BACK RIVER PROJECT
Water Management Plan

October 2017

BACK RIVER PROJECT
WATER MANAGEMENT PLAN

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Appendix B. Water Quality Monitoring

Revision Log

Version	Date	Section	Page	Revision
1	October 2017	All	All	Supporting Document for Type A Water Licence Application, submitted to Nunavut Water Board for review and approval

Acronyms

AEMP	Aquatic Effects Management Plan
AN	Ammonium nitrate
ANFO	Ammonium Nitrate Fuel Oil
ARD	Acid Rock Drainage
BMP	Best Management Practices
CCME	Canadian Council of Ministers of the Environment
DFO	Fisheries and Oceans Canada
ECCC	Environment and Climate Change Canada
FEIS	Final Environmental Impact Statement
GCL	Geosynthetic Clay Liner
LOM	Life of Mine
MAD	Main Application Document
masl	metres above sea level
mbgs	metres below ground surface
mg/L	milligrams per litre
ML	Metal Leaching
MLA	Marine Laydown Area
MMER	Metal Mining Effluent Regulations
MWRMP	Mine Waste Rock Management Plan
NH_3	ammonia
NIRB	Nunavut Impact Review Board
NPAG	Non-Potentially Acid Generating
NWB	Nunavut Water Board
PAG	Potentially Acid Generating
Project	Back River Project
Sabina	Sabina Gold & Silver Corp.
SOP	Standard Operating Procedure
STP	Sewage Treatment Plant
SSWQO	Site-specific Water Quality Objectives
TF	Tailings Facility
TSF	Tailings Storage Facility

TSS	Total Suspended Solids
WIR	Winter Ice Road
WMP or Plan	Water Management Plan
WRSA	Waste Rock Storage A rea
WTP	Water Treatment Plant

1. Introduction

The Back River Project (the Project) is a proposed gold project owned by Sabina Gold & Silver Corp. (Sabina) within the West Kitikmeot region of southwestern Nunavut. It is situated approximately 400 kilometres (km) southwest of Cambridge Bay, 95 km southeast of the southern end of Bathurst Inlet, and 520 km northeast of Yellowknife, Northwest Territories. The Project is located predominantly within the Queen Maud Gulf Watershed (Nunavut Water Regulations, Schedule 4).

The Project is comprised of two main areas with interconnecting winter ice roads (WIR) (Main Application Document [MAD] Appendix A, base Figure 2): Goose Property (MAD Appendix A, base Figure 3) and the Marine Laydown Area (MLA) (MAD Appendix A, base Figure 4) situated along the western shore of southern Bathurst Inlet. The majority of annual resupply will be completed using the MLA, and an approximately 160 km long WIR will connect the MLA to the Goose Property. Refer to MAD Appendix A, base Figures 1 to 5 for general site layout and locations. A detailed project description is provided in the MAD.

The Water Management Plan (WMP or Plan) outlines the procedures necessary to manage the quality and quantity of water interacting with Project components throughout the Construction, Operations, Closure and Post-Closure phases of the mine. It includes management practices that reduce the potential for adverse impacts to receiving waters, to aquatic ecosystems, and to fish and fish habitat.

The Plan was prepared: following the requirements of the Supplementary Information Guidelines (SIG) for Mining and Milling MM3 and Water Works M1 issued by Nunavut Water Board (NWB 2010 b, c), and the Environmental Impact Statement (EIS) Guidelines issued by the Nunavut Impact Review Board (NIRB) (NIRB 2013); in accordance with best management practices (BMPs); and in conformance with current Federal and Territorial statutory requirements (See Applicable legislation and Guidelines Section 4.0).

This Plan is a living document to be updated upon changes in related regulatory requirements, engineering design, management reviews, incident investigations, changes to facility operation or maintenance, and environmental monitoring results, best practice updates or other Project specific protocols once construction starts through to Project closure activities. Any updates will be filed with the Annual Report submitted under the Type A Water Licence.

The information presented herein is current as of September 2017. An update will be initiated prior to the start of construction and will incorporate issue-for-construction engineering drawings of associated water management infrastructure. Final design plans will include the quality assurance/quality control measures that will be applied during the Construction Phase. A detailed schedule for construction of water works is provided in Table 6.3-1 of the MAD. The WMP will be reviewed as needed for changes in operation and technology, and as directed by the NWB in the Type A Water Licence or other regulatory authorizations where appropriate. Completion of the updated Plan will be documented through signatures of the personnel responsible for reviewing, updating, and approving the Plan.

A record will document all significant changes that have been incorporated in the Plan subsequent to the latest review. The record will include the names of the persons who made and approved the change, as well as the date of the approval.

Sabina will maintain a distribution list providing contact details for all parties to receive the Plan including key personnel, contractors, organizations, and external agencies.

2. Scope and Objectives

The WMP is the key document that forms part of Sabina's overall Water Management Program for the Project. The Plan has been written to meet requirements of a Type A Water Licence.

This plan is divided into the following components:

- Applicable Legislation and Guidelines (Section 3);
- Roles and Responsibilities (Section 4);
- Planning and Implementation (Section 5);
- Water Modelling and Design Criteria (Section 6);
- Water Management (Section 7);
- Water Management Phases (Section 8);
- Environmental Protection Measures (Section 9);
- Monitoring Program (Section 10);
- Environmental Reporting (Section 11); and
- Adaptive Management (Section 12).

This plan describes the procedures necessary to manage the quality and quantity of water interacting with Project components throughout the Construction, Operations, Closure, and Post-Closure phases of the mine. It includes management practices that reduce the potential for adverse impacts to receiving waters, to aquatic ecosystems, and to fish and fish habitat. The Plan includes:

- A brief summary of the physical setting at the mine site;
- A description of mine development;
- A summary of water treatment and water supply locations and requirements throughout the life of mine (LOM), including sewage disposal facilities;
- Water quantity thresholds and water quality objectives and discharge criteria;
- A summary of water management infrastructure design;
- A description of the water management at the mine site during Construction, Operations, and Closure;
- A presentation of the water and load balance model and a summary of its results;
- A summary of environmental protection measures;
- A description of the mine site water quality monitoring program; and
- An overview of mitigation and adaptive management.

The Plan is structured to help ensure that: the Project is built as proposed; predicted adverse environmental effects are promptly mitigated; the applied mitigation measures are successful; and relevant laws and regulations are met. It outlines procedures for the reassessment, improvement, or reorientation of the Plan if determined at any point in the Project's development that it no longer meets the initial purpose or objective.

Results of monitoring identified in this plan will be publicly reported, and may feed into other ongoing regional initiatives or programs with relevant government organizations, or regional authorities.

2.1 RELATED PLANS OR STUDIES

Documents within the Application for the Type A Water Licence that support this plan include the following:

- Road Management Plan (Supporting Document [SD]-02);
- Borrow Pit and Quarry Management Plan (SD-03);
- Ore Storage Management Plan (SD-07);
- Waste Rock Management Plan (SD-08);
- Tailings Management Plan (SD-09);
- Landfill and Waste Management Plan (SD-10);
- Landfarm Management Plan (SD-12);
- Environmental Management and Protection Plan (SD-20);
- Aquatic Effects Management Plan (SD-21);
- Marine Monitoring Plan (SD-23);
- Interim Closure and Reclamation Plan (SD-26);
- the Mine Plan (Part 6 of MAD);
- Back River Water and Load Balance Report (MAD Appendix E-2);
- Geochemical Characterization Report (MAD Appendix E-3);
- Back River Project Site-Wide Water Management Report (MAD Appendix F-1);
- Tailings Management System Design Report (MAD Appendix F-4);
- SRK Hydrogeological Characterization and Modelling (MAD Appendix F-5);
- Cultural and Heritage Resources Protection Plan (FEIS Volume 10, Chapter 27);
- Explosives Management Plan (FEIS Volume 10, Chapter 13); and
- SRK Hydrology Report (FEIS Volume 2, Appendix V2-7B).

3. Applicable Legislation and Guidelines

Specific legislation, regulations, and guidelines related to water management in Canada, and specifically within Nunavut, are summarized in Table 3-1.

Sabina will also be bound by the terms and conditions of its land use permits to be issued by the Kitikmeot Inuit Association for Inuit Owned Land, and its Type A Water Licence to be issued by the NWB.

Table 3-1. Applicable Legislation to Water Management in Nunavut

Acts	Regulations	Guidelines
Federal		
Canadian Environmental Protection Act (CEPA; 1999)		
Nunavut Waters and Nunavut Surface Rights Tribunal Act (2002)	Nunavut Water Regulations (2013)	
Territorial Lands Act (1985)	Territorial Land Use Regulations (CRC, c.1524) Northwest Territories and Nunavut Mining Regulations (CRC, c.1516)	Implications of Global Warming and the Precautionary Principle in Northern Mine Design and Closure (BGC 2003)
Fisheries Act (1985)	Metal Mining Effluent Regulations (SOR/2002-220)	Fisheries Protection Policy Statement (2013) Fisheries Productivity Investment Policy: A Proponent Guide to Offsetting (2013 Protocol for Winter Water Withdrawal from Ice-Covered Waterbodies in the Northwest Territories and Nunavut (DFO 2010) Freshwater Intake End-of-Pipe Fish Screen Guideline (DFO 1995)
Territorial – Nunavut		
Nunavut *Environmental Protection Act* (1988)	Spill Contingency Planning and Reporting Regulations (NWT Reg (Nu) 068-93)	Government of Nunavut (GN) Environmental Guidelines for the Management of:
Public Health Act (1998)	Public Water Supply Regulations (RRNWT. 1999, c.P-23) Public Sewerage Systems Regulations (RRNWT. 1999, c.P-22)	
Mine Health and Safety Act (SNWT (Nu) 1994, c.25)	Mine Health and Safety Regulations (NWT Reg (Nu) 125-95)	

4. Roles and Responsibilities

The General Manager is ultimately responsible for the success of the Plan and approves all relevant policies and documents, auditing, action planning, and the verification process.

The Environmental Superintendent and his/her direct reports are responsible for the implementation of this plan including:

- Overall management of the Plan;
- Monitoring;
- Operational aspects;
- Internal reporting;
- External reporting; and
- Ensuring compliance and adaptive management.

5. Planning and Implementation

Water is an essential component of any mine. Understanding the existing physical setting and the overall mine development plan are essential components for development of an effective WMP for the Project.

5.1 PHYSICAL SETTING

5.1.1 Topography

The topography of the region is dominated by undulating landscapes of low relief that present in a sequence of smooth, non-linear rises and hollows, and elongated rises and valleys that repeat in a wave-like pattern. Slopes are generally uniform and range between 0 and 5%. Terrain elevation ranges between 300 and 700 metres above sea level (masl) in the region.

Uplands are typically covered by veneers of morainal materials deposited on Precambrian, sedimentary, metamorphic or intrusive rocks. The thickness of overburden, defined as unconsolidated organic or mineral material, is generally small; it is greatest in areas of plains or gentle slopes where it can range from 1 to 37 m (average of 10.8 m). A number of distinct landforms also exist throughout the region including small and medium sized kettle lakes, eskers, moraines, and boulder fields.

5.1.2 Seismicity

The Back River Property is located in an area of low seismic risk. The peak ground acceleration for the area was estimated using seismic hazard calculator from the National Building Code of Canada's website (NRCC 2014a). The peak ground acceleration value of 0.036 (corresponding to the 1:2,475 year event) was accounted for in the design.

5.1.3 Permafrost and Groundwater

The Back River Property is located in the continuous permafrost region of the Canadian Arctic. Although permafrost may extend in excess of 400 metres below the ground surface (mbgs), it is expected that some of the underground development will extend below this depth into unfrozen rock and soil. In addition, both open pit and underground developments will occur underneath or in close proximity to lakes associated with taliks. Therefore, while the permafrost is essentially impermeable, groundwater inflows are expected during open pit and underground mining.

As part of the Project, a groundwater prediction model was completed to estimate potential groundwater inflows during mining at the Goose Property. Groundwater will also flow through the active layer (the top 1 to 3 m of overburden) during unfrozen months; however, the volume of flow is likely insignificant.

At the Goose Property, groundwater modelling and analysis determined that inflows are expected from Llama Open Pit, Llama Underground, Umwelt Underground, and Goose Main Underground (Table 5.1-1). Llama underground and open pit mining will be developed below Llama Lake within a through talik that is connected to the groundwater system. It is also expected that Llama, Umwelt, and Goose Main underground stopes will intercept the groundwater system below the permafrost layer. These inflows were included as input in the water balance model.

The remaining developments (Umwelt Open Pit, Goose Main Open Pit, and Echo Open Pit, and Echo Underground) are not expected to have notable groundwater inflows.

Table 5.1-1 provides a summary of estimated annual groundwater inflows at the Goose Property. Linear interpolation was assumed for groundwater flow into Llama open pit during pit flooding, ranging from a maximum of 702 m^3/day at an elevation of 165 masl to 0 m^3/day at 385 masl (Appendix E-2 of the MAD).

A more detailed description of the groundwater prediction model and results through all mine phases can be found in the Hydrogeological Characterization and Modelling Report for the Project (FEIS Volume 2, Appendix V2-7A).

Table 5.1-1. Goose Property Groundwater Inflows

Year	Flow in m^3/d			
	Umwelt Underground	Llama Underground	Llama Open Pit	Goose Main Underground
-2	0	0	0	0
-1	0	168	0	0
1	0	334	120	0
2	89	350	109	0
3	543	264	702	0
4	440	246	Interpolated	0
5	596	0	Interpolated	0
6	498	0	Interpolated	21
7	405	0	Interpolated	85
8	359	0	Interpolated	77
9	329	0	Interpolated	64
10	312	0	Interpolated	0

Note: Umwelt underground completed Yr10Q2, Llama underground completed Yr4Q3, Llama open pit completed Yr3Q3 and Goose Main underground completed Yr9Q1. Llama Pit flooding was not simulated in the groundwater modelling study.
Highlighted grey cells illustrate underground pre-development and blue cells illustrate mining period.

Multiple hypothetical scenarios were modelled to assess the sensitivity of groundwater model predictions to hydraulic conductivity (K) values, the potential presence of fault conduits, lake sediment K values, and permafrost distribution. The hypothetical scenarios were used to contextualize the overall groundwater model in terms of both quantity and quality of water estimated to report to the mines. Refer to the Hydrogeological Characterization and Modelling Report for the Project (FEIS Volume 2, Appendix V2-7A) for additional details.

Sabina recognizes that there is a chance that flow in the mines may be dominated by specific fractures or features that are intercepted. This uncertainty exists for all mining projects and is never completely alleviated until structural geology and hydrogeology data is regularly collected from mining operations. The influx of water into a mine is a normal and well understood phenomenon, and is regularly managed by standard operating procedures (SOPs) in operating mines.

Sabina is aware of the uncertainty related to fault zones and will safely and appropriately manage groundwater inflows. Actions may include use of surface and underground exploration information to identify enhanced permeability that may be intercepted, advancing cover and probe drilling (i.e., exploration drainage holes), and interpretation of groundwater pressure and inflow data when high permeability formations are encountered.

5.1.4 Climate and Hydrometric Characteristics

Baseline meteorological and hydrometric programs have been initiated for the Back River Property spanning the period from 2004 to 2014. Detailed climate and hydrometric characteristics are presented in the Hydrology Report (FEIS Volume 2, Appendix V2-7B), and the Meteorological Baseline Report (FEIS Volume 4, Appendix V4-3A).

Meteorological parameter estimates utilize the Goose Lake meteorological station located at elevation 277 masl. The data collected at this station were combined with historical data from the Meteorological Services of Canada branch of Environment and Climate Change Canada (ECCC), and were used in conjunction with research conducted by Waterloo University and ECCC to develop long-term meteorological estimates for the Project.

Available site data was correlated to the corresponding monthly temperature data at the Lupin Meteorological Services of Canada station using a linear regression analysis. The resulting synthetic temperature record has an average annual temperature of -10°C. The minimum and maximum average monthly temperatures of -28°C and 14°C occur in January and July, respectively. Channel freeze-up generally occurs in late October or early November, and ice break-up generally occurs in May or early June.

Regional wind speed data are not available near the Project area, so mean monthly values were derived from the measured Goose Property record. The mean annual wind speed on site is approximately 4.4 m/s, with the wind direction exhibiting strong seasonality. The maximum recorded wind gust during the monitoring period was measured at 30.7 m/s (111 km/h).

The mean annual precipitation at the Property is estimated to be 412 mm, with approximately 55% falling as rain and 45% falling as snow. This estimate takes into consideration potential undercatch at the Goose Property station, and is calibrated to the long-term mean annual runoff derived for the Project area. Monthly average total precipitation is presented in Table 5.1-2.

The annual long-term lake evaporation (including sublimation) in the region is about 324 mm; the strongest control on evaporation is net radiation. Annual actual evapotranspiration from the tundra is estimated to be approximately 199 mm.

Hydrometric data are currently being collected at 25 stations in the immediate Project area. Of these stations, the Propeller Lake inflow (PL-H2) and outflow (PL-H1) stations were deemed to be the most complete and representative for the Property. The 2011 monitoring year had the longest continuous record, including spring freshet and late summer flows, and was therefore used in the development of long-term synthetic flow series for the Project area.

Due to the incompleteness of the records, a regional analysis was conducted using 11 hydrometric stations from the Water Survey of Canada to determine regional hydrologic trends. The Baillie River near the Mouth Water Survey of Canada station (10RA002) was found to be the most comparable regional station to the 2011 local hydrometric station records (i.e., PL-H1 and PL-H2). The 25 years of flow data from Baillie River were corrected to the site, generating a continuous flow record for the Project. The resultant long-term mean annual runoff for the Project area is 149 mm.

Table 5.1-2 presents the annual precipitation, evaporation, and temperature characteristics of the Back River Property. Table 5.1-3 presents the estimated extreme values of annual precipitation and runoff for various return periods at the mine site based on frequency analyses. Table 5.1-4 summarizes the extreme

24-hour rainfall events derived for the mine site based on frequency analyses of regional meteorological stations (FEIS Volume 2, Appendix V2-7B for Hydrology Report).

Table 5.1-2: Summary of Mean Monthly Climate Characteristics

Month	Mean Runoff (mm)	Total Precipitation[1] (mm)	Mean Evaporation (mm)	Temperature (°C)		
				Minimum	Average	Maximum
January	0.0	26.9	0	-35	-28	-23
February	0.0	22.5	0	-37	-28	-8
March	0.0	29.2	0.1	-36	-28	0
April	0.0	27.9	5.9	-23	-16	0
May	5.9	28.9	25.8	-13	-5	2
June	75.3	39.4	96.4	0	6	12
July	28.3	41.6	106.7	6	14	19
August	12.9	61.1	65.8	4	10	16
September	17.8	40.4	22.4	-3	2	9
October	8.2	39.3	0.4	-12	-6	-2
November	0.6	29.7	0	-26	-19	-11
December	0.0	25.1	0	-31	-25	-16
Annual	**149.0**	**412.1**	**323.6**	**-17**	**-10**	**0**

Source: Z:\01_SITES\Back River\1CS020.008_FEIS\700_Water_Mgt_System_Update\Water Balance\Analysis\Hydrology\Monthly_Water_Balance_Rev1_SPB.xlsx
1) Monthly total precipitation was calculated using monthly calibrated undercatch correction factors, where the average annual adjustment was equal to 1.61.

Table 5.1-3: Summary of Frequency Analysis for Annual Runoff and Precipitation

Hydrological Condition	Return Period	Annual Runoff (mm)	Annual Precipitation (mm)
Wet	200	269	658
	100	258	632
	50	245	603
	20	227	562
	10	210	527
	5	190	487
Average	-	149	412
Dry	5	112	344
	10	92	311
	20	75	284
	50	56	256
	100	44	238
	200	32	221

Table 5.1-4: Precipitation Frequency Analysis (Depth in mm)

Storm Duration	Return Period (year)						
	200	100	50	25	10	5	2
24-hr	75	67	58	50	40	33	22

5.1.4.1 Climate Change

While not specifically addressed in the Water and Load Balance Report (FEIS Volume 2, Appendix V2-7H), water management system designs include consideration of climate change. Based on the assessment of climate change completed for the Project (FEIS Volume 4, Appendix V4-3B), the variability in precipitation from baseline conditions during the LOM is expected to be less than 10%. As a result, rainfall depths adopted in the design of all water management infrastructure (e.g., water storage ponds, event ponds, and water diversions) have been increased by 10% over baseline conditions (FEIS Volume 2, Appendix V2-7I), which provides contingency in the form of containment for additional flows.

5.1.4.2 Hydrology

5.1.4.2.1 Waterbody Description

The Property is predominantly located within the Queen Maud Gulf Watershed with a small portion in the Back River Watershed (Nunavut Water Regulations, Schedule 4). This is shown in MAD Appendix A, base Figure 1. The Project is composed of two main areas, the Goose Property area and the MLA. The majority of proposed infrastructure at the Goose Property area is within the Queen Maud Gulf Watershed, which flows northwest and enters the ocean on the west side of Bathurst Inlet. The Back River Watershed is located south of the Goose Property and flows east eventually entering the Arctic Ocean south of Gjoa Haven. The MLA is a narrow strip of land that drains directly to the west side Bathurst Inlet. A list of all waterbodies within the Potential Development Area can be found FEIS Volume 6, Chapter 3.

The Goose Property is divided by several smaller drainage areas each contributing to the larger, previously described watersheds. These drainage areas are shown on Figure A-21. This figure also indicates flow direction and the lakes in which bathymetry has been completed.

5.1.4.2.2 Hydrological Processes

The Project lies within the continuous permafrost zone of the continental Canadian Arctic. The physiography of the region is dominated by vegetated tundra hillslopes with lakes and scattered wetlands. The presence of permafrost is hydrologically influential, as it has very low hydraulic conductivity, and thus acts as a barrier to deep groundwater recharge. The physical restriction tends to increase surface water runoff and decrease infiltration.

Compared to unfrozen regions, permafrost watersheds tend to have higher peak flows and lower baseflows (Kane 1997). Streamflow in the continuous permafrost zone is governed by the Arctic nival regime, where runoff is dominated by high, snowmelt-driven flows in spring (the freshet). Following freshet, streamflow declines throughout the summer and early fall, with the exception of rare and episodic rainfall-generated runoff (Church 1974).

Channel freeze-up typically occurs between late October and early November. In smaller drainage basins, stream channels typically freeze to their bottom, with zero flow occurring in winter. In very large catchments and larger lake outlets, depth, flow energy, and water turbulence may be sufficient to maintain streamflow and prevent downstream reaches from freezing completely.

Ice begins to form in October and is generally present on lakes until July. Ice depths are typically 1.5 to 2 m, and reach their maximum depth in February (Conceptual Fish Offsetting Plan). Shallow water bodies, including most streams in the Project area, generally freeze to bottom over winter.

The maximum daily snowmelt rate was determined to be 28 mm/day (FEIS Volume 2, Appendix V2-7B). Snowmelt occurs in the month of May and June. The open water season typically starts in July and ends in September; however, there are variations in the length of the open water season year to year (Rescan 2014).

Return period unit peak flows were calculated using the index flood method, and a precipitation based hydrology model with Soil Conservation Service unit hydrographs and curve numbers. Curve numbers were calibrated for each return period using two smaller regional gauging stations from the Ekati Diamond Mine (FEIS Volume 2, Appendix V2-7B).

5.2 MINE DEVELOPMENT PLAN

The total mine life of the Project from Construction to the end of Closure is estimated to be approximately 21 years. The mine life was divided into four phases and three stages to describe key periods as detailed in Table 5.2-1.

Table 5.2-1: Mine Phase and Stage

Phase	Stage	Description	Start	End	Comment
1	-	Mobilization and Construction	Y-3,Q1	Y-1,Q3	Build Process Plant and TSF; start Umwelt open pit mining and Llama underground development
2	1	Operations - TSF	Y-1,Q4	Y2,Q3	Begin milling and tailings deposition in TSF
	2	Operations - Umwelt TF	Y2,Q4	Y6,Q3	Tailings deposition in Umwelt TF
	3	Operations - Goose Main TF	Y6,Q4	Y10,Q2	Tailings deposition in Goose Main TF
3	-	Closure	Y10,Q3	Y18,Q3	Active site closure, continue water treatment (seasonal) and remove site infrastructure
4	-	Post-Closure	Y18,Q3	Y23,Q3	Site closed; performance monitoring

The Construction Phase will occur over approximately three years, and involve dewatering, pit excavation, and the construction of tailings management and water management structures. Major mine development infrastructure will be constructed at both the Goose Property and the MLA. The design of water management conveyance structures is described in detail in Section 8.

The major infrastructure at the Goose Property will include the following:

- Goose Plant Site (Goose Camp Accommodations and Process Plant);
- Ore Stockpile;
- Tailings management facilities (Tailings Storage Facility [TSF], Umwelt Pit as Umwelt Tailings Facility [TF], and Goose Main Pit as Goose Main TF);
- Waste rock storage areas (WRSA) (Umwelt WRSA, Llama WRSA, Echo WRSA, and TSF WRSA);
- Airstrip;

- Saline Water Pond;
- Llama Reservoir (Llama Pit as meromictic lake);
- Event Ponds (Llama WRSA Pond, Primary Pond, Umwelt WRSA Pond, Echo WRSA Pond, Ore Stockpile Pond, TSF WRSA Pond, and Echo Diversion Pond;
- Haul and service roads; and
- Open pits and underground mine workings (Umwelt, Llama, Goose Main, and Echo).

The infrastructure at the MLA will include the following:

- Industrial area including camp and storage areas;
- Hazardous waste management area and landfarm;
- Desalination plant and associated water management infrastructure;
- Construction laydown area; and
- Fuel storage and offloading pad.

The Operations Phase will extend for ten years, and will consist of both open pit and underground mining at the Goose Property. Three tailings management facilities will be operated sequentially through Operations; a purpose-built TSF and two mined-out open pits (Umwelt TF and Goose Main TF). Deposition in each tailings management facility is presented as a separate stage within the Operations Phase.

Four deposits, namely Umwelt, Llama, Echo, and Goose Main, will be mined, each by both open pit and underground methods. The mining schedule for each deposit is described in Table 5.2-2. Ore will be produced over approximately ten years. A total of 19.8 Mt of ore will be processed from open pit and underground developments, at a milling rate of 6,000 tpd.

Table 5.2-2: Summary of Mine Schedule

Mine Operation	Start	End
Open Pit Development		
Umwelt open pit	Y2,Q2	Y2,Q1
Llama open pit	Y1,Q1	Y3,Q3
Goose Main open pit	Y2,Q3	Y6,Q1
Echo open pit	Y4,Q3	Y5,Q3
Underground Development		
Umwelt underground mine	Y2,Q1	Y10,Q2
Llama underground mine	Y1,Q1	Y4,Q3
Goose Main underground mine	Y5,Q1	Y9,Q1
Echo Underground mine	Y6,Q1	Y9,Q4

The Closure Phase will occur over approximately eight years. The majority of the mine workings, tailings structures, and water management structures will be decommissioned throughout Closure. The Project will subsequently enter Post-Closure, which will consist of monitoring and adaptive management.

The development sequence for mining and water management activities is summarized in Table 5.2-3 and is shown in Figures A-03 through A-10 in Appendix A. For detailed activity descriptions of the phases and stages of Water Management refer to Section 8.

Table 5.2-3: Mine Development Sequence

Mine Year	Mine Development Sequence and Key Activities
-3	**Phase 1 – Construction** Llama Lake and Umwelt Lake commence fish out and dewatering to allow for open pit development. Water discharge infrastructure is constructed at Goose Lake to prepare for dewatering activities. Llama Lake is partially dewatered to Goose Lake. Portion of water is treated for suspended solids. Llama Lake becomes Llama Reservoir, which stores contact water throughout Construction. Non-contact diversion berms are constructed to divert runoff from entering Llama Reservoir. Umwelt Lake is fully dewatered to Goose Lake to allow for construction of the Saline Water Pond. Portion of water is treated for suspended solids. Refer to Figure A-03 and Section 8.1 for additional clarification.
-2	**Phase 1 – Construction** Umwelt Pit mining operations begin. Waste rock deposition begins in the Umwelt WRSA. The Saline Water Pond is constructed. Contact water diversion berms are constructed in the current development area (near Llama and Umwelt); event pond areas are constructed in conjunction with berm construction: The Ore Stockpile Pond is constructed. The Umwelt WRSA Pond is constructed. The Primary Pond is constructed. Pumping of contact water that is collected in the ponds to the Llama Reservoir begins. Treatment of contact water within Llama Reservoir begins during the open water season. Commission the Saline Water Pond. Refer to Figure A-03 and Section 8.1 for additional clarification.
-1	**Phase 1 – Construction** Llama Underground pre-development begins and is completed. The TSF Containment Dam and TSF South Dyke are constructed; the downstream collection berm (called the TSF WRSA Diversion Berm) is also constructed. The Ore Stockpile is developed. Treatment of contact water within Llama Reservoir continues and is completed during the open water season. Groundwater from Llama Underground mining operations is pumped to the Saline Water Pond and continues throughout underground operations. One culvert crossing location in the Goose Airstrip and four culvert crossing locations in the haul roads are constructed. Water intake infrastructure is constructed at Big Lake to meet the freshwater demands for the camp. Water intake infrastructure is constructed at Goose Lake to meet the freshwater demands for Construction and Goose Process Plant. Refer to Figure A-03 and Section 8.1 for additional clarification.

(continued)

Table 5.2-3: Mine Development Sequence (continued)

Mine Year	Mine Development Sequence and Key Activities
1	**Phase 2 – Operations: Stage 1** Milling operations begin (* this could occur as early as Y-1,Q4) Withdrawal of ore from the Ore Stockpile begins. Tailings deposition begins in the TSF (* this could occur as early as Y-1,Q4); TSF WRSA Diversions Berm will collect any seepage from the TSF which will be pumped back into the TSF, or discharged to the environment, as appropriate. Llama Pit mining operations begin. Llama Underground mining operations begin. Waste rock deposition in the Llama WRSA begins. The Llama WRSA containment dam and diversion berm are built, which create the Llama WRSA Pond. Contact water from the Llama WRSA Pond and the ponds constructed in Phase 1 will be pumped to the TSF for as long as tailings deposition in the TSF occurs (until the end of Stage 1). Reclaim water is pumped from the TSF supernatant pond to the Process Plant. Umwelt Underground pre-development begins and is completed. Umwelt Underground groundwater is pumped to the Saline Water Pond, which continues throughout underground operations. Refer to Figure A-04 and Section 8.2 for additional clarification.
2	**Phase 2 – Operations: Stage 1** Umwelt Pit mining operations are completed. Goose Main Open Pit mining operations begin. Umwelt Underground mining operations begin. A non-contact water diversion berm is constructed at Goose Main Open Pit to divert water away from the pit, towards Goose Culvert, and into Goose Lake. At the end of Year 2, tailings deposition is transitioned from the TSF into Umwelt Pit (Umwelt TF). **Phase 2 – Operations: Stage 2 begins** Tailings deposition in the TSF is completed. Tailings deposition in the Umwelt Pit (Umwelt TF) begins. Waste rock deposition on the TSF (TSF WRSA) begins; waste rock sourced from Goose Main Open Pit. The Echo WRSA Pond is constructed. The TSF becomes the TSF WRSA. Water collected in the TSF WRSA Pond is pumped to the Echo WRSA Pond, then to Umwelt TF. Reclaim water is pumped from the TSF until it is dewatered and reclaim is no longer possible. The TSF WRSA diversion berm collects seepage and runoff, and pumps it back into the TSF WRSA Pond. Contact water in Goose Main Open Pit is pumped to the Echo WRSA Pond (and subsequently to the Umwelt TF and then the Llama Reservoir). Refer to Figure A-04 (Stage 1), Figure A-05 (Stage 2) and Section 8.2 for additional clarification.
3	**Phase 2 – Operations: Stage 2** Llama Pit mining operations are completed. Deposition in the Llama WRSA is completed. Llama Open Pit permanently becomes Llama Reservoir and stores excess contact water. Refer to Figure A-05 (Stage 2) and Section 8.2 for additional clarification.

(continued)

Table 5.2-3: Mine Development Sequence (continued)

Mine Year	Mine Development Sequence and Key Activities
4	**Phase 2 – Operations: Stage 2** Echo Pit mining operations begin. Goose Underground pre-development begins and is completed. Llama Underground mining operations are completed. The Llama Reservoir non-contact diversion berms are breached, allowing the reservoir to begin to fill. The East Echo Diversion Berm is constructed and diverts non-contact water away from Echo Pit and into the Echo Diversion Pond, which is contained by the Echo Containment Dam. Non-contact water is then pumped to the West Echo Diversion Berm and flows to the Echo Culvert and into Goose Lake. A contact water diversion berm is constructed to divert contact water from the Echo WRSA into the Echo WRSA Pond. Groundwater inflow to the Goose Main Underground working is pumped to the Saline Water Pond and continues throughout underground operations. From Year 4 to Year 9, groundwater from Saline Water Pond will be pumped to the bottom of the partially flooded Llama Reservoir to create a meromictic lake. In total, approximately 1 Mm^3 of saline water will be pumped into the Llama Reservoir. Refer to Figure A-05 (Stage 2) and Section 8.2 for additional clarification.
5	**Phase 2 – Operations: Stage 2** Echo Pit mining operations are completed. Waste rock deposition in the Echo WRSA is completed. Goose Underground mining operations begin. Echo Underground pre-development begins and is completed. 325,000 m^3 of saline water is pumped from the Saline Water Pond into the Llama Underground mine. Refer to Figure A-05 (Stage 2) and Section 8.2 for additional clarification.
6	**Phase 2 – Operations: Stage 2** Goose Main open pit mining operations are completed. Waste rock deposition in the TSF WRSA is completed. Echo Underground mining operations begin. Tailings deposition in Umwelt TF is completed and tailings deposition is transitioned to the Goose Main Open Pit (Goose Main TF). **Phase 2 – Operations: Stage 3 begins** From Year 6 to Year 10, contact water collected in the TSF WRSA, Ore Stockpile Pond, Primary Pond, and Echo, Umwelt and Llama WRSA Ponds is pumped to Goose Main TF. Refer to Figure A-05 (Stage 2), Figure A-06 (Stage 3) and Section 8.2 for additional clarification.
7	**Phase 2 – Operations: Stage 3** No new development. Water treatment plant becomes operational year-round from Year 7 to Year 10 at the Goose Main TF with water recirculated back into Goose Main TF. Refer to Figure A-06 (Stage 3) and Section 8.2 for additional clarification.
8	**Phase 2 – Operations: Stage 3** No new development. Water management strategies beginning in Year 6 and Year 7 continue. Refer to Figure A-06 (Stage 3) and Section 8.2 for additional clarification.

(continued)

Table 5.2-3: Mine Development Sequence (completed)

Mine Year	Mine Development Sequence and Key Activities
9	**Phase 2 – Operations: Stage 3** Goose Underground mining operations are completed. Echo Underground mining operations are completed. Dewatering of Saline Water Pond to Llama Pit (Llama Reservoir) is completed. Water management strategies beginning in Year 6 and Year 7 continue. Refer to Figure A-06 (Stage 3) and Section 8.2 for additional clarification.
10	**Phase 2 – Operations: Stage 3** Withdrawal of ore from the Ore Stockpile is completed. Umwelt Underground mining operations are completed. Deposition in the Goose Main TF is completed. Dewatering of Saline Water Pond to Goose Main and Umwelt undergrounds begins and is completed (approximately 800,000 m3). Year-round treatment of Goose Main TF water is completed, treatment during open-water season only begins at the same rate. All remaining saline water in the Saline Water Pond is pumped to the underground workings of Umwelt and Goose Main. Refer to Figure A-06 (Stage 3) and Section 8.2 for additional clarification. **Phase 3 – Closure begins** Refer to Figure A-07 and Section 8.3 for additional information related to closure. Refer to Diversion and Containment Berm Breach Schedule during Closure Period outline in Table 8.3-1 and the Interim Closure and Reclamation Plan (SD-26) for additional information.
11 – 18	**Phase 3 – Closure** Recirculated water treatment in Goose Main TF continues during the open water season. Infrastructure is decommissioned. Refer to Figure A-07 and Section 8.3 for additional information related to closure. Refer to Diversion and Containment Berm Breach Schedule during Closure Period outline in Table 8.3-1 and the Interim Closure and Reclamation Plan (SD-26) for additional information.
18+	**Phase 3 – Post-Closure** Final decommissioning, including water treatment plant. Refer to Figure A-08 and Section 8.4 for additional information related to post-closure. Refer to the Interim Closure and Reclamation Plan for additional information.

5.2.1 Mine Waste Management Summary

This subsection provides a summary of the mine waste management plans. Detailed plans regarding the management of tailings, overburden, and waste rock are presented in the Tailings Management Plan (SD-09) and the Mine Waste Rock Management Plan (MWRMP; SD-08).

Table 5.2-4 presents a summary of the estimated tonnages of waste materials that will be produced by the Project. The table also indicates the quantities of waste materials that will be deposited in each waste storage facility, or if the material will be used for another purpose. There are four WRSAs: Umwelt WRSA, Llama WRSA, Echo WRSA, and TSF WRSA. Where two storage facilities are presented in the table as the destination for a quantity of materials, the exact quantity distribution between the facilities will be determined based on on-site conditions and requirements.

Table 5.2-4: Mine Waste Summary

Waste Type	Estimated Quantities (t)		Source Area and Destination
Overburden	**5,330,000**	1,289,000	Removed from the Umwelt Open Pit and stored in the TSF and the Umwelt WRSA.
		1,037,000	Removed from the Llama Open Pit and stored in the Llama WRSA.
		2,754,000	Removed from the Goose Main Open Pit and stored in the TSF WRSA and the Echo WRSA.
		250,000	Removed from the Echo Open Pit and stored in the TSF WRSA and the Echo WRSA.
Waste Rock	**58,950,000**	18,653,000	Removed from the Umwelt Open Pit and stored in the Umwelt WRSA, as well as used for construction of the TSF Main and South Dams.
		14,968,000	Removed from the Llama Open Pit and stored in the Llama WRSA.
		24,356,000	Removed from the Goose Main Open Pit and stored in the Echo WRSA and used for cover over the TSF (TSF then becomes TSF WRSA).
		973,000	Removed from the Echo Open Pit and Stored in the Echo WRSA and used for cover over the TSF WRSA.
Tailings	**19,805,000**	3,778,000	Stored in the TSF.
		8,581,000	Stored in the Umwelt TF.
		7,446,000	Stored in the Goose Main TF.

5.2.2 Overburden Management

Overburden will be removed from the surface footprint of the four open pits (quantities as shown in Table 5.2-4). A majority of the overburden materials will be co-disposed of with waste rock in the WRSAs. Depending on the physical characteristics of the overburden material, a portion may be used for the construction of site infrastructure, kept for future revegetation studies/efforts, or used for WRSA cover material. Refer to the MWRMP (SD-08) for more details on overburden.

5.2.3 Waste Rock Management

A summary of the location and surface areas of each WRSA is included in Table 5.2-5. Details regarding approximate final waste rock material quantities and source locations are shown in Table 5.2-4. Only waste rock from the open pit mining operations will be deposited in the WRSAs. Waste rock from underground workings will be redeposited underground. Refer to the MWRMP (SD-08) for more details on waste rock.

Table 5.2-5: Waste Rock Storage Area Summary Information

Facility	Approximate Location	Surface Area (ha)
Llama WRSA	200 m southeast of the Llama Open Pit	37.5
Umwelt WRSA	200 m east of the Umwelt Open Pit	16.2
Echo WRSA	200 m northeast of the Echo Open Pit	3.3
TSF WRSA	1,800 m south of the Goose Main Open Pit	119.1

5.2.4 Tailings Management

Approximately 19.8 Mt of tailings will be produced over the 10-year LOM. All tailings will be deposited as slurry. Initially, tailings will be deposited in the TSF, which is the only purpose-built tailings management facility on-site. Tailings deposition will transition to the Umwelt and Goose Main open pits once mining operations have ceased in each location (called Umwelt TF and Goose Main TF, respectively). The Operations Phase is described in stages according to the tailings storage and water management plans, as follows:

- Stage 1 – Tailings Storage Facility – For the first two years of Operations (Years 1 and 2), a purpose-built TSF will be utilized;
- Stage 2 – Umwelt Tailings Facility (Umwelt TF) – From Years 2 to 6, the mined-out Umwelt Pit will be used for tailings deposition; and
- Stage 3 – Goose Main Tailings Facility (Goose Main TF) – From Year 6 onward, tailings will be disposed of in the mined-out Goose Main Pit.

The TSF will be covered with waste rock and overburden material once tailings deposition is complete. Water covers with a minimum water depth of 5 m will be used for closure of the Umwelt and Goose Main TFs.

Refer to the Tailings Management Plan for further tailings management details and design drawings associated with TSF retaining structures.

5.2.5 Ore Management

There will be one main Ore Stockpile at the Goose Property located north of the Process Plant, and temporary stockpiles at underground laydowns areas (MAD Appendix A, base Figure 3). The main stockpile area will contain three stockpiles: low-grade, mid-grade, and high-grade ore. Ore will be processed during the Operations Phase only, and runoff from the ore stockpile areas will be collected and managed as site contact water. Refer to the Ore Storage Management Plan (SD-07) for more details.

6. Water Modelling and Design Criteria

The focus of water management is to control the inventory of mine water stored on site, and to maximize the separation of saline, contact, and non-contact water. Water management at the Property entails multiple, codependent components which include storage facilities and conveyance facilities. Water is stored using ponds (short-term storage) and reservoirs (long-term storage). Ponds are structures with a finite operational life and will be fully decommissioned at Closure. The majority of ponds on site are event ponds. Event ponds are sized with retention capacity for specific design storms and are normally empty or will hold only a nominal amount of water. The only non-event pond on site is the Saline Water Pond, which has a defined storage capacity and will remain operational as a storage facility until the transfer of saline water to Llama Reservoir and the underground mines are completed at the end of the operational LOM.

Long-term (i.e., permanent) water storage facilities are denoted reservoirs, and include the four pit lakes (Llama, Umwelt, Echo, and Goose Main).

Sumps in each of the open pits will be used to collect water, which may later be conveyed to an alternative reservoir via pipeline in accordance with the WMP.

Diversions are engineered structures that maintain separation between contact and non-contact water. These structures are constructed for the Operations Phase of the Project and are completely decommissioned during Closure.

6.1 WATER AND LOAD BALANCE

The water and load balance model was used as a tool to analyze water management options during the life of the Project. Refer to MAD Appendix E-2 for additional information regarding the Water and Load Balance Report (SRK 2015b). Where necessary, treatment and discharges of mine water were assessed to manage excess site-wide contact water and meet water quality guidelines downstream of discharge points from the Goose Property.

The water and load balance model for the Project was developed using the GoldSim© software package (version 11.1.2, GoldSim Technology Group 2014). The model was run on a daily time step, and runs from Year -2 to Year 42. This run length was chosen as it allows the model to run until steady-state conditions are reached in pits and downstream receptors.

The Water and Load Balance Report (MAD Appendix E-2) includes a detailed description of the model assumptions, framework, inputs and results, and an overview of the model limitations and sensitivity analysis. The report also provides details on the main mine components relevant to the water quality predictions, including the mine plan, open pits, underground facilities, WRSAs, ore stockpile, and water reservoirs. Flowsheets for each phase of the Project, including Construction, Operations, and Closure, are presented in MAD Appendix F-7, Attachment 1 and Attachment 2, and illustrate the water balance results for an average hydrological year. The flowsheets depict the water management strategy that was implemented for the Project, cumulative volumes, and change in storage over the period of a specified Project phase.

6.1.1 Water Balance Overview

The monthly operational water balance model is based on mass balance principles, available hydrology inputs, mining and production schedules, developed water management plans, and best available water chemistry and source load inputs. The water balance tracks all inputs, outflows, and available storage at the site. The water balance can be represented in a simplistic form as follows:

$$\text{Water Storage} = \text{Water Input} - \text{Water Output} \qquad \text{(eq. 6a)}$$

The total water inputs to the site are groundwater from taliks, as described in Section 5.1, and precipitation (direct precipitation on ponds/lakes, and runoff). The primary sources of storage available at the Goose Property are the open pits, TSF, tailings pores, and waste rock voids. Water outputs from the Goose Property are discharges such as treated effluent, pit overflows to downstream receptors, evaporation, and seepage.

In general terms, runoff and direct precipitation on ponded areas can be represented as follows:

$$Surface\ Runoff = Area \times Precipitation \times Runoff\ Coefficient \qquad \text{(eq. 6b)}$$

$$Direct\ Precipitation\ Rate = Pond\ Area \times Precipitation\ Release\ Rate \qquad \text{(eq. 6c)}$$

The runoff coefficient accounts for losses such as evaporation and infiltration.

The modelling of the WRSAs was simplified in the water balance. A runoff coefficient was applied to estimate the net total runoff at the toe of a WRSA. This runoff coefficient accounts for all losses such as evaporation, seepage to the groundwater table, and loss of storage in the waste rock voids. As such, runoff from a waste rock surface area was evaluated using equation 6b.

Additional details on the water and load balance model, including model inputs and hydrology assumptions, are presented in Water and Load Balance Report (MAD Appendix E-2).

6.1.2 Water Quality Overview

The load balance for the Project was developed to evaluate the potential effects of water quality parameter loadings from mine components on water quality in downstream receptors, such as Goose Lake and Propeller Lake. The load balance and water quality predictions were also used as a tool to optimize the water management and treatment requirements during Operations and Closure.

The load balance is based on conservation of mass. Loadings and concentrations were calculated for each mine component, and loading rates were generated for each corresponding inflow of the water balance. There are two types of loading rates included in the load balance model:

- Direct loadings based on a defined input source term; and
- Linked loading from reservoirs (i.e., open pits or lakes).

The majority of the loading rates are calculated based on the concentrations of source terms (eq. 6d), but can also be based on loading per unit volumes (eq. 6e).

$$Inflow\ Loading\ Rate = Inflow \times Source\ Term\ Concentration \qquad \text{(eq. 6d)}$$

$$Inflow\ Loading\ Rate = Load\ per\ Unit\ Volume \times Rock\ Volume\ Flooded \times Flush\ Factor \qquad \text{(eq. 6e)}$$

Linked inflow loading rates (eq. 6f) from another facility are calculated based on the calculated concentration (eq. 6g) for the facility and associated inflow volume from the water balance.

$$Inflow\ Loading\ Rate = Inflow \times Calculated\ Concentration \qquad \text{(eq. 6f)}$$

$$Concentration = \frac{Load\ (L)}{Volume\ (V)} \qquad \text{(eq. 6g)}$$

Detailed source term concentrations and loading rates are presented in Appendix C of the Water and Load Balance Report (MAD Appendix E-2).

6.1.3 Prediction Nodes

The objective of the water and load balance model is to predict water quality at the Goose Property, as well as the effect to downstream receptors, if any.

Predictions were evaluated in pits and ponds at the Goose Property, as well as at downstream control points. A total of 14 prediction nodes were included in the model. The prediction nodes were strategically chosen to assess the flow and water quality effects from Project infrastructure and to optimize the required water treatment to meet water quality objectives. Details regarding the catchment areas and mine infrastructure contributing runoff to each node are shown in Figure A-01, and presented in Table 3-4 of the Water and Load Balance Report (MAD Appendix E-2). The water diversions upstream of Goose Lake were accounted for in the water and load balance model.

To protect essential fish habitat in Goose Lake and downstream in Propeller Lake, the maximum volume limit for year-round water withdrawal was set at 900 m^3/day. An additional 400 m^3/day was allowed to be withdrawn during the peak flow period (June to October), such that the maximum amount of water withdrawn from Goose Lake during any peak usage was modelled at 1,300 m^3/day. At this maximum water withdrawal limit, the water level and outflow volume of Goose Lake is expected to decrease, but remain within the range of natural variation to protect fish habitat. The limit to water drawdown will prevent lake levels from decreasing more than 0.06 m; this anticipated reduction in water level is considered negligible and within Fisheries and Oceans Canada (DFO) guidelines. Further details can be found in the Fish and Fish Habitat Chapter of the FEIS (FEIS Volume 6, Chapter 6, Section 6.5.3.2).

6.1.4 Water Balance Predictions

Water balance predictions were generated by running the model as a Monte Carlo simulation. Predictions are presented for the 5^{th}, 50^{th}, and 95^{th} percentiles, where the 50^{th} percentile represents the median of all outcomes. The median values represent the results that are most likely to occur, (i.e., which have the highest probability of occurrence).

6.1.4.1 Open Pit and Reservoir Surface Water

The open pits will be passively filled by breaching various water management structures, thereby allowing both contact and non-contact water to fill the pits. Pit water will meet applicable discharge criteria and then be allowed to overtop into nearby watercourses. The year and quarter that each pit is expected to fill under the 5^{th}, 50^{th}, and 95^{th} percentile are presented in Table 6.1-1.

Table 6.1-1: Goose Property Pit and Reservoir Fill Time

Facility	Result	5th Percentile	50th Percentile	95th Percentile
Umwelt TF	Fill Date	Y13, Q3	Y13, Q2	Y12, Q2
Llama Reservoir	Fill Date	Y13, Q2	Y12, Q2	Y11, Q3
Goose Main TF	Fill Date	Y20, Q3	Y17, Q3	Y16, Q3
Echo Pit	Fill Date	Y15, Q2	Y14, Q2	Y13, Q2

6.1.4.2 Open Pit and Underground Workings Groundwater

Umwelt Underground, Llama Underground, Llama Open Pit, and Goose Main Underground all capture groundwater inflows (Table 5.1-1). These inflow quantities were included in the water and load balance (MAD Appendix E-2).

6.1.4.3 Prediction Node Flow Results

To assess the effect of the Project to baseline hydrology, the change in monthly flows at each prediction node and water levels for Goose Lake and Propeller Lake for the 5th, 50th, and 95th percentile water balance predictions were modelled. Detailed monthly summary of the results for each prediction node can be found in Appendix G of the Water and Load Balance Report (MAD Appendix E-2). Figures 6-8 through 6-13 in the Water and Load Balance Report (MAD Appendix E-2) provide a summary of annual flows for the downstream prediction nodes, and Figure 6-14 of the same report provides a summary of the average annual change in water levels for Goose Lake and Propeller Lake.

The prediction node PN01 (MAD Appendix E-2, Figure 6-8) has negligible effects from the Project as it includes a large catchment area compared to the Project infrastructure. PN02 and PN03 are located at the outlet of Propeller Lake and Goose Lake, respectively. These prediction nodes illustrate that during Operations and Closure, downstream flows are reduced as water is kept on site for water reclaim and pit filling. During Post-Closure, flows are greater than baseline as runoff coefficients from the Property infrastructure (i.e., frozen WRSA) are greater than natural conditions.

PN04 illustrate flows downstream of Llama and Umwelt open pit. As expected, flows during Operations are lower than baseline as water from Project infrastructure is captured and used for Operations.

PN06 Project flows are greater than baseline as PN07 flows are directed towards PN07 during Construction, Operation, Closure and Post-Closure. This is due to the Goose Main open pit being located immediately upstream of PN07 cutting off flows to PN07.

PN08 flows are not affected by Project infrastructure and PN09 flows are lower during Operations and a portion of Closure until Echo open pit is filled. PN10 illustrate flows downstream of Llama open pit and the Saline Water Pond. As expected, flows during Operations are lower than baseline as water from Project infrastructure is captured and used for Operations.

PN11, PN12, and PN13 Project flows are greater than baseline during Operations as Llama Lake diversions prevent the natural spill that typically occurs at freshet. Once, the diversions are removed at Closure, flows return to baseline conditions.

6.1.5 Water Quality Predictions

The predicted water quality concentrations are based on a deterministic modelling approach, assuming average hydrological conditions. This approach is consistent with the derivation of source terms, which were developed based on average hydrology. The predicted water quality under these conditions provides the most likely results to occur. Water quality results at each prediction node are presented in MAD Appendix F-7, Attachment 1 and Attachment 2. Results as shown in Table 6.1-2 were compared to Metal Mining Effluent Regulations (MMER; Government of Canada 2002), proposed Metal and Diamond Mining Effluent Regulations (MDMER; Canada Gazette 2017), guidelines for protection of aquatic life (CCME 1999), and the arsenic site-specific water quality objective (SSWQO; Appendix E-1). This section of the water management plan provides a summary of receiving water quality during the Closure and Post-Closure phases. There will be no discharge of effluent to the receiving environment during Operations. It should also be noted that Umwelt and Goose Main TFs, Llama Reservoir and Echo Pit will at no time be fish bearing waterbodies.

Monthly average water quality predictions for dissolved metal concentrations were evaluated for all open pits and downstream prediction points to understand water treatment requirements, and to assess the parameters that are predicted to be elevated in comparison to the MMER or the MDMER. A summary of the average monthly concentrations at the time of flooding and the average open water long-term steady state conditions in each of the flooded open pits are provided in Table 6.1-2. As additional monitoring data become available, Sabina will update and validate the model prediction, and results will be provided through an updated water and load balance report. The updated report would include discussion on exceedances of CCME water quality guidelines or SSWQOs at the end of mine life and how this might alter the conclusions associated the residual effects on freshwater. Sabina confirms that up to date water quality guidelines (e.g., silver and zinc) will be used in future reporting, as well as when assessing whether changes to water quality are triggering the need for adaptive management.

Sabina commits to modelling of total metal concentrations, as may be required, to establish appropriate discharge criteria and predict downstream compliance. For parameters not requiring total metals modelling, appropriate justification will be provided. This information will be provided for review as part of the Type A Water Licence Application process.

Table 6.1-2: Water Quality Results for the Goose Property

Parameter	MMER[1]	MDMER[2]	CCME[3]	Umwelt TF		Llama Reservoir		Goose Main TF		Echo Open Pit	
				At Flooding[4]	Long-term[5]	At Flooding[4]	Long-term[5]	At Flooding[4]	Long-term[5]	At Flooding[4]	Long-term[5]
Total CN as N	1	0.5	0.005	0.000073	0.000058	0.000055	0.000065	0.000038	0.00017	0.00051	0.00051
Chloride	-	-	120	0.16	0.14	**170**	2.3	110	0.92	0.94	0.94
Ammonia	-	0.5[6]	0.019[6]	**0.052**	0.00045	0.0031	0.0004	0.0024	0.0011	0.0047	0.0047
Nitrate as N	-	-	2.9	2.3	0.0027	0.37	0.011	2.6	0.006	0.0061	0.0061
Nitrite as N	-	-	0.06	**0.11**	0.00023	0.028	0.0012	**0.49**	0.00092	0.00094	0.00094
Aluminum	-	-	0.1	**0.26**	**0.28**	0.034	0.035	**0.14**	0.037	0.023	0.013
Arsenic	0.5	0.1	0.01	**0.096**	**0.066**	0.0063	0.006	**0.028**	0.0068	0.0025	0.00045
Boron	-	-	1.5	0.00079	0.0007	0.47	0.0085	0.014	0.0046	0.0047	0.0047
Cadmium	-	-	0.00004	0.0000024	0.0000018	**0.00011**	0.00001	0.000024	0.0000092	0.0000094	0.0000094
Copper	0.3	0.1	0.002	**0.0073**	**0.0076**	**0.0022**	0.0019	**0.0047**	0.002	0.0017	0.0014
Iron	-	-	0.3	0.3	**0.31**	**0.48**	0.046	0.29	0.042	0.026	0.016
Lead	0.2	0.08	0.001	0.0000079	0.000007	0.00055	0.00005	0.00033	0.000046	0.000047	0.000047
Mercury	-	-	0.000026	**0.000033**	**0.000035**	0.000008	0.000012	**0.000027**	0.000013	0.0000099	0.0000096
Molybdenum	-	-	0.073	0.0032	0.0034	0.0051	0.00037	0.047	0.0004	0.00007	0.000052
Nickel	0.5	0.25	0.025	**0.042**	**0.044**	0.005	0.0071	0.022	0.0072	0.0049	0.0035
Selenium	-	-	0.001	**0.0013**	**0.0013**	**0.0011**	0.00021	**0.0013**	0.00023	0.00011	0.0001
Silver	-	-	0.00025	0.000028	0.000029	0.00011	0.000012	**0.00033**	0.000012	0.00001	0.0000097
Thallium	-	-	0.0008	0.0000079	0.000007	0.00055	0.00005	0.000014	0.000046	0.000047	0.000047
Uranium	-	-	0.015	0.0000016	0.0000014	0.00011	0.00001	0.0000034	0.0000092	0.0000094	0.0000094
Zinc	0.5	0.4	0.03	0.012	0.012	**0.038**	0.0041	0.0068	0.0039	0.0034	0.003

Source: \\VAN-SVR0\Projects\01_SITES\Back River\1CS020.006_FS_Study\!020_Project_Data\010_SRK\Water Balance\Analysis\Water Quality Results.xlsx
Note: Units are mg/L unless otherwise noted; - = no guideline; values in bold are above CCME or site-specific objective
1) Metal Mining Effluent Regulations (Government of Canada 2002); Maximum Monthly Mean Concentrations
2) Proposed Metal and Diamond Mining Effluent Regulations; Maximum Monthly Mean Concentrations
3) Guidelines for protection of aquatic life (CCME, 1999); chronic aquatic life.
4) Monthly Average
5) Annual Open Water Average
6) unionized ammonia expressed as nitrogen-N
7) mg-N/L
8) site specific water quality objective (Appendix E-1 of the MAD)

6.2 HYDROTECHNICAL DESIGN CRITERIA

The hydrotechnical design criteria for the Project include a combination of BMPs and specified criteria based on engineering and operational judgement and/or constructability considerations. Four classes of design criteria were considered: Table 6.2-1 presents the hydrologic design criteria used to formulate peak flows; Table 6.2-2 presents the design criteria used for sizing of pond infrastructure; Table 6.2-3 presents containment dam and diversion berm design criteria, and Table 6.2-4 presents culvert design criteria. All design criteria presented in this section are from the Site-wide Water Management Report (Appendix F-1 of the MAD), unless otherwise noted.

Table 6.2-1: Hydrologic Design Criteria for Formulating Peak Flows

Item	Value	Unit	Source
SCS Curve Number (Waste Rock)	84	-	George (2008)
SCS Curve Number (Natural Ground)	72-89	-	SRK (2015a)
SCS Curve Number (Pit Walls)	92	-	George (2008)
Critical Snowmelt Month	June	-	SRK (2015a)
June Average Snowmelt Rate	28	mm/day	SRK (2015a)
Rainfall Distribution	Type I	-	USDA (1986)
Minimum Time of Concentration	10	minutes	Engineering Judgement

SCS = Soil Conservation Service

Table 6.2-2: Pond (Event and Saline Water) Design Criteria

Item		Value	Unit	Source/Comments
Event Ponds	Event Return Period	10-100	Years	BMP. See Table 6.4-1
	Minimum Dewatering Requirement	2	days	Operational consideration
	Storage Requirement	24-hour total rainfall volume + snowmelt	m^3	BMP
	Minimum Freeboard	0.5	m	Engineering Judgement
Saline Water Pond	Storage Volume	1.1	Mm^3	95th percentile volume from SRK Water Balance (SRK 2015a)
	Minimum Freeboard	1.0 – 1.3	m	Appendix A of MAD Appendix F-1: Saline Water Pond Freeboard Memo

Table 6.2-3: Containment Dams (Event and Saline Water Ponds) and Diversion Berm Design Criteria

	Item	Value	Unit	Source/Comments
Diversion Berm Design	Event Return Period	10-100	Years	BMP
	Conveyance Capacity	24-hour total rainfall volume + Snowmelt	m³	BMP
	Manning's Roughness	0.035	-	For minor natural steam with stones and weeds (Chow 1994)
	Minimum Slope	0.005	m/m	BMP
	Upstream Side Slopes	2:1	(H:V)	Constructability consideration
	Downstream Side Slopes	1.5:1	(H:V)	Engineering judgement
	Berm Top Width	6	m	Constructability consideration
	Minimum Berm Height	2	m	Constructability consideration
	Minimum Berm Freeboard	0.5	m	Engineering judgement
Event Pond Containment Dam Design	Minimum Dam Height	2	m	Constructability consideration
	Bedding Material Thickness around GCL	0.5	m	Engineering judgement
	Liner Tie-Back Length	3	m	Engineering judgement
	Upstream Side Slope (Ponded Water Level > 4m)	3:1	(H:V)	Constructability consideration
	Upstream Side Slope (Ponded Water Level < 4m)	2:1	(H:V)	Constructability consideration
	Downstream Side Slopes	1.5:1	(H:V)	Engineering judgement
Saline Water Pond Containment Dam Design	Bedding Material Thickness around GCL	0.5	m	Engineering judgement
	Dam Top Width	8	m	Constructability consideration
	Minimum Dam Height	2	m	Constructability consideration
	Upstream Side Slope	3:1	(H:V)	Constructability consideration
	Downstream Side Slope	2:1	(H:V)	Engineering Judgement
	Liner Tie-Back Length	3	m	Engineering Judgement
	Key Trench Tie-in Depth	2.2	m	MAD Appendix F-1, Appendix C

Table 6.2-4: Culvert Design Criteria

Item	Value	Unit	Source
Event Return Period	100	Years	BMP; SRK (2014)
Conveyance Capacity	24-hour total rainfall volume	m³	BMP; SRK (2014)
Maximum Velocity during Average June flow for Fish Passage	1.5	m/s	SRK (2014)
Manning's Roughness for culverts with cobble stone base	0.040	-	Chow (1994)
Manning's Roughness for culverts without cobble stone base	0.024	-	Chow (1994)

6.3 HYDROLOGIC MODEL

Hydrologic modelling was completed to appropriately design and size the water management infrastructure including ponds and pumps, and to verify the diversion structures were not likely to overtop during specified design storm events.

6.3.1 Catchment Delineation

The Goose Property was delineated into catchments associated with the TSF, and each pit (or TF), WRSA, underground pad, event pond, and diversion. Areas were also incorporated into the water and load balance model to form predictive flow and water quality estimates.

Catchments were delineated in AutoCAD (AutoDesk) using available LiDAR topography. Once delineated, the catchment characteristics, including average slope, total area and head differential, were calculated in Global Mapper™ (Blue Marble Geographics). Catchments are presented in Figure A-01, and in Table 6.3-2.

6.3.2 Approach

Instantaneous peak flows and volumes for design storm events were generated in HEC-HMS software (US Army Corps of Engineers) using the design criteria summarized in Table 6.2-1 along with catchment areas presented in Table 6.3-2. Peak flows derived for a rain-on-snow event were used to size the water management infrastructure, and required storage volumes were determined based on the total snowmelt and rainfall accumulation over a 24-hour period.

Rainfall depths are based on the precipitation frequency analysis, as presented in Table 5.1-4 of Section 5.1.4, with a 10% increase to account for climate change, as discussed in Section 5.1.4.1. Resultant rainfall depths are summarized in Table 6.3-1.

6.3.2.1 Return Period Selection

The return period was selected for each structure based on the qualitative level of risk associated with overtopping or breaching of the structure, whether it was an event pond, open pit, or diversion. Three levels of risk were selected for the Project, with an associated return period (Table 6.3-1). The risk was determined using engineering judgement, taking into consideration the human health and safety, environmental, reputational, and economic consequences of the specified failure events.

Table 6.3-1: Return Period Selection Criteria

Level of Risk	Type of Facility	Return Period	Rainfall Depth[3] (mm)
Low	Non-contact water diversions[1] Pit sumps[2]	10	44.4
Medium	Contact water diversions Contact water event ponds with additional water infrastructure downstream	50	64.2
High	Contact water event ponds without downstream water infrastructure	100	73.4

1) With the exception of non-contact diversions around Echo Open Pit, which have High risk due to prolonged access to the open pit once mined out
2) With the exception of Echo Open Pit sump, which is rated as High risk due to prolonged access to the open pit once mined out
3) From SRK Hydrology Report (SRK 2015a) and increased by 10% to account for climate change (SRK 2015c).

Infrastructure which has the potential to overtop/breach and discharge to the downstream environment was assigned a "High Risk". At the Goose Property, this includes the Umwelt and Llama WRSA ponds, Ore Stockpile Pond, Saline Water Pond, Echo WRSA Pond, and TSF WRSA diversion berm. The Goose Property infrastructure and corresponding risk level are listed in Table 6.3-2, as well as their associated catchment areas.

Table 6.3-2: Level of Risk for Each Item of Goose Infrastructure and Contributing Catchment Areas

Infrastructure	Catchment ID	Catchment Area (km²)	Level of Risk
Umwelt Pit Sump	UP UU	0.23 0.10	Low
Umwelt WRSA Containment Dam (Umwelt WRSA Pond)	UCP2	0.11	High
Umwelt WRSA Diversion Berm	UCP2	0.11	Medium
Primary Pond Haul Road Containment Dam (Primary Pond)	UCP1 UWD2 LWD1	0.38 0.21 0.18	Medium
West Llama Reservoir Diversion Berm	LD1	0.57	Low
East Llama Reservoir Diversion Berm	LD2	0.19	Low
Southwest and South Llama Reservoir Diversion Berms	LP	0.16	Low
Llama WRSA Diversion Berm	LWD2	0.19	Medium
Llama WRSA Containment Dam (Llama WRSA Pond)	LCP LWD2	0.10 0.19	High
Llama Pit Sump	LP LU	0.16 0.07	Low
Ore Stockpile Containment Dam and Diversion Berm (Ore Stockpile Pond)	OD MA	0.14 0.45	High
Saline Water Pond East and South Containment Dams, and Diversion Berms (Saline Water Pond)	SWP	0.52	High
Echo Pit Sump	EP	0.07	Medium
East Echo Containment Dam and Diversion Berm (Echo Diversion Pond)	ED2	0.19	Medium
West Echo Diversion Berm	ED1	0.38	Medium
Echo WRSA Containment Dam (Echo WRSA Pond)	ECP EU	0.04 0.09	High
Echo WRSA Diversion Berm	EWD	0.06	Medium
Goose Main Pit Sump	GP GU	0.28 0.10	Low
Goose Main Diversion Berm	GD1	31.52	Medium
TSF WRSA Pond	TWD1	1.90	High
TSF WRSA Diversion Berm	TWD2	0.14	High

6.3.2.2 Interpretation of Results

The resultant peak instantaneous flows and 24-hour storage volumes were used to size water management infrastructure. Peak flows were used to size culverts and diversion structures, and total storm volumes were used to size water management event ponds and pumping rates.

Since all diversions are constructed as berms as opposed to excavating into existing ground, the minimum berm height defines the conveyance configuration. In all cases, the 2 m minimum berm height (Table 6.2-3) was greater than the design flow depth and freeboard, and therefore governed the design requirements.

6.4 POND AND PUMP SIZING

Table 6.4-1 summarizes the pond capacities and associated pumping rate requirements for the Goose Property. The location of each of the ponds is illustrated on Figure A-02 based on the Pond ID number listed in Table 6.4-1. In addition to those infrastructure listed in Table 6.4-1, a pumping system will be installed at the TSF WRSA Diversion Berm to pump seepage through the dam back to the TSF WRSA Pond. Sabina is committed to providing detailed design details 60 days prior to construction.

The pumping rate for each pond was set to allow dewatering the pond in 2 days (Table 6.2-2), to allow for quick re-establishment of storage capacity after large storm event. The dewatering duration was increased beyond the 2 days only for the ponds that have an available capacity significantly larger than the minimum required capacity. This additional available capacity will allow for managing storm events that may occur during the longer dewatering period. From a practical operational perspective, the maximum design pumping rate was set at 0.15 m^3/s.

Table 6.4-1: Goose Property Pond Capacity and Pumping Rate Summary

Pond ID	Description	Design Return Period	Required Capacity (m^3)	Available Capacity (m^3)	% Full	Dewatering Duration (days)	Pumping Rate (m^3/s)
P1	Umwelt Pit Sump	10	18,000	n/a	n/a	2	0.10
P2	Umwelt WRSA Pond	100	27,000	30,100	90%	2	0.15
P3	Ore Stockpile Pond	100	10,000	11,000	91%	2	0.06
P6	TSF WRSA Pond	100	174,000	1,163,100	15%	16	0.13
P7	Primary Pond	50	109,500	316,650	35%	23	0.06
P8	Llama WRSA Pond	100	20,000	26,000	77%	2	0.11
P9	Llama Pit Sump	10	12,000	n/a	n/a	2	0.07
P10	Goose Pit Sump	10	20,000	n/a	n/a	2	0.11
P11	Echo Pit Sump	50	5,000	n/a	n/a	2	0.03
P12	Echo Diversion Pond	50	11,000	18,000	61%	2	0.06
P13	Echo WRSA Pond	100	48,000	61,000	79%	10	0.06

1) Pit sump actual capacities are defined by the open pit design, and as a result are always larger than the required capacity.

As described in the design criteria outlined in Table 6.2-2, all collection ponds will be sized with sufficient freeboard contingency to provide both operational flexibility and accommodate large flows. Further refinements to the design will be completed during detailed engineering and will be captured in an updated version of this plan prior to construction.

6.5 CULVERT SIZING

There are five proposed culvert crossing locations at the Goose Property: one crossing through the airstrip and four crossings through the all-weather roads. Two types of culverts are considered for the all-weather roads and airstrip:

- Non fish-bearing crossings; and
- Fish-bearing crossings.

The non-fish-bearing crossings will consist of corrugated steel pipe and are currently designed with a diameter of either 1.2 m or 2.5 m, depending on the associated design flow. The fish-bearing crossings will be sized to keep maximum water velocities below 1.5 m/s for the average June flow such that they do not present a velocity barrier to migrating Arctic Grayling. In addition, all culverts, will meet the 0.3 m criteria for maximum water depth above the top of culvert. The fish-bearing culverts will be embedded at depth and a thin layer of streambed material will be placed to promote fish passage and habitat suitability. The design criteria for the culverts are presented in Table 6.5-1; Figure A-02 shows the culvert locations.

Table 6.5-1: Goose Property Culvert Characteristics – Design Storm

	Culvert Description	Goose Culvert	Gander Pond Culvert	Goose Airstrip Culvert	Echo Culvert	Goose Creek Culvert
	Culvert ID	C1	C2	C3	C4	C5
Characteristics	Slope (%)	1.0	3.6	1.0	1.5	3.5
	Diameter (m)	2.5	2.5	2.5	1.2	2.5
	Culvert Shape	Circ.	Circ.	Circ.	Circ.	Circ.
	Number of Barrels	2	2	2	1	1
	Culvert Material	CSP	CSP	CSP	CSP	CSP
	Embedment Depth (m)	0	0.4	0	0	0
100 Year Event	Total Discharge (m^3/s)	19.27	9.64	18.82	1.99	10.47
	Culvert Inlet Elevation (m)	100	100	100	100	100
	Headwater Elevation (m)	102.27	101.89	102.23	101.46	102.39
	Water Depth above Culvert (m)	0	0	0	0.26	0
	Invert Control Depth (m)	2.27	1.49	2.23	1.32	2.39
	Outlet Control Depth (m)	1.31	0	0.23	1.46	1.01
	Normal Depth (m)	1.18	0.98	1.17	1.20	1.06
	Critical Depth (m)	1.41	1.21	1.4	0.77	1.10
	Outlet Depth (m)	1.20	0.99	1.18	0.77	1.47
	Tail Water Depth (m)	0.82	0.54	0.83	0.06	0.12
	Outlet Velocity (m/s)	4.14	4.21	4.12	2.58	5.03
	Tail Water Velocity (m/s)	2.34	1/.8	2.27	0.64	0.49

Refer to Section 9.4 for additional information on environmental protection measures related to culvert installations and stream crossing or diversions.

6.6 DIVERSION BERMS AND CONTAINMENT DAMS

Three types of berms will be constructed to support water management across the Project area:

- Unlined non-contact water diversion berms;
- Lined contact water containment dams and berms; and
- Unlined contact water diversion berms.

All diversion berms will be constructed directly onto the tundra surface with non-potentially acid generating (NPAG) run of mine or run of quarry material that contains sufficient fines to contain and convey water. All containment dams and berms will be constructed with run of mine or run of quarry material; in addition, all lined structures and will contain a geosynthetic clay liner (GCL) that will be tied into the active permafrost layer if the operational head is less than 4 m, and into permafrost if the operational head is greater than 4 m. Additional design criteria are summarized in Table 6.2-3. Table 6.6-1 summarizes the conveyance structures, in terms of their purpose and whether or not they require a liner.

Table 6.6-1: Diversion and Containment Structure Summary

Structure	Lining Details	Notes
Llama Lake Diversion Berms (Southwest, West, East, and South)	Unlined	Divert upstream non-contact runoff from entering Llama Lake
Umwelt WRSA Containment Dam	Lined	Contains contact water runoff from Umwelt WRSA
Umwelt WRSA Diversion Berm	Unlined	Diverts runoff from Umwelt WRSA into Umwelt WRSA Pond
Primary Pond Haul Road Containment Dam	Lined	Contains contact water in the Primary Pond to the east, alignment along haul road
Llama WRSA Diversion Berm	Unlined	Diverts seepage and runoff from the Llama WRSA towards the Llama WRSA Pond
Llama WRSA Containment Dam	Lined	Contains runoff from Llama WRSA into Llama WRSA Pond. North section of dam constructed before west section to contain small section of Llama Lake that will store contact water
Ore Stockpile Pond Diversion Berm	Unlined	Diverts contact water runoff from the Ore Stockpile, along western edge of Ore Stockpile
Ore Stockpile Pond Containment Dam	Lined	Contains contact water from Ore Stockpile, along northern and eastern edges of Ore Stockpile Pond
Saline Water Pond Containment Dams (East and South)	Lined	East and South section of dam containing saline water, around former Umwelt Lake footprint
Saline Water Pond Diversion Berms	Unlined	Diverts runoff from entering the Saline Water Pond
East Echo Containment Dam	Unlined	Contains non-contact runoff south of Echo Pit
Echo Diversion Berm (East and West)	Unlined	Diverts non-contact runoff around Echo Pit

(continued)

Table 6.6-1: Diversion and Containment Structure Summary (completed)

Structure	Lining Details	Notes
Echo WRSA Containment Dam	Lined	Contains contact water from the Echo WRSA and Echo Pit, along the southern edge of the haul road
Echo WRSA Diversion Berm	Unlined	Diverts contact runoff from the Echo WRSA to the Echo WRSA Pond
Goose Main Diversion Berm	Unlined	Diverts non-contact runoff around Goose Main Pit
TSF WRSA Diversion Berm	Lined	Collects seepage and runoff from the TSF WRSA

As described in the Geotechnical Design Parameters Report (FEIS Volume 2, Appendix V2-7C), permafrost soils are sensitive to damage if they are altered in any way. Therefore, excavation into these soils will be avoided as much as practical. The diversions and containment structure designs are presented in Appendix A, Figures A-13 to A-17 and the Site-Wide Water Management Report (MAD Appendix F-1). If diversion structures result in water flowing and/or ponding over previously dry areas, it is possible that permafrost degradation may result due to the additional heat source imparted from the water. If the underlying soils are ice rich, the subsequent differential settlement resulting from ice melting may be notable. This may result in increased localized ponding that might affect the natural drainage. These potential occurrences will be monitored, and if degradation is observed, then clean overburden soil or NPAG material will be imported to manage and stabilize the settlement.

7. Water Management

Many water management considerations and design criteria apply throughout the LOM. Sections 5 and 6 outline those considerations; this section provides details on the specific plans that occur during different phases of the mine life.

7.1 WATER CLASSIFICATION

Site water at Goose Property is categorized into three types:

- Contact water: surface water that is impacted by/contacts mine workings (runoff over waste rock, ore stockpiles, open pits, tailings, etc.);
- Non-contact water: surface water that is not impacted by/does not contact mine workings; and
- Saline water: groundwater that flows into the open pits or underground workings.

Each type of water is managed separately throughout each Project phase, to the extent practicable. Contact water is contained within event ponds and tailings management facilities, and is conveyed on site via diversions and pumped pipelines. Non-contact water is diverted off site through event ponds, pumped pipelines, berms, and culverts.

Saline water is pumped out of the underground facilities, as well as Llama open pit, and stored in the Saline Water Pond (previously Umwelt Lake). During Closure, saline water is pumped back into the underground workings or into the bottom of the mined-out Llama Pit (then called Llama Reservoir). Sabina commits to continue looking for alternative strategies/locations for temporary storage of saline water, before pumping it to the Llama Reservoir.

The MLA does not require any pond or diversion infrastructure for water management purposes, and remains in the same condition for both the Construction and Operations phase. A desalination plant will produce domestic and industrial water, and greywater will be discharged to the tundra.

7.2 WATER MANAGEMENT OBJECTIVES

The key water management objectives for the Project include:

- Minimizing the impact of mining activities on the aquatic environment surrounding the mining area to the greatest reasonable extent;
- Using BMPs, recognizing the unique constraints of each project element;
- Providing a reliable freshwater supply to the Process Plant;
- Managing contact, non-contact, and saline water separately in order to minimize fresh water withdrawal from Goose Lake and Big Lake;
- Facilitating mining operations by managing inflows that occur as a result of groundwater or direct precipitation; and
- Collecting and treating contact water as required to meet SSWQOs in the receiving environment.

7.3 WATER SUPPLY

Water intake structures will be constructed in Goose Lake and Big Lake to supply domestic, industrial, and process make-up water. The selected locations for these intakes are deep and close to shore. The structures will consist of PVC pipe installed on a rockfill base within the lake to keep the pipe above the lake bottom and the intakes will be screened. See Figure A-18 for a typical plan and section of the fresh water intake pipeline. Rock armouring will protect the pipeline from ice scour. Water intakes will be equipped with screens to prevent the entrainment or impingement of fish in accordance with current DFO requirements.

High-density polyethylene pipelines will convey freshwater from the intakes at Goose and Big lakes to dedicated pumphouses for the Process Plant and Goose Camp. A potable Water Treatment Plant (WTP) will be constructed at the end of the domestic supply pipeline.

The water intake structures are temporary as they will only be used throughout the LOM. Both intake structures at Goose and Big lakes will be constructed in Year -1.

Construction of these intakes will involve in-water works. To limit disruption to aquatic resources, the following practices will be implemented:

- Only NPAG armour rock that is free of sediment will be placed in the water during construction to minimize acid generation and turbidity;
- Work will be isolated using silt curtains;
- Work will be carried out during calm water periods to minimize any turbidity effects due to the re-suspension of sediment; and
- Total suspended solids (TSS) and turbidity levels will be monitored throughout construction and work will be delayed if TSS levels and turbidity become too high.

In-water blasting is not planned for the construction of the water intakes.

At Closure, all pumphouses will be drained, decommissioned, and landfilled. All pipelines will be cut at the shoreline, decommissioned, and landfilled. The pipelines extending into the water, along with the surrounding rock armour and rock bases, will be left in place and capped at the substrate so not as to disturb the in-water environment. Additional design details will be provided in future updates to this plan. For additional information, refer to the Conceptual Fish Offsetting Plan (SD-22) Section 6.3.1 and Table 5.1-1.

The proposed fresh water intake structure locations are presented in Figure A-03, and a typical intake design is shown on Figure A-18. The intake locations and consumption rates during the various Project phases are summarized in Table 7.3-1. The natural storage capacity or water level in Goose Lake or Big Lake will not be altered; water withdrawal will not exceed the operational limits given by DFO.

Table 7.3-1: Water Supply Locations and Volumes by Project Phase

Project Area	Water Use	Construction		Operations		Closure		Water Source
		Daily (m^3/d)	Annual (m^3/yr)	Daily (m^3/d)	Annual (m^3/yr)	Daily (m^3/d)	Annual (m^3/yr)	
Goose Property	Domestic	211	77,068	148	54,057	7	2,557	Big Lake
	Industrial/Miscellaneous - Dust Suppression and Construction Use	400	146,100	400	60,000[1]	400	146,100	Goose Lake
	Milling	200	73,000	900	328,725	-	-	Goose Lake
Marine Laydown Area	Domestic	48	17,520	48	17,520	-	-	Bathurst Inlet (marine)
	Industrial/Miscellaneous - Dust suppression and Construction Use	24	8,760	24	8,760	-	-	
Winter Ice Road	Construction Use	-	675/km	-	675/km	-	-	Multiple Sources

1) This annual volume is based on a daily use of 400 m^3/day for 5 months.

During Operations, water consumption requirements from Goose Lake include 900 m^3/d of freshwater make-up year-round and 400 m^3/d for dust suppression during the open water season (Table 7.3-1). No water use is required for hydrostatic testing of Goose Property and MLA fuel tanks at the respective fuel storage areas. Tanks will be commissioned using non-destructive examination techniques (e.g., tank x-ray, vacuum testing of tank floors, and air testing of fittings); this testing will be completed in accordance with API650 (API 2013).

Llama Lake will be partially dewatered to Goose Lake in the open water season of Year -3 to create a temporary reservoir for contact water that will be collected throughout the Construction Phase. Llama Lake has a natural capacity of 1.1 Mm^3; 0.65 Mm^3 of which will be dewatered in Year -3. The remaining volume will be dewatered in the open water season of Year -2 and Year -1 (Table 7.4-1). Umwelt Lake, which has a natural capacity of 0.24 Mm^3, will be completely dewatered to Goose Lake in Year -3; this will allow for construction of the Saline Water Pond. Depending on process water start up requirements (Table 7.3-2), water from Llama and Umwelt lakes may be stored and directed to the Process Plant for use during Operations.

Table 7.3-2: Milling Rates and Parameters

Parameter	Value
Average Production Rate	6,000 tpd
Specific Gravity of Tailings	2.88
Tailings Dry Density	1.20
Void Ratio[1]	1.40
Slurry Percent Solids	50%
Ore Moisture Content	3%
Average Reclaim Rate	4,914 m^3/d
Process Freshwater Demand	900 m^3/d
Water Loss to Voids	3,000 m^3/d

1) The void rate was calculated based on material properties.

Used Process Plant water will be directed towards the active tailings management facility and eventually used as reclaim at a rate of 4,914 m^3/d (Table 7.3-2). Based on the tailings properties, the tailings slurry will result in 6,000 m^3/d of water and 5,000 m^3/d of solids. The volume of water entrained in tailings voids is a function of the void ratio and tailings density.

All water will be withdrawn, distributed, and directed via pumped pipelines.

7.4 WATER TREATMENT

Water treatment is required throughout the mine life for various water uses and constituent reductions. The following sections describe the various types of water treatment.

7.4.1 Marine Laydown Area Desalination Plant

Freshwater requirements at the MLA are met using a desalination plant, drawing ocean water from Bathurst Inlet. The plant will operate using reverse osmosis or similar process, and will discharge brine to Bathurst Inlet as a product of the desalination process.

Discharge of brine water from the desalination plant will meet the CCME salinity guideline for the protection of marine life and will not cause the salinity of the receiving environment to fluctuate by more than 10% of the natural expected salinity (CCME 2015). The desalination plant is designed with an intake flow rate of 33 m^3/h and a discharge rate of 30 m^3/h; therefore, only a small portion of intake water will be desalinated. Assuming the fresh water plant product has a salinity of zero, the discharge from the plant is predicted to be no more than 10% more saline, and therefore within the CCME salinity guideline at the point of ocean discharge. The discharged effluent is expected to mix in the receiving environment, and is not expected to be detectable beyond the outfall. The locations of the water intake and discharge are identified in Figure A-09. Consumption rates at the MLA during the various Project phases are summarized in Table 7.3-1.

7.4.2 Goose Property Water Treatment Plant

A WTP will be required at Goose Property during the initial dewatering of Llama Lake and Umwelt Lake, as well as to treat site contact water in the Goose Main TF.

Flows from dewatering efforts in Llama and Umwelt lakes will be treated for TSS, and contact water stored in Llama Reservoir will be treated for both TSS and arsenic. Inventory from dewatering efforts will be treated and discharged to Goose Lake during the open water season only. After partial dewatering of Llama Lake, the contact water stored in Llama Reservoir will be treated during the open water season. The effluent discharge pipeline associated with the dewatering of Llama and Umwelt lakes will be located in Goose Lake. This pipeline, including details on the end of pipe diffuser, is presented on Figure A-19.

Water treatment will be inactive between Years -1 and 6, but will begin again year-round in Year 7 to treat water from the Goose Main TF for TSS, arsenic, and copper; this treated water will be recirculated back into the Goose Main TF for reclaim. Note that for the length of Operations, the Process Plant will have a tailings handling circuit which includes cyanide destruction with sodium metabisulphite (JDS 2015). Additional details on process water chemistry can be found in Section 4.2.5 of the Water and Load Balance Report (MAD Appendix E-2).

In the years when no treatment occurs, all mine effluent will be stored in the active tailings management facility and used as reclaim water for the Process Plant. Once mining is complete, water treatment will continue during the open water season throughout the Closure Phase until Year17.

The same WTP will be used during Construction, Operations, and Closure. The WTP is modular, can be relocated, and combined as necessary to achieve the appropriate water treatment at different phases of the Project. Table 7.4-1 summarizes the water treatment activities at Goose Property throughout the LOM.

Table 7.4-1: Water Treatment Operations at Goose Property

Source	Discharge Location	Period Start	Period End	Flow Rate (m^3/d)	Parameter	Comment	Final Treated Volume (m^3)
Llama Lake	Goose Lake	Yr-3, Q3	Yr-3, Q3	5,000	TSS	Initial dewatering, open water season	125,000
Umwelt Lake	Goose Lake	Yr-3, Q3	Yr-3, Q3	1,390	TSS	Initial dewatering, open water season	128,000
Llama Reservoir	Goose Lake	Yr-2, Q3	Yr-1, Q3	15,000	TSS, Arsenic	Contact water dewatering, open water season	754,000
Goose Main TF	Goose Main TF	Yr 7, Q4	Yr 10, Q2	8,500	TSS, Arsenic, Copper	Recirculation of treated water back into Goose Main TF, year-round	14,650,000
Goose Main TF	Goose Main TF	Yr 10, Q2	Yr 17, Q1	8,500	TSS, Arsenic, Copper	Recirculation of treated water back into Goose Main TF, open water season only	7,500,000

7.4.3 Sewage Treatment and Disposal

7.4.3.1 Goose Property Sewage Treatment and Disposal

Sewage at the Goose Property will be treated using a package Sewage Treatment Plant (STP), such as a Membrane Bioreactor or similar. The STP will be located in the Goose Plant Site area, and during the Construction Phase (i.e., before the TSF is available) and Closure Phase (i.e., when all tailings management facilities are no longer available), treated sewage effluent will be discharged to the tundra south of the Goose Plant Site (Figure A-20). It will be land discharged to maximize attenuation distance prior to entering an outflow watercourse from Fox Lake and ultimately entering Goose Lake. Off-specification treated sewage during upset conditions will be discharged to the closest collection pond. Any discharges of sewage effluent from the collection pond will need to meet the applicable discharge criteria. In-pond treatment by coagulation can be applied if required as a contingency. Refer to the Landfill and Waste Management Plan (SD-10) for details on STP treated effluent volumes.

In Operations, effluent will be discharged to the active tailings management facility. During Post-Closure, the Goose Camp will convert to Pacto or incinerating toilets and effluent discharge will not be necessary. If STP effluent meets discharge requirements during Operations, Sabina may choose to discharge on land consistent with Construction Phase STP effluent management. See the Landfill and Waste Management Plan (SD-10) for information on sludge disposal.

7.4.3.2 Marine Laydown Area Sewage Management

There will be no direct discharge of treated sewage effluent or camp greywater to the marine environment. The MLA camp will employ Pacto or incinerating toilets for all Project phases to avoid the need for a STP.

Greywater from domestic use will be pumped through an oil and grease separator prior to discharge to the tundra. It will be discharged through a designated pipeline to a relatively flat, non-channelized area on the tundra north of the Laydown Area (Figure A-09), and will ultimately flow into Bathurst Inlet. Water management at the MLA will consist of the following:

- o Greywater will be discharged in an area of low slope to minimize velocities, encourage sheet flow, and minimize channelization.
- o The discharge will be directed towards gravel beds or rock to reduce water velocities as appropriate.
- o To maximize attenuation, the expected flow path to the nearest receiving environment (Bathurst Inlet) will be greater than 1.5 km. This is due to the gently sloping topography extending to the west and north of the discharge location.

Greywater will meet the ocean disposal criteria identified in Table 7.5-.

7.4.4 Potable Water Treatment

Public water supply of potable water is regulated under the *Public Health Act* and Public Water Supply Regulations administer by the Government of Nunavut. Sabina plans to develop SOP that will include the use of chlorination to ensure potability of water. Regular test work of water quality will be conducted to ensure potable water meets Canadian drinking water standards. Sabina will meet all regulatory requirements around the management of potable water.

7.5 EFFLUENT CRITERIA

If the monitored changes in water quality result in levels above the regulated effluent discharge criteria define in the Type A Water Licence, Sabina will implement further appropriate mitigation measures.

7.5.1 Runoff Criteria

Site runoff from the Goose Plant Site area and pads is expected to contain suspended solids, or oils and grease from heavy equipment. General site runoff will meet the discharge criteria presented in Table 7.5-1.

Table 7.5-1: Site Runoff Discharge Criteria

Parameter	Maximum Average Concentration (mg/L)	Grab Sample Maximum Concentration (mg/L)
TSS	50	100
Oil and Grease	No visible sheen[1]	No visible sheen[1]
pH	Between 6.0 and 9.5[1]	Between 6.0 and 9.5[1]

1) Source: Standard NWB Licence requirement

These proposed discharge criteria are the same discharge criteria that have been considered protective of the receiving environment by the NWB for multiple mining Projects in Nunavut to date, including the Mary River Project, Doris North Project, and Meadowbank Project.

Due to similar site conditions, these Arctic projects are considered applicable to, and analogous of, the Project. Hydrological and meteorological conditions for the above projects are typical of conditions in the Project area, namely; hydrological conditions are snowmelt dominated, with peak flow events occurring from early May to mid-June, and meteorological conditions consist of occasional rainfall driven high flow events occurring between June and September.

Note that the minimum 31 m buffer distance from waterbodies reported in the FEIS, intended to minimize surface flow impacts on water quality, has been adopted in the above water licences provided by the NWB. This 31 m buffer was identified based on guidance documents and commonly established riparian zone buffer widths used in many regions, including the Arctic.

Sediment and erosion control are an important component of the environmental protection plan for the Project. Mitigation and management measures for sediment and erosion control measures are presented in the Aquatic Effects Management Plan (SD-21) and in the mitigation and adaptive management section in the freshwater water quality assessment chapter (FEIS Volume 6, Chapter 5, Section 5.8).

7.5.2 Dewatering Discharge Criteria

In advance of dewatering, a fish-out program will be completed. For additional information related to conservation, and mitigation measures to be implemented refer to section 9.3. Dewatering discharge criteria are presented in Table 7.5-2.

Table 7.5-2: Dewatering Discharge Criteria

Parameter	Maximum Average Concentration (mg/L)	Grab Sample Maximum Concentration (mg/L)
TSS[1]	15	30
pH	Between 6.0 and 9.5	Between 6.0 and 9.5

1) As per MMER

7.5.3 For Discharges to Land

At both the Goose Property and MLA, hydrocarbon contaminated soil resulting from accidental release of fuel, will be placed in a lined containment area (landfarm). Water pooling within the landfarm will be monitored for quality and will be sent to the active tailings management facility or released to designated locations on land, at a minimum setback of 31 m from waterbodies provided that the water meets the criteria specified in Table 7.5-3. Otherwise, treatment will be provided. Additional details regarding the Goose Property and MLA landfarms are included in the Landfarm Management Plan (SD-12).

Oily (hydrocarbon contaminated) water, ice, and snow may be generated from the following activities:

- Snow clearing operations;
- Precipitation accumulating in the landfarms;
- Heavy equipment and truck washing;
- Precipitation accumulating in lined bulk fuel storage facilities; and
- Accidental releases of fuel or other substances.

Rock quarries, and potentially sand/gravel borrow areas, will be developed at each of the Project sites to facilitate construction. The Borrow Pits and Quarry Management Plan (SD-03) outlines operating quarry procedures that include environmental protection measures and monitoring plans. Runoff from quarries and borrow area excavations will be managed in accordance with the environmental protection measures outlined in Section 9.6.

Runoff from quarries and borrow pits can be elevated in suspended solids as well as possibly hydrocarbons from minor spills during refueling of equipment, and residual concentrations of ammonia from the use of ammonia nitrate fuel oil (ANFO) explosives. Runoff will be collected within the work area and will only be discharged to land if meeting the water quality criteria in Table 7.5-3. If any water source from quarry or borrow areas does not meet the discharge criteria, this water will be pumped to the active tailings management facility and managed with other site contact water.

Table 7.5-3: Discharge to Land Criteria

Parameter	Grab Sample Maximum Concentration (mg/L)[1]
pH	Between 6.0 and 9.5
Total Suspended Solids	30
Oil and Grease	5 and no visible sheen
Benzene	0.370
Toluene	0.002
Ethylbenzene	0.09

1) Source: Standard NWB Licence requirement

Landfills will be constructed and operated at the Goose Property. The landfills will be used for the disposal of non-combustible inert waste, and as such, are expected to generate minimal leachate. The Goose Property landfills will be located within the Umwelt and TSF WRSAs that are shown in Figures A-11 and A-12. Any potential seepage from the Goose landfills will be collected along with mine contact water via the water management system of collection ponds and berms, and will therefore be subject to meeting the same mine contact water quality requirements. Inert non-combustible waste from the MLA will be temporarily stored at the site until the waste can either be transferred to the Goose Property or backhauled by sealift for final disposal. Additional details and figures on landfills can be found the Landfill and Waste Management Plan (SD-10).

7.5.4 Sewage Effluent Discharge Criteria

Treated sewage effluent discharged by the Project will meet the discharge limits in Table 7.5-4. Distinct criteria are presented for land discharges (ultimately reporting to freshwater), discharges to the active tailings management facility, and discharges to the tundra prior to entering the ocean based on an average flow rate of 170 m^3/day.

Table 7.5-4: Treated Sewage Effluent Criteria

Parameter	Land Discharges – Freshwater Environment MAC[1] (mg/L)	Discharges to Tailings Facilities MAC[1] (mg/L)	Land Discharges – Marine Environment MAC[1] (mg/L)
BOD_5	30	100	100
Total Suspended Solids (TSS)	35	120	120
Fecal Coliform (CFU/100 mL)	1,000	10,000	10,000
Ammonia (NH_3-N)	4[1], 8[2]		--
Phosphorus	4[1], 8[2]		--
Oil and Grease	No visible sheen	Not applicable[3]	No visible sheen
pH	between 6.0 - 9.5		between 6.0 - 9.5
Toxicity	Not acutely toxic		Not acutely toxic

1) MAC – Maximum Average Concentration
2) Maximum Grab Concentration
3) At the breach date of each tailings management facility, the discharge will need to meet Metal Mine Effluent Regulation (MMER) discharge limits.

Treated effluent water discharge locations are shown on Figure A-02 and A-09 for the Goose Property and MLA, respectively.

7.6 WINTER ICE ROAD

Overland access to the Project is possible between January and April each year. Annually, in early December, preparation for the WIR linking the MLA to the Goose Property will be undertaken. Once the WIR is ready for traffic, the equipment, materials, fuel, and supplies staged at the MLA will be transported by trucks over the WIR to the Goose Property. It is expected that the transfers will occur annually between January and April.

7.6.1 Winter Ice Road Construction and Use

Winter ice road construction will adhere to the following guidelines based on DFO Operational Statements:

- Use existing trails or WIRs wherever possible as access routes to limit unnecessary clearing of additional vegetation and prevent soil compaction;
- Construct approaches and crossings perpendicular to the watercourse wherever possible;
- Construct ice bridge and snow fill approaches using clean, compacted snow and ice to a sufficient depth to protect the banks of the lake, river or stream;
- Install sediment and erosion control measures before starting work to prevent the entry of sediment into the watercourse. Inspect the installed control measures regularly during the course of construction and decommissioning activities and make all necessary repairs if damage occurs;
- Operate machinery on land or on ice, and in a manner that minimizes disturbance to the banks of the lake, river or stream;
- Ensure that the intakes are sized and adequately screened to prevent debris blockage and fish mortality;
- Crossings do not impede water flow at any time of the year;
- When the crossing season is over and where it is safe to do so, create a v-notch in the centre of the ice bridge to allow it to melt from the centre, and to also prevent blocking fish passage, channel erosion and flooding. Compacted snow should be removed from snow fills prior to the spring freshet;
- Stabilize any waste materials removed from the work site to prevent them from entering the lake, river, or stream. This could include covering spoil piles with biodegradable mats or tarps; and
- The site should be stabilized using effective sediment and erosion control measures. In areas with permafrost, care should be exercised to ensure these measures do not cause thawing or frost heave.

Water withdrawal for the construction of WIRs will also adhere to the following DFO guidelines taken from the *Protocol for Winter Water Withdrawal from Ice-Covered Waterbodies in the Northwest Territories and Nunavut* (DFO 2010):

- In one ice-covered season, total water withdrawal from a single waterbody is not to exceed 10% of the available water volume;

- In cases where there are multiple users withdrawing water from a single waterbody, the total combined withdrawal volume is not to exceed 10% of the available water volume; and
- Only waterbodies with a minimum unfrozen water thickness of 1.5 m under ice should be considered for water withdrawal.

Water for the WIRs will be drawn from various sources along the WIR alignment. The supply locations and consumption rates will be provided at least 60 days prior to water withdrawal. Consistent with the Project terms and conditions (NIRB 2017), Sabina will provide bathymetry, depth, and location of proposed water withdrawal sites, volumes to be extracted, anticipated water level decreases, and fish habitat features within each waterbody proposed to be used for winter water withdrawal in support of the annual construction of the WIRs. If additional waterbodies are required, Sabina will provide all required information on the additional proposed lakes prior to the use of the waterbodies.

In addition, Sabina will implement all applicable DFO BMPs to avoid and mitigate serious harm to fish as a result of the construction, operation, and decommissioning of WIRs, and from under ice water withdrawals. This includes adequately screening the water intakes pipes to prevent impingement and entrainment of fish.

8. Water Management Phases

Water management throughout the mine life is described in a series of phases:

- Phase 1: Construction (Year -3 to Year -1)
- Phase 2: Operations (Year -1 to Year 10)
- Phase 3: Closure (Year 10 to Year 18)
- Phase 4: Post-Closure (Year 18 +)

These phases are illustrated in Figures A-03 through A-11. The Operations Phase (Phase 2) is subdivided into three stages; each stage represents the duration of tailings deposition in a single TSF. The three stages are:

- Phase 2, Stage 1: Tailings Storage Facility (Year -1 to Year 2)
- Phase 2, Stage 2: Umwelt Pit (Umwelt TF) (Year 2 to Year 6)
- Phase 2, Stage 3: Goose Main Pit (Goose Main TF) (Year 6 to Year 10)

The following subsections describe the water management details of each phase and stage.

8.1 PHASE 1: CONSTRUCTION

A summary of the key water management activities during Phase 1 are included in Table 8.1-1. Further details on the water management activities are included in the subsections that follow. General water management activities in this phase are also depicted in Figure A-03.

Table 8.1-1: Summary of Water Management Activities during Phase 1

Mine Year	Figure	Water Management Activities
-3	A-03	• Water discharge infrastructure is constructed at Goose Lake to prepare for fish out and dewatering activities. • Llama Lake is partially dewatered to Goose Lake. Portion of water is treated for TSS. o Llama Lake becomes Llama Reservoir, which stores contact water throughout Construction. o Non-contact diversion berms are constructed to divert runoff from entering Llama Reservoir. • Umwelt Lake is fully dewatered to Goose Lake to allow for construction of the Saline Water Pond. Portion of water is treated for TSS.
-2		• The Saline Water Pond is constructed. • Contact water diversion berms are constructed in the current development area (near Llama and Umwelt); event pond areas are constructed in conjunction with berm construction: o The Ore Stockpile Pond is constructed. o The Umwelt WRSA Pond is constructed. o The Primary Pond is constructed. • Pumping of contact water that is collected in the ponds to the Llama Reservoir begins. • Treatment of contact water in Llama Reservoir begins during the open water season, which is fully dewatered and discharged into Goose Lake.
-1		• Treatment of contact water in Llama Reservoir continues and is completed during the open water season. • Groundwater from Llama Underground mining operations is pumped to the Saline Water Pond. • One culvert crossing location in the Goose Airstrip and four culvert crossing locations in the all-weather roads are constructed. • Water intake infrastructure is constructed at Big Lake to meet the freshwater demands for the camp. • Water intake infrastructure is constructed at Goose Lake to meet the freshwater demands for construction and the Process Plant. • The TSF Containment Dam and TSF South Dyke are constructed; the downstream collection berm is also constructed.

8.1.1 Lake Dewatering

Llama Lake will be partially dewatered to Goose Lake in the open water season of Year -3 to create a temporary reservoir for contact water that will be collected throughout the Construction Phase. Llama Lake has a natural capacity of 1.1 Mm^3; 0.65 Mm^3 of which will be dewatered in Year -3. Prior to dewatering, the Southwest, West, East, and South Llama Lake diversion berms will be constructed to divert upstream non-contact runoff from entering Llama Lake.

Umwelt Lake, which has a natural capacity of 0.24 Mm^3, will be completely dewatered in Year -3. Dewatering will allow for construction of the Saline Water Pond.

Water from Llama and Umwelt lakes may be stored and directed to the Process Plant for use water during Operations.

In advance of dewatering, a fish-out program will be completed. For additional information related to conservation, and mitigation measures to be implemented refer to Section 9.3.

8.1.2 Water Treatment

A WTP will be operational in the open water season at the Goose Property in the Construction Phase to initially dewater Llama and Umwelt lakes in order to create storage for contact water and saline water, respectively.

It is assumed that 50% of the water from both lakes can be dewatered directly to Goose Lake, while the other 50% will require treatment for TSS prior to discharge to Goose Lake. If TSS is higher than expected, a greater percentage of water will be treated. Any treatment sludge generated will be disposed of in the Umwelt WRSA. Once lake dewatering is complete, lake bottom sediments within the pit boundaries will be excavated and placed in the Umwelt WRSA.

Contact water collected in the Llama Reservoir will be treated during the open water season of Year -2 and Year -1. The treated water will then be discharged into Goose Lake.

8.1.3 Open Pits

The development of Umwelt Open Pit will commence during the Construction Phase. Water will be collected in the Umwelt Open Pit using sumps and will be pumped to the Primary Pond. Refer to Section 5.1.3 for more information on groundwater inflows.

8.1.4 Underground Facilities

Groundwater inflows in the Llama Underground workings are expected in Year -1 during development. All groundwater inflows will be pumped to the Saline Water Pond for storage during the Construction Phase.

8.1.5 Tailings Storage Facility

Milling may commence towards the end of the Construction Phase. Any tailings generated during the Construction Phase will be deposited in the purposed-built TSF, located 2 km south of Goose Main Open Pit (MAD Appendix A, base Figure 3).

Containment will be achieved with construction of a frozen foundation dam with a GCL on the northern end of the facility (TSF Containment Dam) and a small control structure at the south end of the facility (TSF South Dyke). The TSF will be constructed prior to the Process Plant starting production. Construction of the TSF Containment Dam and TSF South Dyke will start at the end of Year -2. Refer to the Tailings Management Plan for further details on the TSF.

The GCL is the preferred liner option for the TSF Containment Dam in consideration of freeze thaw effects, hydraulic conductivity, and installation. Laboratory and field testing has shown that impacts of freeze-thaw cycles on the hydraulic performance GCLs is minimal (Kraus et al. 1997). The GCL hydraulic conductivity, which specifically accounts for predicted porewater chemistry, is estimated to be between 10^{-9} and 10^{-8} cm/s, which is within manufacturer's product specifications. From an installation perspective, GCL liners are significantly more robust than other thinner geomembranes (e.g., LLDPE). Any puncture in the GCL will self-heal once the GCL is hydrated, due to the soft nature of the hydrated clay that would migrate into the puncture defect, thereby sealing it.

8.1.6 Waste Rock Storage Areas

Runoff and seepage from the Umwelt WRSA will be collected in perimeter berms and directed towards collection ponds (Primary Pond and Umwelt WRSA Pond). Separate berms will be used to direct non-contact surface water away from the WRSA, to minimize the amount of contact water that needs to be managed.

8.1.7 Ore Stockpile

The ore stockpile will be used for ore deposition in Year -2 and Year -1 from mining of Umwelt Open Pit; this will occur prior to the Process Plant becoming operational. Runoff and seepage from the stockpile will be directed towards the Ore Stockpile Pond via the Ore Stockpile Pond Diversion berm. This pond will be contained by the Ore Stockpile Containment Dam. Water from the Ore Stockpile Pond is pumped to the Primary Pond, which is ultimately pumped to the Llama Reservoir during the Construction Phase (Year -3 and beyond).

8.1.8 Saline Water Pond

Umwelt Lake will be dewatered to construct the Saline Water Pond. To minimize surface flows towards the Saline Water Pond, it will be isolated by means of diversion berms. The South and East Containment Dams will be constructed in Year -2, as well as the diversion berms around the Saline Water Pond's perimeter. The pond will be completed before receiving saline water inflows pumped from the Llama underground development, which will first occur in Year -1.

To manage saline groundwater and minimize potential associated impacts to permafrost, soil, surface water vegetation and wildlife, Sabina is committed to providing additional details reflecting any direction provided by the NIRB and NWB. Sabina proposes to include a Saline Water Management Plan as a component of the next revision to the Water Management Plan. For an overview of the commitment, refer to Section 9.4.2.

8.1.9 Stream Diversions

The majority of Project infrastructure has been located to avoid fish-bearing water and, wherever possible, to avoid encroaching on freshwater fish habitat. Additional mitigation to avoid adverse effects on fish is required for streams that may experience reduced discharge resulting in the potential for increased fish and egg stranding. In these cases, all potential fish use (migration, spawning, rearing, and egg incubation) will be prevented by creating permanent fish barriers at migratory pathways into channels prior to ice melt. These barriers will be constructed at the following locations:

- Umwelt Outflow at the limit of the southern flowing downstream end where the stream connects to eastern flows toward Goose Lake;
- Goose Inflow East at the downstream limit where the stream enters Goose Lake; and
- Rascal Stream East: upstream of the airstrip culverts.

Blocking fish access to these locations will involve creating a permanent impassable fall or cascade barrier to prevent fish access to upstream water management areas.

The Goose Airstrip is constructed in Year -1, crossing the Rascal Stream East. A culvert crossing denoted as the Goose Airstrip Culvert, or C3 in Figure A-03, will facilitate drainage through the Goose Airstrip. A second culvert crossing, denoted as the Goose Culvert (C1), will be installed on the Rascal Stream East in the haul road, downstream of the airstrip and upstream of the Rascal Stream East discharge into Goose Lake. Three additional culvert crossings along the haul road are constructed in Year -1, including the

Goose Creek Culvert (C5) south of Umwelt Pit, the Echo Culvert (C4) north of the Echo Pit development area, and the Gander Pond Culvert (C2), northwest of the Goose Airstrip. Further culvert details can be found in Section 6.5.

To allow for mining of Goose Main Pit, a diversion berm (Goose Diversion) is proposed to route non-contact water around the open pit and into Goose Lake. Construction will be completed during winter, while the lake and outlets are completely frozen to eliminate any need for cofferdams. No instream blasting is currently planned during these works.

8.1.10 Roads

All-weather roads at Goose Property include haul roads, which will connect the ore bodies to the WRSAs and the Plant Site; and service roads, which connect other on-site infrastructure. Where possible, the roadways servicing the mining area will be constructed so that drainage will be directed towards the proposed contact water management infrastructure. Five culvert crossings will be installed within the Goose Property, four of which cross all-weather roads; culvert details are included in Section 6.5.

8.1.11 Marine Laydown Area

Water management strategies at the MLA will remain the same during the Construction Phase (Year -4 to Year -1) and the Operations Phase (Year 1 to Year 10) (Figure A-09). The MLA will not require ponds or other diversion infrastructure for water management purposes and will discharge towards Bathurst Inlet along the same flow paths as the predevelopment topography.

MLA infrastructure will be designed such that footprints are minimized to limit changes to local drainage patterns. Roads and pads, which will be constructed using geochemically suitable material, will be designed to have runoff as dispersed sheet flow to minimize channelized flow.

Non-contact water will be diverted around MLA infrastructure as much as practicable and directed to natural downstream drainage networks to maintain local drainage patterns. Clean water and snow will be managed to restrict contribution to potentially poor-quality water, and will be diverted to maintain natural drainage networks as much as possible.

8.2 PHASE TWO: OPERATIONS

A summary of the key water management activities during Operations (Phase 2) are included in Table 8.2-1 to Table 8.2-3. The tables break Phase 2 into its three stages, based on the active tailings management facility at the time. Further details of the water management activities are included in the subsections following the tables.

Table 8.2-1: Summary of Water Management Activities during Phase 2, Stage 1

Mine Year	Figure	Mine Development Sequence and Key Activities
1	A-04	• Milling operations begin (* this could occur as early as Y-1,Q4). • Tailings deposition begins in the TSF (* this could occur as early as Y-1,Q4). • The TSF downstream berm (called the TSF WRSA Diversion Berm) will collect any seepage from the TSF; this seepage will be pumped back into the TSF, or discharged to the environment, as appropriate. • The Llama WRSA containment dam and diversion berm are built, which create the Llama WRSA Pond. • Contact water from the Llama WRSA Pond and the ponds constructed in Phase 1 will be pumped to the TSF for as long as tailings deposition in the TSF occurs (until the end of Stage 1). • Reclaim water is pumped from the TSF supernatant pond to the Process Plant. • Umwelt Underground groundwater is pumped to the Saline Water Pond, which continues throughout underground operations • Groundwater and runoff collected in Llama Open Pit is pumped to the Saline Water Pond, which continue throughout open pit operations
2	A-04	• A non-contact water diversion berm is constructed at Goose Main Open Pit to divert water away from the pit, towards Goose Culvert, and into Goose Lake. • At the end of Year 2, tailings deposition is transitioned from the TSF into Umwelt Pit (Umwelt TF).

Table 8.2-2: Summary of Water Management Activities during Phase 2, Stage 2

Mine Year	Figure	Mine Development Sequence and Key Activities
2	A-05	• Tailings deposition begins in Umwelt TF (anticipated in Y2Q4). • The Echo WRSA Pond is constructed. • The TSF becomes the TSF WRSA. Water collected in the TSF WRSA Pond is pumped to the Echo WRSA Pond, then to Umwelt TF. Reclaim water is pumped from the TSF until it is dewatered and reclaim is no longer possible. • The TSF WRSA diversion berm collects seepage and runoff, which in turn is pumped back into the TSF WRSA Pond. • Contact water in Goose Main Open Pit is pumped to the Echo WRSA Pond (and subsequently to the Umwelt TF and then Llama Reservoir).
3	A-05	• Llama Open Pit permanently becomes Llama Reservoir and stores excess contact water.
4	A-05	• The Llama Reservoir non-contact diversion berms are breached, allowing the reservoir to begin to fill. • The East Echo Diversion Berm is constructed and diverts non-contact water away from Echo Pit and into the Echo Diversion Pond, which is contained by the Echo Containment Dam. Non-contact water is then pumped to the West Echo Diversion Berm and flows to the Echo Culvert and into Goose Lake. • A contact water diversion berm is constructed to divert contact water from the Echo WRSA into the Echo WRSA Pond. • Groundwater from Goose Main Underground operations is pumped to the Saline Water Pond. • Ground water inflow to the Goose Main Underground workings is pumped to the Saline Water Pond. • From Year 4 to Year 9, groundwater from the Saline Water Pond will be pumped to the bottom of the partially flooded Llama Reservoir to create a meromictic lake. In total, approximately 1 Mm^3 of saline water will be pumped into the Llama Reservoir.

(continued)

Table 8.2-2: Summary of Water Management Activities during Phase 2, Stage 2 (completed)

Mine Year	Figure	Mine Development Sequence and Key Activities
5	A-05	• 325,000 m³ of saline water is pumped from the Saline Water Pond into the Llama Underground mine; begins and is completed.
6	A-05	• Tailings deposition in Umwelt TF is completed.

Table 8.2-3: Summary of Water Management Activities during Phase 2, Stage 3

Mine Year	Figure	Mine Development Sequence and Key Activities
6	A-06	• Tailings deposition in Umwelt TF is completed and tailings deposition is transitioned to the Goose Main Open Pit (Goose Main TF). • From Year 6 to Year 10, contact water collected in the TSF WRSA, Ore Stockpile Pond, Primary Pond, and Echo, Umwelt and Llama WRSA Ponds are pumped to Goose Main TF.
7	A-06	• Water treatment plant becomes operational year-round from Year 7 to Year 10 at the Goose Main TF with treated water recirculated back into Goose Main TF.
8	A-06	• Water management strategies beginning in Year 6 and Year 7 continue.
9	A-06	• Water management strategies beginning in Year 6 and Year 7 continue.
10	A-06	• Year-round treatment of Goose Main TF water is completed, treatment during open-water season only begins at the same rate. • All remaining saline water in the Saline Water Pond is pumped to the underground workings of Umwelt and Goose Main.

8.2.1 Open Pits and other Contact Water

During Operations, precipitation will accumulate in open pits, which will be collected using in-pit sumps. Sumps will pump water across the site, eventually discharging to the active tailings management facility, or in the case of Llama Pit, the Saline Water Pond. Other contact water across the mine site will be collected by contact water berms and channeled into the Primary Pond or into a temporary holding pond (WRSA ponds). In Stage 1, the final destination for contact water is the TSF; in Stage 2, the final destination is the Llama Reservoir or the Umwelt TF (when Umwelt TF is nearing capacity, excess is pumped to the Llama Reservoir); and in Stage 3, the final destination is the Goose Main TF.

During Stage 2, when Umwelt TF becomes the active tailings management facility, the Primary Pond and the Umwelt WRSA Pond are breached via a culvert crossing through the haul road, allowing water to flow by gravity directly into the Umwelt TF. When Llama open pit mining is completed in Year 3, the Llama WRSA Pond is also breached, allowing runoff to flow by gravity directly into the Llama Reservoir.

The Llama Reservoir will be used to store saline water beginning in Year 4. Water will be pumped from the Saline Water Pond into the bottom of the Llama Reservoir with the intent to create a meromictic (stratified) lake. The meromictic lake will have a freshwater cover and saline water is not expected to mix with the surface layer. The freshwater cover will consist of non-contact runoff water; the non-contact water berms surrounding the Llama Reservoir will be breached in Year 4 to allow the freshwater cover to form until the reservoir reaches capacity and overflows in Year 12. Further details on the meromictic lake are included in Appendix F of the Water and Load Balance Report (MAD Appendix E-2).

8.2.2 Water Treatment

Treatment is inactive between Year 1 and 6, but begins again year-round in Year 7 in the Goose Main Tailings Facility (Goose Main TF) to reduce metal and suspended solids loading in the facility. From Year 7 to Year 10, the Goose Main TF water is treated year-round and is circulated back into the Goose Main TF for use as reclaim water. Once mining is complete in Year 10, water treatment continues during the open water season only from the Goose Main TF, until Year 17, with the Property finally closed in Year 18.

8.2.3 Underground Facilities

Average groundwater inflows into the underground mines during the Operations Phase have been estimated for the Umwelt (379 m^3/d), Llama (283 m^3/d), and Goose Main (50 m^3/d) underground mines; inflows have been estimated to be as high as 596 m^3/d, 350 m^3/d, and 85 m^3/d, respectively. Total dissolved solids concentrations from the underground mine inflows are expected to be between 15,000 and 30,000 mg/L, particularly at the Umwelt and Goose Main deposits (FEIS Volume 2, Appendix V2-7A).

Groundwater accumulating in the underground workings will be pumped to the Saline Water Pond during the operational LOM. At Closure, water from the Saline Water Pond will be pumped back into the underground mines, and to the bottom of Llama Reservoir to create a meromictic lake.

Echo underground is located completely within permafrost and as such no groundwater inflows are expected to report to those workings.

8.2.4 Waste Rock Storage Areas

During the Operations Phase (Phase 2), water accumulating in the WRSA collection ponds at the Goose Property will be monitored and ultimately pumped to the active tailings management facility (Figures A-04 to A-06). Shallow groundwater around the WRSAs prior to freeze back will be intercepted by the diversion berms around each facility and will ultimately report to the event ponds, situated at the local topographic low points. The containment dams around each pond will be lined with geosynthetic materials (liners) which will be keyed into bedrock where possible. If bedrock is not practical, the liners will be keyed into the permafrost foundation. Further information on the design criteria and monitoring of the event ponds can be found in the Site-Wide Water Management Report (MAD Appendix E-2).

At Stage 1 of Operations, the TSF is the active tailings management facility and mining occurs at Umwelt and Llama open pits, and Llama and Umwelt underground facilities. As such, both Llama and Umwelt WRSAs are active waste rock facilities during this stage. Contact water from both the Llama and Umwelt WRSAs is diverted into the Llama WRSA Pond, the Umwelt WRSA Pond, and Primary Pond, all of which are pumped to the TSF.

During Stage 2 of Operations, Umwelt TF is the active tailings management facility and mining occurs at Llama Pit, Goose Main Pit, and Echo Pit, along with the four underground facilities. All four WRSAs (Llama, Umwelt, Echo, and TSF) will be progressively closed during this stage, and permafrost aggradation will happen in parallel. Water from all four WRSAs will continue to be collected during this stage and ultimately pumped to Umwelt TF. Water collected by the TSF WRSA Diversion Berm from seepage through the dam is pumped back to the TSF WRSA Pond. Water from the TSF WRSA Pond will be pumped to the Echo WRSA Pond, which in turn will be pumped to Umwelt TF.

During Stage 3 of Operations, Goose Main TF is the active tailings management facility and mining occurs in Umwelt, Goose Main, and Echo underground facilities only. All four WRSAs will be substantively closed during this stage, and permafrost aggradation will continue. Contact water from all WRSA ponds will be pumped to Goose Main TF, including any excess water from the Umwelt TF.

8.2.5 Ore Stockpile

During Operations, runoff water from the Ore Stockpile will be collected in the Ore Stockpile Pond, which will be pumped to the active tailings management facility.

8.2.6 Tailings Management Facilities

The tailings management strategy is based on the principle of maximizing the use of open pits for tailings storage. To that end, tailings will be stored in mined-out open pits as soon as the pits are available for tailings deposition (Table 8.2-4).

Table 8.2-4: Back River Property Tailings Management System Storage Requirements

Location	Stage	Period (Year and Quarter)	Tailings (tonnes)
TSF	1	Y-1 Q4 to Y2 Q3	3,777,749
Umwelt TF	2	Y2 Q4 to Y6 Q3	8,581,468
Goose Main TF	3	Y6 Q4 to Y10 Q2	7,446,079
Total Project		**Y-1 Q4 to Y10 Q2**	**19,805,296**

The TSF will store both tailings solids and supernatant water for the first two years of Operations. As development continues, the mined-out open pits of Umwelt and Goose Main will be used to store tailings and supernatant water. While each tailings management facility is active, it will also serve as the main source of reclaim water for the Process Plant, which will average 4,900 m^3/d.

A seepage analysis of the TSF Containment Dam liner predicts that minor seepage through the TSF Containment Dam at an anticipated rate of 1,210 m^3/year is expected while it is an active tailings management facility. The TSF WRSA Diversion Berm, constructed downstream of the TSF, will collect surface runoff and sub-surface seepage through the active layer, which in turn will be pumped back into the TSF. Once the TSF is closed, the TSF WRSA Diversion Berm will collect runoff from the TSF WRSA, which will ultimately be captured in the active tailings management facility. No seepage or discharge from the TSF WRSA collection pond during active TSF operations or once the TSF becomes a WRSA will be released to environment unless discharge criteria are met.

Seepage analysis for the TSF South Dyke was also completed during the FEIS process and flow is anticipated to be 92 m^3/year; this minimal seepage will be easily managed by intermittent pumping.

The bulk of tailings that will be stored in the TSF will have a moderate to high acid rock drainage (ARD)/metal leaching (ML) potential. During Operations, if tailings material that forms the TSF beaches is not buried under fresh material before a lag time on the order of 10 to 20 years is exceeded, then ARD could develop. This understanding of lag times has informed the tailings deposition plan in order to prevent the development of ARD. The water and load balance model has taken the tailings deposition schedule into account in the prediction of the TSF runoff quality.

8.2.7 Saline Water Pond

Saline water from the Llama, Umwelt, and Goose Main underground mines, and the Llama Pit, will be collected and pumped to the Saline Water Pond. In Year 4, saline water from the Saline Water Pond is pumped at a rate of 500 m^3/day to the bottom of the partially flooded Llama Reservoir, creating a meromictic (stratified) lake. In total, just over 1 Mm^3 of saline water will be pumped into the Llama Reservoir over the remaining LOM. Saline water will also be pumped into the mined-out Llama

Underground (Year 5), Goose Main Underground (Year 10), and Umwelt Underground (Year 10). Additional details regarding the Llama Reservoir meromictic system are presented in Appendix F of the Water and Load Balance Report (MAD Appendix E-2).

8.2.8 Explosives Manufacture and Storage

Pre-packaged explosives delivered by air will be used early in construction until an ammonium nitrate (AN) facility is constructed at the Goose Property. Ammonium nitrate for ANFO production will be delivered to the mine site in shipping containers. The storage of pre-packaged explosives and AN is expected to represent a low potential to impact water resources.

An explosives truck wash facility will be constructed and operated at the AN Facility. Wash water from this facility may be high in ammonia, suspended solids, and/or metals. This wash water will be treated at the AN Facility in an evaporator. Alternatively, the truck wash water will be transported to a water management pond for treatment or discharge as appropriate.

8.2.9 Marine Laydown Area

Water management strategies at the MLA will remain the same during the Construction Phase (Year -4 to Year -1) and the Operations Phase (Year 1 to Year 10) (Figure A-09). Refer to Section 8.1.11 for further details.

8.3 PHASE THREE: CLOSURE

Milling ends and closure begins in the second quarter of Year 10. The total duration of the closure period is 13 years, with a Closure Phase of 8 years and a Post-Closure Phase of 5 years. Water management during the Closure Phase relates to ongoing camp operation, passive filling of open pits, runoff control from WRSAs, and recirculation treatment within the Goose Main TF. The Plan will continue to be implemented until the contact water meets site-specific discharge limits and receiving water quality objectives. At that point, passive discharge to the environment will be possible. Complete details regarding the closure and reclamation of the site are presented in the Interim Closure and Reclamation Plan (SD-26).

Water management activities during the Closure Phase at the Goose Property are presented in Table 8.3-1 and are depicted in Figure A-07.

Further details regarding the closure activities outlined in 8.3.1 to 8.3.9 are discussed in the Interim Closure and Reclamation Plan.

Table 8.3-1: Diversion and Containment Berm Breach Schedule during Closure and Post-Closure Period

Mine Year	Figure	Structures to be Decommissioned	Notes
10-18	A-07	**Phase 3 – Closure**	
		Saline Water Pond Containment Dams and Berms	After dewatering of Saline Water Pond to underground workings and Llama Reservoir is complete
		Echo Non-Contact Water Diversion Berm	Pond floods into Echo Pit
		Echo WRSA Containment Dam and Diversion Berm	WRSA Pond floods into Echo Pit
		Primary Pond Containment Dam	Primary Pond floods to Umwelt TF
		Ore Stockpile Pond Containment Dam and Diversion Berms	Pond floods to Umwelt TF
		Llama WRSA Containment Dam (West)	Drains Llama WRSA Pond into Llama Reservoir
		Goose Non-Contact Water Diversion Berm	Allows Goose Main TF to overflow after treatment is completed
18 – 23	A-08	**Phase 4 – Post Closure**	
		Llama WRSA Diversion Berm and WRSA Pond Containment Dam (North)	WRSA will be fully capped and frozen, no need to divert water any longer
		Umwelt WRSA Diversion Berm and WRSA Pond Containment Dam	WRSA will be fully capped and frozen, no need to divert water any longer
		Main TSF Containment Dam and TSF WRSA Diversion Berm	TSF WRSA Pond will be breached towards Goose Main TF and onwards to Goose Lake
		Goose Main Pit Diversion Berm	Restores natural drainage and allows Goose Main TF to fill

8.3.1 Culvert Closure

Culverts will be removed from all-weather roads and the natural drainage restored. Roads will otherwise remain intact to ensure preservation of permafrost and facilitate long-term site access for monitoring and inspection.

8.3.2 Berm Closure

During the closure period, the diversion and containment berms will be breached to restore natural drainage and allow runoff to naturally fill the open pits. Table 8.3-1 presents a breaching schedule for the diversion and containment structures at the Goose Property.

Berm closure is not expected to significantly impact the water quality of site runoff water. All runoff is expected to meet the site runoff quality standards as indicated in Table 7.5-1. Water quality monitoring will occur at strategic locations throughout Closure to identify whether water quality criteria are being met.

Breached diversion structures will remain in place during the Post-Closure Phase. Collection ponds will have been breached, liners removed and landfilled, and the breaches re-contoured and armoured (if necessary) to allow for passive runoff.

8.3.3 Open Pit Closure

The open pits will be passively filled by breaching various water management structures, thereby allowing both contact and non-contact water to fill the pits. Pit water will meet applicable discharge criteria and then be allowed to overtop into nearby watercourses.

Table 6.1-2 provides a summary of the average monthly water quality concentrations at the time of flooding and the average open water long-term steady state conditions in each of the flooded open pits. These predictions are compared to MMER discharge limits. All parameters in each pit lake facility are expected to meet MMER limits at the time of flooding and long-term steady state conditions are expected to meet CCME guidelines or SSWQOs as appropriate. The results in Table 6.1-2 include the effects of water treatment required in Goose Main TF to reduce TSS, arsenic, and copper concentrations.

Llama Pit, which was already partially flooded by the operation of Llama Reservoir, will be further flooded as all Llama diversion berms will be breached. Runoff from the Llama WRSA will also be routed to Llama Reservoir. The Llama Reservoir will overtop under average hydrologic conditions in Year 12 and discharge towards the reclaimed Umwelt Lake.

Umwelt Pit will be allowed to fill with catchment water, as well as water from the breached Primary Pond and breached Ore Stockpile Pond. Water from the Umwelt WRSA will also be routed to Umwelt Pit. Umwelt Pit will be breached at the north end and will overtop in Year 13 under average hydrologic conditions.

Echo Pit will be allowed to fill with catchment water from the south, as well as water from the breached Echo WRSA Pond. Echo Pit is expected to overtop in Year 14 under average hydrologic conditions, and will eventually discharge into Echo Stream, which flows into Goose Lake.

Recirculation treatment in Goose Main Pit will continue during the open water season until Year 17, at the same time the pit will overtop, under average hydraulic conditions. Water from the TSF WRSA Pond will continue to be pumped into Goose Main TF throughout this period as well. The pit will be breached at the north end into Goose Lake once water quality objectives have been met.

Pit lake water quality monitoring will be conducted to ensure it meets discharge criteria prior to pit overtopping and passive discharge. In the unlikely event that the water in any of the pit lakes is not suitable for discharge, the pit lake water will be batch-treated to address remaining water quality impairments. Five years of post-closure water quality monitoring will continue for each open pit to ensure that water quality objectives are met.

8.3.4 Underground Facility Closure

During mine operations, saline groundwater entering the underground workings will be pumped to the Saline Water Pond at surface. At Closure, the Saline Water Pond will be dewatered back into Llama, Umwelt, and Goose Main underground mines. Vent raises and underground portals will be capped with concrete and waste rock, respectively. Echo underground mine will be filled with natural runoff.

8.3.5 Waste Rock Storage Area Closure

During Operations, potentially acid generating (PAG) WRSAs will be progressively covered beginning in Year 2 with a 5-m cap of NPAG waste rock to promote the aggradation of permafrost into the WRSAs so that the PAG rock remains frozen. Final sloping and minor NPAG covering activities will occur during the Closure Phase. Permafrost aggradation into the WRSAs will be monitored during placement and once the WRSAs are closed.

Once the WRSA runoff consistently meets the site-specific contact water discharge criteria following completion of WRSA operations, the WRSA collection ponds will be breached and removed, and the final post-closure discharge will be established. Five years of post-closure water quality monitoring from the WRSAs will take place to confirm water quality objectives are being met.

8.3.6 Ore Stockpile Facility Closure

Milling of all remaining stockpiled material will be completed in Year 10. The Ore Stockpile Pond Containment Dam will be breached at the beginning of the Closure Phase so the pond flows towards Goose Neck. No remaining seepage or runoff from the area is expected. Five years of post-closure water quality monitoring will be conducted in the area to confirm runoff meets water quality objectives.

8.3.7 Tailings Management Facility Closure

No tailings deposition or milling will occur during the Closure period. Umwelt TF will be flooded during the Closure period as proximal water management berms are breached and it is allowed to passively fill. Confirmatory water quality monitoring will take place before the pit is breached to confirm water quality objectives have been met.

Seepage collected by the TSF WRSA Diversion Berm will continue to be pumped back into the TSF WRSA Pond. Water collected in the TSF WRSA Pond will continue to be pumped to the Goose Main TF. This process will continue until Year 17 when Goose Main TF is full. At the end of Closure (Year 18), both the TSF Containment Dam and the TSF WRSA Diversion Berm will be breached, allowing any remaining runoff to flow towards the Goose Main TF.

Table 8.3-2 presents a summary of the expected water quality discharge from the TSF at Closure, when the TSF WRSA is frozen.

Table 8.3-2. Water Quality Prediction Results for the TSF at Closure

Parameter	MMER (mg/L)	Closure Concentration (mg/L)
Total CN as N	1	0.00016
Chloride	n/a	0.30
Ammonia	6	0.022
Nitrate as N	n/a	0.035
Nitrite as N	n/a	0.0019
Aluminum	n/a	0.28
Arsenic	0.5	0.067
Boron	n/a	0.0015
Cadmium	n/a	0.0000030
Copper	0.3	0.0081
Iron	n/a	0.30
Lead	0.2	0.000015
Mercury	n/a	0.000038
Molybdenum	n/a	0.0036
Nickel	0.5	0.042
Selenium	n/a	0.0014
Silver	n/a	0.000031
Thallium	n/a	0.000015
Uranium	n/a	0.0000030
Zinc	0.5	0.012

Recirculation treatment within the Goose Main TF will continue during the open water season at a rate of 8,500 m^3/d until it overtops in Year 17, under average hydrologic conditions, and water quality monitoring has confirmed that the water quality objectives have been met. The Goose Main Pit Diversion Berm and the Goose Main Pit rim will then be breached to allow water to flow into Goose Lake. The closure period may be extended if water quality objectives are not satisfied, thus necessitating further treatment.

Five years of post-closure water quality monitoring will be conducted at the former tailings facilities to confirm water quality objectives are being met.

8.3.8 Saline Water Pond Closure

The Saline Water Pond will be dewatered into Llama, Umwelt, and Goose Main underground mines. Once the Saline Water Pond is dewatered, the top 2 m of sediment around the original footprint of Umwelt Lake, but within the Saline Water Pond footprint, is planned to be excavated and placed into Goose Main TF. The remaining chloride in the porewater of the sediments underlying the original footprint Umwelt Lake is assumed to diffuse upwards into Umwelt Lake within the first year of it being re-established. This chloride load has been accounted for in the water and load balance model, which predicts that CCME long term guidelines for chloride will be exceeded in the first year after closure at point PN04, but will not exceed the CCME short term guideline of 640 mg/L (FEIS Volume 2, Appendix V2-7H). No further exceedances were predicted after the first year of closure.

The proposed depth of sediment excavation was determined by a chloride diffusion model that calculated the concentration of chloride in the porewater of the sediment underlying the Saline Water Pond over time, based on the predicted chloride concentration in the Saline Water Pond water itself. The model predicted that the chloride concentration in the porewater of the sediments underlying the Saline Water Pond would be 120 mg/L, equivalent to the long term CCME guideline for chloride. Should the chloride concentration at the 2-m depth be higher than the long term CCME guideline, more sediment around the original footprint of Umwelt Lake will be excavated and placed in the Goose Main TF. The chloride load from the sediments deposited in the Goose Main TF has been accounted for in the water and load balance model, and no exceedances have been modelled at the control point PN06, which is located downstream of Goose Main TF.

Following excavation of the lake bed sediment, the Saline Water Pond diversion berms and dams will be breached allowing Umwelt Lake to re-establish. No further water management activities at the Saline Water Pond will take place during Closure. Water quality monitoring will happen during the closure and five-year post-closure periods to confirm water quality objectives are being met.

8.3.9 Water Treatment Closure

As mentioned above, 8,500 m^3/d of recirculation treatment for TSS, arsenic, and copper will continue during the open water season throughout Closure at the Goose Main TF. Based on the load balance model, water quality within the Goose Main TF is expected to meet or exceed water quality objectives by Year 17, the time at which Goose Main TF is also expected to flood. Once this has been confirmed by water quality sampling, all pumping and piping infrastructure, as well as the WTP itself, will be dismantled and landfilled. Sludge produced from water treatment during the Closure period will also be landfilled.

8.3.10 Marine Laydown Area Closure

Water management strategies at the MLA will remain the same during the Closure Phase (Year 11 to Year 18) and the Post-Closure Phase (Year 19 to Year 23).

The MLA will require minimal closure with the respect to water management as the site does not require ponds or other diversion infrastructure for water management purposes (Figure A-10). Decommissioned roads and pads, which will be constructed using geochemically suitable material, will be designed to have runoff as dispersed sheet flow to minimize channelized flow.

Refer to the Interim Closure and Reclamation Plan for discussion on other closure aspects of the MLA.

8.4 PHASE FOUR: POST-CLOSURE

Water management activities during the Post-Closure Phase at the Goose Property are presented in Table 8.3-1 and are depicted in Figure A-08. In Year 17, water treatment from the Goose Main TF will be decommissioned. The Goose Main Diversion Berm, south of the Goose Main TF, will be breached, allowing Rascal Stream East to discharge into the Goose Main TF. The Goose Airstrip Culvert will also be removed, and the Goose Airstrip will be breached. The Goose Main TF will be allowed to fill with non-contact water to create a pit lake, and will be breached to discharge towards the tributary to Goose Lake, along the historic Goose Inflow East location.

The TSF WRSA Pond is also breached in Year 18, allowing runoff to flow into the Goose Main TF. At this time, all dams and berms on site will be breached, and all culvert crossings removed.

Water management strategies at the MLA will remain the same during the Closure Phase (Year 11 to Year 18) and the Post-Closure Phase (Year 19 to Year 23) (Figure A-10).

8.5 WATER MANAGEMENT – CARE AND MAINTENANCE

Temporary closure (also termed Care and Maintenance) is defined as the cessation of mining and processing operations for a finite period of time with the intention of resuming operations upon resolution of the cause of cessation (MVLWB/AANDC 2013). Care and Maintenance activities will depend on the phase at which cessation of operations takes place. For more details, refer to the Interim Mine Closure and Reclamation Plan.

Monitoring will take place and continue as outlined in Section 10 at whatever phase cessation occurs. Key surface water infrastructure will be maintained through Care and Maintenance to ensure proper operation. Depending on the stage at which temporary closure occurs, the water level in the active tailings management facility at the time may need to be monitored as there will be a net buildup of water due to precipitation inflows and no water reclaim for processing. Should temporary closure occur for an extended period of time (i.e., two or more years), it may be necessary to begin pumping from the active tailings management facility and treating the excess water for discharge.

9. Environmental Protection Measures

9.1 GENERAL OBJECTIVES

The purpose of environmental protection measures for site water management is to eliminate or reduce Project effects on water quality.

The main objectives of Sabina's water management strategies are to:

- Minimize the amount of water that contacts mine ore and wastes, which ultimately reduces the volume of water requiring management;
- Appropriately manage all contact water and discharges to protect local aquatic resources; and
- Implement water conservation and recycling to maximize water reuse and minimize the use of natural waters.

Protection measures may include the planning and design of engineered structures, the application of control technologies, the implementation of BMPs, and specific requirements from regulatory authorizations. Monitoring of the protection measures and adaptive management are also an integral part of effective environmental protection measures.

Pending further direction from the NWB, Sabina is committed to maintain a Water Management Plan designed to the above main objectives. The plan includes monitoring that demonstrates that contact water (runoff and shallow groundwater) from the ore storage and WRSAs is adequately captured and managed consistent with the MWRMP (SD-08).

9.2 WATER USAGE

The following protection measures will be applied to water usage:

- Freshwater intake and discharge pipelines will be designed to limit erosion and sedimentation, protect against freezing, and accommodate peak flows;
- Controlled construction of the engineered intake and discharge pipelines will ensure minimal changes in turbidity and resuspension of sediment;
- All material used in construction will be clean, free of sediment, and geochemically stable; and
- All intake and discharge pipelines will be screened in accordance with the *Freshwater Intake End-of-Pipe Fish Screen Guideline* (DFO 1995). The water withdrawal rate will be controlled such that fish do not become impinged on screens.

Water will be recycled to the maximum extent possible. The most significant water recycling activities will be within the tailings management facilities. The TSF and the Umwelt TF and Goose Main TF will store both tailings solids and supernatant water. The supernatant water will include contact water from the open pits and WRSAs. Water will be recycled and form the main source of water for the Process Plant.

9.3 CONSERVATION MEASURES

Long-term water usage has been closely evaluated; the focus has been on identifying maximum water use, while protecting fish and fish habitat. Short-term use will be required for various Project activities (i.e., WIR construction, dust suppression, etc.). Potential short-term water sources will be evaluated in advance to determine if they will be adequate for the activity in accordance with the DFO (2010) winter water withdrawal guidelines, including:

- Total water withdrawal from a single waterbody will not exceed 10% of the available water volume; and
- Only waterbodies with a minimum unfrozen water thickness of 1.5 m under ice will be considered for water withdrawal.

Sabina is committed to minimize and mitigate impacts to fisheries. For fish bearing crossings, Sabina will implement all applicable DFO BMPs to avoid and mitigate serious harm to fish as the result of water crossing construction, operation, and decommissioning for all fish-bearing water crossings. These measures will include, but are not limited to, appropriate design of water crossings to facilitate fish passage at both high and low flows; timing windows that incorporate spawning, incubation and hatch times for all species using watercourses; sediment and erosion control; protection of riparian vegetation; and other forms of bank stabilization.

Sabina will ensure that all project infrastructure in watercourses are designed and constructed in such a manner that they do not unduly prevent and limit the movement of water in fish bearing streams and rivers, unless otherwise authorized by DFO. In addition, unless otherwise directed by DFO, Sabina's monitoring program for culverts on fish bearing watercourses during Construction, Operations, and Closure phases will include measures to ensure that barriers to fish passage do not form over time as a result of crossing damage due to ice blockage, flooding, or movement of debris; all of which may occur at freshet. Detailed design drawings and an updated monitoring program for culverts on fish bearing watercourses will be produced prior to construction.

Sabina will continue to engage DFO, the Kitikmeot Inuit Association, and other interested parties during the regulatory phase on the design, construction, and operation of adequate fish passage to permit migration of Arctic Grayling from Goose Lake to natural spawning and rearing habitat located in upper Rascal Stream East, south of the planned airstrip. Any additional information required to ensure the design of the fish passage will be completed prior to significant construction activities at the Goose Property. Specifically, Sabina will provide annual monitoring updates regarding the Rascal Stream Fish Passage that enables parties to determine its effectiveness.

Inline with dewatering, a fish-out program will be completed. The fish-out program will follow the DFO's *General Fish-Out Protocol for Lakes and Impoundments in the Northwest Territories and Nunavut* (Tyson et al. 2011). Lake dewatering will commence once the catch-per-unit-effort (CPUE)/recapture phase of the fish-out program has been completed (typically between August and September).

The fish-out program will aim to be completed outside of periods where there is high migratory bird use of the lake (i.e., nesting, brood rearing, and migration periods) to avoid the incidental take of migratory birds through entanglement in gill nets. Mitigation measures for minimizing mortalities of diving birds may include increasing the visibility of gill nets, use of visual or auditory deterrents to prevent birds from landing on the lake during active gill-netting, monitoring migratory bird usage of the lake, determining high use feeding areas prior to setting gill nets and avoiding these areas, and reporting of by-catch to adjust mitigation measures.

9.4 GENERAL SITE RUNOFF

Collected water or runoff that meets the criteria specified in Table 7.5-1 will be discharged to land, and where possible at a minimum setback of 31 m from a waterbody. To protect the freshwater environment during construction and decommissioning activities, the Project will minimize runoff and the transport of material into freshwater by the following planning and design measures:

- WRSAs will be confined to the local watersheds where the deposits are located to limit potential effects on water quality in local drainage areas;
- Infrastructure will be located, whenever feasible, on competent bedrock or appropriate base material that will limit permeability and the transport of potentially lower quality water into the active layer and ultimately to the freshwater environment;
- Footprint areas of Project components will be minimized to the extent practicable, such as locating infrastructure nearer to the central location of Project sites around the deposits; and
- The landscape will be reclaimed as soon as feasible to minimize erosion potential.

At select water crossings, pumping or siphoning may be employed to facilitate the transfer of water from one side of the structure to the other side. Pumping can also serve as a temporary solution during freshet or prior to a culvert installation.

9.4.1 Sediment and Erosion Control Measures

Surface water will be managed within the Project footprint such that sediment-laden runoff is minimized, intercepted, and/or treated prior to entering downstream receiving waters or mine process facilities. Effective sediment control depends on the isolation of easily-eroded, disturbed ground surfaces.

Measures will be implemented to reduce the quantity of runoff where the mobilization of sediments cannot be eliminated. Sediment-laden water will be captured and routed to sediment basins.

Sediment and erosion management and control during initial and ongoing construction may involve establishing contact water collection ditches/berms, constructing sediment ponds, limiting land disturbance to a practical minimum, reducing water velocities across the ground through surface texturing and re-contouring, and progressively rehabilitating and stabilizing disturbed land surfaces to minimize erosion.

Exposed landscape surfaces will be protected by the installation of covering material such as riprap, aggregate, or rolled erosion control products. Runoff flow may be controlled by a combination of measures, including:

- Texturing/grading of slopes to slow runoff and reduce effective slope length;
- Synthetic permeable barriers and/or fibre rolls to reduce runoff velocities and retain sediments; and
- Check dams, gabions, and energy dissipation structures to reduce flow velocities in channels.

Sediment levels in runoff will be minimized by intercepting sediment before it reaches the freshwater environment. In addition to measures aimed at controlling runoff flow, the quantity of transported material in runoff may be controlled by measures including:

- Preserving riparian zones which trap sediment and reduce flow velocities;

- o Installing synthetic permeable barriers, fibre rolls, and/or silt fences as required;
- o Installing check dams, gabions, and sediment basins to reduce flow velocities and encourage sediment deposition;
- o Maintaining and repairing any machinery prior to use that has the potential to result in a fluid release or leak; and
- o Locating fuel transfer and maintenance activities greater than 31 m from a watercourse or waterbody, except for approved activities near water.

9.4.2 Saline Water Management

Sabina will, pending direction from the Nunavut Water Board, maintain a saline water management plan which includes monitoring of thermal conditions, monitoring of saline water at the Goose Property, and mitigation measures designed to address the potential for higher-than-predicted volumes of saline water inflows into the open pit and the underground mines, treatment, and disposal methods. This plan will include accurate characterization of saline water inflows into the underground mine workings.

9.4.3 Mine Water Runoff Management

Environmental protection measures will be implemented to manage mine water runoff, including:

- o Collection of all mine water runoff through use of diversions, collection ditches/berms and pipelines;
- o Recycling of mine contact water to the extent possible at the Goose Property;
- o Treatment of mine contact water prior to discharge to the environment during Construction, Operations, and Closure;
- o Land discharge of mine contact water where possible, rather than direct discharge to surface waters; and
- o Passive discharge of mine contact water during the Post-Closure Phase, provided discharge criteria are met.

At the Goose Property, these measures will be achieved by collecting all mine contact water from open pits, ore stockpiles, WRSAs, and the TSF. Water will be recycled from the TSF and TFs for use in the milling process. At Closure, water from the Goose Main TF will be circulated through the WTP until water quality has improved to discharge criteria. As previously mentioned, passive discharge of untreated mine contact water will occur only if discharge criteria and receiving water quality objectives are met. In the unlikely event that mine water runoff from pit lakes and WRSAs do not meet discharge criteria, water treatment will be provided by directing runoff from these areas to a central location and treating from there.

Diversion structures will be required around Llama, Goose Main and Echo open pits to divert non-contact water away from mining areas. This strategy will reduce the total amount of contact water generated by the Project. Mine water runoff management has been optimized based on the plans as outlined in Section 6 of the MAD. The management strategies will continue to evolve and will be finalized during detailed design.

9.5 ACID ROCK DRAINAGE / METAL LEACHING

This plan will be periodically updated as new geochemical information becomes available. The MWRMP (SD-08) will be updated during the water licencing process to incorporate criteria and procedures for the segregation of PAG and NPAG waste rock.

Goose Property Waste Rock

Goose Property mine workings and waste rock represent a moderate ARD/ML potential. Low to moderate bulk Neutralizing Potential contents could result in acidic drainage after a lag time of 14 to 20 years. Interaction with the deposit material and air/water could result in runoff/drainage exhibiting concentrations of arsenic and copper greater than MMER limits. This plan has been designed to minimize exposure time of the mine workings and waste rock to air/water and, wherever possible, to ensure the exposure time is less than the expected lag time.

Tailings Geochemistry

The bulk of tailings that will be stored in the TSF will have a moderate to high ARD/ML potential. During Operations, if tailings material that forms the TSF beaches is not buried under fresh material before the lag time (on the order of 10 to 20 years) is exceeded, then ARD could develop. This understanding of lag times has informed the tailings deposition plan to prevent the development of ARD. The water and load balance model has taken the tailings deposition schedule into account in the water quality prediction of the TSF runoff.

9.6 BORROW PIT AND QUARRY DEVELOPMENT

Plans to develop aggregate sources, as well as the identified environmental protection measures and monitoring plans, are described in the Borrow Pits and Quarry Management Plan (SD-03). The following summarizes the environmental protection measures identified to minimize impacts to water during borrow area and quarry planning and development:

- Maintain a setback distance of 31 m from creeks and streams;
- Preserve vegetative buffers to limit impacts on water quality;
- Use berms and ditches to direct runoff away from the excavation;
- Slope rock quarry floors so that water is diverted to a sump within the quarry or adjacent to the quarry boundaries where it can be monitored prior to release;
- Sample accumulated water within water collection areas for TSS, oil and grease, and ammonia-nitrogen;
- Apply sediment and erosion control measures such as those described in Section 9.4.1;
- Use dust skirts on conveyors and apply dust suppression measures as identified in the Air Quality Monitoring and Management Plan (FEIS Volume 10, Chapter 17);
- Monitor for ground ice during excavation of borrow areas;
- Monitor and address any subsequent settlement to maintain positive drainage and avoid the ponding of water (which can further exacerbate thawing of ground ice); and
- Routinely inspect the effectiveness of water management structures.

Sabina will maintain an appropriate setback distance between Project quarries and fish-bearing or permanent waterbodies, or implement appropriate mitigation measures, as required to prevent acid rock drainage or metal leaching into such waterbodies.

These environmental protection measures are described further in the Borrow Areas and Quarry Management Plan (SD-03). Individual quarry development plans and SOPs will be prepared by the contractor before extraction activities commence.

9.7 DUST MANAGEMENT

Dust from ore stockpiles and WRSAs is not expected to be substantial; however, dust will be monitored and managed to the extent reasonable. Crushing and screening operations will be conducted with equipment designed to mitigate dust dispersion. In the unlikely event that an unacceptable amount of dust is generated from end-dumping or front-loading during stockpiling and transferring operations, additional dust mitigation measures will be applied as identified in the MWRMP (SD-08). A nominal amount of water has been requested for dust suppression if needed (Table 7.3-1).

9.8 AMMONIA MANAGEMENT PLAN

Ammonium nitrate will be used in large quantities by the Project. ANFO is the main explosive mixture to be used for mining at the Project. Ammonium nitrate will be delivered by sealift in solid form in tote bags within seacans. They will be protected from the elements to prevent contact with water during transport and storage. The seacans will be placed on a laydown pad at the Goose AN Facility. Diversion berms will direct any runoff water to a sump at the AN Facility pad. Collected runoff from the AN Facility area will be treated as contact water as described in Section 8.2.8. Water from the AN Facility truck wash will be transported to a water management pond for treatment or discharge as appropriate, or will be collected and treated in an evaporator.

Ammonia concentration predictions for all sources were incorporated in the water and load balance model; these sources include blasting residues associated with rock, process plant/tailings contributions, and camp wastewater. Ammonia, nitrate, and nitrite concentrations as a result of blast residue were derived from methods described by Ferguson and Leask (1998). These methods calculate the annual release of total AN as nitrogen based on the powder factor, fraction of ammonium nitrate in ANFO, the fraction of nitrogen content in AN, and the residual nitrogen remaining. Assumptions are presented in Table 4-7 of Section 4.2.7 of the Water and Load Balance Report (FEIS Volume 2, Appendix V2-7H).

To provide some perspective on predicted future pit water ammonia concentrations, the maximum baseline ammonia lake water concentration within the local study area was compared to predicted pit water concentrations. The maximum baseline ammonia concentration of 0.0671 mg/L (reported as N-NH3) is greater than the predicted pit water concentrations (at flooding and long-term) at the various locations indicating ammonia concentrations within pit water will be within baseline concentrations and will not be of concern to wildlife.

With adherence to BMPs for AN storage and handling there is minimal risk of AN spillage; however, ammonium nitrate and/or ANFO may be spilled during handling or during use in the open pit or underground. Spill locations would be generally limited to single storage bags within the AN Facility or seacans in the storage pad areas. These areas will be inspected regularly according to operating procedures. Spill prevention and response actions will include the following:

- establish and use SOPs for handling and working around storage areas;
- ensure proper containers are used for the storage and transport of explosives and AN;

- restrict access to authorized and trained personnel;
- conduct regular inspections of storage areas, containers, and transport vehicles with frequency driven by activity levels;
- clean up dry AN according to established SOPs, to minimize likelihood of nitrates entering watercourses;
- manage and limit contact with snow and water, with particular anticipation of spring thaw/freshet period; and
- properly dispose of spill material and any impacted rock pad material, which could include placing within a blast pattern prior to initiation.

More detailed spill response procedures for AN and explosives will be provided with the explosives supplier Emergency Response Assistance Plan. An Emergency Response Assistance Plan will be prepared by the explosives supplier for the transportation of explosives to all storage sites for the Project as required by the Transportation of Dangerous Goods regulations. For detailed information related to spill response for potential explosives refer to the Spill Contingency Plan (SD-17).

For specific water quality monitoring related to ammonia management refer to Section 10.

10. Monitoring Program

The three levels of monitoring proposed for mine development are:

- o Environmental Monitoring; which further refines three forms of general monitoring into:
  - – regulated discharge monitoring (i.e., set by legislation or authorization requiring specific discharge/effluent criteria to be met for compliance);
  - – verification monitoring (i.e. internal operation management monitoring); and
  - – general monitoring (i.e., NWB general monitoring requirements set in Type A Water Licence);
- o Performance Measurement Monitoring; which tracks performance of mitigation measures implemented, identifies environmental changes in the receiving environment, and validates environmental effects predictions; and
- o Design Support monitoring which is site-specific field monitoring required to support detailed engineering designs and confirm modelling assumptions.

All three types of monitoring will be used at the Project. The sum of all three types of monitoring will provide sufficiently robust data to support decisions in mine and water management.

The proposed general water monitoring program is outlined in Appendix B. Environmental monitoring station locations are shown on Appendix B, Figure B-01 and Figure B-02 for the Goose Property and MLA respectively. In addition, Table B-01 and Table B-02 summarizes proposed water quality and flow monitoring of the Project during the Construction, Operations, Closure phases, and includes monitoring station location, monitoring type, description, purpose, mine phase, parameters grouping, and sample frequency for each location. The list of constituents in each parameter group is provided in Table B-03.

Additional information supporting the general water monitoring plan can be found in the General and Aquatic Effects Monitoring Program documents. The Program includes the following documents:

- o Environmental Management and Protection Plan (SD-20);
- o Aquatic Effects Management Plan (SD-21);
- o Conceptual Fish Offsetting Plan (SD-22);
- o Marine Monitoring Plan (SD-23); and
- o Quality Assurance/Quality Control Plan (SD-24).

The Aquatic Effects Management Plan (AEMP; SD-21) is a comprehensive monitoring program that considers Project related effects on the aquatic environment and is harmonized to meet MMER and Environmental Effects Monitoring requirements. Monitoring established in the Type A Water Licence has to be at least as stringent as the requirements set by any Regulation under the *Fisheries Act* (refer to the Conceptual Fish Offsetting Plan for additional information). Further, Sabina's proposed monitoring program for culverts on fish bearing watercourses during the Operations and Closure phases will include measures to ensure that barriers to fish passage do not form over time as a result of crossing damage due to ice blockage, flooding, or movement of debris.

Where appropriate all monitoring will be undertaken using established methods and defined Quality Assurance/Quality Control measures. Refer to the QA/QC Plan (SD-24) for additional detail. Sabina will also have in place an internal inspection plan to monitor activities and mine components that could adversely affect the use of water or the deposit of waste into water. Sabina's internal due diligence plan for inspections Table 8.4-1 is provided in the Environmental Management and Protection Plan (SD-20), and be completed for each mine component or activity, including all earthworks or facilities constructed for the use, storage, treatment, and/or disposal of water and/or waste into water.

In addition, Sabina is committed to collect additional baseline water quality data to characterize the lakes and streams within the freshwater aquatic environment prior to Construction, and use this data to update the water and load balance model to account for potential seasonal variation. Results will be submitted to the NIRB for distribution to stakeholders. Water samples will be collected to characterize seasonal variation. The following water samples will be collected:

- Under ice;
- During freshet as confirmed by measurements of flow;
- During the period of low flow in the open water season as confirmed by measurements of flow; and
- In September as precipitation increases.

11. Environmental Reporting

Internal reporting structures will provide the framework so monitoring results can be reviewed, instances of non-compliance with this plan can be identified, and subsequent corrective action can be undertaken in a timely manner. Items of non-compliance with applicable permits, licenses, and authorizations will be reported to the respective agency as outlined in those authorizations.

External reporting of Sabina's monitoring results and performance against this management plan will be in accordance with the following permits, licenses, approvals, and authorizations (Table 11-1).

Table 11-1: Reporting Requirements

Regulatory Instrument	Responsible Agency	Information to be Reported	Frequency	Compliance Inspections
Project Certificate	NIRB	Terms and conditions relevant to water management	Annually	A NIRB Monitoring Officer will inspect the site against the Project Certificate annually
Type A Water Licence	NWB	Water licence reporting requirements, including those identified in this plan	Monthly (General Monitoring requirements); Summary results in Annual Report	A waters inspector will inspect the site
Authorization for HADD of fish habitat under the Fisheries Act	DFO	Specified in the authorization – focused on protection of fish habitat	Annually	A fisheries officer may inspect the site periodically to determine compliance
MMER	ECCC	Effluent quality and toxicology; sediment, benthics, fish population data	Monthly reporting of effluent quality and receiving water quality; annual reporting	
AEMP	NWB	To be determined – possibly inclusive of water and sediment quality and freshwater biota	As prescribed in the AEMP; Summary results in Annual Report	The AEMP will be submitted to the NWB and reviewed by other relevant agencies including DFO and ECCC

12. Adaptive Management

The mine design, including the water management design, has been carefully prepared taking into consideration the vast database of site characterization data gathered for the Project, coupled with rigorous engineering analysis. Where data was limited, conservative assumptions were consistently applied. Notwithstanding, a key element of monitoring as outlined in Section 10 is to verify that mitigation measures in relation to water management activities are being implemented and are achieving their intended outcomes. Adaptive management will be employed where mitigation is not achieving the intended result. Alternative mitigation measures may be identified at a later time, and will be reflected in updates to this plan and related management plans.

Possible water management scenarios and the potential contingency strategies are outlined Table 12-1.

Table 12-1: Water Management Contingency Strategies

Possible Scenario	Contingency Strategy
While dewatering Llama and Umwelt lakes to Goose Lake, the concentration of TSS may be higher than the expected 50% volume requiring treatment before discharge.	Treat a greater percentage of the water from Llama and Umwelt lakes. Additional contingencies described below.
The volume of seepage from the TSF Containment Dam is greater than expected.	Larger return pumps may be required.
Seepage from any of the contact berms or other dams on site occurs.	Repairs to the berms/dams may be required. Alternatively, seepage collection berms may need to be constructed and return pumps may be required.
Saline inflows into the mine workings are greater than expected.	Additional storage locations will need to be identified, or treatment to desalinate the water may be required.
Waste rock leaches a greater concentration of metals or other constituents than expected.	Additional settlement time or water treatment may be required.
Underground mining operations cease prior to the underground deposition of the required volume of saline water from the Saline Water Pond.	Additional storage locations will need to be identified, or treatment to desalinate the water may be required.
The results Water quality monitoring (WMP, Appendix B) or the Aquatic Effects Monitoring Program (AEMP) shows non-compliance.	Identify the issue (i.e. contact water not collected by contact berms, seepage through contact berms, ineffective treatment, etc.) and develop a strategy to improve treatment or reduce the release of mine water.

Checking and corrective action will occur during dewatering through the evaluation of continuous flow data and daily TSS and turbidity data. Results of the monitoring program will be reviewed by the Environmental Team, and water quantity and quality trends will be updated on a time scale relevant to the dewatering activity. If the dewatering activity will take two weeks or less, then data will be updated daily. If dewatering will take longer, then a more appropriate time scale may be used (e.g., every 3 days or weekly). This program will allow early detection of changes in water quality and implementation of corrective actions, if required. If trigger levels or thresholds are approached or exceeded, dewatering activities will be suspended.

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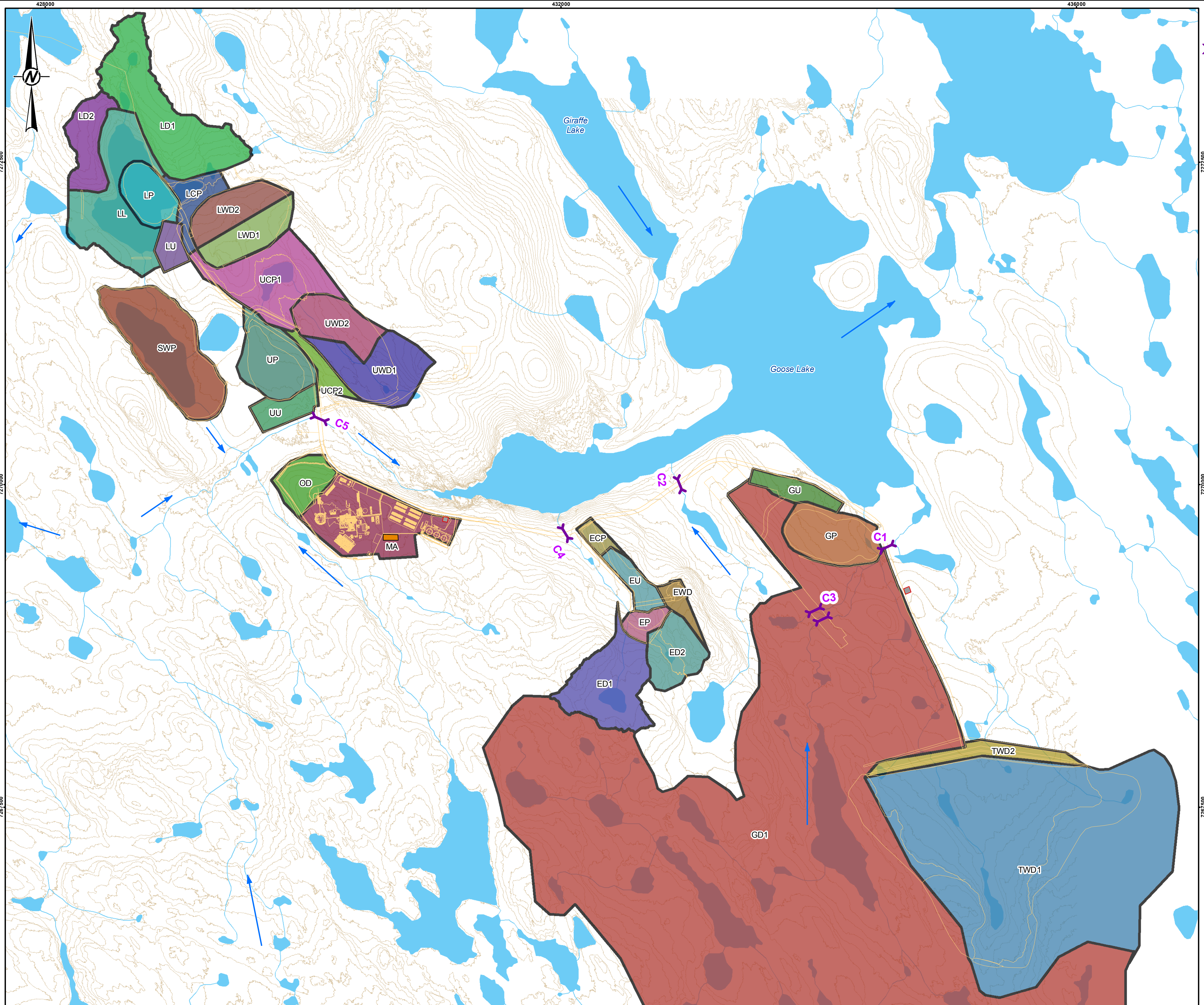
Appendix A. Figures



LEGEND

- CONTOUR (2 m)
- CULVERT
- FLOW DIRECTION
- SITE INFRASTRUCTURE
- WATERCOURSE
- LANDFARM
- TAILINGS EMERGENCY POND
- WATERBODY

CATCHMENT

- ECP - ECHO WRSA POND (0.04 km²)
- ED1 - WEST ECHO PIT DIVERTED (0.38 km²)
- ED2 - EAST ECHO PIT DIVERTED (0.19 km²)
- EP - ECHO PIT (0.07 km²)
- EU - ECHO UNDERGROUND PAD (0.09 km²)
- EWD - ECHO WRSA (0.06 km²)
- GD1 - GOOSE MAIN PIT DIVERTED (35.52 km²)
- GP - GOOSE MAIN PIT (0.28 km²)
- GU - GOOSE UNDERGROUND PAD (0.10 km²)
- LCP - LLAMA WRSA POND (0.10 km²)
- LD1 - EAST LLAMA LAKE DIVERTED (0.57 km²)
- LD2 - WEST LLAMA LAKE DIVERTED (0.19 km²)
- LL - LLAMA LAKE AROUND LLAMA PIT DIVERTED (0.47 km²)
- LP - LLAMA PIT (0.16 km²)
- LU - LLAMA UNDERGROUND PAD (0.07 km²)
- LWD1 - SOUTH LLAMA WRSA (0.18 km²)
- LWD2 - NORTH LLAMA WRSA (0.19 km²)
- MA - GOOSE PLANT SITE (0.45 km²)
- OD - ORE STOCKPILE POND (0.14 km²)
- SWP - SALINE WATER POND (0.52 km²)
- TWD1 - TSF WRSA (1.90 km²)
- TWD2 - TSF WRSA DOWNSTREAM SEEPAGE COLLECTION (0.14 km²)
- UCP1 - PRIMARY POND (0.38 km²)
- UCP2 - UMWELT WRSA POND (0.11 km²)
- UP - UMWELT PIT (0.23 km²)
- UU - UMWELT UNDERGROUND PAD (0.10 km²)
- UWD1 - SOUTH UMWELT WRSA (0.30 km²)
- UWD2 - NORTH UMWELT WRSA (0.21 km²)

ISSUED FOR PERMITTING

0 750 1,500

1:30,000 METRES

REFERENCE(S)

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PROJECTION: UTM ZONE 13N DATUM: NAD 83

YYYY-MM-DD	2017-10-03
DESIGNED	SRK
PREPARED	RC
REVIEWED	DRW
APPROVED	PC

CLIENT
Sabina

CONSULTANT
Golder Associates

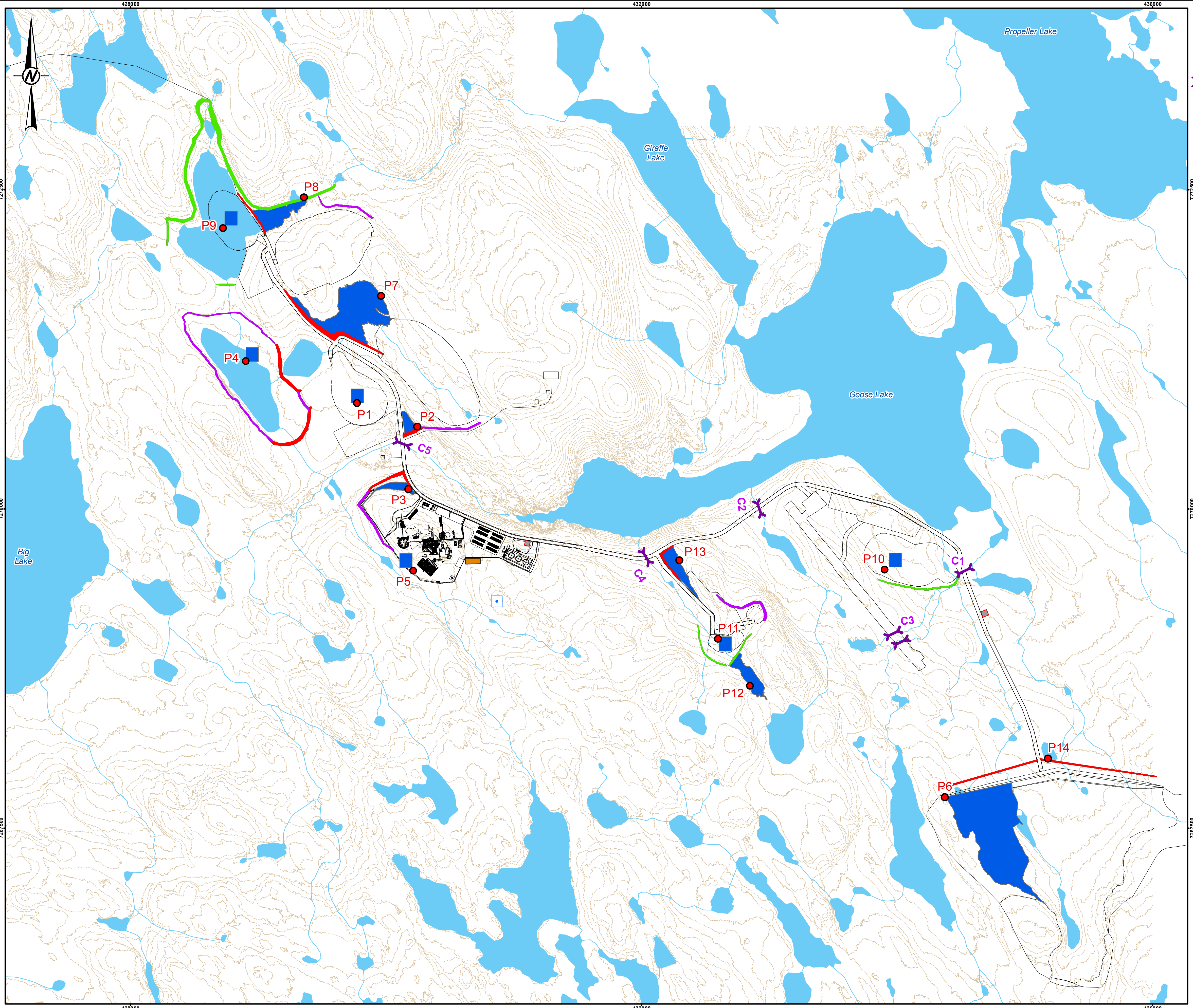
PROJECT
SABINA BACK RIVER PROJECT, WATER LICENCE PHASE, NUNAVUT CANADA

TITLE
GOOSE PROPERTY CATCHMENTS

PROJECT NO.	FIGURE	REV.
1776921	A-01	B

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

PATH: I:\2017\1774320\Mapping\MXD\Hydrology\1776921_Figure_A_01.mxd PRINTED ON: 2017-10-03 AT: 12:46:02 PM



LEGEND

- PUMP
- TREATED EFFLUENT WATER DISCHARGE
- CONTOUR (2 m)
- CULVERT
- SITE INFRASTRUCTURE
- WATERCOURSES
- CONTACT WATER DIVERSION BERM (UNLINED)
- CONTACT WATER CONTAINMENT DAM (LINED)
- NON-CONTACT WATER DIVERSION BERM (UNLINED)
- LANDFARM
- TAILINGS EMERGENCY POND
- POND/SUMP LOCATION
- WATERBODY

Culvert ID	Name
C1	GOOSE CULVERT
C2	GANDER POND CULVERT
C3	GOOSE AIRSTRIP CULVERT
C4	ECHO CULVERT
C5	GOOSE CREEK CULVERT

Pump ID	Name
P1	UMWELT PIT
P2	UMWELT WD POND
P3	ORE STOCKPILE POND
P4	SALINE WATER POND
P5	WATER TREATMENT PLANT
P6	TSF WD POND
P7	PRIMARY WD POND
P8	LLAMA WD POND
P9	LLAMA PIT
P10	GOOSE MAIN PIT
P11	ECHO PIT
P12	ECHO NCW POND
P13	ECHO WD POND
P14	TSF WRSA DIVERSION BERM

ISSUED FOR PERMITTING

0 750 1,500
1:30,000 METRES

REFERENCE(S)
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CLIENT
Sabina

CONSULTANT
Golder Associates

PROJECT
SABINA BACK RIVER PROJECT, WATER LICENCE PHASE, NUNAVUT CANADA

TITLE
GOOSE PROPERTY PUMPING AND CULVERT SCHEMATIC

PROJECT NO. 1776921
FIGURE A-02
REV. B