HOPE BAY PROJECT
GROUNDWATER MANAGEMENT PLAN

HOPE BAY, NUNAVUT

APRIL 2018

Hope Bay Project Groundwater Management Plan

Plain Language Overview:

This Groundwater Management Plan describes how TMAC will manage and work to minimize water that flows into the mine to protect workers, the environment, and ensure the mine can keep operating.

Hope Bay, Nunavut

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Revisions

Revision #	Date	Section	Changes Summary	Author	Approver
00	June 2016	Entire Document	Initial Document	SRK	TMAC
01	August 2016	Section 2.2	Updated clarification of possible increased groundwater inflow to the mine		
		Section 6	Updated remedial stage actions for mine inflow management		
		Section 5.2	Updated water quality testing requirements		
		Section 2.3.1, Table 2 and Section 8	Addition of management response for mine inflows exceeding 3,000 m^3/day		
02	November 2017	Entire Document	Transfer to new template	SRK	
		Section 1	Updated this section to consider all mines, i.e., Doris, Madrid, and Boston mines. Added objective of avoiding taliks or subpermafrost where mining is planned to remain encapsulated in permafrost. Updated Table 1. Compiled in Table 3 the roles and responsibilities for this plan.		
		Module A	Corrected a typo error with the groundwater pumping rate expressed in m^3/quarter, in the SPT3 row.		
		Module B	Developed a specific MIMP for the Madrid mines		
		Module C	Developed a specific MIMP for the Boston mine		
03	April 2018	Module A	Inclusion of water quality (salinity) specific performance thresholds in MIMPs.	SRK	TMAC
		Module B			
		Module C			

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Tables

Glossary

Term	Definition
ARD	Acid rock drainage
AEMP	Aquatic effects monitoring program
EC	Electrical conductivity
GWMP	Groundwater management plan
L/s	Litres per second
m^3/day	Cubic meter of water per day (equivalent to 1,000 litres per day)
MIMP	Mine inflow management program
MMER	Metal mining effluent regulations
NIRB	Nunavut impact review board
NWB	Nunavut water board
QA/QC	Quality assurance / quality control
SOP	Standard operating procedure
SPT	Specific performance thresholds
TIA	Tailings impoundment area
TDS	Total dissolved solids
TMAC	TMAC Resources Inc.
TSS	Total suspended solids
WAD	Weak acid dissociable
WMP	Water management plan

1 Introduction

This Hope Bay *Hope Bay Project Groundwater Management Plan* (the Plan) has been prepared by TMAC Resources Inc. (TMAC) in accordance with various water licences held by TMAC associated with developments throughout the Hope Bay region.

The Plan is intended primarily for use by TMAC and its contractors to ensure that best practices for minimizing potential environmental impacts and potential environmental liabilities with respect to groundwater management are followed, and that the conditions of water licences are met.

This Plan is structured in a manner such that one document pertaining to groundwater management is approved and implemented across all TMAC Hope Bay project sites, while still addressing site- and licence-specific needs: the main document outlines TMAC's approach to groundwater management as it pertains to all TMAC Hope Bay developments; subsequent modules provide details for each site and the associated water licence. In the event of a new water licence, or an existing licence amendment, only the specific modules pertaining to that licence and site will need to be revised. This is intended for consistency and efficiency across operations and for compliance management.

1.1 Objectives

The Hope Bay Project is being developed in permafrost, talik (i.e., unfrozen ground formed by lakes) and subpermafrost (i.e., the non-frozen ground below the permafrost). No groundwater interaction will be encountered in permafrost zones but mining in taliks or subpermafrost will result in groundwater inflows from defined geological features or open drill holes. The mine inflows will be made up of fresh water from lake infiltrations and hypersaline water from the surrounding rock, with a water quality dominated by high salinity, specifically chloride. Groundwater will be collected in underground sumps and pumped to surface, from where it will be discharged to a marine outfall diffuser in Roberts Bay, either directly, or via the Tailings Impoundment Area (TIA). The estimated mine inflows (quantity and quality) are not expected to cause safety concerns or environmental impacts. To ensure this, TMAC will actively manage and mitigate inflows to protect workers, the environment, and ensure the mine can keep operating. The objectives of the GWMP are to:

- Avoid taliks or subpermafrost in areas where mining is planned to remain encapsulated in permafrost;
- Minimize influence of mining in taliks on lake water levels; and
- Integrate the mine inflow volumes and chemistry, and resulting loading into the Water Management Plan (WMP).

This is accomplished by:

- Describing issues related to groundwater flow into the mines; and
- Outlining management responses, mitigations and adaptive management measures taken to protect workers and the environment, and to minimise operational impacts.

1.2 Relevant Legislation and Guidance

Table 1.1 provides a summary of federal and territorial regulations, and associated guidelines, governing the Hope Bay Groundwater Management Plan.

Table 1.1: List of federal and territorial regulations governing the Hope Bay Project Groundwater Management Plan

Regulation	Year	Governing Body	Relevance
Nunavut Mine Health and Safety Act (S.N.W.T, 1994, c.25)	1994	Government of Nunavut	Regulate the operations of underground mines, including the management of incoming water.
Mine Health Safety Regulations (R-125-95)	1995	Department of Justice of the Northwest Territories Government	
Nunavut Waters Regulations	2013	Nunavut Water Board (NWB)	License for mining and milling undertaking to use water and deposit of waste in relation to the construction, operation, closure and reclamation.
Environmental Protection Act	2011	Government of Nunavut (GN), Department of Environment (DOE), Environmental Protection division	Legislation to authorize discharge of water.
Environmental Rights Act	2011	GN, DOE, Environmental Protection division	Grants all residents the ability to launch an investigation.
Metal Mining Effluent Regulations (MMER)	2015	Federal Department of Fisheries and Oceans & Environment Canada	Outlines requirements for mine-related discharges.
Guideline	**Year**	**Governing Body**	**Relevance**
Canadian Environmental Quality Guidelines	1999	Canadian Council of Ministers of the Environment (CCME)	Provides guidance on water quality for the protection of aquatic life; both freshwater and marine.

1.3 Related Documents

Table 1.2 provides a summary of documents related to the Hope Bay Groundwater Management Plan.

Table 1.2. List of documents related to the Hope Bay Project Groundwater Management Plan

Document Title	Year	Relevance
Hydrogeological Modeling of the Proposed Doris North Project	June 2015	Documents the hydrogeological data and results of modelling designed to estimate inflows into the Doris underground mine during operations.(SRK 2015a)
Doris North Project – Water and Load Balance	June 2015	Evaluation and predictions of water quantity and quality at the Doris North project, including alternative discharge scenarios for groundwater and TIA effluent. (SRK 2015b)
Response to NRCan IR-3 & AANDC IR#13: Estimation of the Time Required for the Underground Mine to Fill	Dec. 2015	Provides an estimate of the time for reflooding the Doris underground mine once dewatering stops (TMAC, 2015).
Appendix V3-4B issued for the FEIS of the Phase 2 Hope Bay Project.	Nov. 2017	Documents the hydrogeological data and results of modelling designed to estimate inflows into the Madrid and Boston underground mines during operations. (SRK 2017a)
Hope Bay Project – Water and Load Balance	Nov. 2017	Evaluation and predictions of water quantity and quality at the Hope Bay project, including mining at Doris, Madrid, and Boston, as well as alternative discharge scenarios for groundwater and TIA effluent. (SRK 2017b)
Water Management Plan	Nov. 2017	Describes the water management procedures including discharge from the TIA and associated water quality criteria. (TMAC 2017a)
Aquatic Effects Monitoring Plan	Nov. 2017	Describes the monitoring of the fisheries habitat.(TMAC 2017b)
Quality Assurance and Quality Control Plan	Nov. 2017	Sampling practices document that is reviewed and approved by the NWB. (TMAC 2017c)

1.4 Plan Management

This Plan is reviewed annually and updated as needed. Revisions can be triggered by activities such as changes in the mine plan, operational performance, personnel or organizational structure, mine ownership, regulatory or social considerations, and life cycle or design philosophy. Personnel responsible for implementing and updating the Plan are identified in Table 1.3.

Table 1.3. Roles and Responsibilities

Role	Responsibility
Mine General Manager	• Overall responsibility for and implementation of this management plan; • Provide the on-site resources to operate, manage, and maintain the groundwater management infrastructure, such as sumps, pumps, ponds and holding tanks; • Provide input on modifications to design and operational procedures to improve operational performance.
Mine Manager	• Conduct regular inspections of the groundwater management facilities and audits of the maintenance records; • Responsible for tracking water movements from the underground sumps to the surface water management system; • Maintain records of underground inflows and their locations; • Report irregularities identified during visual inspections to the Mine General Manager.
Mine Superintendent	• Review and update this management plan as required; • Monitor water quality in the sumps (i.e. calcium chloride concentrations); • Track discrete underground inflows, their locations, and flow rates; • Coordinate with the Surface Manager responsible for water movements between the various water management facilities to ensure compliance with all licence requirements; • Audit of groundwater management tracking records and all associated required reporting.
Environmental Coordinator	• Collect water quality samples from sumps and backfilled stopes during periods of discharge; • Maintain records of water quality sampling results.

2 Groundwater Management Issues

2.1 Mine Inflow Rates

The mine inflow rates may exceed the predicted inflows.

2.1.1 Management Action

Mine inflow thresholds are set for each mine, beyond which adaptive management needs to occur to mitigate increasing flow volume. Rates are reassessed as part of the annual review process of this Plan as understanding of the system increases.

Prior to new development, risk zones are mapped and control/exclusion measures are put in place as outlined in Section 3. Management actions (i.e., control/exclusion measures) are implemented based on a Mine Inflow Management Program (MIMP), as outlined in Section 4.

2.2 Mine Inflow Chemistry

The chemistry of discharged mine water may diverge from the predicted water quality.

2.2.1 Management Action

Operations induced water quality changes are managed to the extent practical. The use of calcium chloride is minimized to the extent possible in underground sumps and mine water is internally recycled for drilling purposes to reduce the amount of additional calcium chloride introduced to the mine.

Blasting practices are continuously reviewed to evaluate opportunities to reduce nitrates from blast residues in the mine water.

Mine inflow quality is monitored in accordance with Section 5 of this Plan. If mine water discharge exceeds MMER water quality criteria, discharge to Roberts Bay occurs via the TIA and/or with treatment.

2.3 Mine Discharge

The discharge rate from the mine may exceed the maximum acceptable inflow for a given period.

2.3.1 Management Action

The pumping designs comprise a primary set of pump(s) that can accommodate the design capacity, plus standby pump(s). Standby pump(s) are required to ensure that the full design capacity is available when pumps require servicing or when pumps have mechanical issues. As a result there is capacity to pump water in excess of the design capacity if necessary.

If groundwater pumping exceeds the maximum acceptable inflow into the mine for a prolonged period, the Nunavut Water Board is notified and the analyses and assessment described in the Aquatic Effects Monitoring Plan (AEMP) are carried out.

2.4 Lake Water Levels

The level of lakes located directly above underground mines may be affected by mining.

2.4.1 Management Action

Adaptive management strategies are implemented based on the MIMPs to limit the effects from mining to groundwater in taliks.

Lake water levels are monitored as outlined in the AEMP.

3 Inflow Control Measures

Inflow control measures (i.e. risk zone mapping and inflow control/exclusion measures) are put in place to limit the inflows from fractures, faults, or historic drill holes (referred to as “features” in the following discussion). These measures aim to:

- Protect worker health and safety;
- Prevent negative impacts due to mine inflow; and
- Provide improved working conditions for operations.

3.1 Risk Zone Mapping

Risk zone mapping is part of the official mine plan and is used to guide daily development plans, with control measures worked into the mine schedule and consideration of related costs. It is carried out prior to mining into a new development heading (i.e., new mining excavation) or major travel way.

Although it is difficult to predict accurately where features occur, mining allows TMAC to continuously refine the 3D geology models of the mines and assess the probability of intercepting a significant flow feature.

The mine volumes are divided into risk zones ranked as Low, Moderate, or High based on:

- Mine layout/geometry;
- Access issues;
- Estimated boundaries of permafrost;
- Geology;
- Expected density and open size (aperture) of fractures;
- Suspected inflow features; and
- Known locations of old drill holes.

The zones are regularly reassessed based on performance observations and evaluation, therefore zone boundaries can change as mining progresses and knowledge of the site increases.

3.2 Inflow Control/Exclusion Measures

Inflow control measures aim at plugging flowing features. Inflow exclusion measures aim at stopping new development in a specific zone (for example, keeping a section of the mine within permafrost and outside talik).

Inflow control/exclusion measures are tailored to the risk rating of inflow risk zones, and follow specific assessment and control procedures as defined in the MIMP. These measures include:

- Probe drilling – to conform to Mine Health and Safety Act and Regulations, additional drilling contingent on risk zones; and
- Pre-grouting – mandatory or discretionary based on zone “rules”.

When isolation of an area is deemed an appropriate strategy to control mine inflow, a suitable isolation barrier is designed and constructed under the direction and guidance of a qualified engineer, with approval of the Mines Inspector.

4 Mine Inflow Management and Monitoring Program

The Mine Inflow Management Programs (MIMP) are decision-based frameworks specific to each mine aimed at preventing negative impacts from underground inflows; they complement the site Water Management Plans (TMAC 2017a). The MIMPs of the Doris, Madrid, and Boston mines are presented respectively in Module A, B and C.

4.1 Specific Indicators

Specific Indicators are used to assess performance of the system and trigger management actions. They are defined as:

Total Mine Inflow

- Daily flow measured at the main portal flow metering point.

Point Source Inflow

- Estimate of flow from a specific geological feature (structure/joint set) or drill hole; and
- Estimate of flow from a limited, specific mine area (i.e. heading or stope).

4.2 Specific Performance Thresholds

Specific Performance Thresholds (SPTs) are inflow rate-based decision points, triggering an escalating level of actions to manage the total mine discharge volumes and/or localised inflows. To ensure SPTs are appropriate, the inflows are measured such that the behaviour of the inflow system can be assessed as mining progresses and the SPTs are re-evaluated as part of the review process.

4.3 Specific Responses

Given that the mine inflow is expected to come from defined geological features or open drill holes in taliks, rather than dispersed inflow through the general rock mass, “Point Source” inflow monitoring is an important part of the continuing underground inflow characterisation as it relates to the understanding of the hydrogeological system and interaction with the mine development. Consequently, the SPTs and responses are set to assess the effectiveness of control measures and outline a review process for on-going management.

5 Monitoring and Evaluation

5.1 Inflow Quantification Monitoring

Monitoring underground flows aids in providing a feedback loop for evaluation of the effectiveness of the control measures and the accuracy of the predictive zone mapping. The accuracy and detail of the monitoring is a key component in the Plan review and evaluation process, so is included in the daily reporting structure of the underground management team (i.e. part of the Shift Boss daily report).

Underground flow monitoring includes pre- and post-grout flow measurements and flow feature description.

5.1.1 Pre-Grout Flow Measurement

Pre-grout flow measurement is needed to both aid in characterizing the feature and to support verifying the effectiveness of the grouting program. Inflow from specific features or stopes is measured by monitoring pumping rates at the nearest collection sump. If inflow rates exceed pumping rates, this is noted as a rise in sump level, and another pump is mobilised to increase pumping capacity. These observations are documented in the daily mine reports.

5.1.2 Post-Grout Flow Measurement

Post-grout flow measurement is the primary means of verifying the effectiveness of the grouting program. Measurement techniques are the same as for pre-grouting.

The results and observations of the post-grouting measurements are considered as part of the review phases in the MIMP and the review of inflow control procedures.

5.1.3 Flow Feature Description

Detailed geological and geotechnical mapping is carried out using predetermined codes for specific rock types and conditions. To make the mapping of inflow features accessible for the review and evaluation process, a descriptive code system is incorporated into the site mapping codes. These coded features are added to the site geological/geotechnical mapping database for review and visualisation using standard reporting and modelling tools for the project.

5.2 Mine Inflow Quality Monitoring

During periods of mine water discharge, either directly to Roberts Bay, or to the TIA, mine water is sampled as follows:

- Weekly at the mine sumps, for chloride, total dissolved solids (TDS), and nitrate;
- Monthly at the mine sumps, for total ammonia-N, nitrate-N, nitrite-N, pH, EC, ICPMS metals, alkalinity, acidity, sulphate, total suspended solids (TSS), major ions and total and weak acid dissociable (WAD) CN; and
- Twice annually from backfilled stopes, for total ammonia-N, nitrate-N, nitrite-N, pH, EC, ICPMS metals, alkalinity, acidity, sulphate, and total and WAD CN.

The Environmental Coordinator is responsible for conducting and documenting inflow water quality sampling. A record of this sampling and results of this analysis will be maintained on site.

5.3 Annual Geotechnical Inspection

A geotechnical inspection of the underground workings will be conducted by a qualified Geotechnical Engineer between July and September each year. The inspection will take into account the groundwater conditions underground and groundwater inflow in the underground mine workings.

6 Adaptive Management

The review process outlined in the MIMP allows for performance (ingress control) to be assessed relative to the expanding knowledge of the site hydrogeological system. The following adaptive changes to inflow control measures could include:

- Review of discretionary vs. mandatory pre-grouting planning;
- Confirmation that pre-grouting plans are adequate for anticipating and preventing inflow;
- Modifications to pre-grouting plans or procedures to provide better inflow control;
- Changes to grouting techniques and materials;
- Modifying and/or adjusting the mine plan to avoid areas of concern; and
- Isolation of mining sections to avoid areas of concern.

When the mine plan is modified or adjusted, the risk zone mapping is updated.

7 Documentation and Reporting

Documenting inflows, adhering to inflow control measures, and consistent recording of grouting operations allow for an accurate assessment of the effectiveness of the ingress prediction and controls. Records pertaining to inflows and grouting are maintained and reviewed as part of the Plan review and evaluation process.

7.1 Inflow Inspections and Documentations

The underground operational crews are responsible for regular inspections of safely accessible non-working areas and providing daily reports of active work areas. Non-working areas are inspected on a monthly basis, or as necessary, if combined flows from those areas are observed to increase at main collection sumps.

Where new inflow or a change in inflow higher than 250 m^3/day is encountered, a description of the feature and related inflow characteristics are documented as part of the shift boss's daily mining report. This report includes:

- Description of features encountered;
- Inflow rates; and
- Estimated pressures.

7.2 Grouting Logs

Grouting operations are documented to record the specific work done to stop/reduce inflows and to provide data for the Plan evaluation process. To capture the required data, the following details are logged during grouting events:

- Grout zone, location in mine plan, date, time, shift, crew members, and pre-grouting flow from numbered holes;
- Observations (i.e., geology, features, inflow) from the probe drilling completed in the zone;
- Materials used (type and volume); and
- Injection data such as packer position, pressures at start and end of each hole, flow rate development, and especially any cross-hole grout flow observed to come out of other holes or fractures as this gives an indication of fracture connectivity.

8 Contingencies

In circumstances of ensuring safety of workers and facilities, short term pumping of greater volumes with standby pumps might be required. If groundwater pumping rate and duration are greater than criteria specified in the MIMPs, the Nunavut Water Board is notified and the analyses and assessment described in the AEMP are carried out and reported quarterly. Pumping will be directed to the TIA as opposed to directly to Roberts Bay. The TIA has sufficient holding capacity for storing one year of mine inflow at the maximum predicted rate for the Doris mine (1,095,750 m^3/year) or about one year and a half at the maximum predicted rate for the Madrid mines (632,000 m^3/year). The holding capacity of the TIA will be confirmed with the TIA Engineer of Record prior to pumping of groundwater to the TIA.

In the event that excess inflow to the mine occurs and TMAC is unable to reduce total inflow to below the SPT-3 level within a reasonable period of time, the mines will have emergency storage capacity to store excess inflow if required. Underground in sumps or lower parts of the mines can be use temporarily to manage and store groundwater, assuming it does not pose a safety risk.

9 References

SRK Consulting (Canada) Inc. 2015a. Hydrogeological Modeling of the Proposed Doris North Project, Hope Bay, Nunavut. Report Prepared for TMAC Resources Inc., 1CT022.002.200.1000. June 2015.

SRK Consulting (Canada) Inc. 2015b. Doris North Project – Water and Load Balance. Report prepared for TMAC Resources Inc., 1CT022.002.200.700, June 2015.

SRK Consulting (Canada) Inc., 2017a.Hydrogeological Characterization and Modeling of the Proposed Boston, Madrid South and Madrid North Mines, Hope Bay Project. Report Prepared for TMAC Resources Inc., 1CT022.013. November 2017.

SRK Consulting (Canada) Inc., 2017b. Madrid-Boston Project Water and Load Balance, Hope Bay Project. Report Prepared for TMAC Resources Inc., 1CT022.013. November 2017.

TMAC Resources Inc. 2015. Response to NRCan IR-3 & AANDC IR#13: Estimation of the Time Required for the Underground Mine to Fill, December 2015.

TMAC Resources Inc. 2017a. Water Management Plan, Hope Bay, Nunavut. August 2016.

TMAC Resources Inc. 2017b. Hope Bay Project, Doris Aquatic Effects Monitoring Plan. August 2016.

TMAC Resources Inc., 2017c. Quality Assurance and Quality Control Plan, Hope Bay Nunavut. January 2017

TMAC Resources Inc., 2017d, Madrid—Boston of the Hope Bay Project, FINAL ENVIRONMENTAL IMPACT STATEMENT, Volume 3, Project Description and Alternatives. December 2017.

HOPE BAY PROJECT GROUNDWATER MANAGEMENT PLAN

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Module A: Doris Mine Inflow Management Plan (MIMP)

Conformity Table

Licence	Part	Item	Topic	Report Section
2AM-DOH1323	F	3	The Board has approved, with the issuance of this amended Licence, the Plan entitled "Hope Bay Project Groundwater Management Plan" dated August 2016. The Plan shall be reviewed annually in order to capture any revisions or updates necessary to adapt to changing circumstances regarding groundwater inflows and discharge rates.	1.4
	J	16	The Licensee shall undertake a geotechnical inspection annually between July and September, by a Geotechnical Engineer. The inspection shall be conducted in accordance with the *Canadian Dam Safety Guidelines* where applicable and take into account all major earthworks, including the following:	5.3
		16. n	Groundwater condition underground; and	5.3
		16. o	Rock temperature measurements and groundwater inflow in the underground mine workings.	5.3

Contents: Module A

A1 Doris MIMP

Table A.1 presents the Mine Inflow Management Program for the Doris mine. SPT-3 is set to be lower than the predicted maximum mine inflow of 3,000 m^3/d or 1,095,750 m^3/year. The maximum inflow rate was estimated based on the hydrogeological model developed for the Doris Mine in 2015 (SRK, 2015a). The modelling took into account the site hydrogeological testing, mine design (3D geometry and void volumes), and sequencing (when tunnels and stopes are developed and then backfilled).

Discharge from the mine is at a rate of 3,000 m^3/day directly to Roberts Bay via the marine mix box, or if required via the TIA. This discharge can be intermittent and occur any time of the year as the mine sumps fill naturally.

Table A.1: Doris Mine Inflow Management Program (MIMP)

Specific Indicators	Specific Performance Thresholds	Specific Responses

Mine inflows/quality measured as:
 	
Total Mine Inflow
• Daily flow measured at the main portal flow metering point
Point Source Inflow
• Estimate of flow from specific geological feature (structure/joint set) or area
• Estimate of flow from a limited, specific mine area (i.e. heading or stope)
	SPT-1
	• Total mine pumping rate exceeds 1,000 m^3/day
	• Point source inflow exceeds 250 m^3/day (~1.25 Lps) for > 3 days
	• Point source chloride concentration exceeds the predicted chloride concentration profile by more than 20%:
	  ○ From 0 to 60 mbgs: [Predicted Cl in mg/L] = 0.5012 + [vertical depth in mbgs] / 0.0043
	  ○ Greater than 60 mbgs: [Predicted Cl in mg/L] = 13293.92 + [vertical depth in mbgs] / 0.0909
		Notification
		• TMAC Management
		Review
		• Identify inflow point sources/areas and correlate to mine plan and MIMP
		• Review of pre-grouting work carried out (QA/QC of work to date)
		• Review inflow management records for development in affected areas
		• Review inflow records versus geological model and mine layout to assess correlation
		• Review lake level monitoring data
		• Review records of mine pumping rates and discharge chemistry
		Evaluation
		• Review of UG inflow monitoring data to be undertaken by qualified professional and appropriate recommendations to be developed
		• Review must consider the risk narrative (i.e. impact on Doris Lake water level and site discharge water quality objectives)
		• Determine if lake level fluctuations exceed natural variability
		• Review of mine inflow chemistry data to be undertaken by qualified professional and appropriate recommendations to be developed
		Action
		• Point source flow feature/area to be assessed by TMAC geological staff and compared to current geological model with objective to improve ability to predict significant inflow areas and correlation to pre-grouting planning
		• Review of inflow control plan to see if techniques, coverage, materials, etc. should be modified or enhanced
		• Supplemental grouting of source to reduce inflow

	SPT-2 • Total mine pumping rate exceeds 2,000 m^3/day • Point source inflow exceeds 500 m^3/day (~3 Lps) for > 3 days • Total mine water chloride concentration exceeds 15,000 mg/L, during a period when TIA mine water is being discharged	**Notification** • As in SPT-1 • Mines Inspector • INAC Inspector **Review** • As in SPT-1 • Review of geological model versus underground mapping and any new drilling data available • Review probe drilling procedures and control measures in MIMP **Evaluation** • Review of underground inflow monitoring data to be undertaken by qualified professional, and appropriate recommendations to be developed • Review must consider the effectiveness of predictive and control measures to date • Review of mine inflow chemistry data to be undertaken by qualified professional and appropriate recommendations to be developed; and • Confirm chloride concentration of the combined mine water and TIA discharge water being discharged to Roberts Bay does not exceed 15,000 mg/L **Action** • As in SPT-1 • Update MIMP to integrate recommendations from review of prediction and control measures
	SPT-3 • Total mine pumping rate exceeds 2,500 m^3/day • Point source inflow exceeds 800 m^3/day (~6 Lps) for > 3 days • Total mine water chloride concentration exceeds 15,000 mg/L, but TIA mine water is not being discharged	**Notification** • As in SPT-2 **Review** • As in SPT-2 **Evaluation** • Detailed review of all inflow events/sources to be undertaken by qualified professional, in addition to a 3rd party grouting specialist to provide peer review on control program • Review of underground water management plan to deal with unexpected inflows that may exceed total mine discharge rate of 3,000 m^3/day • Confirm available storage capacity in Doris TIA; and • Consider timing to initiate TIA discharge assuming the combined mine water and TIA discharge water being discharged to Roberts Bay chloride concentration is below 15,000 mg/L **Action** • As in SPT-2 • Provide update to MIMP based on outcome of Peer Review • assess potential impacts on Site Water Management Plan • assess potential change in risk narrative • Determine if mitigation measures required to maintain Doris Lake levels • If groundwater pumping exceeds 3,000 m^3/day for a prolonged period, specifically 270,000 m^3/quarter, the Nunavut Water Board will be notified and the analyses and assessment described in the Aquatic Effects Monitoring Plan (AEMP) will be carried out and reported quarterly • Pump mine water to Doris TIA

HOPE BAY PROJECT GROUNDWATER MANAGEMENT PLAN

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Module B: Madrid Mine Inflow Management Plan (MIMP)

Conformity Table

*To be completed upon issue of new water licence

Licence	Part	Item	Topic	Report Section

Contents: Module B

B1 Madrid MIMP

Table B.1 presents the Mine Inflow Management Program for the Madrid North and Madrid South mines combined. SPT-3 is set to be lower than the predicted maximum mine inflow of 1,730 m^3/d or 631,882 m^3/year. The maximum inflow rate was estimated based on the hydrogeological model developed for the Madrid North and Madrid South Mine (SRK, 2017a). The modelling took into account the site hydrogeological testing, the mine design based on prefeasibility conditions and the mine production plan (TMAC 2017d).

The combined discharge from the Madrid North mine and Madrid South mine is to be at a rate of 3,000 m^3/day to Roberts Bay via the marine mix box, or if required via the TIA. This discharge can be intermittent and occur any time of the year as the mine sumps fill naturally.

Table B.1: Madrid Mine Inflow Management Program (MIMP)

Specific Indicators	Specific Performance Thresholds	Specific Responses

Mine inflows/quality measured as:
 	
Total Mine Inflow
• Daily flow measured at the main portal flow metering point
Point Source Inflow
• Estimate of flow from specific geological feature (structure/joint set) or area
• Estimate of flow from a limited, specific mine area (i.e. heading or stope)
	SPT-1
	• Total mine pumping rate exceeds 600 m^3/day
	• Point source inflow exceeds 250 m^3/day (~1.25 Lps) for > 3 days
	• Point source chloride concentration exceeds the predicted chloride concentration profile by more than 20%:
	  ○ From 0 to 60 mbgs: [Predicted Cl in mg/L] = 0.5012 + [vertical depth in mbgs] / 0.0043
	  ○ Greater than 60 mbgs: [Predicted Cl in mg/L] = 13293.92 + [vertical depth in mbgs] / 0.0909
		Notification
		• TMAC Management
		Review
		• Identify inflow point sources/areas and correlate to mine plan and MIMP
		• Review of pre-grouting work carried out (QA/QC of work to date)
		• Review inflow management records for development in affected areas
		• Review inflow records versus geological model and mine layout to assess correlation
		• Review lake level monitoring data
		• Review records of mine pumping rates and discharge chemistry
		Evaluation
		• Review of UG inflow monitoring data to be undertaken by qualified professional and appropriate recommendations to be developed
		• Review must consider the risk narrative (i.e. impact on Patch and Wolverine Lake water level and site discharge water quality objectives)
		• Determine if lake level fluctuations exceed natural variability
		• Review of mine inflow chemistry data to be undertaken by qualified professional and appropriate recommendations to be developed
		Action
		• Point source flow feature/area to be assessed by TMAC geological staff and compared to current geological model with objective to improve ability to predict significant inflow areas and correlation to pre-grouting planning
		• Review of inflow control plan to see if techniques, coverage, materials, etc. should be modified or enhanced
		• Supplemental grouting of source to reduce inflow

	SPT-2 • Total mine pumping rate exceeds 1,200 m^3/day • Point source inflow exceeds 500 m^3/day (~3 Lps) for > 3 days • Total mine water chloride concentration exceeds 15,000 mg/L, during a period when TIA mine water is being discharged	**Notification** • As in SPT-1 • Mines Inspector • INAC Inspector **Review** • As in SPT-1 • Review of geological model versus underground mapping and any new drilling data available • Review probe drilling procedures and control measures in MIMP **Evaluation** • Review of underground inflow monitoring data to be undertaken by qualified professional, and appropriate recommendations to be developed • Review must consider the effectiveness of predictive and control measures to date • Review of mine inflow chemistry data to be undertaken by qualified professional and appropriate recommendations to be developed; and • Confirm chloride concentration of the combined mine water and TIA discharge water being discharged to Roberts Bay does not exceed 15,000 mg/L **Action** • As in SPT-1 • Update MIMP to integrate recommendations from review of prediction and control measures
	SPT-3 • Total mine pumping rate exceeds 1,500 m^3/day • Point source inflow exceeds 800 m^3/day (~6 Lps) for > 3 days • Total mine water chloride concentration exceeds 15,000 mg/L, but TIA mine water is not being discharged	**Notification** • As in SPT-2 **Review** • As in SPT-2 **Evaluation** • Detailed review of all inflow events/sources to be undertaken by qualified professional, in addition to a 3rd party grouting specialist to provide peer review on control program • Review of underground water management plan to deal with unexpected inflows that may exceed total mine discharge rate of 1,730 m^3/day • Confirm available storage capacity in Doris TIA; and • Consider timing to initiate TIA discharge assuming the combined mine water and TIA discharge water being discharged to Roberts Bay chloride concentration is below 15,000 mg/L **Action** • As in SPT-2 • Provide update to MIMP based on outcome of Peer Review – assess potential impacts on Site Water Management Plan – assess potential change in risk narrative • Determine if mitigation measures required to maintain Patch and/or Wolverine Lake levels • If groundwater pumping exceeds 1,730 m^3/day for a prolonged period, specifically 158,000 m^3/quarter, the Nunavut Water Board will be notified and the analyses and assessment described in the Aquatic Effects Monitoring Plan (AEMP) will be carried out and reported quarterly • Pump mine water to Doris TIA

HOPE BAY PROJECT GROUNDWATER MANAGEMENT PLAN

HOPE BAY, NUNAVUT

Module C: Boston Mine Inflow Management Plan (MIMP)

Conformity Table

*To be completed upon issue of new water licence

Licence	Part	Item	Topic	Report Section

Contents: Module C

C1 Boston MIMP

Table C.1 presents the Mine Inflow Management Program for the Boston mine. The Madrid-Boston mine plan assumes mining in Boston will be limited to resources encapsulated in permafrost (TMAC 2017d). The spatial distribution of permafrost is based on the analyses of isotherms measured from thermistors at 08SBD381A, 08SBD382, and 10WBW004 (SRK 2017a).

Table C.1: Boston Mine Inflow Management Program (MIMP)

Specific Indicators	Specific Performance Thresholds	Specific Responses
Mine inflows/quality measured as: **Point Source Inflow** • Estimate of flow from probe drillhole or specific geological feature (structure/joint set) in new development. • Estimate of flow from a limited, specific mine area (i.e. heading or stope)	**SPT-1** • Point source inflow greater than 30 m^3/day (~0.3 Lps) for > 3 days • Total mine pumping rate exceeds 60 m3/day • Point source chloride concentration exceeds the predicted chloride concentration profile by more than 20%: ○ From 0 to 60 mbgs: [Predicted Cl in mg/L] = 0.5012 + [vertical depth in mbgs] / 0.0043 ○ Greater than 60 mbgs: [Predicted Cl in mg/L] = 13293.92 + [vertical depth in mbgs] / 0.0909	**Notification** • TMAC Management **Review** • Identify inflow point sources/areas and correlate to mine plan and MIMP • Review underground thermal measurements (QA/QC of monitoring to date) • Review drilling records in affected areas • Review permafrost model, geological model and mine layout to assess correlation with observed inflow • Review records of mine pumping rates and discharge chemistry **Evaluation** • Review of UG inflow and thermal monitoring data to be undertaken by qualified professional and appropriate recommendations to be developed • Review must consider the risk narrative (i.e. impact on site water management objectives) • Review of mine inflow chemistry data to be undertaken by qualified professional and appropriate recommendations to be developed **Action** • Point source flow feature/area to be assessed by TMAC to confirm inflow is generated from talik or subpermafrost • Modification to mine plan to keep Boston development in permafrost if inflow is confirmed to come from talik or subpermafrost • Inflow control (i.e., supplemental grouting of source inflow or installation of a borehole plugin device) or exclusion measures (i.e. isolation of the area concerned)
	SPT-2 • Point source inflow greater than 60 m3/day (~0.6 Lps) for > 3 days • Total mine pumping rate exceeds 180 m3/day • Total mine water chloride concentration exceeds 15,000 mg/L, during a period when TIA mine water is being discharged	**Notification** • As in SPT-1 • Mines Inspector • INAC Inspector **Review** • As in SPT-1 • Review of geological model versus underground mapping and any new drilling data available • Review probe drilling procedures and control measures in MIMP **Evaluation** • Review of underground inflow monitoring data to be undertaken by qualified professional, and appropriate recommendations to be developed • Review must consider the effectiveness of predictive and control measures to date • Action • As in SPT-1 • Update MIMP to integrate recommendations from review of prediction and control measures • Review of mine inflow chemistry data to be undertaken by qualified professional and appropriate recommendations to be developed; and • Confirm chloride concentration of the combined mine water and TIA discharge water being discharged to Roberts Bay does not exceed 15,000 mg/L
	SPT-3 • Point source inflow greater than 360 m3/day (~4.2 Lps) is observed in a new development • Total mine pumping rate exceeds 360 m3/day for > 7 days • Total mine water chloride concentration exceeds 15,000 mg/L, during a period when TIA mine water is not being discharged	**Notification** • As in SPT-2 **Review** • As in SPT-2 **Evaluation** • Detailed review of all inflow events/sources to be undertaken by qualified professional, in addition to a 3rd party grouting specialist to provide peer review on control program • Review of water management plan to deal with unexpected inflows. • Confirm available storage capacity in Doris TIA; and • Consider timing to initiate TIA discharge assuming the combined mine water and TIA discharge water being discharged to Roberts Bay chloride concentration is below 15,000 mg/L **Action** • As in SPT-2 • Provide update to MIMP based on outcome of Peer Review – assess potential impacts on Site Water Management Plan – assess potential change in risk narrative • Pump excess groundwater to surface to contact water ponds or directly to water truck for transport to Doris Marine Mixing Box. Dispose of via Marine Mixing box to Roberts Bay. • Pump mine water to Doris TIA • If groundwater pumping exceeds 360 m3/day for a period of 30 days, the Nunavut Water Board will be notified and mining of the area concerned will stop.