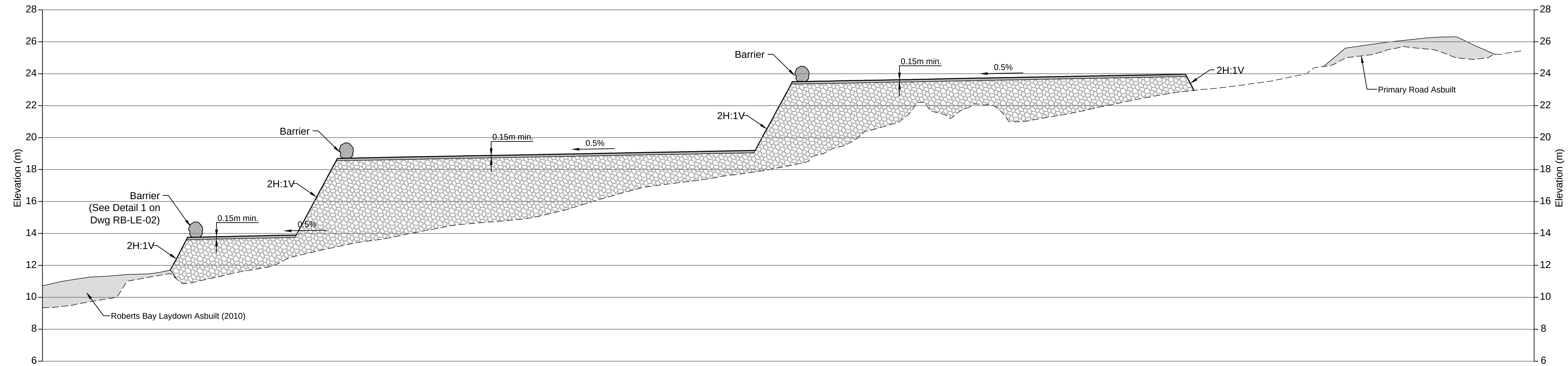
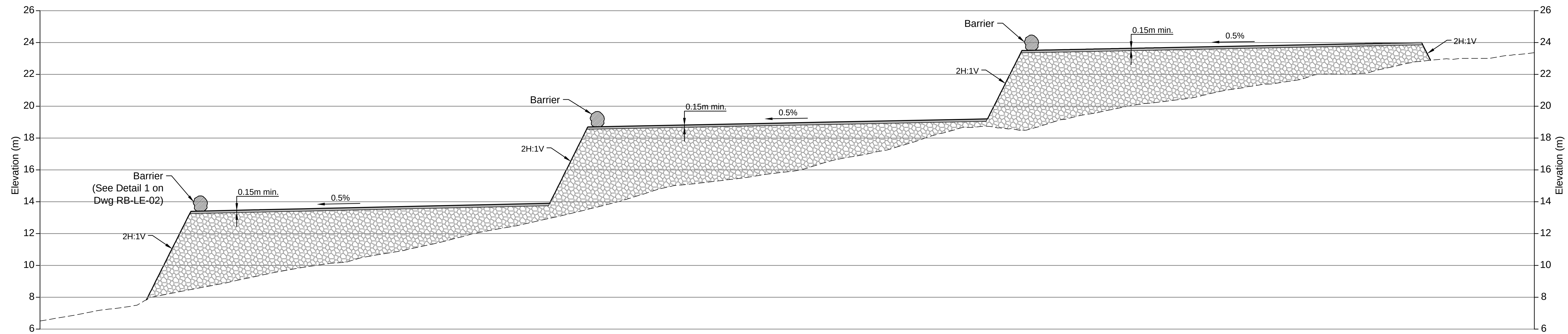


D RB-LE-01 **SECTION D - D'**



E RB-LE-01 **SECTION E - E'**

0 5 10 15 20 25
Scale in Metres (Horizontal)

0 1 2 3 4 5
Scale in Metres (Vertical)

4X VERTICAL EXAGGERATION

LEGEND

- Original Ground
- Surfacing Material
- Run of Quarry Material
- Existing Roberts Bay Infrastructure

NOTES

1. All dimensions in metres unless noted otherwise.
2. Where the thickness of the pads is greater than 3.0m allow for the placement of barriers.
3. The barriers are to consist of boulders larger than 1m in diameter, or a rock fill berm 0.5m high. Maximum spacing between boulders is 3.3m.
4. Notes in this drawing apply to all other active drawings.

NO.	DESCRIPTION	CHK'D	APP'D	DATE
B	Issued for Discussion	LW	EMR	29May15
A	Issued for Discussion	JBK	EMR	13Jun11

REVISIONS

DRAWING NO.	DRAWING TITLE	DRAWING NO.	DRAWING TITLE

REFERENCE DRAWINGS

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DESIGN: JBK | DRAWN: NV/MDDS | REVIEWED: LW
CHECKED: LW | APPROVED: EMR | DATE: May 29, 2015

FILE NAME: 1CT022.002_RB-LE-02_03 RevB.dwg

HOPE BAY PROJECT

SRK JOB NO.: 1CT022.002.200.1300

Roberts Bay Laydown

DRAWING TITLE:

Roberts Bay Laydown Expansions
Sections (2 of 2)

SRK DWG NO.: RB-LE-03 | SHEET 4 OF 5 | REVISION NO. B

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Materials List and Quantities

Item	Quantity/Area/Volume		Description[1]
Surfacing Material (1-1/4" Crush)	West Laydown Area	1,830 m³	Volumes derived from Gemcom (Gems 6.3)
	Southwest Laydown Area	3,330 m³	
	Southeast Laydown Area	1,220 m³	
	Total	6,380 m³	
Run of Quarry Material (ROQ)	West Laydown Area	39,350 m³	Volumes derived from Gemcom (Gems 6.3)
	Southwest Laydown Area	66,440 m³	
	Southeast Laydown Area	13,210 m³	
	Total	119,000 m³	
Bedrock Excavation (Southwest Laydown Area)		101,150 m³	Volume derived from Civil 3D

1. All volumes reported are calculated to neat lines. No bulking/shrinking factor have been utilized in the volume determination. Losses into the Tundra are not accounted for.

Tolerances on Road Material Placement:

Location	Fill (mm)	Excavation (mm)
Vertical Tolerance on Roads	0 to +75	n/a
Horizontal Tolerance on Roads	-150 to +150	

Note: Grade shall not be uniformly high or low.

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DRAWING NO.	DRAWING TITLE	DRAWING NO.	DRAWING TITLE

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
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CHECKED: LW | APPROVED: EMR | DATE: May 29, 2015

FILE NAME: 1CT022.002_RB-LE-01 RevB.dwg

TMAC RESOURCES

HOPE BAY PROJECT

SRK JOB NO.: 1CT022.002.200.1300

Roberts Bay Laydown

DRAWING TITLE:

Material Specifications and Quantities

SRK DWG NO.: RB-LE-04 | SHEET 5 OF 5 | REVISION NO. B

Package 6
Engineering and Design Documents

P6-10 Site-Wide Water and Load Balance

Doris North Project – Water and Load Balance

Prepared for

TMAC Resources

Prepared by

SRK Consulting (Canada) Inc.
1CT022.002
June 2015

Doris North Project – Water and Load Balance

June 2015

Prepared for

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

Project No: 1CT022.002

File Name: DorisNorth_Water&LoadBalance_1CT022_002_700_KW_LW_20150612_FNL

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Appendices

1 Introduction

1.1 Background

TMAC Resources Inc. (TMAC) plan to revise their operational plan to allow processing of a greater volume of ore from the Doris North Project (the Project), located in Nunavut, approximately 120 km southwest of Cambridge Bay.

The current licensed Project entails processing of 0.4 Mt of ore over a period of about two years. The revised operational plan will increase this amount to 2.5 Mt over a period of about six years. This increase requires changes to the tailings management system, which in turn requires a change in the water management plan, specifically the discharge strategy for the Project.

The original discharge strategy required discharge of Tailings Impoundment Area (TIA) water to Doris Creek during the open water season, such that water licence criteria could be met at a discharge point immediately downstream of the Doris Creek waterfall (TL-2). The revised discharge strategy entails discharging TIA water to a marine outfall system in Roberts Bay. During operations, this discharge will be at a constant rate during the open water season. In addition, the revised operational plan requires mining in talik zones, which means interception of saline connate groundwater. This groundwater will also be discharged to Roberts Bay, mixing with the TIA water at times.

1.2 Scope of Work

SRK Consulting (Canada) Inc. was retained by TMAC to revise the existing site wide water and load balance model to match the new requirements. The model was designed to evaluate water management needs and predict water quality at the Project and downstream receptors.

Other key objectives of the model are to optimize reclaim demand for mill operations, assess the effect of underground mining on Doris Lake water levels and discharge, and evaluate alternative discharge scenarios for groundwater and TIA effluent.

1.3 Document Layout

Section 2 of this document provides a summary of the mine plan and conceptual model for the Project. The water balance and load balance model descriptions and inputs are presented in Sections 3 and 4 respectively.

Section 5 provides a summary of the model implementation, including the structure and approach used in developing the water and load balance model. Section 6 provides a summary and discussion of water balance and water quality results. Conclusions are included in Section 7.

2 Model Framework

2.1 Mine Plan and Infrastructure

The water and load balance model integrated the most recent mine plan provided by TMAC. The key dates of planned activities are presented in Table 2-1. Mining will recommence in April 2015 (Year -2) and will continue until April 2021 (Year 5).

Table 2-1: Key Activity Dates

Activity	Mining Year	Calendar Date
Start Doris Hinge and North Ore (Permafrost)	-2	4/1/2015
Start Connector and Central Ore (Talik)	1	1/1/2017
Start Milling Operations	1	1/1/2017
End Doris Hinge and North Ore (Permafrost)	3	1/1/2019
End Connector and Central Ore (Talik)	5	1/1/2021
Start Closure	5	4/1/2021
Start Dewatering TIA	5	4/1/2021
Mine Site Reclamation Complete	6	1/1/2022

Source: \\Van-svr0.van.na.srk.ad\projects \01_SITES\Hope.Bay\1CT022.002_2015_Hope Bay Ongoing Support\200_Type_A_ Water_License\700_Site_Wide_WQ_Model\Inputs\ Doris Amendment Mine Plan 15-02-04_Rev2_EMR_KPW with Chloride Flush.xlsx

Table 2-2 provides a summary of the planned mining quantities and schedule implemented in the model. There are 183,000 tonnes of waste rock and 9,400 tonnes of ore from the Doris Mine (permafrost zone) extracted in 2011 located on the surface. A total of 2.5 Mt of ore will be processed from underground development of the Doris Mine over a six-year mine life.

Milling operations will be conducted over four years, at a rate of 1,000 tonnes per day (tpd) for the first two years, increasing to 2,000 tpd in the subsequent years. Tailings will be deposited subaerially in the TIA upstream of the Interim Dike that separates the Reclaim Pond from the tailings. The tailings beach will be covered with a 0.3-m layer of quarry rock at closure.

The model was run from 2010 to 2035, through operations and post-closure. Table 2-3 provides a reference of model years (calendar years) and the corresponding mining years.

Table 2-2: Mining Quantities

Mining Year	Calendar Year	Material (tonnes)					
		Doris Hinge and North			Connector and Central		
		Ore Mined	Waste Rock On Surface[3]	Ore Processed	Ore Mined	Waste Rock On Surface[3]	Ore Processed
-6	2011	9,400	183,000				
-2[1]	2015		220,000				
-1	2016	160,000	220,000				
1	2017	410,000	290,000	365,000			
2	2018			214,400	530,000	470,000	150,600
3	2019				730,000	140,000	730,000
4	2020				460,000		730,000
5[2]	2021				15,000		124,400

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Water_License\700_Site_Wide_WQ_Model\Inputs\ Doris Amendment Mine Plan 15-02-04_Rev2_EMR_KPW with Chloride Flush.xlsx

Note:
1. Mining starts in April (Q2).
2. Closure starts in April (Q2)
3. Waste rock on surface is the tonnage of rock on surface at any given time (assumed to be the tonnage at the end of the year for the purposes of modeling).

Table 2-3: Model and Mining Years

Model Year	Mining Year	Model Year	Mining Year
2010	-7	2023	7
2011	-6	2024	8
2012	-5	2025	9
2013	-4	2026	10
2014	-3	2027	11
2015	-2	2028	12
2016	-1	2029	13
2017	1	2030	14
2018	2	2031	15
2019	3	2032	16
2020	4	2033	17
2021	5	2034	18
2022	6	2035	19

Source: \\Van-svr0.van.na.srk.ad\projects \01_SITES\Hope.Bay\1CT022.002_2015_Hope Bay Ongoing Support\200_Type_A_
Water_License\700_Site_Wide_WQ_Model\Inputs\ Doris Amendment Mine Plan 15-02-04_Rev2_EMR_KPW with Chloride Flush.xlsx

2.2 Conceptual Model

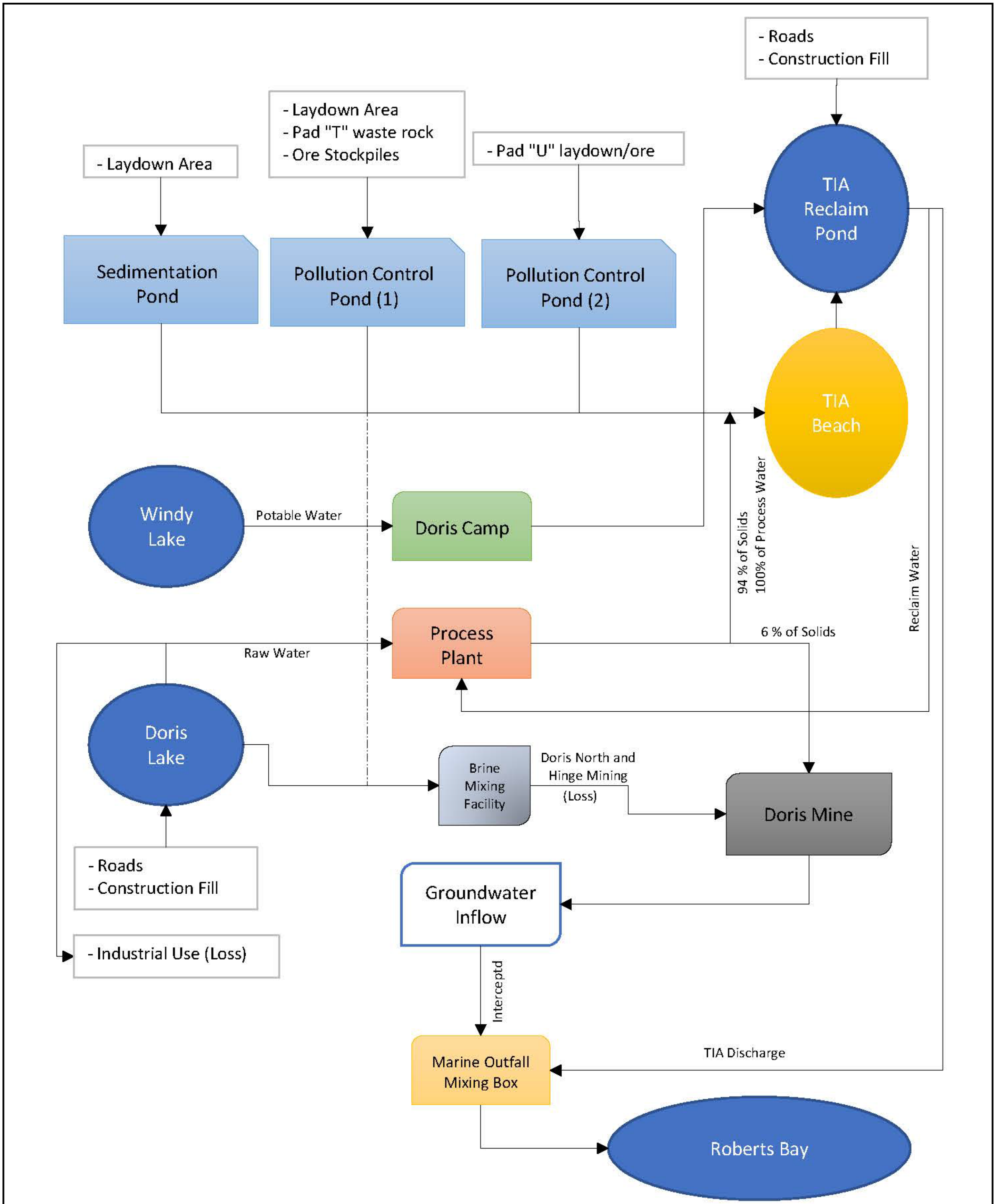
The water and load balance model was used as the framework for evaluating and optimizing strategies for managing the collection, storage and discharge of water on site.

TMAC plans to extend the Doris Mine to mine underneath Doris Lake into the talik, where it is anticipated that underground workings will intercept saline groundwater. The intercepted saline groundwater and contact water from mining activities as well as excess water from the TIA will need to be managed during operations and closure.

Figure 2-1 illustrates the conceptual water balance for the TIA during operations. Freshwater make-up and water for industrial uses will be obtained from Doris Lake, and potable water will be sourced from Windy Lake. Tailings slurry will be pumped to the TIA, and the TIA pond will provide the source of reclaim water for the Mill. Excess water from the TIA will be pumped to the Mill Building, located on Pad D at the Doris North Camp, and mixed with the saline groundwater in the Marine Outfall Mixing Box[1]. From the Mixing Box, a single pipeline will convey the blended water to the Marine Outfall within Roberts Bay.

The current configuration of discharge from the TIA to Doris Creek will continue in 2015 and 2016 (Years -2 and -1). Discharge from the TIA to Roberts Bay will commence in 2017 (Year 1). At closure, the TIA will be dewatered by year-round pumping to Roberts Bay to accelerate improved water quality. Once the TIA refills, provided the water quality meets the applicable discharge criteria, the North Dam will be breached and natural discharge to the Tail Lake Outflow channel will resume.

[1] Beginning in 2017 (Year 1)



srk consulting	MAC RESOURCES	Water and Load Balance Model
		Conceptual Water Balance
Job No: 1CT022.002.200.800	Hope Bay Project	Date: May 29, 2015
Filename: Figure 2-1 Conceptual Water Balance.pptx		Approved: SPB
		Figure: **2-1**

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3 Water Balance Model Description

3.1 Water Balance Overview

The water balance for the Project was developed in GoldSim for the purposes of generating water quality predictions and evaluating water management plans. Figure 3-1 shows a schematic of the water balance model.

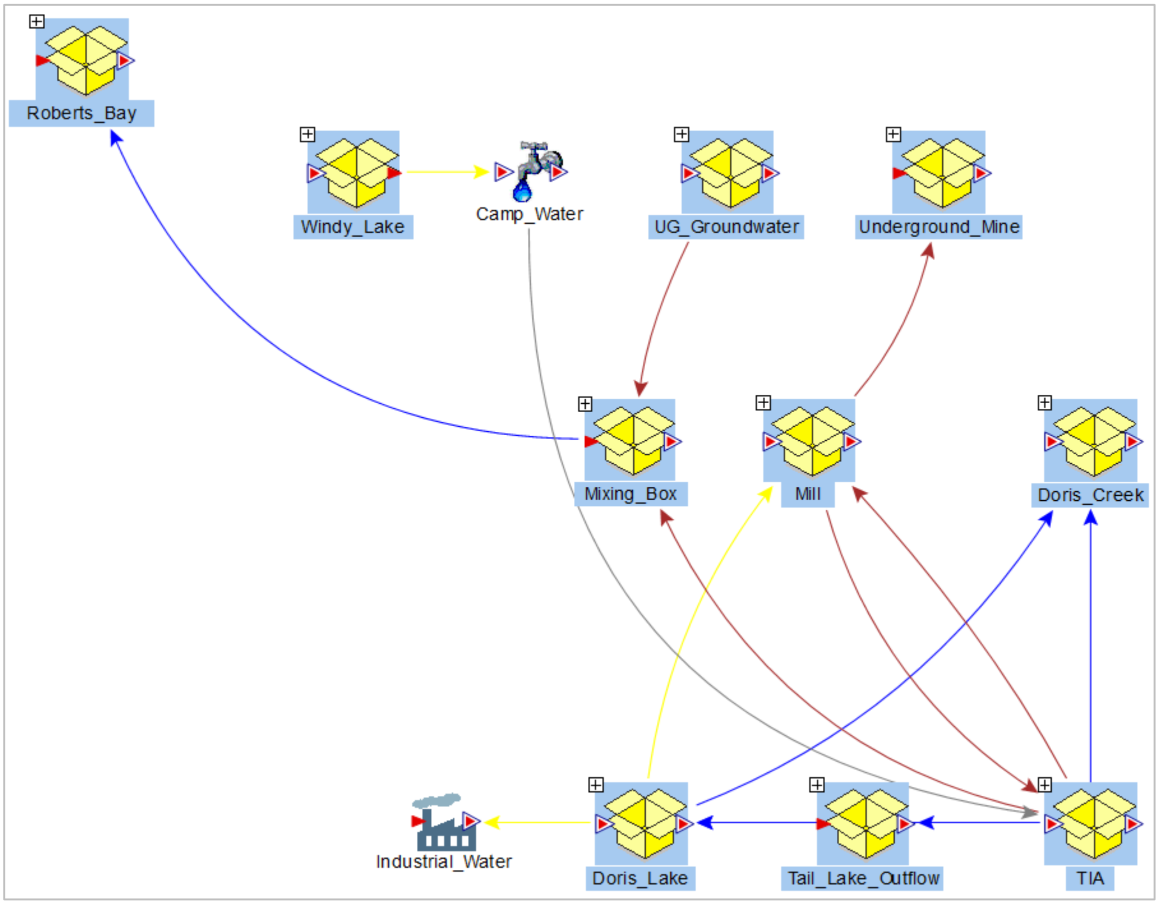


Figure 3-1: Water Balance Schematic

Source: \\Van-svr0\projects\01_SITES\Hope.Bay\1CT022.002_2015_Hope Bay Ongoing Support\200_Type_A_Water_License\700_Site_Wide_WQ_Model\Model\HopeBay_WLBalance_TypeA_Rev19_SPB_KPW.gsm

The water balance tracks all inputs, outflows and available storage in GoldSim reservoirs. The volume in a reservoir at time t can be simplistically represented as follows:

$$Volume_t = Volume_{t-1} + (Computational\ Timestep) \times \left(\sum \text{Inflows} - \sum \text{Outflows}\right)$$

The key water inflows at the Project site are groundwater and precipitation. Water outflows include evaporation, industrial water use, and discharges to Doris Creek and Roberts Bay. The primary storage facility at the site is the TIA, which stores tailings solids and water in the reclaim pond and within tailings voids.

3.2 Water Balance Inputs

Table 3-1 provides a summary of key inputs required for the water balance model, which are described in the following sections.

Table 3-1: Water Balance Inputs

Water Balance Component	Input Required
Surface Runoff and Direct Precipitation	Historical precipitation and temperature Open water evaporation rates Catchment areas Runoff coefficients
Water Storage	TIA volume Tailings deposition
Milling Quantities	Water content in ore Reclaim demand Freshwater requirement
Water Consumption	Camp use Industrial use
Groundwater	Open talik inflows Doris Lake drawdown
Water discharge	Excess calculated by water balance Rating curve equations

3.2.1 Precipitation and Temperature

Climate data is collected at the Doris meteorological (Met) station and Doris micro-meteorological weather station. Full recordings of winter precipitation are not available due to freezing conditions. As a result, it was necessary to transpose data from a nearby station to the site for the water balance. The Cambridge Bay station (Environment Canada ID 2400600) was selected for this purpose as it is the closest, active station with the longest record and was used as the reference station in the 2008 hydrology baseline report (Golder 2009).

Based on a regional analysis of precipitation data in the Project area and a review of coincident precipitation data at the Doris Met and Cambridge Bay stations, there is little orographic effect in the area (SRK 2014). Consequently, no adjustment was made for transposing the Cambridge Bay precipitation data to the Project site. A correlation between coincident temperature measured at Doris Met and Cambridge Bay was derived and was applied for transposing temperature data from the Cambridge Bay record to the site.

A combination of historical precipitation and temperature from the Doris Met record starting in 2010 (ERM Rescan 2010a, 2011a, 2013, 2014b) and the Cambridge Bay record starting in 1953 (Environment Canada 2015) were applied in the model. For historical predictions during the calibration period, precipitation from the Doris Met station was applied as the base rainfall from June to September[2]. Rainfall measured at other times at the Cambridge Bay station was also

[2] Rainfall recordings outside this timeframe were excluded to avoid inadvertently including snowfall that melts in the gauge and is recorded as rainfall.

included. Snowfall (in mm snow water equivalent, SWE) from the Cambridge Bay station was used exclusively for winter precipitation. Daily mean temperatures from the Doris Met station were applied throughout the model. All rainfall and snowfall data were adjusted for undercatch using the undercatch factors derived by Environment Canada for the Cambridge Bay station.

For future predictions, the historical Cambridge Bay record was applied, with precipitation adjusted for undercatch and temperatures adjusted for the site. Variable climate data was generated by projecting the historical record in the future and randomly selecting a start year from the record at the beginning of each model run. The model can also be run exclusively under average hydrological conditions. The average adjusted total annual precipitation for the Project site is 215 mm.

A snowmelt model was incorporated to allow snowfall to be accumulated over the winter and released in the spring based on the temperature index method (Alberta Transportation 2004). The snowmelt rate is calculated as follows:

$$Snowmelt\ Rate\ (mm/d) = (Mean\ Temperature - Threshold\ Temperature) \times Melt\ Factor$$

Where,

$$Melt\ Factor\ is\ in\ \frac{mm}{°C} \cdot day$$

A threshold temperature of 1°C was applied. The melt factors for the Doris Lake and TIA ponded water surfaces (referred to as ponds) and catchments were adjusted as part of the model calibration and are currently set to 4 mm/°C-day for the catchments and 6 mm/°C-day for the ponds.

3.2.2 Runoff Coefficients

Runoff coefficients were used in the model to estimate the total yield from precipitation released and to account for losses due to evapotranspiration, soil storage and infiltration.

Monthly runoff coefficients for upstream undisturbed areas were adjusted to calibrate the water balance model. The calibrated coefficients are 0.2 in the summer months and 0.6 in the winter months.

3.2.3 Precipitation and Runoff Flows

Undisturbed runoff and tailings beach runoff are modeled as a function of precipitation, where the runoff coefficient accounts for losses such as evaporation and infiltration (see Section 3.2.2 for the runoff coefficients applied). Runoff and direct precipitation on ponded areas are calculated as follows:

$$Runoff\ Rate = Catchment\ Area \times Runoff\ Coefficent \times Precipitation\ Released\ Rate$$

$$Direct\ Precipitation\ Rate = Pond\ Area \times Precipitation\ Released\ Rate$$

The precipitation released rates are calculated as the sum of the rainfall and the snowmelt estimated from the snowmelt model:

$$Precipitation\ Released\ to\ Pond = Rainfall + Snowmelt\ to\ Pond$$

$$Precipitation\ Released\ to\ Runoff = Rainfall + Snowmelt\ to\ Runoff$$

3.2.4 Lake Evaporation

Monthly lake evaporation provided in the 2008 baseline hydrology report (Golder 2009) was applied (220 mm/year). Lake evaporation rates are calculated based on data from the micro-meteorological station installed seasonally at Doris Lake. These rates were not applied as they are lower than estimates provided in the 2008 baseline report (Golder 2009) and at regional stations (SRK 2014), and they resulted in an over-prediction of water elevations in the TIA.

3.2.5 Catchment Delineation

Mine infrastructure and upstream catchments were delineated for the Project using Arc GIS based on existing topography and final footprints of mine infrastructure. Doris Mine and the TIA are located within the Doris Lake watershed. The TIA is located within Tail Lake, which naturally drains into Doris Lake. The existing North Dam and proposed South Dam impound water within the TIA.

Table 3-2 provides a summary of total catchment delineations and associated infrastructure areas. The areas applied in the model vary with time as new facilities are added based on the planned construction schedule.

Table 3-2: Catchment Delineations

Catchment Description	Total Area (km^2)
Total Doris Lake watershed (TL-2)[1]	91
Total Tail Lake watershed	4.4
Existing Site Area	0.19
Pad U	0.031
Pad T	0.039
Doris Central/Connector (including roads)	0.016
Other Existing Pads in Doris Lake watershed	0.075
Existing Roads in Doris Lake watershed	0.19
Other Existing Pads in Tail Lake watershed	0.057
Existing Roads in Tail Lake watershed	0.08
Tailings Beach Area[2]	0.44

Source: \\Van-svr0.van.na.srk.ad\projects\01_SITES\Hope.Bay\1CT022.002_2015_Hope Bay Ongoing Support\200_Type_A_ Water_License\700_Site_Wide_WQ_Model\Analysis\ Catchment_Area_Calculation_Rev03_SPB.xlsx

Note: highlighted cells represent new infrastructure

[1] Total Doris Lake watershed does not include the Tail Lake catchment area.

[2] The tailings beach area at final deposition.

3.2.6 Volume-Area-Elevation Data

Volume-area-elevation data were generated for the TIA and Doris Lake based on historical surveys. A revised volume-elevation curve was applied for the TIA to simulate the reduction in reservoir volume as tailings are deposited. The volume-elevation data is used to estimate the initial volumes of water in the TIA and Doris Lake at the start of the model based on measured elevations, and to predict water elevations from the simulated volumes in the reservoirs. Area-elevation curves are used to calculate the predicted pond area for direct precipitation and evaporation flows.

Measured elevations in the TIA and Doris Lake are relative elevations that are not referenced to a geodetic datum. These elevations must be adjusted such that they can be used with the volume-area-elevation data, which is georeferenced. Measurements for the TIA were adjusted based on a coincident surveyed water elevation in the TIA. However, this could not be done for Doris Lake as coincident surveyed elevations were not available at the time this document was prepared. An elevation adjustment was estimated based on the available data for modeling purposes.

3.2.7 Milling Quantities and Freshwater Demand

The tailings production rate for the Project starts in 2017 at a rate of 1,000 tpd for the first two years and increases to 2,000 tpd in subsequent years. Table 3-3 provides a summary of the parameters used to calculate water lost to tailings voids, reclaim demand and storage capacity consumed by tailings deposition.

Table 3-3: Tailings Parameters

Parameter	Value	
Specific Gravity of Tailings	2.8 tonne/m^3	
Tailings Dry Density	1.4 tonne/m^3	
Void Ratio	1.0	
Slurry Percent Solids	0.39	
Ore Moisture Content	0.96	
Average Production Rate	1,000 tpd	2,000 tpd
Average Reclaim Rate[1]	1,510 m^3/d	3,020 m^3/d
Process Freshwater Demand	300 m^3/d (110,000 m^3/y)	600 m^3/d (220,000 m3/y)

Source: \\VAN-SVR0\Projects\01_SITES\Hope.Bay\1CT022.002_2015_Hope Bay Ongoing Support\200_Type_A_Water_License\700_Site_Wide_WQ_Model\Analysis\WB Calculations_rev03_spb_SAB_EMR_SAB.xlsx

[1] Average reclaim rate includes freshwater

3.2.8 Water Use

Camp water use is equivalent to 63 m^3/day (22,995 m^3/y), as permitted under License No. 2BE-HOP1222. This water is sourced from Windy Lake. The sewage effluent rate was estimated assuming a unit rate of 0.15 m^3/day per person and a camp size of 280 people, which is 42 m^3/day (15,500 m^3/y). Camp water use was assumed to occur up to one year after closure, in April 2022. During mining operations, from April 2015 to April 2021, grey water is discharged to the TIA. After closure, it is assumed to be released to the tundra.

Industrial water use at a rate of 552 m^3/day (202,000 m^3/y) will be extracted from Doris Lake during mining operations, which includes uses in facilities such as washbays and machine shops, as well as dust suppression. This water is assumed to be lost and is removed to a water balance sink. Freshwater for the mill, which ranges from 300 m^3/d (110,000 m^3/y) to 600 m^3/d (220,000 m^3/y) depending on production rates is also sourced from Doris Lake.

The current water licence water demand from Doris Lake of 480,000 m^3/day will remain unchanged. With the expected withdrawal rate of 422,000 (industrial water plus maximum freshwater demand), this provides a contingency buffer of about 58,000 m^3/y for unforeseen water use.

3.2.9 Permafrost and Groundwater

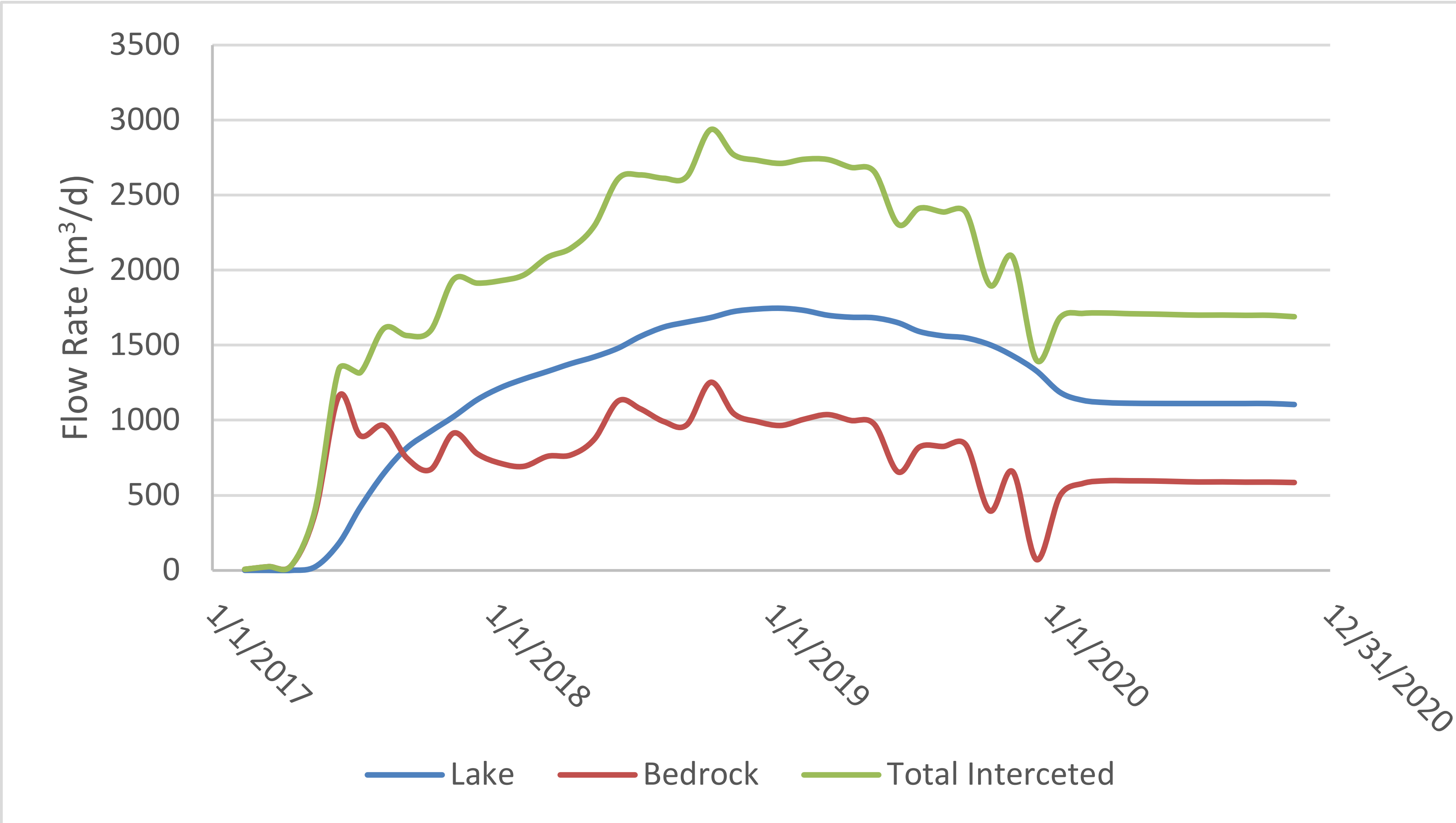
The Hope Bay project is located in the continuous permafrost region of the Canadian arctic. The Doris North and Doris Hinge deposits are both located within permafrost. Doris Central and Doris Connector are located under Doris Lake within an open-talik. Groundwater inflows are expected during underground mining in open-talik.

A groundwater prediction model was developed to estimate potential groundwater inflows during mining of the Doris Central and Doris Connector deposits. Based on the groundwater prediction model, it was found that intercepted underground flows will be composed of water stored in the rock, Doris Lake and regional flows at the base of the talik. A more detailed description of the groundwater prediction model and results can be found in *Hydrogeological Modeling of the Proposed Doris Mine* (SRK 2015b).

Figure 3-2 illustrates the total intercepted underground flows, where the maximum annual peak flow is 610,000 m^3, with a daily peak of just under 3,000 m^3/d. At the early stage of mining under Doris Lake, inflows are primarily from storage and bedrock, but are quickly replaced by Doris Lake inflows. The rates of drawdown in Doris Lake from the groundwater model were applied to the Doris Lake model to predict potential reduction in discharge and lake drawdown levels (below the Doris Creek invert).

3.2.10 Mine Site Collection Pond Flows

Water from sumps and collection ponds in the mine area is pumped and hauled to the TIA. Measured volumes pumped and hauled were applied in the model to the end of 2014 based on records provided by TMAC. Predicted future inflows from the mine site collection ponds were estimated by calculating the runoff volumes reporting to the ponds based on the catchment delineations.



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MAC RESOURCES

Water and Load Balance

Intercepted Groundwater Inflows

Job No: 1CT022.002.200.700 Filename: Figure 3-2 Intercepted Groundwater Flows.pptx	Hope Bay Project	Date: May 29, 2015	Approved: SPB	Figure: **3-2**

3.2.11 TIA Discharge

Measured discharge from the TIA to Doris Creek was applied in the model to the end of 2014 based on pumping records provided by TMAC. The predicted discharge to Doris Creek in 2015 and 2016 was estimated as 10% of the background flow in Doris Creek at TL-2, in accordance with the conditions of Water License 2AM-DOH1323. Discharge is limited to the existing pumping capacity of 0.14 m^3/s or the allowable discharge, whichever is smaller. The background flow in Doris Creek was predicted based on a baseline model of Doris Lake. Discharge from Doris Lake was estimated using an empirical relationship derived based on coincident measured heights of water above the Doris Creek invert and measured discharge at TL-2 (ERM Rescan 2010b, 2011b, 2012, 2014a, 2015).

A pumping rate of 4,000 m^3/day was applied to pumping from the TIA to the Marine Outfall Mixing Box. This rate was applied during the open water season during operations until the target elevation of 28.3 m was reached. At closure, this same rate was applied year-round to dewater the TIA to Roberts Bay until the target elevation of 23 m was reached.

Once the TIA refills, discharge to the Tail Lake Outflow channel was modeled based on the same methodology as discharge to Doris Creek, that is, 10% of background flow in Doris Creek at TL-2 (calculated from the baseline model of Doris Lake).

4 Load Balance Model Description

4.1 Load Balance Overview

The load balance was developed to evaluate the potential effects of water quality in the TIA and water pumped to Roberts Bay, which will be a combination of groundwater and TIA effluent.

The model is based on the principle of conservation of mass. Loadings and concentrations were calculated for each facility within the GoldSim Contaminant Transport module using mixing cells. Mixing cells solve simultaneous differential equations to calculate loads and concentrations. A mixing cell was created for each facility. The loads are tracked within the mixing cells. The volumes in the mixing cells are linked to the associated reservoirs in the water balance.

The concentrations are calculated within the Contaminant Transport module by dividing the load in a mixing cell by the associated reservoir volume:

$$Concentration = \frac{Load\ (L)}{Volume\ (V)}$$

There are two types of inflow loading rates: 1) direct loadings based on a defined source term; and 2) linked loadings from another facility.

The majority of direct loading rates are calculated based on the concentration of a source and the associated flow. Direct loading rates are also calculated based on rock and ore mass.

$$Inflow\ Loading\ Rate\ 1 = Inflow \times Source\ Term\ Concentration$$

$$Inflow\ Loading\ Rate\ 2 = Load\ per\ Unit\ Mass\ per\ Unit\ Time \times Cumulative\ Rock\ Mass$$

$$Inflow\ Loading\ Rate\ 3 = Load\ per\ Unit\ Mass \times Rock\ Mass\ per\ Unit\ Time \times Flush\ Factor$$

Inflow loading rate type 2 assumes there is an unlimited source of a given parameter and releases occur based on the mass of rock exposed. This applies to most parameters modeled. Inflow loading rate type 3 applies in cases where a finite amount of a source is available for a given rock/ore mass. This source is stored within the rock/ore mass and is depleted over time by flushing, as in the case of chloride and blasting residues.

Direct loadings that are linked to another facility are tracked and routed directly between the mixing cells.

4.2 Load Balance Inputs

4.2.1 Overview

Table 4-1 shows a summary of geochemical source terms developed for the Project, where each source term represents an estimate of runoff water quality (mg/L) or parameter loadings (mg/year) contributed by a Project component. The following sections provide more detailed explanations of the source terms included in the load balance.

Table 4-1: Summary of Load Balance Source Terms

Source Term	Units	Applies to
Background Water Quality	mg/L	Undisturbed catchments, initial water quality in lakes and non-contact runoff
Groundwater Inflows	mg/L	Intercepted flows during mining in the talik
Process Water Effluent	mg/L	Effluent from Process Plant (tailings slurry water)
Sewage Water	mg/L	Effluent from sewage treatment plant
Exposed Tailings Beaches	mg/L	Tailings beach surface area from subaerial deposition
Surface Infrastructure Areas	mg/L	Pads and roads
Mine Site Collection Ponds	mg/L	Water from Sediment/Pollution Control ponds
Ore Stockpiles	mg/kg/day	Ore stockpile surface areas
Waste Rock Stockpiles	mg/kg/day	Waste rock stockpile surface areas
Blasting/Drilling Residuals	mg/year	Waste rock and ore on surface and processed
Brine Residuals	mg/year	Waste rock and ore on surface and processed

Source terms were primarily derived based on site monitoring data. Figure 4-1 shows the locations of the Project sample stations.

4.2.2 Background Water Quality

Baseline water quality is based on median monthly concentrations of historical water quality measured at monitoring stations TL-1 (TIA) and TL-2 (Doris Lake outflow), which are provided in Table A- 1 and Table A- 2, respectively (Appendix A). In the calculation of the medians, any measurement below the detection limit was taken to be equal to the detection limit.

Concentrations at TL-2 were used as background concentrations to calculate loads from upstream undisturbed runoff. For most parameters, concentrations at TL-1 were used as the initial concentration in the TIA at the start of the model (September 2010). In cases where concentrations for the same parameter were higher at TL-2, the concentration at TL-2 was used as the initial concentration in the TIA for that parameter as a conservative measure.

Background concentrations were observed to exceed Canadian Council of Ministers of the Environment (CCME) long-term freshwater aquatic life guidelines for some parameters.