	0.007	0.002	0.0025	0.156	28.5	8.7	106.8
June	0.0035	0.00009	0.0022	0.46	0.239	0.017	34.9	0.08	0.12	0.008	0.003	0.0028	0.202	28.9	8.8	108.3
July	0.0047	0.00011	0.0022	0.55	0.275	0.020	44.6	0.10	0.14	0.010	0.004	0.0032	0.242	30.8	9.2	114.8
August	0.0047	0.00013	0.0023	0.62	0.309	0.023	37.0	0.12	0.16	0.011	0.005	0.0034	0.272	27.9	8.6	104.9
September	0.0047	0.00013	0.0023	0.63	0.313	0.023	36.0	0.13	0.16	0.011	0.005	0.0034	0.275	27.5	8.5	103.6
October	0.0066	0.00018	0.0025	0.84	0.405	0.031	44.2	0.19	0.21	0.014	0.008	0.0042	0.370	27.7	8.5	104.0
November	0.0122	0.00034	0.0028	1.50	0.690	0.057	68.2	0.39	0.38	0.024	0.016	0.0067	0.664	27.7	8.5	104.2
December	0.0194	0.00054	0.0033	2.33	1.053	0.090	99.2	0.64	0.59	0.037	0.026	0.0097	1.037	28.0	8.5	104.8

Wet Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0131	0.00036	0.0029	1.60	0.733	0.061	71.8	0.42	0.40	0.026	0.017	0.0070	0.707	27.8	8.5	104.3
Feb	0.0240	0.00066	0.0036	2.86	1.282	0.111	118.8	0.80	0.72	0.045	0.033	0.0117	1.273	28.1	8.5	105.2
March	0.0209	0.00058	0.0034	2.51	1.129	0.097	105.7	0.69	0.63	0.040	0.028	0.0104	1.115	28.0	8.5	105.0
April	0.0035	0.00010	0.0022	0.49	0.250	0.017	32.6	0.08	0.12	0.009	0.003	0.0029	0.211	28.0	8.6	105.4
May	0.0019	0.00005	0.0021	0.29	0.162	0.010	26.1	0.02	0.07	0.006	0.001	0.0022	0.121	28.2	8.6	106.1
June	0.0022	0.00006	0.0022	0.33	0.180	0.011	27.7	0.03	0.08	0.006	0.001	0.0023	0.139	28.3	8.7	106.3
July	0.0028	0.00007	0.0021	0.36	0.192	0.013	34.6	0.04	0.09	0.007	0.002	0.0025	0.155	29.9	9.0	111.7
August	0.0030	0.00007	0.0021	0.37	0.195	0.013	38.8	0.05	0.09	0.007	0.002	0.0025	0.161	31.0	9.2	115.3
September	0.0029	0.00007	0.0021	0.38	0.199	0.013	35.8	0.05	0.09	0.007	0.002	0.0025	0.163	30.0	9.0	112.1
October	0.0034	0.00009	0.0022	0.47	0.243	0.017	31.5	0.08	0.12	0.009	0.003	0.0029	0.203	27.9	8.6	104.8
November	0.0056	0.00015	0.0024	0.73	0.356	0.027	39.7	0.16	0.19	0.012	0.006	0.0038	0.319	27.5	8.5	103.7
December	0.0085	0.00023	0.0026	1.06	0.502	0.040	52.1	0.26	0.27	0.018	0.010	0.0051	0.470	27.6	8.5	103.9

Table A10 Option 2A Predicted Water Quality in Victoria Creek (mg/L) - Worst Case Source Terms

Average Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0180	0.00101	0.0040	2.43	0.844	0.171	112.8	0.67	0.66	0.040	0.028	0.0101	1.085	29.6	9.0	111.0
Feb	0.0328	0.00187	0.0056	4.37	1.464	0.316	193.5	1.25	1.19	0.071	0.052	0.0173	1.955	31.5	9.5	117.8
March	0.0288	0.00163	0.0052	3.84	1.294	0.276	171.4	1.09	1.04	0.062	0.045	0.0154	1.717	31.0	9.3	115.9
April	0.0045	0.00051	0.0028	0.65	0.317	0.092	45.4	0.13	0.19	0.012	0.005	0.0035	0.283	29.0	8.8	108.8
May	0.0020	0.00009	0.0022	0.32	0.171	0.018	27.7	0.03	0.09	0.006	0.001	0.0023	0.136	28.3	8.7	106.2
June	0.0026	0.00015	0.0023	0.38	0.193	0.028	35.4	0.05	0.10	0.007	0.002	0.0025	0.163	29.7	9.0	111.1
July	0.0032	0.00019	0.0023	0.44	0.212	0.034	40.1	0.07	0.12	0.008	0.003	0.0028	0.191	30.4	9.1	113.3
August	0.0033	0.00018	0.0023	0.47	0.220	0.032	38.3	0.08	0.13	0.009	0.003	0.0029	0.205	29.6	8.9	110.6
September	0.0033	0.00015	0.0023	0.48	0.221	0.027	33.8	0.08	0.13	0.009	0.003	0.0029	0.210	28.2	8.7	106.1
October	0.0043	0.00034	0.0026	0.60	0.278	0.060	45.1	0.12	0.17	0.011	0.005	0.0034	0.265	29.8	9.0	111.4
November	0.0075	0.00047	0.0029	1.05	0.412	0.082	56.2	0.25	0.29	0.018	0.010	0.0050	0.462	28.3	8.7	106.6
December	0.0027	0.00019	0.0025	0.66	0.424	0.025	49.0	0.22	0.17	0.013	0.024	0.0028	0.150	36.1	9.7	129.9

Dry Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0267	0.00151	0.0049	3.57	1.209	0.256	160.2	1.01	0.97	0.058	0.042	0.0144	1.596	30.7	9.3	115.0
Feb	0.0478	0.00274	0.0073	6.33	2.092	0.462	275.2	1.85	1.72	0.102	0.076	0.0246	2.836	33.5	9.9	124.6
March	0.0421	0.00241	0.0066	5.60	1.855	0.407	244.4	1.62	1.52	0.090	0.067	0.0219	2.504	32.8	9.8	122.0
April	0.0063	0.00087	0.0033	0.86	0.427	0.158	60.8	0.20	0.26	0.016	0.008	0.0043	0.381	30.3	9.1	113.2
May	0.0024	0.00013	0.0023	0.36	0.187	0.024	30.9	0.04	0.10	0.007	0.002	0.0025	0.156	28.7	8.7	107.5
June	0.0032	0.00015	0.0023	0.46	0.214	0.026	35.8	0.08	0.12	0.009	0.003	0.0028	0.201	29.0	8.8	108.8
July	0.0041	0.00024	0.0024	0.55	0.247	0.043	46.3	0.10	0.15	0.010	0.004	0.0032	0.241	30.9	9.2	115.1
August	0.0043	0.00023	0.0025	0.62	0.268	0.040	39.0	0.12	0.17	0.011	0.005	0.0034	0.272	28.2	8.6	106.0
September	0.0043	0.00021	0.0025	0.63	0.268	0.037	37.7	0.13	0.17	0.011	0.005	0.0034	0.275	27.8	8.6	104.7
October	0.0059	0.00035	0.0027	0.84	0.343	0.062	47.6	0.19	0.23	0.015	0.008	0.0042	0.370	28.2	8.7	106.0
November	0.0109	0.00062	0.0032	1.49	0.547	0.106	74.0	0.39	0.41	0.025	0.016	0.0066	0.662	28.7	8.8	107.8
December	0.0172	0.00096	0.0039	2.32	0.807	0.163	108.0	0.63	0.63	0.038	0.026	0.0097	1.033	29.5	9.0	110.6

Wet Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0116	0.00063	0.0033	1.59	0.574	0.108	77.6	0.41	0.43	0.026	0.017	0.0070	0.705	28.8	8.8	108.0
Feb	0.0211	0.00119	0.0043	2.84	0.974	0.201	129.7	0.79	0.77	0.046	0.033	0.0116	1.267	30.0	9.1	112.4
March	0.0185	0.00103	0.0040	2.49	0.863	0.176	115.2	0.69	0.68	0.041	0.028	0.0103	1.111	29.7	9.0	111.2
April	0.0033	0.00039	0.0026	0.49	0.258	0.071	37.5	0.08	0.14	0.009	0.003	0.0029	0.211	28.6	8.8	107.5
May	0.0018	0.00008	0.0022	0.29	0.160	0.015	26.8	0.02	0.08	0.006	0.001	0.0022	0.121	28.3	8.7	106.5
June	0.0021	0.00009	0.0022	0.33	0.171	0.016	28.3	0.03	0.09	0.006	0.001	0.0023	0.139	28.4	8.7	106.5
July	0.0025	0.00015	0.0022	0.36	0.187	0.029	35.8	0.04	0.10	0.007	0.002	0.0025	0.155	30.0	9.0	112.1
August	0.0027	0.00025	0.0023	0.37	0.202	0.046	41.7	0.05	0.10	0.007	0.002	0.0025	0.160	31.3	9.3	116.5
September	0.0027	0.00027	0.0024	0.38	0.208	0.049	39.1	0.05	0.11	0.008	0.002	0.0025	0.162	30.5	9.1	113.7
October	0.0031	0.00023	0.0024	0.47	0.230	0.042	34.0	0.08	0.13	0.009	0.003	0.0028	0.203	28.2	8.7	106.1
November	0.0050	0.00027	0.0026	0.73	0.302	0.048	42.1	0.15	0.20	0.013	0.006	0.0038	0.319	27.9	8.6	105.1
December	0.0076	0.00040	0.0028	1.06	0.406	0.069	55.7	0.26	0.29	0.018	0.010	0.0050	0.469	28.2	8.7	106.2

Table A11 Option 2B Predicted Water Quality in Victoria Creek (mg/L) - Worst Case Source Terms

Average Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0204	0.00057	0.0033	2.45	1.103	0.094	103.5	0.67	0.62	0.039	0.028	0.0102	1.089	28.0	8.5	104.9
Feb	0.0375	0.00104	0.0044	4.42	1.959	0.172	176.6	1.27	1.11	0.069	0.052	0.0175	1.970	28.5	8.5	106.4
March	0.0328	0.00091	0.0041	3.88	1.724	0.151	156.6	1.10	0.97	0.061	0.046	0.0155	1.729	28.4	8.5	106.0
April	0.0049	0.00014	0.0023	0.65	0.320	0.024	39.0	0.13	0.17	0.011	0.005	0.0035	0.284	28.2	8.6	105.9
May	0.0021	0.00006	0.0022	0.32	0.176	0.011	27.0	0.03	0.08	0.006	0.001	0.0023	0.136	28.2	8.6	105.9
June	0.0028	0.00007	0.0021	0.38	0.201	0.013	33.9	0.05	0.10	0.007	0.002	0.0025	0.164	29.5	8.9	110.3
July	0.0034	0.00009	0.0022	0.44	0.226	0.016	38.2	0.07	0.11	0.008	0.003	0.0028	0.191	30.1	9.0	112.4
August	0.0036	0.00009	0.0022	0.47	0.242	0.017	36.7	0.08	0.12	0.009	0.003	0.0029	0.205	29.3	8.9	109.7
September	0.0035	0.00010	0.0022	0.48	0.249	0.017	32.6	0.08	0.12	0.009	0.003	0.0029	0.210	28.0	8.6	105.4
October	0.0047	0.00013	0.0023	0.61	0.300	0.022	41.4	0.12	0.15	0.011	0.005	0.0034	0.265	29.3	8.9	109.6
November	0.0083	0.00023	0.0026	1.05	0.495	0.039	51.5	0.25	0.27	0.017	0.010	0.0050	0.463	27.6	8.5	103.9
December	0.0131	0.00036	0.0029	1.60	0.733	0.061	71.9	0.42	0.40	0.026	0.017	0.0070	0.707	27.8	8.5	104.3

Dry Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0304	0.00084	0.0040	3.60	1.605	0.140	146.4	1.02	0.90	0.056	0.042	0.0145	1.606	28.3	8.5	105.8
Feb	0.0548	0.00152	0.0055	6.42	2.831	0.251	251.2	1.87	1.61	0.100	0.077	0.0249	2.870	29.1	8.6	107.9
March	0.0483	0.00134	0.0051	5.66	2.502	0.221	223.1	1.64	1.42	0.088	0.068	0.0221	2.530	28.9	8.6	107.3
April	0.0069	0.00019	0.0024	0.87	0.415	0.032	49.4	0.20	0.22	0.015	0.008	0.0043	0.383	28.9	8.8	108.1
May	0.0025	0.00007	0.0022	0.36	0.195	0.013	29.8	0.05	0.09	0.007	0.002	0.0025	0.156	28.5	8.7	107.0
June	0.0034	0.00009	0.0022	0.46	0.239	0.017	34.7	0.08	0.12	0.008	0.003	0.0028	0.202	28.8	8.8	108.1
July	0.0044	0.00011	0.0022	0.55	0.274	0.020	43.9	0.10	0.14	0.010	0.004	0.0032	0.241	30.6	9.1	113.9
August	0.0047	0.00013	0.0023	0.62	0.309	0.023	37.0	0.12	0.16	0.011	0.005	0.0034	0.272	27.9	8.6	104.8
September	0.0047	0.00013	0.0023	0.63	0.313	0.023	36.0	0.13	0.16	0.011	0.005	0.0034	0.275	27.5	8.5	103.6
October	0.0066	0.00018	0.0025	0.84	0.405	0.031	44.2	0.19	0.21	0.014	0.008	0.0042	0.370	27.7	8.5	104.0
November	0.0122	0.00034	0.0028	1.50	0.690	0.057	68.2	0.39	0.38	0.024	0.016	0.0067	0.664	27.7	8.5	104.2
December	0.0194	0.00054	0.0033	2.33	1.053	0.090	99.2	0.64	0.59	0.037	0.026	0.0097	1.037	28.0	8.5	104.8

Wet Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0131	0.00036	0.0029	1.60	0.733	0.061	71.8	0.42	0.40	0.026	0.017	0.0070	0.707	27.8	8.5	104.3
Feb	0.0240	0.00066	0.0036	2.86	1.282	0.111	118.8	0.80	0.72	0.045	0.033	0.0117	1.273	28.1	8.5	105.2
March	0.0209	0.00058	0.0034	2.51	1.129	0.097	105.7	0.69	0.63	0.040	0.028	0.0104	1.115	28.0	8.5	105.0
April	0.0035	0.00010	0.0022	0.49	0.250	0.017	32.6	0.08	0.12	0.009	0.003	0.0029	0.211	28.0	8.6	105.4
May	0.0018	0.00005	0.0021	0.29	0.162	0.010	26.2	0.02	0.07	0.006	0.001	0.0022	0.121	28.3	8.6	106.2
June	0.0022	0.00006	0.0022	0.33	0.180	0.011	27.7	0.03	0.08	0.006	0.001	0.0023	0.139	28.3	8.7	106.2
July	0.0026	0.00007	0.0021	0.36	0.192	0.013	34.3	0.04	0.09	0.007	0.002	0.0025	0.155	29.8	9.0	111.4
August	0.0029	0.00007	0.0021	0.37	0.195	0.013	38.7	0.05	0.09	0.007	0.002	0.0025	0.161	31.0	9.2	115.2
September	0.0028	0.00007	0.0021	0.38	0.199	0.013	35.9	0.05	0.09	0.007	0.002	0.0025	0.163	30.1	9.0	112.3
October	0.0034	0.00009	0.0022	0.47	0.243	0.017	31.5	0.08	0.12	0.009	0.003	0.0029	0.203	27.9	8.6	104.9
November	0.0056	0.00015	0.0024	0.73	0.356	0.027	39.7	0.16	0.19	0.012	0.006	0.0038	0.319	27.5	8.5	103.7
December	0.0085	0.00023	0.0026	1.06	0.502	0.040	52.1	0.26	0.27	0.018	0.010	0.0051	0.470	27.6	8.5	103.9

Table A12 Option 3 Predicted Water Quality in Victoria Creek (mg/L) - Upper Estimate Source Terms

Average Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0182	0.00091	0.0031	0.27	0.349	0.170	39.7	0.04	0.11	0.007	0.002	0.0024	0.113	29.9	9.0	111.7
Feb	0.0349	0.00178	0.0041	0.30	0.553	0.330	57.6	0.08	0.15	0.009	0.004	0.0029	0.125	32.4	9.5	120.1
March	0.0302	0.00153	0.0038	0.29	0.495	0.284	52.5	0.07	0.14	0.008	0.003	0.0027	0.122	31.7	9.4	117.7
April	0.0045	0.00040	0.0024	0.24	0.199	0.074	45.6	0.01	0.08	0.006	0.000	0.0021	0.102	33.3	9.7	123.1
May	0.0020	0.00009	0.0022	0.24	0.152	0.017	25.3	0.01	0.06	0.005	0.000	0.0020	0.100	28.3	8.7	106.5
June	0.0026	0.00014	0.0022	0.24	0.158	0.026	30.9	0.01	0.07	0.005	0.000	0.0020	0.101	29.8	9.0	111.5
July	0.0031	0.00017	0.0022	0.24	0.164	0.032	33.7	0.01	0.07	0.005	0.000	0.0020	0.101	30.5	9.1	113.8
August	0.0033	0.00016	0.0022	0.24	0.165	0.030	30.9	0.01	0.07	0.005	0.000	0.0020	0.101	29.7	9.0	111.2
September	0.0032	0.00014	0.0022	0.24	0.164	0.026	26.0	0.01	0.07	0.005	0.000	0.0020	0.101	28.4	8.7	106.7
October	0.0042	0.00029	0.0024	0.24	0.190	0.055	32.9	0.01	0.07	0.006	0.000	0.0021	0.102	29.9	9.0	111.9
November	0.0073	0.00041	0.0026	0.25	0.226	0.077	28.9	0.02	0.08	0.006	0.001	0.0022	0.104	28.4	8.7	106.7
December	0.0115	0.00057	0.0027	0.26	0.267	0.105	32.4	0.03	0.09	0.006	0.001	0.0023	0.108	28.9	8.8	108.4

Dry Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0278	0.00141	0.0037	0.29	0.466	0.262	50.0	0.06	0.13	0.008	0.003	0.0027	0.120	31.4	9.3	116.5
Feb	0.0538	0.00276	0.0053	0.34	0.782	0.510	77.9	0.11	0.20	0.011	0.006	0.0033	0.140	35.2	10.1	129.5
March	0.0464	0.00238	0.0048	0.33	0.693	0.440	70.0	0.10	0.18	0.010	0.005	0.0032	0.134	34.1	9.9	125.8
April	0.0060	0.00061	0.0026	0.23	0.230	0.115	62.2	0.01	0.08	0.006	0.000	0.0021	0.103	37.4	10.6	137.1
May	0.0024	0.00012	0.0022	0.24	0.157	0.022	27.1	0.01	0.07	0.005	0.000	0.0020	0.101	28.8	8.8	107.9
June	0.0031	0.00013	0.0022	0.24	0.161	0.025	28.9	0.01	0.07	0.005	0.000	0.0020	0.101	29.3	8.9	109.5
July	0.0040	0.00021	0.0022	0.24	0.173	0.040	36.5	0.01	0.07	0.005	0.000	0.0021	0.102	31.2	9.3	116.1
August	0.0042	0.00020	0.0023	0.24	0.178	0.037	27.1	0.01	0.07	0.005	0.000	0.0021	0.102	28.5	8.7	107.1
September	0.0042	0.00019	0.0023	0.24	0.178	0.035	24.7	0.01	0.07	0.005	0.000	0.0021	0.102	27.9	8.6	104.9
October	0.0058	0.00031	0.0024	0.25	0.202	0.057	29.3	0.02	0.08	0.006	0.001	0.0021	0.103	28.8	8.8	108.1
November	0.0108	0.00055	0.0027	0.26	0.262	0.102	32.0	0.03	0.09	0.006	0.001	0.0022	0.107	28.8	8.8	108.1
December	0.0173	0.00087	0.0031	0.27	0.338	0.161	38.6	0.04	0.11	0.007	0.002	0.0024	0.112	29.8	9.0	111.3

Wet Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0115	0.00057	0.0027	0.26	0.267	0.105	32.4	0.03	0.09	0.006	0.001	0.0023	0.108	28.9	8.8	108.4
Feb	0.0216	0.00109	0.0033	0.28	0.390	0.202	43.3	0.05	0.12	0.007	0.002	0.0025	0.115	30.4	9.1	113.4
March	0.0187	0.00094	0.0032	0.27	0.355	0.174	40.2	0.04	0.11	0.007	0.002	0.0024	0.113	30.0	9.0	112.0
April	0.0034	0.00031	0.0023	0.24	0.183	0.058	41.2	0.01	0.07	0.006	0.000	0.0020	0.101	32.3	9.5	119.7
May	0.0018	0.00007	0.0021	0.24	0.149	0.015	25.3	0.01	0.06	0.005	0.000	0.0020	0.100	28.4	8.7	106.6
June	0.0021	0.00008	0.0022	0.24	0.150	0.015	25.5	0.01	0.06	0.005	0.000	0.0020	0.100	28.5	8.7	106.8
July	0.0025	0.00014	0.0022	0.24	0.157	0.026	31.9	0.01	0.07	0.005	0.000	0.0020	0.101	30.1	9.0	112.4
August	0.0027	0.00022	0.0022	0.24	0.168	0.041	37.1	0.01	0.07	0.005	0.000	0.0020	0.101	31.4	9.3	116.7
September	0.0026	0.00023	0.0023	0.24	0.172	0.044	34.2	0.01	0.07	0.005	0.000	0.0020	0.101	30.5	9.1	113.8
October	0.0031	0.00020	0.0023	0.24	0.175	0.039	26.4	0.01	0.07	0.005	0.000	0.0020	0.101	28.3	8.7	106.4
November	0.0049	0.00024	0.0024	0.25	0.190	0.045	25.6	0.01	0.07	0.005	0.000	0.0021	0.103	28.0	8.6	105.2
December	0.0074	0.00035	0.0025	0.25	0.218	0.066	28.0	0.02	0.08	0.006	0.001	0.0022	0.105	28.3	8.7	106.3

Table A13 Option 4 Predicted Water Quality in Victoria Creek (mg/L) - Upper Source Terms

Average Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0074	0.00076	0.0033	0.40	0.571	0.138	32.7	0.01	0.08	0.006	0.000	0.0020	0.100	28.6	8.8	107.8
Feb	0.0135	0.00147	0.0044	0.55	0.994	0.268	43.8	0.02	0.10	0.008	0.000	0.0020	0.100	29.9	9.2	112.3
March	0.0117	0.00127	0.0041	0.51	0.874	0.231	40.6	0.02	0.09	0.007	0.000	0.0020	0.100	29.5	9.1	111.0
April	0.0028	0.00015	0.0022	0.26	0.200	0.028	41.0	0.01	0.06	0.005	0.000	0.0020	0.100	32.7	9.6	121.2
May	0.0016	0.00006	0.0021	0.24	0.156	0.012	24.7	0.01	0.06	0.005	0.000	0.0020	0.100	28.3	8.7	106.2
June	0.0019	0.00008	0.0021	0.25	0.165	0.016	29.8	0.01	0.06	0.005	0.000	0.0020	0.100	29.7	9.0	110.9
July	0.0022	0.00010	0.0021	0.25	0.175	0.019	32.3	0.01	0.06	0.005	0.000	0.0020	0.100	30.3	9.1	113.2
August	0.0022	0.00011	0.0022	0.25	0.182	0.021	29.7	0.01	0.06	0.005	0.000	0.0020	0.100	29.6	8.9	110.6
September	0.0020	0.00011	0.0022	0.26	0.187	0.021	25.2	0.01	0.06	0.005	0.000	0.0020	0.100	28.3	8.7	106.2
October	0.0025	0.00015	0.0023	0.26	0.207	0.028	30.0	0.01	0.06	0.005	0.000	0.0020	0.100	29.5	8.9	110.5
November	0.0035	0.00029	0.0025	0.30	0.294	0.054	25.4	0.01	0.07	0.005	0.000	0.0020	0.100	27.8	8.6	104.9
December	0.0050	0.00047	0.0028	0.33	0.400	0.086	28.2	0.01	0.07	0.006	0.000	0.0020	0.100	28.1	8.7	106.0

Dry Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0109	0.00117	0.0039	0.49	0.814	0.213	39.1	0.02	0.09	0.007	0.000	0.0020	0.100	29.3	9.0	110.4
Feb	0.0203	0.00228	0.0057	0.73	1.477	0.415	56.4	0.02	0.12	0.009	0.000	0.0020	0.100	31.3	9.6	117.4
March	0.0176	0.00197	0.0052	0.66	1.288	0.358	51.5	0.02	0.11	0.009	0.000	0.0020	0.100	30.7	9.4	115.4
April	0.0036	0.00020	0.0021	0.26	0.219	0.037	54.7	0.01	0.06	0.005	0.000	0.0020	0.100	36.5	10.4	134.0
May	0.0018	0.00008	0.0022	0.25	0.164	0.015	26.2	0.01	0.06	0.005	0.000	0.0020	0.100	28.6	8.7	107.5
June	0.0021	0.00011	0.0022	0.25	0.181	0.020	28.1	0.01	0.06	0.005	0.000	0.0020	0.100	29.1	8.8	109.1
July	0.0025	0.00013	0.0022	0.26	0.194	0.025	34.7	0.01	0.06	0.005	0.000	0.0020	0.100	30.9	9.2	115.2
August	0.0024	0.00016	0.0023	0.26	0.212	0.029	25.7	0.01	0.07	0.005	0.000	0.0020	0.100	28.3	8.7	106.4
September	0.0024	0.00016	0.0023	0.27	0.215	0.030	23.5	0.01	0.07	0.005	0.000	0.0020	0.100	27.7	8.5	104.2
October	0.0030	0.00022	0.0024	0.28	0.252	0.041	26.8	0.01	0.07	0.005	0.000	0.0020	0.100	28.4	8.7	106.9
November	0.0047	0.00044	0.0028	0.33	0.381	0.080	27.7	0.01	0.07	0.006	0.000	0.0020	0.100	28.1	8.7	105.8
December	0.0071	0.00072	0.0032	0.39	0.547	0.131	32.0	0.01	0.08	0.006	0.000	0.0020	0.100	28.6	8.8	107.6

Wet Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0050	0.00047	0.0028	0.33	0.400	0.086	28.2	0.01	0.07	0.006	0.000	0.0020	0.100	28.1	8.7	106.0
Feb	0.0086	0.00090	0.0035	0.43	0.655	0.164	34.9	0.01	0.08	0.007	0.000	0.0020	0.100	28.9	8.9	108.7
March	0.0076	0.00078	0.0033	0.40	0.583	0.142	33.0	0.01	0.08	0.006	0.000	0.0020	0.100	28.7	8.8	107.9
April	0.0024	0.00011	0.0021	0.25	0.176	0.020	37.5	0.01	0.06	0.005	0.000	0.0020	0.100	31.8	9.4	118.2
May	0.0015	0.00005	0.0021	0.24	0.150	0.010	24.8	0.01	0.06	0.005	0.000	0.0020	0.100	28.3	8.7	106.4
June	0.0017	0.00006	0.0021	0.24	0.157	0.013	25.2	0.01	0.06	0.005	0.000	0.0020	0.100	28.4	8.7	106.6
July	0.0019	0.00008	0.0021	0.24	0.161	0.015	30.6	0.01	0.06	0.005	0.000	0.0020	0.100	29.9	9.0	111.8
August	0.0021	0.00008	0.0021	0.24	0.161	0.015	34.6	0.01	0.06	0.005	0.000	0.0020	0.100	31.1	9.3	115.7
September	0.0020	0.00008	0.0021	0.25	0.163	0.016	31.6	0.01	0.06	0.005	0.000	0.0020	0.100	30.2	9.1	112.7
October	0.0020	0.00011	0.0022	0.25	0.184	0.021	24.4	0.01	0.06	0.005	0.000	0.0020	0.100	28.0	8.6	105.5
November	0.0026	0.00019	0.0024	0.27	0.234	0.035	23.8	0.01	0.07	0.005	0.000	0.0020	0.100	27.7	8.5	104.2
December	0.0035	0.00030	0.0025	0.30	0.297	0.055	25.5	0.01	0.07	0.006	0.000	0.0020	0.100	27.8	8.6	104.9

Table A14 Summary of Predicted Concentrations (mg/L) in Victoria Creek - Upper Estimate Source Terms

Summary of Predicted Concentrations (mg/L) in Victoria Creek for the Upper Estimate Source Terms and Dry Precipitation Scenario

		Existing Water Quality[c]			Option 1a					Option 1b					Option 2a					Option 2b					Option 3					Option 4				
	CCME Guideline	Minimum	Median	Winter Maximum[d]	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances
Arsenic	0.005	0.001	0.0016	0.0075	0.0024	0.0061	0.0146	0.0478	7	0.0026	0.0066	0.0166	0.0548	7	0.0024	0.0059	0.0146	0.0478	7	0.0025	0.0066	0.0165	0.0548	7	0.0024	0.0059	0.0155	0.0538	7	0.0018	0.0033	0.0065	0.0203	4
Cadmium	0.00034[a]	0.000005	0.00003	0.0003	0.00013	0.00049	0.00087	0.00274	7	0.00007	0.00018	0.00046	0.00152	5	0.00013	0.00035	0.00087	0.00274	7	0.00007	0.00018	0.00046	0.00152	5	0.00012	0.00043	0.00081	0.00276	7	0.00008	0.00021	0.00064	0.00228	5
Copper	0.002 - 0.004[b]	0.0005	0.002	0.003	0.0022	0.0030	0.0036	0.0073	12	0.0022	0.0024	0.0031	0.0055	12	0.0023	0.0027	0.0036	0.0073	12	0.0022	0.0024	0.0031	0.0055	12	0.0022	0.0025	0.0030	0.0053	11	0.0021	0.0024	0.0030	0.0057	11
Iron	0.3	0.044	0.25	0.3	0.36	0.85	1.97	6.33	12	0.36	0.84	1.99	6.42	12	0.36	0.84	1.97	6.33	12	0.36	0.84	1.99	6.42	12	0.23	0.25	0.26	0.34	2	0.25	0.27	0.37	0.73	5
Manganese		0.0025	0.0396	0.0401	0.19	0.38	0.71	2.09		0.20	0.41	0.90	2.83		0.19	0.34	0.71	2.09		0.20	0.41	0.90	2.83		0.16	0.22	0.32	0.78		0.16	0.24	0.50	1.48	
Zinc	0.03	0.0005	0.009	0.02	0.024	0.084	0.149	0.462	10	0.013	0.031	0.076	0.251	7	0.024	0.062	0.149	0.462	10	0.013	0.031	0.076	0.251	7	0.022	0.080	0.151	0.510	10	0.015	0.039	0.116	0.415	7
Sulphate		6.23	29.6	60.9	30.91	54.17	96.76	275.21		29.71	44.64	88.66	251.23		30.92	47.56	96.65	275.21		29.78	44.18	88.59	251.23		24.70	34.22	42.01	77.86		23.51	30.09	35.54	56.44	
Ammonia-N	0.832	0.005	0.005	0.01	0.04	0.19	0.53	1.85	3	0.05	0.19	0.54	1.87	3	0.04	0.19	0.53	1.85	3	0.05	0.19	0.54	1.87	3	0.01	0.02	0.04	0.11	0	0.01	0.01	0.01	0.02	0
Nitrate-N	2.9	0.005	0.1	0.24	0.098	0.246	0.537	1.722	0	0.093	0.214	0.500	1.610	0	0.098	0.230	0.537	1.722	0	0.093	0.214	0.500	1.610	0	0.066	0.079	0.101	0.202	0	0.055	0.067	0.076	0.119	0
Nitrite-N	0.06	0.0025	0.005	0.05	0.007	0.015	0.033	0.102	2	0.007	0.014	0.032	0.100	2	0.007	0.015	0.033	0.102	2	0.007	0.014	0.032	0.100	2	0.005	0.006	0.007	0.011	0	0.005	0.005	0.006	0.009	0
Cyanide-T				0	0.002	0.008	0.022	0.076		0.002	0.008	0.022	0.077		0.002	0.008	0.022	0.076		0.002	0.008	0.022	0.077		0.000	0.000	0.002	0.006		0.000	0.000	0.000	0.000	
CN_WAD		0.002	0.002	0.002	0.002	0.004	0.008	0.025		0.002	0.004	0.008	0.025		0.002	0.004	0.008	0.025		0.002	0.004	0.008	0.025		0.002	0.002	0.002	0.003		0.002	0.002	0.002	0.002	
Cyanate		0.2	0.1	0.1	0.155	0.375	0.877	2.836		0.156	0.370	0.884	2.870		0.156	0.370	0.877	2.836		0.156	0.370	0.884	2.870		0.101	0.103	0.111	0.140		0.100	0.100	0.100	0.100	
Calcium		7.4	27.3	47.3	27.8	29.3	29.9	33.5		27.5	28.5	28.5	30.8		27.8	29.0	29.9	33.5		27.5	28.5	28.5	30.6		27.9	29.5	30.9	37.4		27.7	28.9	29.8	36.5	
Magnesium		2	8.75	16	8.6	8.9	9.1	9.9		8.5	8.6	8.6	9.2		8.6	8.8	9.0	9.9		8.5	8.6	8.6	9.1		8.6	8.9	9.2	10.6		8.5	8.8	9.1	10.4	
Hardness		26.7	103	182	104.7	109.8	111.9	124.6		103.6	106.8	106.7	114.8		104.7	108.8	111.8	124.6		103.6	107.0	106.6	113.9		104.9	110.4	115.2	137.1		104.2	108.3	111.7	134.0	

Summary of Predicted Concentrations (mg/L) in Victoria Creek for the Upper Estimate Source Terms and Average Precipitation Scenario

		Existing Water Quality[c]			Option 1a					Option 1b					Option 2a					Option 2b					Option 3					Option 4				
	CCME Guideline	Minimum	Median	Winter Maximum[d]	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances
Arsenic	0.005	0.001	0.0016	0.0075	0.0020	0.0046	0.0102	0.0328	5	0.0021	0.0049	0.0115	0.0375	5	0.0020	0.0043	0.0102	0.0328	5	0.0021	0.0047	0.0114	0.0375	5	0.0020	0.0044	0.0104	0.0349	5	0.0016	0.0027	0.0047	0.0135	3
Cadmium	0.00034[a]	0.000005	0.00003	0.0003	0.00009	0.00040	0.00060	0.00187	7	0.00006	0.00013	0.00031	0.00104	4	0.00009	0.00034	0.00060	0.00187	7	0.00006	0.00013	0.00031	0.00104	4	0.00009	0.00034	0.00055	0.00178	7	0.00006	0.00015	0.00042	0.00147	5
Copper	0.002 - 0.004[b]	0.0005	0.002	0.003	0.0022	0.0027	0.0031	0.0056	12	0.0021	0.0023	0.0027	0.0044	12	0.0022	0.0026	0.0031	0.0056	12	0.0021	0.0023	0.0027	0.0044	12	0.0022	0.0024	0.0027	0.0041	11	0.0021	0.0022	0.0027	0.0044	11
Iron	0.3	0.044	0.25	0.3	0.32	0.63	1.39	4.37	12	0.32	0.61	1.39	4.42	12	0.32	0.60	1.39	4.37	12	0.32	0.61	1.39	4.42	12	0.24	0.24	0.25	0.30	1	0.24	0.26	0.32	0.55	4
Manganese		0.0025	0.0396	0.0401	0.17	0.30	0.52	1.46		0.18	0.30	0.64	1.96		0.17	0.28	0.52	1.46		0.18	0.30	0.64	1.96		0.15	0.19	0.26	0.55		0.16	0.20	0.37	0.99	
Zinc	0.03	0.0005	0.009	0.02	0.018	0.071	0.104	0.316	9	0.011	0.022	0.053	0.172	5	0.018	0.060	0.104	0.316	9	0.011	0.022	0.053	0.172	5	0.017	0.065	0.102	0.330	9	0.012	0.028	0.077	0.268	5
Sulphate		6.23	29.6	60.9	27.72	45.49	73.22	193.48		26.98	39.04	67.49	176.63		27.73	45.12	73.11	193.48		27.03	39.04	67.42	176.63		25.25	32.68	36.37	57.59		24.71	29.88	31.94	43.79	
Ammonia-N	0.832	0.005	0.005	0.01	0.03	0.12	0.35	1.25	2	0.03	0.12	0.36	1.27	2	0.03	0.12	0.35	1.25	2	0.03	0.12	0.36	1.27	2	0.01	0.01	0.03	0.08	0	0.01	0.01	0.01	0.02	0
Nitrate-N	2.9	0.005	0.1	0.24	0.085	0.179	0.377	1.188	0	0.082	0.153	0.351	1.108	0	0.085	0.168	0.377	1.188	0	0.082	0.153	0.351	1.108	0	0.065	0.075	0.088	0.152	0	0.059	0.064	0.071	0.099	0
Nitrite-N	0.06	0.0025	0.005	0.05	0.006	0.012	0.023	0.071	2	0.006	0.011	0.023	0.069	2	0.006	0.011	0.023	0.071	2	0.006	0.011	0.023	0.069	2	0.005	0.006	0.006	0.009	0	0.005	0.005	0.006	0.008	0
Cyanide-T				0	0.001	0.005	0.014	0.052		0.001	0.005	0.014	0.052		0.001	0.005	0.014	0.052		0.001	0.005	0.014	0.052		0.000	0.000	0.001	0.004		0.000	0.000	0.000	0.000	
CN_WAD		0.002	0.002	0.002	0.002	0.003	0.006	0.017		0.002	0.003	0.006	0.017		0.002	0.003	0.006	0.017		0.002	0.003	0.006	0.017		0.002	0.002	0.002	0.003		0.002	0.002	0.002	0.002	
Cyanate		0.2	0.1	0.1	0.136	0.274	0.615	1.955		0.136	0.265	0.618	1.970		0.136	0.265	0.615	1.955		0.136	0.265	0.618	1.970		0.100	0.102	0.107	0.125		0.100	0.100	0.100	0.100	
Calcium		7.4	27.3	47.3	28.3	29.6	29.5	31.5		27.6	28.4	28.6	30.2		28.2	29.6	29.5	31.5		27.6	28.4	28.6	30.1		28.3	29.9	30.1	33.3		27.8	29.5	29.4	32.7	
Magnesium		2	8.75	16	8.7	9.0	9.0	9.5		8.5	8.6	8.7	9.1		8.7	9.0	9.0	9.5		8.5	8.6	8.7	9.0		8.7	9.0	9.0	9.7		8.6	8.9	8.9	9.6	
Hardness		26.7	103	182	106.2	110.9	110.7	117.8		103.9	106.0	107.1	112.6		106.1	111.0	110.6	117.8		103.9	106.0	107.1	112.4		106.5	111.6	112.4	123.1		104.9	110.6	110.1	121.2	

Summary of Predicted Concentrations (mg/L) in Victoria Creek for the Upper Estimate Source Terms and Wet Precipitation Scenario

		Existing Water Quality[c]			Option 1a					Option 1b					Option 2a					Option 2b					Option 3					Option 4				
	CCME Guideline	Minimum	Median	Winter Maximum[d]	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances
Arsenic	0.005	0.001	0.0016	0.0075	0.0018	0.0032	0.0069	0.0211	5	0.0019	0.0034	0.0076	0.0240	5	0.0018	0.0031	0.0068	0.0211	5	0.0018	0.0034	0.0076	0.0240	5	0.0018	0.0033	0.0069	0.0216	4	0.0015	0.0022	0.0034	0.0086	2
Cadmium	0.00034[a]	0.000005	0.00003	0.0003	0.00008	0.00027	0.00042	0.00119	6	0.00005	0.00009	0.00021	0.00066	3	0.00008	0.00027	0.00042	0.00119	6	0.00005	0.00009	0.00021	0.00066	3	0.00007	0.00024	0.00037	0.00109	5	0.00005	0.00011	0.00027	0.00090	4
Copper	0.002 - 0.004[b]	0.0005	0.002	0.003	0.0022	0.0025	0.0028	0.0043	12	0.0021	0.0022	0.0025	0.0036	12	0.0022	0.0024	0.0028	0.0043	12	0.0021	0.0022	0.0025	0.0036	12	0.0021	0.0023	0.0025	0.0033	12	0.0021	0.0022	0.0025	0.0035	12
Iron	0.3	0.044	0.25	0.3	0.29	0.48	0.95	2.84	11	0.29	0.47	0.95	2.86	11	0.29	0.47	0.95	2.84	11	0.29	0.47	0.95	2.86	11	0.24	0.24	0.25	0.28	0	0.24	0.25	0.29	0.43	3
Manganese		0.0025	0.0396	0.0401	0.16	0.24	0.38	0.97		0.16	0.24	0.45	1.28		0.16	0.23	0.38	0.97		0.16	0.24	0.45	1.28		0.15	0.18	0.21	0.39		0.15	0.18	0.28	0.66	
Zinc	0.03	0.0005	0.009	0.02	0.015	0.049	0.073	0.201	9	0.010	0.017	0.036	0.111	4	0.015	0.048	0.073	0.201	9	0.010	0.017	0.036	0.111	4	0.015	0.045	0.069	0.202	9	0.010	0.020	0.049	0.164	5
Sulphate		6.23	29.6	60.9	26.74	40.46	55.33	129.66		26.14	35.76	51.27	118.77		26.77	39.12	55.28	129.66		26.20	35.86	51.25	118.77		25.26	32.13	32.58	43.25		23.84	29.42	29.51	37.54	
Ammonia-N	0.832	0.005	0.005	0.01	0.02	0.08	0.22	0.79	0	0.02	0.08	0.22	0.80	0	0.02	0.08	0.22	0.79	0	0.02	0.08	0.22	0.80	0	0.01	0.01	0.02	0.05	0	0.01	0.01	0.01	0.01	0
Nitrate-N	2.9	0.005	0.1	0.24	0.076	0.137	0.259	0.771	0	0.074	0.120	0.241	0.718	0	0.076	0.130	0.259	0.771	0	0.074	0.120	0.241	0.718	0	0.064	0.072	0.079	0.117	0	0.059	0.064	0.067	0.085	0
Nitrite-N	0.06	0.0025	0.005	0.05	0.006	0.009	0.016	0.046	0	0.006	0.009	0.016	0.045	0	0.006	0.009	0.016	0.046	0	0.006	0.009	0.016	0.045	0	0.005	0.005	0.006	0.007	0	0.005	0.005	0.005	0.007	0
Cyanide-T				0	0.001	0.003	0.009	0.033		0.001	0.003	0.009	0.033		0.001	0.003	0.009	0.033		0.001	0.003	0.009	0.033		0.000	0.000	0.001	0.002		0.000	0.000	0.000	0.000	
CN_WAD		0.002	0.002	0.002	0.002	0.003	0.005	0.012		0.002	0.003	0.005	0.012		0.002	0.003	0.005	0.012		0.002	0.003	0.005	0.012		0.002	0.002	0.002	0.003		0.002	0.002	0.002	0.002	
Cyanate		0.2	0.1	0.1	0.121	0.207	0.419	1.267		0.121	0.203	0.420	1.273		0.121	0.203	0.419	1.267		0.121	0.203	0.420	1.273		0.100	0.101	0.104	0.115		0.100	0.100	0.100	0.100	
Calcium		7.4	27.3	47.3	27.9	28.7	29.2	31.3		27.5	28.1	28.5	31.0		27.9	28.8	29.2	31.3		27.5	28.1	28.5	31.0		28.0	29.5	29.6	32.3		27.7	28.5	29.1	31.8	
Magnesium		2	8.75	16	8.6	8.8	8.9	9.3		8.5	8.6	8.7	9.2		8.6	8.8	8.9	9.3		8.5	8.6	8.7	9.2		8.6	8.9	8.9	9.5		8.5	8.8	8.9	9.4	
Hardness		26.7	103	182	105.1	107.8	109.4	116.6		103.7	105.4	107.0	115.3		105.1	108.0	109.3	116.5		103.7	105.4	107.0	115.2		105.2	110.2	110.6	119.7		104.2	107.3	109.1	118.2	

Notes:

a. At Hardness = 150 mg/L as $CaCO_3$ - hardness dependent

b. 0.002 mg/L at hardness of 0 - 120 mg/L as $CaCO_3$, 0.003 mg/L at hardness of 120 - 180 mg/L as $CaCO_3$, and 0.004 mg/L at hardness of > 180 mg/L as $CaCO_3$

c. Existing water quality data set for Victoria Creek at Road (2007 to 2010)

d. Maximum of available winter water quality data (2007 to 2010) collected in November, December, January and February.