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June 19, 2018

Karén Kharatyan
Director of Technical Services
Nunavut Water Board
P.O. Box 119
Gjoa Haven, NU, X0B 1J0

Re: TMAC Response to Phase 2 Hope Bay Belt Project Type "A" Water License Applications: 2AM-DOH1323 Amendment No. 2 and 2AM-BOS----; Technical Meeting Issues and Commitments.

Dear Karén,

TMAC Resources Ltd. (TMAC) is pleased to submit to the Nunavut Water Board (NWB) responses to commitments made during the Technical Meetings held in Cambridge Bay on May 14 and 15, 2018, and outlined in the NWB correspondence on May 29, 2018. Please find the list of deliverables and associated commitments in the table below and in the attached documents.

No.	Commitment	Issue-TM Commitment	Deliverable
1.	ECCC-WL-4.1.9	Mitigation and Monitoring of In-water Construction Activities in Freshwater TMAC will develop an Environmental Protection Plan Procedure prior to the ignition of in water construction activities (in the freshwater environment). The EPP will include, though no exclusive, mitigation measures for management total suspended solids and turbidity, monitoring procedures, as well as proposed limits and trigger values, to satisfy all applicable requirements during construction activities.	TMAC Resources. **DRAFT** Environmental Protection Plan. June 19, 2018 - Appendix A. A preliminary draft is being provided with this submission for review by ECCC and will be expanded upon in consultation with interested parties prior to and post project approval and water licencing
1	INAC-Rec-16	Scope o f Type " A" Licences In Relation to existing Type "B" Exploration Licences Clarify scope of amendments to existing Type "A" Water Licence	TMAC Memo: A Scope of the amended Type "A" Licence 2AM-DOH1323 and new Boston Type "A"

No.	Commitment	Issue-TM Commitment	Deliverable
		2AM-DOH1323 including overlap with 2 BB-MAE1727 and 2BE- HOP1222, and also clarify scope of new Boston Type " A" Licence 2AM-BOS---- including overlap w the 2BB-BOS1727 Type " B" exploration licence and identify plans for, and timing of transition of components already approved under exploration Type "B" licences into the Type "A" Licences.	Licence 2AM-BOS---- for the Madrid-Boston (Phase 2) Proposal in relation to existing Type 2BE-HOP1222, Type 2BB-MAE1727 and 2BB-BOS1727 – June 19, 2018 - Appendix B
2	INAC-Rec-11	Water Treatment Plant Effluent Quality TMAC commits to treat to 0.1 m g /L arsenic in the contact and process water treatment plants. TMAC commits to document that this level of treatment remains protective of the environment and is consistent with the environmental effects assessment.	ERM. Memo: Response to INAC-Rec-11: Hydrodynamic Mixing Modelling: Arsenic Predictions for Discharges to Aimaokatalok Lake. June 19, 2018 - Appendix C
3	INAC-Rec-2, 4, 5, 6 and 9	Doris Tailings Impoundment Area TMAC w ill provide a detailed compilation of the component-specific potential failure m odes to inform long term maintenance up to 100 years post closure and closure design uncertainties.	SRK. Memo: TMAC Response to INAC-Rec 2, 4, 5, 6 and 9. June 15, 2018. Component Specific Failure modes at 100 years - Appendix D
4	INAC-Rec-3	Boston Tailings Management Area Seep age TMAC will provide analysis is to demonstrate the potential geomembrane liner failure rate 100 years post closure and the associated arsenic loadings under this scenario.	SRK. Memo: TMAC Response to INAC-FC-2-Rec-3. June 11, 2018. Geomembrane liner failure rate at 100 year - Appendix E
5	INAC-Rec-15	Release of Saline Water from the Mine to the tundra TMAC will provide a description of the potential environmental effects of as pill associated with the transport of saline water from the mine (including pumping and trucking) as a result of accidents and malfunctions. In addition, TMAC will provide conceptual design mitigation	SRK. Memo: TMAC Response to INAC-TC-7-Rec15. June 4, 2015. Impact of Saline Water Spill - Appendix F
6	INAC-Rec-19	Madrid Mine Water Transport TMAC will update the Groundwater Management Plan to include mine	TMAC Resources. Hope Bay Project Groundwater

No.	Commitment	Issue-TM Commitment	Deliverable
		water transport mechanism (pumping or trucking) and submit the updated plan.	Management Plan. May 2018 -Appendix G

TMAC looks forward to next steps in the process and working with the NWB. Should you have any further questions please feel free to contact me at oliver.curran@tmacresources.com.

Sincerely,

Oliver Curran

Vice President, Environmental Affairs
TMAC Resources Inc.

Cc: Stephanie Autut, Executive Director (NWB)
Derek Donald, Technical Advisor (NWB)
Ida Porter, Licensing Administrator (NWB)
Ryan Barry, Executive Director (NIRB)

Appendix A

DRAFT Environmental Protection Plan. June 19, 2018

ENVIRONMENTAL PROTECTION PLAN

HOPE BAY, NUNAVUT

JUNE 2018

Environmental Protection Plan

Plain Language Overview:

The Environmental Protection Plan (EPP) has been developed to ensure that a high level of importance is placed on the protection of the environment by Project Personnel during the life of the Hope Bay Project. This document includes Environmental Standards (ESs) which identify and address environmental issues and concerns associated with the construction and operation of the Project and provide guidance and measures, which may be field fit, to ensure potential adverse environmental effects are avoided, minimized, or mitigated to the greatest extent practicable. The ESs are not intended to be comprehensive and may provide critical cross-references to other relevant documents such as Environmental Management Plans (EMPs), Standard Operating Procedures, Environmental Permits, Licences, and Regulation, etc. The EPP is a living document and is subject to on-going updates.

Hope Bay, Nunavut

Publication Date: June 2018

Hope Bay Project
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100 McMillan Drive
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Fax: 867-766-8667

Revisions

Revision #	Date	Section	Changes Summary	Author	Approver
0	April 30, 2018	All	Created	AG	OC

Contents

Tables

Figures

No table of figures entries found.

Glossary

Term	Definition
ARD	acid rock drainage
ML	metal leaching
NWB	Nunavut Water Board
	Enter definitions in lowercase unless they are proper nouns.

1 Introduction

This Hope Bay Environmental Protection Plan (EPP) for 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 EPP is intended primarily for use by TMAC and its contractors to ensure that best practices for minimizing potential environmental impacts and potential environmental liabilities are followed, and that the conditions of water licences are met.

The EPP has been developed to ensure that a high level of importance is placed on the protection of the environment by Project Personnel during the life of the Hope Bay Project. This document includes Environmental Standards (ESs) which identify and address environmental issues and concerns associated with the construction and operation of the Project and provide guidance and measures, which may be field fit, to ensure potential adverse environmental effects are avoided, minimized, or mitigated to the greatest extent practicable. The ESs are not intended to be comprehensive and provide critical cross-references to other relevant documents such as Environmental Management Plans (EMPs), Standard Operating Procedures, Environmental Permits, Licences, and Regulation, etc. The EPP will be updated as necessary based on management reviews, incident investigations, regulatory changes, or other Project-related changes.

The EPP intends to provide a practical way to facilitate field implementation of environmental regulations, practices, and measures required to eliminate or reduce potential adverse environmental effects. It is a working document for use by Project Personnel, as well as at the TMAC corporate level for ensuring commitments made in policy statements are implemented and monitored. The EPP provides a quick reference for Project Personnel to monitor for compliance and to make suggestions for improvements. This EPP provides the general protection measures for routine and unplanned activities associated with the Project against which the environmental performance of Project Personnel can be readily measured and corrective actions developed and implemented where required. Project Personnel are expected to understand and implement the environmental protection measures provided within the EPP. If, at any time, Project Personnel do not understand or are unclear regarding how or when to implement an environmental protection measure the Environment Department must be contacted to obtain clarification.

The EPP is developed in recognition of applicable permits, authorizations, approvals and Inuit Knowledge. As well, the plan provides operational measures that comply with aforementioned permits, approvals, etc., and provides reference to other associated and relevant documents such as Environmental Management Plans and Standard Operating Procedures.

1.1 Objectives

The specific objectives of the EPP are as follows:

- Provide a reference document to ensure that commitments to minimize adverse environmental effects will be met.
- Document and identify environmental concerns and ensure appropriate protection measures are implemented.
- Provide concise (short and clear) guidance to Project Personnel regarding the implementation of appropriate standards for protecting the environment and minimizing adverse environmental effects.
- Provide a reference and training document for Project Personnel when planning and/or conducting specific activities and working in specific areas.
- Communicate changes in the program through the revision process.
- Provide a reference to related applicable documents such as legislative requirements, guidelines, permits, Environmental Management Plans, Standard Operating Procedures, etc.

1.2 Relevant Legislation and Guidance

The key regulatory and legal documents that relate to activities associated with the Project and provide corresponding terms and conditions is provided in Table 1.1.

Table 1.1. List of Approvals Governing the Environmental Protection Plan

Name	Approval No.	Scope / Purpose	Term / Duration	Expiration Date
NIRB Project Certificate	003	Authorization for Doris to proceed provided certain conditions and requirements are incorporated in the various regulatory permits and authorizations issued by the regulatory agencies with permitting authority for the Hope Bay Project.	Life of Doris Project	None
NWB Type “A” Water Licence Amendment No.1	2AM-DOH1323	Water Licence for Doris with a 10-year term that authorizes the construction, operation and reclamation of the Doris Project. Licence was renewed (with certain amendments) in November 2016.	10 years	August 2023
Framework Agreement		Framework Agreement provides comprehensive land tenure governing the issuance of surface exploration licences, advanced exploration leases, commercial leases, and compensation associated with tenure. Framework Agreement includes a belt-wide Land Use Licence, an Inuit Impact and Benefits Agreement (IIBA) and a Water and Wildlife Agreement. Framework Agreement was signed in March 2015 for belt-wide land tenure.	20 years	March 2035
Water and Wildlife Agreement		Included as a Schedule to the Framework Agreement, this Agreement details compensation to be provided to the KIA and Inuit beneficiaries for negative effects that may occur to wildlife harvesting and water as a result of mining related activities across the belt.	20 years	March 2035

Name	Approval No.	Scope / Purpose	Term / Duration	Expiration Date
Amended and Restated Inuit Owned Lands Commercial Lease	KTCL 313D001	Commercial Lease for use of designated lands associated with the Hope Bay Volcanic Belt (HBVB) area. Currently, lands have been designated that encompass Doris. Expansion to include other areas of the HBVB is administrative in nature. Original Commercial Lease was amended and restated in March 2015 as a means to obtain surety of belt-wide land tenure.	20 years	March 2035
Inuit Impact and Benefits Agreement		Included as a Schedule to the Framework Agreement, this Agreement details the benefits to be provided to the KIA and Inuit beneficiaries from the Hope Bay Project, including compensation, employment and contracting opportunities. The IIBA originally signed in association with Doris was revised in March 2015 and expanded in scope to encompass belt-wide activities.	20 years	March 2035
KIA Advanced Exploration Agreements	KTAEL15C001 KTAEL15C002	Two agreements as per the terms of the Framework Agreement enabling quarry operations at designated locations in the Hope Bay Belt and advanced exploration at Boston.	5 year renewable annually thereafter for up to 20 years	March 2020
KIA Land Use Licences		Enables exploration activities across the Hope Bay belt as per the terms of the Framework Agreement.	1 year automatic renewable for 20 years	March 2016
DFO authorization	NU-02-0117.2	Construction of the jetty in Roberts Bay.		December 2009
DFO authorization	NU-1000-0028	Changes to the Doris jetty.		July 2012
DFO authorizations	NU-02-01117.3	Construction of the Doris Tailings Impoundment Area (TIA) north dam.	Life of Mine	None
Navigable Waters Permit	8200-02-6565	Installation of the jetty in Roberts Bay.	N/A	N/A
Jetty Lease	77A3-1-2	Foreshore lease from the Crown for construction and operation of the Roberts Bay Jetty.	10 years	June 2017
Amendment to Schedule 2 of the Metal Mining Effluent Regulations (MMER)	Registration SOR/2008-216	Designation of Tail Lake as a tailings impoundment.	Life of Mine	None
Type “B” Water Licence for the HBVB including a camp at Windy Lake	2BE-HOP1222	Water Licence that allows for the use of water and disposal of waste associated with regional exploration program for the HBVB including drilling and camp operations.	10 years	June 2022
Type “B” Water Licence for bulk sample exploration at Boston	2BB-BOS1727	Water licence that allows for the use of water and the disposal of waste for the Boston Advanced Exploration Project. Licence was renewed in July 2017, was formerly 2BB-BOS1217.	10 years	July 2027
Type “B” Water Licence for Madrid Advanced Exploration	2BB-MAE1727	Water licence that allows for the use of water and the disposal of waste for an undertaking classified as Mining and Milling as per Schedule II of the Regulations for the Madrid Advanced Exploration Project.	10 years	May 2027

1.3 Related Documents

The key documents that relate to the development and implementation of the EPP are provided in Table 1.2

Table 1.2. List of documents related to the Environmental Protection Plan

Title	Version Date
Hope Bay Project Environmental Management System	Jan-17
Air Quality Management Plan, Hope Bay Project	Sep-16
Hope Bay Project Noise Abatement Plan	Dec-17
Doris North Project Wildlife Mitigation and Monitoring Plan	Dec-16
Hope Bay Project Doris Aquatic Effects Monitoring Plan	Sep-16
Waste Rock and Ore Management Plan, Hope Bay Project, Nunavut, TMAC Resources August 2016 and September 2016 Addendum	Sep-16
Hope Bay Project Doris Tailings Impoundment Area Operations, Maintenance, and Surveillance Manual Aug 2016 & Sept 2016 Addendum	Sep-16
Hope Bay Project Water Management Plan	Feb-17
Hope Bay Project Domestic Waste Water Treatment Plan Doris Project	Feb-17
Hope Bay Project Hazardous Waste Management Plan	Sep-16
The Hope Bay Project Interim Non-Hazardous Waste Management Plan	Nov-16
Hope Bay Landfarm Management and Monitoring Plan	Jan-17
Hope Bay Project Incinerator Management Plan	Apr-16
Hope Bay Project Quarry Management and Monitoring Plan	Feb-17
Hope Bay Project Spill Contingency Plan	Dec-17
Hope Bay Project Surface Emergency Response Plan	Dec-17
Hope Bay Project Underground Emergency Response Plan	Dec-17
Oil Pollution and Emergency Preparedness Plan	Aug-17
Hope Bay Project Quality Assurance Quality Control Plan	Jan-17
Doris North Mine interim Closure and Reclamation Plan and Sept 2016 Addendum	Sep-16
Hope Bay Health and safety management Plan	Dec-17
Hope Bay Project Human Resources Plan	Sep-16
Hope Bay Project Community Involvement Plan	Jan-17
Cultural Heritage and Natural Resources Management Plan	Nov-16
Hope Bay Project Groundwater Management Plan	Aug-16
Hope Bay Project Aircraft De-icing Management Plan	Nov-17
Hope Bay Project Water and Ore/Waste Rock Management Plan for Boston Site	Jan-17
Boston Sewage Treatment Operations and Maintenance Management Plan	Sep-17
Hope Bay Project Boston Camp Interim Closure Plan and Revised Boston Exploration Camp Closure Cost Estimate	Apr-17
Hope Bay Project Windy Camp and Patch Lake Facility Updated Closure Plan (SRK)	May-14
Water Management Plan: Madrid Advanced Exploration Program, North and South Bulk Samples (SRK)	Dec-14
Overview of Madrid North and Madrid South Bulk Sample ML/ARD Characterization Programs and Conceptual Waste Rock Management Plans (SRK)	Dec-14
Hope Bay Project: Madrid Advanced Exploration Program: Conceptual Closure and Reclamation Plan (SRK)	Oct-14

1.4 Plan Management

The following subsections describe the roles which are responsible for the implementation and management of the EPP.

1.4.1 Vice-President, Environmental Affairs

- Provide corporate resources and overall direction to the implementation of the EPP.
- Provide final review and approval of revised versions of EPP.

1.4.2 Environmental Manager(s)

- Provide technical guidance and review of revised versions of EPP.

1.4.3 Environmental Coordinator(s)

- Ensure EPP is properly communicated to departmental Site Managers and ensure adequate training is in place for all site Supervisors.
- Conduct a review and revision of the EPP on an as needed basis to determine if updates are required, or at the request of the VP of Environmental Affairs.
- Review revisions to the EPP.
- Ensure revisions are distributed to managers and supervisors.
- Perform document controls.
- Ensure that managers, supervisors and their staff are familiar with the EPP and its protection measures.
- Obtain approvals from management.

1.4.4 Site Managers (including Contractors)

- Implement the EPP in daily operations.
- Maintain a current copy of each relevant Environment Standard.
- Provide training and support to ensure successful implementation of the EPP.
- Initiate changes to improve and update the plan as needed.

1.4.5 Site Personnel

- Familiarization with the relevant sections of the EPP.
- Have knowledge of reporting procedures.

1.4.6 Environmental Consultants

- Provide technical support to EPP development and ongoing revisions.
- Provide audits of EPP implementation, as requested by the VP of Environmental Affairs.

2 Environmental Standards

2.1 In-Water Works in Marine Environment

Revision Date: June 19, 2018

2.1.1 Potential Concern

The construction of in-water project components has the potential to negatively affect the marine environment. Elevated levels of suspended sediment are the primary change in water quality that could result from work in or around water. Silt and sediment can be transported in the water which may cause turbidity and a variety of other harmful effects on fish. Some of these negative effects include; clogging and abrasion of the gills of fish and other aquatic organisms, behavioral changes such as movement and migration, decreased resistance to disease, impairment of feeding, for example, turbidity interferes with feeding for visual feeders and poor egg and fry development. These are just a few of the potential harmful effects that silt, sediment and turbidity can have on the surrounding marine environment so ensuring that the appropriate precautions are put in place when blasting is essential.

Other potential environmental impacts in marine environment include underwater and airborne noise and accidental introduction of hydrocarbons or other deleterious substances/materials. These potential impacts could affect flow, water and sediment quality, fish and fish habitat, and marine wildlife and mammals.

The following are basic environmental protection measures that apply to all types of works within the marine environment to ensure adequate protection.

2.1.2 Protection Measures

The following measures may be implemented or required depending on the nature of the work:

- In water structures and culverts shall be installed in accordance with approved plans and in accordance to Fisheries and Oceans Canada terms for approval.
- Time work in water to respect timing windows to protect fish, including their eggs, juveniles, spawning adults and/or the organisms upon which they feed.
- Minimize duration of in-water work.
- Sediment and erosion control measures shall be implemented prior to work and shall be left in place and maintained until all disturbed areas have been stabilized.
- Any immobile equipment (pumps) shall be placed in secondary containment to prevent oil, grease, and fuel leaks from entering a waterbody or exposed soils near a waterbody.
- All machinery will be cleaned, fueled, and serviced in a manner that will not contaminate the bed, bank, or boundary of any waterbody.
- A spill response plan shall be in place to respond to spills of deleterious substances and spill kits shall be kept on site.

- Fill and substrate materials will be inspected by a qualified professional before being placed in marine environment to ensure that they are clean and will not introduce excessive sediments to the water or result in high water turbidity.
- Any stockpiled materials shall be stored and stabilized 31 metres away from the High Water Mark of any water body, unless for immediate use.
- All materials and equipment shall be operated and stored in a manner that prevents any deleterious substance (e.g. petroleum products, silt, debris, etc.) from entering the water. This includes checking that equipment is free of fluid leaks, and that grease and other debris is wiped or washed clean from the equipment, before entering the water.
- Re-fuelling and equipment maintenance is to be conducted 31 metres away from the High-Water Mark of any water body.
- All disturbed areas shall be stabilized immediately upon completion of work and restored to a pre-disturbed state or better.
- A environmental practitioner or inspector shall be on-site during all in-water construction, compensation and restoration works to ensure implementation of the designs, as intended in the Plan, and conditions of the fisheries authorization are being met.
- Construct new in-water structures so they are physically overlapping existing structures whenever practicable to avoid additional disturbance.
- Clearing of riparian vegetation will be minimized as much as possible and will be limited to the width of the road surface and area required to maintain appropriate embankment grade
- During decommissioning, banks will be stabilized immediately following construction to prevent erosion and/or sedimentation.
- Bank stabilization methods will include the use of clean, appropriately sized rip-rap and/or gravel.
- Noise-generating equipment shall be maintained, and shall be covered as feasible, to ensure that the potential for noise effects is mitigated.
- Work area shall be isolated using a turbidity curtain (barrier) placed approximately 25 m away from the proposed in-water footprint. The following measures may be implemented or required during operation of turbidity curtain (barrier):
  - Stop work if a marine mammal is observed approaching the barrier or has gained entry past the barrier.
  - Notify DFO-FPP via the Environment Department, if a marine mammal becomes trapped in the work area surrounded by the turbidity barrier, as well as plans to both allow it to exit the area while accommodating sediment and erosion control in the event that the barrier must be breached.

  - Install the barrier with no gaps, and monitor for breaches that must be repaired, such that seals or other marine mammals may not gain entry to the area.

- If Marine Mammals are observed or encountered in the vicinity of the in-water works, the following protection measures apply:
  - Never get close, approach, or make unnecessary noise when a marine mammal is observed regardless of whether the animals are at sea or onshore.
  - Never touch, feed or disturb an animal, even if it comes up to worksites or the shoreline
  - If you encounter marine mammals on a boat, reduce boat speed, minimize wake, wash and noise, and then slowly pass without stopping. Avoid sudden changes of speed or direction and move away slowly at the first sign of disturbance or agitation (if the animal starts to stare, fidget or dive into the water).
  - If you're concerned about a potentially sick or stranded animal, contact the Environmental Department for further instructions.

2.1.3 Supporting Documents

None.

2.2 In-Water Works in Freshwater Environment

Revision Date: June 19, 2018

2.2.1 Potential Concern

The construction of in-water project components has the potential to negatively affect the freshwater environment. Potential environmental impacts in marine environment include sediment, release and transport, underwater and airborne noise and accidental introduction of hydrocarbons or other deleterious substances/materials. These potential impacts could affect flow, water and sediment quality, fish and fish habitat, and marine wildlife and mammals.

There are two (2) types of in-water works in the freshwater environment. These are:

- In water works in waters that are fish bearing and/or subject to Fisheries and Oceans Canada authorization.
- In water works in waters that are *not* fish bearing and/or subject to Fisheries and Oceans Canada authorization.

Based on these two categories, there are basic environmental protection measures that apply to all types of works in the freshwater environment, and additional measures that apply to in-water works in fish bearing waters and/or waters subject to a fisheries authorization.

2.2.2 Protection Measures

2.2.2.1 For All Works in Freshwaters

The following measures may be implemented or required depending on the nature of the work:

- In water structures and culverts shall be installed in accordance with approved plans.
- Work should be conducted during low flow conditions – avoid conducting work during large precipitation/runoff events.
- Sediment and erosion control measures shall be implemented prior to work and shall be left in place and maintained until all disturbed areas have been stabilized. For more information on sediment and erosion control measures see Environment Standard: Sediment and Erosion Control.
- Any stockpiled materials shall be stored and stabilized 31 metres away from the High-Water Mark of any water body, unless for immediate use.
- All materials and equipment shall be operated and stored in a manner that prevents any deleterious substance (e.g. petroleum products, silt, debris, etc.) from entering the water. This includes checking that equipment is free of fluid leaks, and that grease and other debris is wiped or washed clean from the equipment, before entering the water.
- Re-fuelling and equipment maintenance is to be conducted 31 metres away from the High-Water Mark of any water body.

- Install crossings at right angles to the watercourse so that the original direction of stream flow is not significantly altered whenever possible.
- Minimize in-water work (get-in and get-out quickly).
- Water crossings will be backfilled with substrate (fill) material that is clean, competent, and consistent with the existing substrate size and texture found within the watercourse and will remain in/under the crossing.

2.2.2.2 For Works in Waters That Are Fish Bearing and/or Subject to Fisheries and Oceans Canada Authorization

The following measures may be implemented or required depending on the nature of the work:

- In water structures and culverts shall be installed in accordance with Fisheries and Oceans Canada terms for approval (see Environment Department).
- Water depth within the water crossing should be not be less than 20 cm or the same depth as the natural channel, especially during low flows.
- All disturbed areas shall be stabilized immediately upon completion of work and restored to a pre-disturbed state or better.
- An environmental inspector shall be on on-site to assess the crossings prior to the onset of construction to confirm the absence or presence of spawning sites at least 20 metres upstream or downstream of the crossing location, and whether spawning fish are present in the vicinity.
- An environmental inspector shall be present to monitor construction activities and document turbidity levels upstream and downstream of the works.
- A environmental practitioner or inspector shall be on-site during all in-water construction, compensation and restoration works to ensure implementation of the designs, as intended in the Plan, and conditions of the fisheries authorization are being met.
- Construct new in-water structures so they are physically overlapping existing structures whenever practicable to avoid additional disturbance.
- If machinery is required to bring material or equipment to the opposite side of the watercourse, then it shall be restricted to a onetime event (over and back) and only if no other existing crossing can be used. If the stream bed and banks are highly erodible (e.g., dominated by organic materials and silts) and erosion and degradation is likely to occur as a result of equipment crossing, then a temporary crossing structure or other practices shall be used to protect these areas.
- Machinery fording shall occur at least 20 metres upstream or downstream of location where fish and/or spawning sites are noted.

2.2.3 Supporting Documents

Hope Bay Project Doris-Madrid Water Management Plan

Hope Bay Project Boston Water Management Plan

3 Monitoring and Evaluation

3.1 Annual Inspections

3.2 Other Inspections

3.3 Water Quality Monitoring

3.4 Documentation and Reporting

4 Contingencies

5 References

ENVIRONMENTAL PROTECTION PLAN

HOPE BAY, NUNAVUT

Module A:

Conformity Table

Licence	Part	Item	Topic	Report Section
Ex: 2AM-DOH1323				

Contents: Module A

A1 Introduction

Triggers for enhanced mitigation will be developed in concert with ECCC and DFO prior to and post water licencing and will depend on baseline TSS.

A1.1 Background

A2 State the Site-Specific Management

A3 Monitoring and Evaluation

Appendix B

Memo: Scope of the amended Type "A" Licence 2AM-DOH1323 and new Boston Type "A" Licence 2AM-BOS---- for the Madrid-Boston (Phase 2) Proposal in relation to existing Type 2BE-HOP1222, Type 2BB-MAE1727 and 2BB-BOS1727. June 19, 2018

MEMORANDUM

DATE: June 19, 2018
TO: Karén Kharatyan
FROM: Oliver Curran
SUBJECT: Scope of the amended Type "A" Licence 2AM-DOH1323 and new Boston Type "A" Licence 2AM-BOS---- for the Madrid-Boston (Phase 2) Proposal in relation to existing Type 2BE-HOP1222, Type 2BB-MAE1727 and 2BB-BOS1727

The purpose of this technical memo is to address No. 15 of the Nunavut Water Boards ("NWB") issues and commitment list provided to parties on May 29th, 2018 after technical meetings held in Cambridge Bay on May 14th - 15th, 2018. Specifically, the NWB requested TMAC to clarify the "Scope of amendments to existing Type "A" Water Licence 2AM-DOH1323 including overlap with 2BB-MAE1727 and 2BE-HOP1222, and also clarify scope of new Boston Type "A"Licence 2AM-BOS---- including overlap with 2BB-BOS1727 Type "B" exploration licence and identify plans for, and timing of transition of components already approved under exploration Type "B" licences into the Type "A" Licences."

This memo provides the following additional rationale to clarify the scope of amendments to existing Type A Water Licence 2AM-DOH1323 including overlap with existing Type Water Licence 2BB-MAE1727 and 2BE-HOP1222, and also clarifies the scope of the new Type A Licence 2AM-BOS including overlap with Type B Water Licence 2BB-BOS1727 and identifies plans for, and timing of transition of components already approved under exploration Type B licences into the Type A Licences.

Introduction

The Hope Bay Belt is a large area (approximately 1600 km^2), incorporating several watersheds. Historically, TMAC and previous owners of the mineral tenures encompassing the Hope Bay Belt have held multiple water licences for exploration purposes as well as a licence for production purposes. Specifically, TMAC currently holds four water licences regulating their activities in the Hope Bay Belt: 2BE-HOP1222 (for surface exploration purposes), 2BB-MAE1727 (for Madrid North and South bulk sample), 2BB-BOS1727 (for surface exploration purposes and Boston bulk sample) and 2AM-DOH1323 (for production purposes at Doris Mine). TMAC wishes to continue to follow this well-established approach, which is consistent with the requirements of the Nunavut Agreement as well as the *Nunavut Waters and Nunavut Surface Rights Tribunal Act* ("the Act") and its regulations.

TMAC is aware that some proponents have been issued "predevelopment" Type B water licences in advance of being issued Type A water licences for production purposes. These licences generally incorporate construction activities consistent with exploration disturbance under the Type B water licence threshold of 299 m^3/day of water use, and such activities are incorporated into the Type A water licence for production purposes once issued by the NWB. It is possible that this recent NWB practice has caused some confusion in respect to the Madrid-Boston (Phase 2) project and its interaction with the existing Hope Bay Belt water licences. Each

of 2BE-HOP122, 2BB-MAE1727 and 2BB-BOS1727 are for project purposes that are related but distinct from the Phase 2 project. They are not "predevelopment" licences, and instead relate to stand-alone exploration projects.

Ongoing exploration of the region will continue in parallel with production at the Doris Mine and (if approved) the Phase 2 mines. It is therefore important that in the event of issuance of 2AM-BOS and Amendment No. 2 to 2AM-DOH1323, TMAC continue to hold 2BE-HOP122 and 2BB-BOS1727 for regional surface exploration purposes.

The Madrid North and South bulk sample projects permitted under 2BB-MAE1727 and the Boston bulk sample projects permitted under 2BB-BOS1727 are necessary in order for TMAC to further delineate the deposits, to evaluate mining methods and gain information on ore prior to and during initial operations of Phase 2.The Phase 2 project is designed to build upon existing Hope Bay Belt infrastructure, however, the infrastructure permitted under 2BB-MAE1727 and under 2BB-BOS1727 is independently required in order to proceed with the Madrid North and South bulk sample and the Boston Bulk Sample. The Madrid North, Madrid South and Boston bulk sample projects are advanced exploration activities which are below the Type A Water Licence thresholds and are best suited to the procedural flexibility granted to the NWB under the Act and regulations. It is therefore important that 2BB-MAE1727 and 2BB-BOS1727 continue as stand-alone water licences after Amendment No. 2 to 2AM-DOH1323 and 2AM-BOSare issued.

In this memo, TMAC wishes to provide further context for the scope of the existing licences, and to identify appropriate transition points for facilities that are already permitted under 2BB-MAE1727 to 2AM-DOH1323, and under 2BB-BOS1727 to 2AM-BOS.

Type B Water Licence 2BE-HOP1222 and 2BB-BOS1727 (Regional Surface Exploration)

Exploration activities with water use below the threshold for Type A water licences under the Act and its regulations should continue to be permitted under Type B water licences. The NWB has more procedural flexibility in the administration of Type B water licences as compared to Type A water licences. As an example, amendments to Type B Water Licences are granted by the NWB and do not require Ministerial approval. This administrative flexibility is essential to carrying out exploration activities, which by their nature are more subject to change than production mining and better suited to more streamlined regulatory approval processes.

Type B Water Licence 2BE-HOP1222 permits water use for surface exploration in the northern to southern region of the Hope Bay Belt including the Doris area. Type B Water Licence 2BE-HOP1222 has existed alongside 2AM-DOH1323 since the Doris Mine commenced construction. This has not been a subject of confusion for the public or INAC inspectors. No amendments to 2BE-HOP1222 will be triggered by the Phase 2 project.

Type B Water Licence 2BB-BOS1727 also permits regional exploration in the Boston area. This regional exploration will continue after Phase 2 commences production and will be essential to identifying potential future phases of development. For this reason, it is important that regional exploration in the Boston area continue to be permitted under 2BB-BOS1727 licences after 2AM-BOS is issued, as each relates to a different undertaking (exploration work versus production work). No amendments to 2BB-BOS1727 will be triggered by the Phase 2 project.

Type A Water Licence 2AM-DOH1323 (Production Mining)

TMAC has identified consequential amendments to 2AM-DOH1323 required to proceed with Phase 2. These relate primarily to the processing of Phase 2 ore at the Doris Mine site and commencement of Phase 2 commercial mining and related construction. For example, TMAC

proposes to include construction of a concentrator for the Phase 2 mines in 2AM-DOH1323. As noted further below, once TMAC issues a notice to construct to the NWB for Phase 2, certain infrastructure permitted under 2BB-MAE1727 would also transition to 2AM-DOH1323. Transitioning certain infrastructure from 2BB-MAE1727 will not remove the need to maintain the bulk sample licence going forward but rather transfer certain components required to proceed with production mining to the 2AM-DOH1323 licence.

TMAC proposes that these "transition" provisions be included in Amendment No. 2 to 2AM-DOH1323. TMAC will provide a proposed draft Amendment No. 2 to 2AM-DOH1323 to the NWB which further illustrates this approach one week prior to the Prehearing Conference (PHC) to be scheduled by the NWB in the event of a positive Nunavut Impact Review Board (NIRB) decision in respect of Phase 2. The draft licences will take into account the itemized list in Volume 1, Annex V1-7, Package 2, P2-1 (Table 1.2-1) of the application describing what is proposed to be included in Amendment No. 2 to 2AM-DOH1323 and what is already approved and the itemized list in Volume 1, Annex V1-7, Package 2, P2-2 (Table 1.2-1) of the application describing what is proposed to be included in 2AM-BOS and what is already approved under 2BB-BOS1727.

Type B Water Licence 2BB-MAE1727 (Madrid Bulk Sample)

As stated previously by TMAC to the NWB and to the NIRB, the Madrid bulk sample advanced exploration program (2BB-MAE1727) will be an important step in making the decision to proceed with Phase 2.

The Madrid bulk sample is limited to two 50,000-tonne ore samples to be extracted from each of the Madrid sites, North and South, and transported to the Doris process plant. In order to proceed with the Madrid bulk sample, the following infrastructure will be required and is already permitted under 2BB-MAE1727:

- roads (all weather roads and winter roads) and culverts;
- surface ore and wasterock storage pads;
- fuel storage facilities;
- contact water ponds and sumps;
- vent raises;
- offices, emergency shelters, etc.

Should TMAC issue a notice to construct to the NWB for Phase 2, all of this existing infrastructure would be incorporated into the Phase 2 mines. As noted above, additional infrastructure would also need to be constructed before the Phase 2 mines could proceed. The overlap and request for additional infrastructure is described in Volume 1, Annex V1-7, Package 2, P2-1 (Table 1.2-1) of the application.

TMAC understands that INAC is seeking clarity as to when the bulk sample infrastructure permitted under 2BB-MAE1727 would transition to 2AM-DOH1323. Accordingly, TMAC suggests that once TMAC issues a notice to construct for Phase 2, the bulk sample infrastructure listed above and permitted under 2BB-MAE1727 (and any related security) should transition to 2AM-DOH1323. This "trigger" will be incorporated in the draft Amendment No. 2 to 2AM-DOH1323 that will be provided by TMAC to the NWB one week prior to the PHC.

Type B Water Licence 2BB-BOS1727 (Boston Bulk Sample)

Certain advanced exploration activities and infrastructure is also permitted at Boston under 2BB-BOS1727, including:

- a bulk sampling and crushing and sorting plant;
- a camp including domestic use of water, treatment and disposal of greywater and sewage;
- further underground development and underground exploration drilling; and
- the operation of a landfarm and bulk fuel storage facilities.

With the exception of the existing vent raise and airstrip, all remaining activities and infrastructure approved under the Boston Type B Water Licence 2BB-BOS1727 are distinct from the proposed Phase 2 Boston Mine. There is no physical overlap for remaining infrastructure between the Boston Type B 2BB-BOS1727 and proposed Boston 2AM-BOS. As such, TMAC would like to maintain two separate licences for the different activities and infrastructure proposed and approved under the 2BB-BOS1727 and the 2AM-BOS. TMAC will provide a proposed draft 2AM-BOS to the NWB on or before 1 week prior to the PHC which further illustrates this approach.

TMAC looks forward to future dialogue with the NWB and intervening parties on this information.

Appendix C

Memo: Response to INAC-Rec-11: Hydrodynamic Mixing Modelling: Arsenic Predictions for Discharges to Aimaokatalok Lake. June 19, 2018

Memorandum

Date: June 19, 2018

To: Oliver Curran, TMAC Resources Ltd.

From: ERM Consultants Canada Ltd.

Subject: **Response to INAC-Rec-11: Hydrodynamic Mixing Modelling: Arsenic Predictions for Discharges to Aimaokatalok Lake**

1. INTRODUCTION

This memorandum presents hydrodynamic mixing modelling results for the proposed discharge of treated effluent to Aimaokatalok Lake from the Madrid-Boston Project (the Project). This modelling exercise addresses commitment INAC-Rec-11 that was discussed at the Nunavut Water Board's Phase 2 Hope Bay Belt technical meeting on May 15, 2018. The goal of the modelling exercise was to simulate total arsenic concentrations in Aimaokatalok Lake when arsenic concentrations in the water treatment plant (WTP) discharge were set to the maximum amended Metal and Diamond Mining Effluent Regulations (MDMER) arsenic concentration of 0.1 mg/L. This modelling exercise followed the previously completed hydrodynamic modelling presented in the Madrid-Boston Final Environmental Impact Statement (FIES; Appendix V5-4E; ERM 2017). Water quality predictions in Aimaokatalok Lake during the FEIS modelling previously had arsenic concentrations treated to 0.01 mg/L in the WTP effluent (Table 3-19; Package P5-4; SRK 2017).

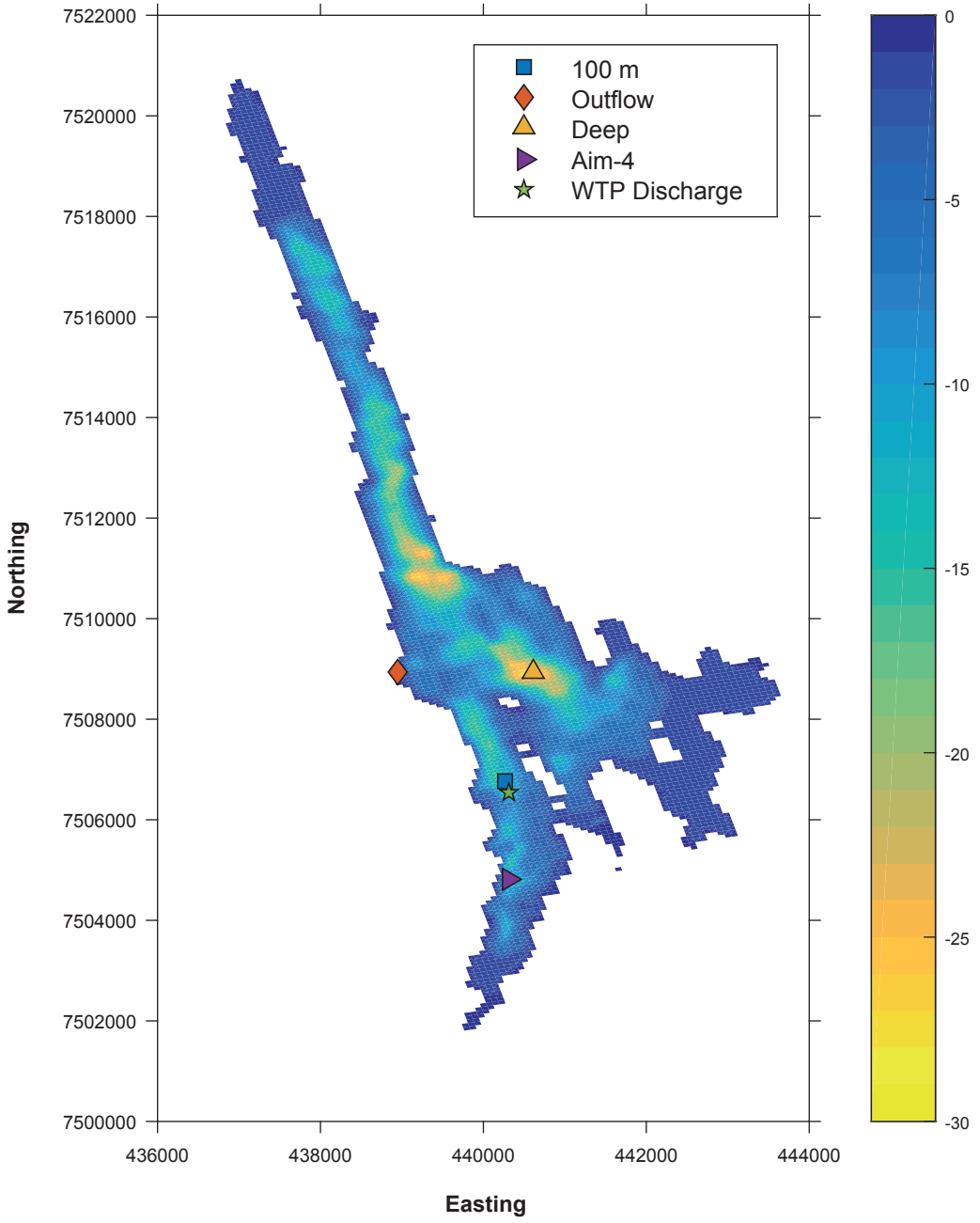
All baseline information, model parameterizations, and external inputs remain the same as previously described in ERM (2017). Only the information pertinent to the current modelling exercise is presented in this memo: Section 2 presents the updated model inputs relevant to the arsenic concentration simulations and Section 3 presents and discusses the results of the modeling and predictive exercises.

2. AIMAOKATALOK LAKE MODEL

The Aimaokatalok Lake model was developed using a three-dimensional, hydrodynamic and water quality model called the Generalized Environmental Modeling System for Surfacewaters (GEMSS®). This model was selected based on its successful use in similar water quality studies for small lakes with introduced effluents, particularly its ability to represent the seasonal onset, extension, and overturn of lake stratification. A detailed model description was presented in ERM (2017), the lake model bathymetry and relevant locations are displayed in Figure 2-1.

Figure 2-1

Bathymetry and Station Locations, Aimaokatalok Lake Model



2.1 Boston Effluent Description

Table 2-1 summarizes the comparison of predicted arsenic concentrations in the Boston combined WTP and sewage treatment plant (STP) discharge (SRK 2017) with the applicable Canadian Council of Ministers of the Environment (CCME) arsenic guideline concentration for the protection of aquatic life and predicted and measured baseline concentrations in Aimaokatalok Lake. The arsenic concentration inputs in the WTP discharge for this newest modelling run were set to the maximum amended MDMER arsenic level of 0.1 mg/L with predicted maximum WTP-STP arsenic concentrations of 0.095 mg/L (i.e., slightly diluted because of STP inputs; Figure 2-2). These arsenic concentrations can be considered conservative as a 0.1 mg/L was always applied to the WTP discharge, but in reality arsenic concentrations are anticipated to be treated to much lower concentrations (0.01 mg/L as presented in the FEIS). It was assumed water quality would be protective of aquatic life in Aimaokatalok Lake if arsenic concentrations were predicted to be less than the CCME threshold of 0.005 mg/L.

Table 2-1. Aimaokatalok Lake Baseline and Predicted Boston Combined Discharge Water Arsenic Concentrations and Dilution required to meet CCME Guideline

Parameter	CCME	Baseline – Aimaokatalok Lake		Predicted WTP-STP Boston Effluent Maximum[b]	Predicted Median: CCME (X:1)	Effective Dilution Required to Meet CCME (X:1)
		Observed 75th	Predicted Median[a]			
Total Arsenic	0.005	0.00019	0.000164	0.0947	0.033	18.9

Notes: All concentrations are in mg/L.

[a] Predicted lake baseline and effluent concentrations from Hope Bay Project - Water and Load Balance (SRK 2017) outputs.

[b] Based on WTP arsenic levels of 0.1 mg/L.

From Table 2-1 it can be surmised that if the Boston combined discharge is diluted by more than 18.9:1 within the Aimaokatalok Lake mixing zone then all water quality will be protective of aquatic life in the lake as it relates to the Boston combined discharge.

3. SIMULATION RESULTS AND DISCUSSION

The Boston combined discharge plume behaviour was numerically simulated in Aimaokatalok Lake based on nominal yearly operating conditions that could occur during the winter (ice covered), freshet, and summer (well mixed, open water) seasons. Total arsenic concentrations were predicted over the temporal scale of the Boston combined discharge and the spatial scale of all of Aimaokatalok Lake (all depths and locations).

3.1 Total Arsenic in Aimaokatalok Lake

Figure 3-1 presents the predicted total arsenic concentrations with time in Aimaokatalok Lake at four locations:

- 100 m north of the Boston outfall location (100 m; at surface, 5, 10, and 15 m depth);
- near the Aimaokatalok Outflow to Koignuk River (OUTFLOW; at surface);
- Station 6 in the deepest portion of the lake (DEEP; at surface, 5, 10, 15, 20, and 25 m depth); and
- AIM-4 station in the southern portion of the lake (at surface, 5, and 10 m depth).

Figure 2-2

Total Arsenic Concentration in Combined WTP-STP Discharge, Aimaokatalok Lake Model

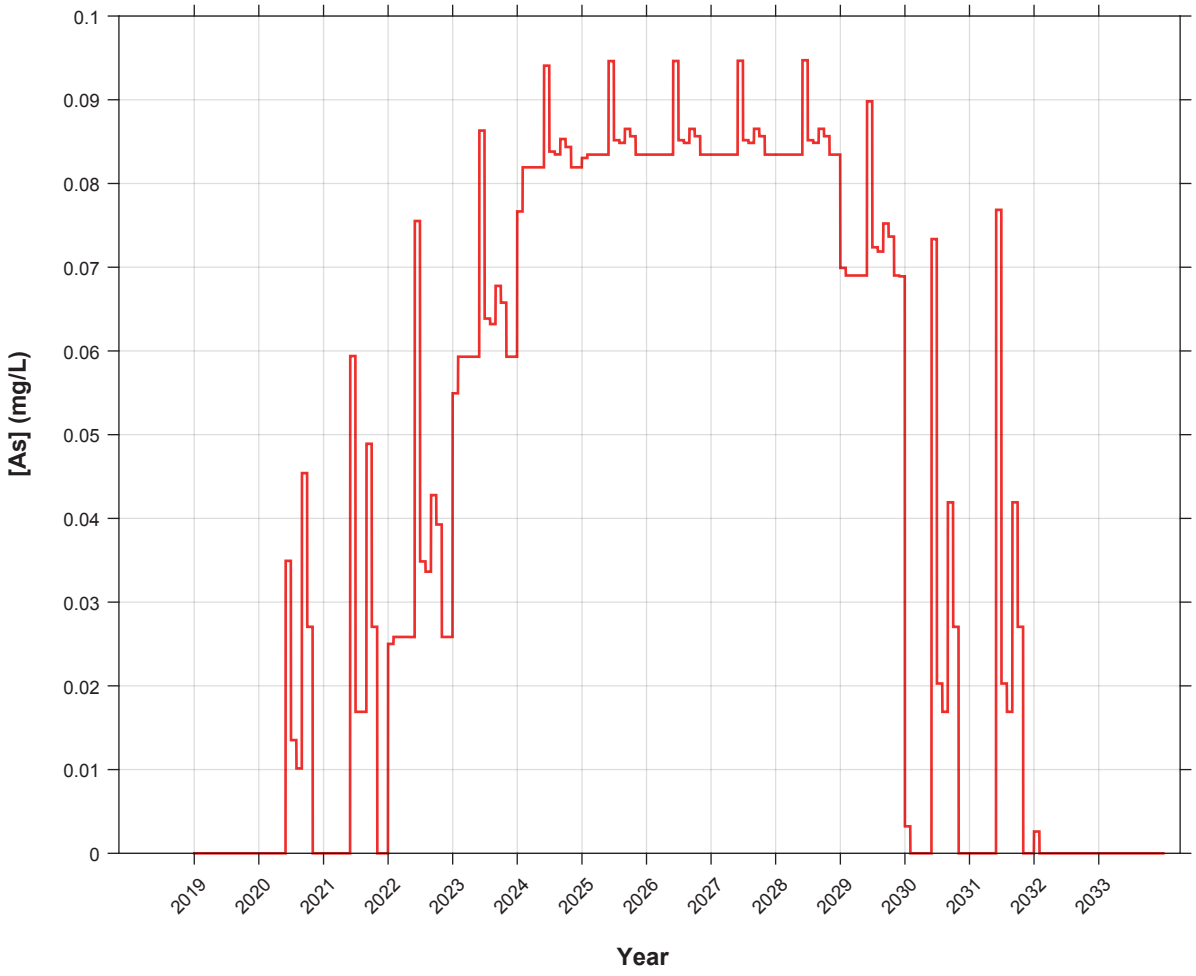
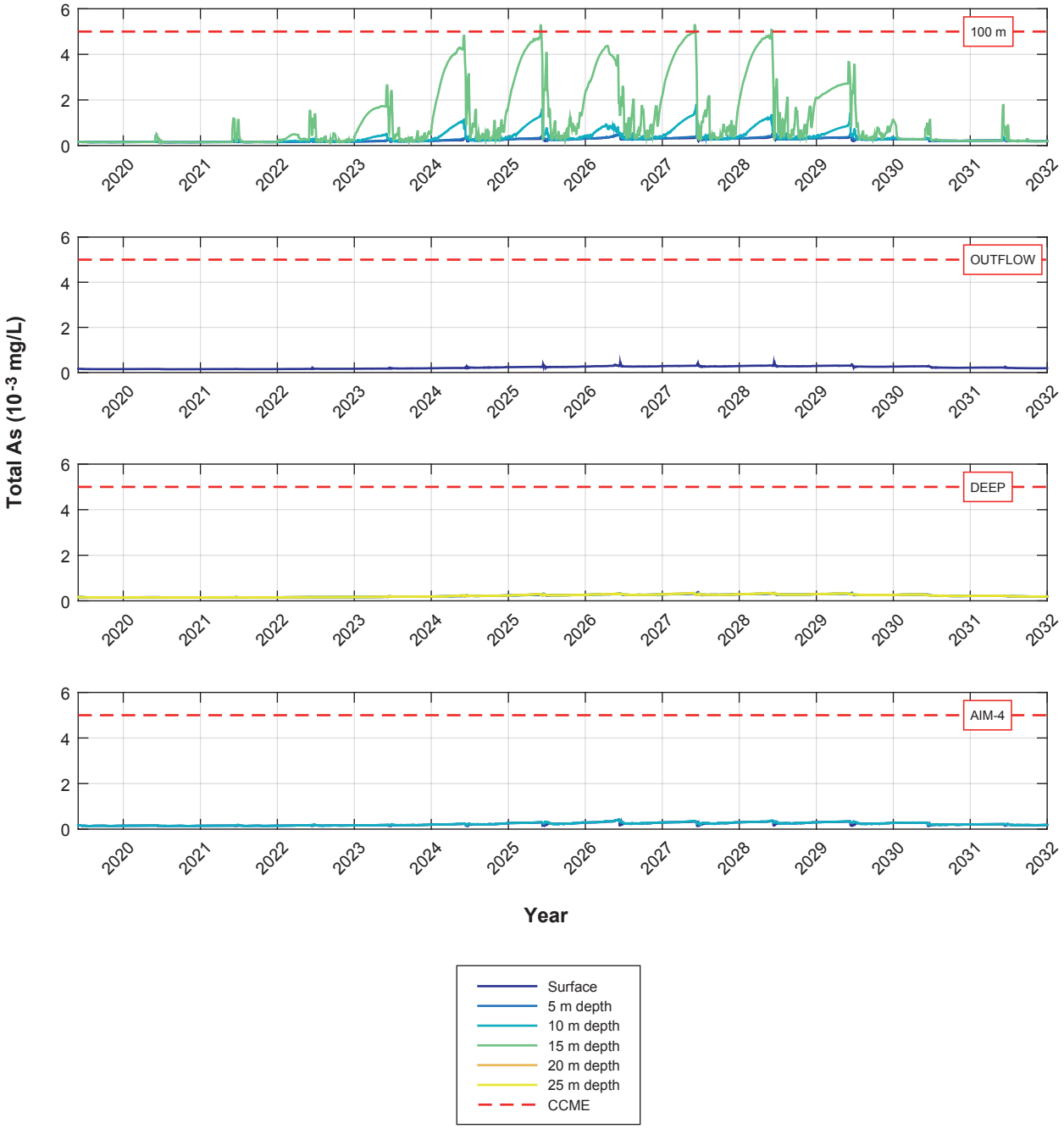


Figure 3-1

Total Arsenic Timeseries for Selected Stations, Aimaokatalok Lake Model



All four of these areas are located either within the long western basin of the lake or nearby within the deep central basin. Similar to the phosphorus and chromium results in the FEIS modelling exercise (ERM 2017), there is very little difference in predicted arsenic concentrations among the three areas not located within the main effluent discharge trench (i.e., OUTFLOW, DEEP, and station AIM-4) as the predicted arsenic concentrations remain indistinguishable from baseline concentrations during the modeled period, and far below the CCME guideline value of 0.005 mg/L.

Within 100 m from the outfall, arsenic concentrations are predicted to approach the CCME guideline below 10 m during the ice-covered period. On June 1st for every modelled year a sharp increase in bottom water arsenic concentrations is observed for a few days due to the elevated effluent flow. These concentration spikes are slightly above CCME guidelines for a few days during the 2025, 2027, and 2028 model years, reaching a maximum of 0.0053 mg/L. However, these concentrations are limited to the small, bottom water mixing zone within 100 m of the outfall during the under-ice season and rapidly decrease after a few days once freshet currents and ice melting thoroughly mix the water column and dilute the effluent. Arsenic concentrations remain near baseline levels at all depths throughout the discharge period beyond the near-field, bottom-water effluent discharge site.

The contour heat plots shown in Figure 3-2 represent average bottom and surface water arsenic concentrations throughout Aimaokatalok Lake for the May and August 2028 simulations (last year of maximum discharge concentrations; Figure 2-2). August results show that the vast majority of the lake area maintains arsenic concentrations near baseline concentrations (below 0.0002 mg/L) during the open-water season, with increased concentrations only present in the immediate near-field mixing area of the Boston WTP-STP combined discharge location. May under-ice concentrations in the bottom waters were more variable, with a peak at the outfall location and greater concentrations found within the deeper trench in the western section of the lake. This demarcation is not apparent in the under-ice surface waters and quickly dissipates once currents mix lake waters in the open-water season.

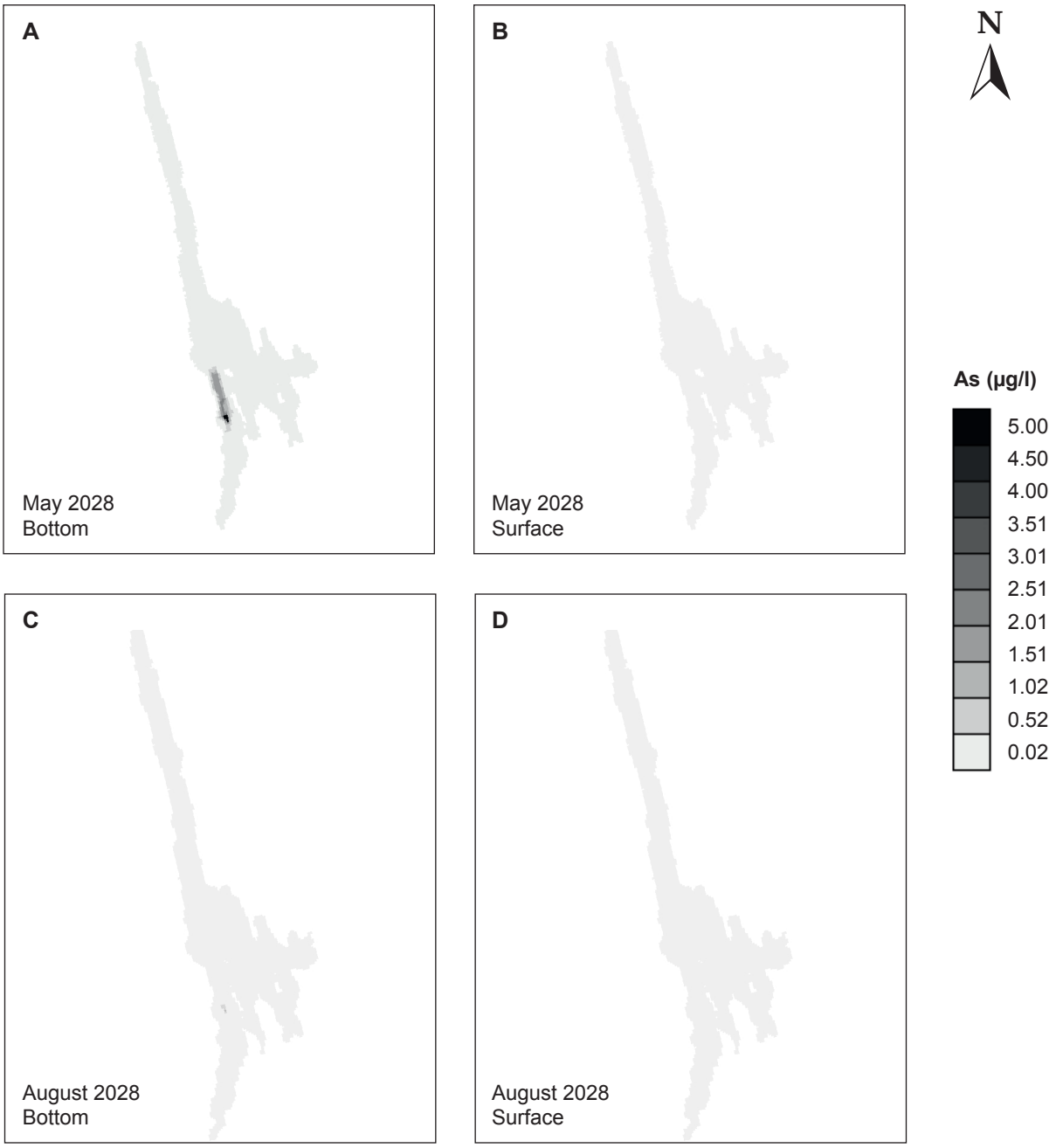
4. CONCLUSIONS

Total arsenic concentrations were predicted over the temporal scale of the Boston combined discharge period (June 2020 to December 2031) and the spatial scale of all of Aimaokatalok Lake (all depths and locations). Both open-water (June to October) and under-ice (November to May) seasons were included in the modelling.

In summary, arsenic concentrations are predicted be near baseline levels throughout Aimaokatalok Lake during the operational phase of the Project when WTP discharge is treated to the conservative concentration of 0.1 mg/L, and therefore protective of aquatic life. The exception is within the small, bottom water mixing zone within 100 m of the outfall during the under-ice season. Within this zone, arsenic concentrations are predicted to approach the CCME arsenic guideline concentration of 0.005 mg/L at the 100 m perimeter near the end of the ice-covered season. Arsenic concentrations may be temporarily greater than the CCME threshold near the effluent outfall due to the sharp June increase in effluent discharge flow, but will decrease rapidly with the onset of freshet.

Figure 3-2

Total Arsenic Average Predictions for Aimaokatalok Lake: May and August 2028



The higher arsenic concentrations within the under-ice, bottom water mixing zone are not expected to affect aquatic life since they are near the CCME guideline of 0.005 mg/L and far below the 0.025 mg/L arsenic site-specific water quality objective determined to be protective of the similar Arctic aquatic habitat for the Back River Project in Nunavut. As well, the arsenic CCME guideline of 0.005 mg/L has a 10-fold safety factor applied (CCME 2018), and the most sensitive species used to derive the guideline was affected at 0.05 mg/L of arsenic, which is half that conservatively predicted in the effluent. This concentration would be met in the Aimaokatalok Lake receiving environment almost immediately based on dilutions modelled previously (ERM 2016). Given the conservative 0.1 mg/L arsenic WTP concentration and the short duration that arsenic concentrations are predicted to be near the CCME guideline in the near-field receiving environment, there are no effects predicted for the aquatic life in Aimaokatalok Lake. Potential environmental effects in the lake will be assessed through the Environment Effects Monitoring program of the MDMER and the Boston-Madrid Aquatic Effects Monitoring Program (AEMP). If effects are found in the lake, they will be adaptively managed through the Aquatic Response Framework built into the AEMP.

REFERENCES

CCME. 2018. *Canadian Water Quality Guidelines for the Protection of Aquatic Life - Arsenic.* http://ceqg-rcqe.ccme.ca/download/en/143 (accessed June 2018).

ERM. 2016. *Near-field Plume Mixing Modelling for Discharges to Aimaokatalok Lake*. Preapred for TMAC Resources Ltd. by ERM Consultants Canada Ltd.: Vancouver, BC

ERM. 2017. *Hydrodynamic Mixing Modelling and Water Quality Predictions for Discharges to Aimaokatalok Lake*. Prepared for TMAC Resources Ltd. by ERM Consultants Canada Ltd.: Vancouver, BC.

SRK. 2017. *Hope Bay Project - Water and Load Balance*. Prepared for TMAC Resources by SRK Consulting (Canada) Inc.: Vancouver, BC.

Appendix D

Memo: TMAC Response to INAC-Rec 2, 4, 5, 6 and 9. June 15, 2018.

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Memo

To:	Oliver Curran, Vice President Environmental Affairs	**Client:**	TMAC Resources
From:	Maritz Rykaart, PhD, PEng Cameron Hore, PEng	**Project No:**	1CT022.022
		Date:	June 15, 2018
Subject:	TMAC Response to INAC-Rec-2, 4, 5, 6 and 9		

1 Context

SRK Consulting (Canada) Inc. has prepared this technical memo to address Indigenous and Northern Affairs Canada's (INAC's) technical comments, INAC-TC-1 Recommendation #2, INAC-TC-2 Recommendation #4, #5, #6 and INAC-TC-3 Recommendation #9 as discussed at the Phase 2 Hope Bay Belt Project technical meeting on May 15, 2018. The commitment to provide this response is listed as Item #6, #8, #9, #10 and #11 in Appendix A of the Nunavut Water Board memo titled "Phase 2 Hope Bay Belt Project Type 'A' Water Licence Applications: 2AMDOH1323 Amendment No. 2 and 2AM-BOS----; Technical Meeting Issues and Commitments", dated May 29, 2018.

2 INAC-Rec-2, 4, 5, 6 and 9: Response

SRK has prepared a detailed compilation of the component specific potential failure modes (i.e. performance uncertainties) to inform closure design uncertainties, as well as long term closure maintenance requirements up to 100 years post closure. This information, presented in Attachment A, clearly lays out any performance and design uncertainties, the consequence and likelihood of the identified uncertainty materializing, the approach to mitigate and/or manage the uncertainty, and whether this uncertainty is already addressed in the existing closure plans and associated closure cost estimates.

Through this table it is clearly and comprehensively demonstrated that the existing closure plans and associated closure cost estimates have:

- Addressed design uncertainties to the level required for this stage of the project such that the closure cost estimate is sufficient to implement the closure design. Therefore, there is no need to conduct any closure research to eliminate or manage closure design uncertainties; and
- Considered post-closure performance and associated uncertainties to the level reasonable such that no long term ongoing maintenance can reasonably be expected to be required.

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

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

Attachment A: Closure Design and Performance Uncertainties Table

Potential Closure Design and Post Closure (100 Years) Maintenance Uncertainties							
Closure Component	**Closure Design or Closure Performance Issue**	**Uncertainty**	**Consequence of Uncertainty Materializing**	**Likelihood of Uncertainty Materializing**	**Approach to Mitigate Uncertainty**	**Approach to Manage Uncertainty**	**Addressed in Closure and Reclamation Plan and Associated Cost Estimate**
All-Weather Roads/Airstrips	Design	The number of locations with permanently ponded areas adjacent to road/airstrip shoulders where sections of the road need to be removed to promote free drainage.	Isolated permanent ponding could occur adjacent to road shoulder which may result in tundra vegetation dieback, which in turn can start onset of long-term thermal erosion. Should this occur additional closure earthworks would be required to excavate drainage pathways through select areas of the roads/airstrips.	None. Roads are constructed with run-of-quarry material that is free draining and does not preclude surface water flow. This is confirmed by the fact that approximately 20 km of the project roads date back to 2007 and there are no locations where this issue has been identified to date. In addition, at the time of closure there will no longer be any uncertainty with regards to the number of locations with permanently ponded water adjacent road/airstrip shoulders as any such areas would have been identified during the operational phase.	None. Continued observation and reporting during operational stage. Such observations are formally documented as part of annual geotechnical site inspections which is a licensing condition.	Not required.	Yes. The potential impact on the cost is negligible, and can reasonably be considered under the contingency allowance. The total length of all the project all-weather roads/airstrips is about 95 km, including the Madrid-Boston All-Weather Road. Assuming there is one location every 5 km along the roads and the amount of material requiring removal at each location is 20 m^3, the total volume of additional earthworks removal is 360 m^3 which equates to a total cost of $1,800 (cost rate = $5/$m^3$). This is equivalent to a fraction of one percent of the provided contingency.
	Design	Geochemistry of construction material.	Onset of acid rock drainage or neutral metal leaching leading to poor quality drainage that may impact water bodies and therefore aquatic, terrestrial or bird life. Poor quality drainage can also cause tundra vegetation dieback which in turn can start onset of long-term thermal erosion. Should this occur additional closure mitigation would be required in the form of relocation or cladding of impacted material.	None. All roads and airstrips are constructed using geochemically suitable material. Appropriate testing and seep survey sampling are done and reported to the licensing agencies during the construction and operations phase to demonstrate this. Unsuitable material identified are removed.	None. Licensing requirements in place during the construction phase addresses this issue.	Not required.	Yes.
	Performance	Long term active layer deepening resulting in overburden consolidation and differential settlement of road.	None. Roads are not required to be used post-closure and therefore undulations are of no consequence.	Low. Road thicknesses are based on rigorous thermal modeling during design. This is supported by the performance of approximately 20 km of road that has been on site for approximately 10 years with no signs of deformation confirming the conservativeness in the engineering analysis. Engineering assessment confirm that even considering long term climate change predictions, active layer thickness deepening won't result in road settlement of more than 100 to 200 mm which is of no consequence.	None. Roads are designed based on rigorous thermal analysis which takes the active layer into account.	Not required.	Yes.
All-Weather Pads	Design	Amount of pad fill material classified as contaminated and therefore requiring removal.	None. All areas with contamination that had not been remediated as part of the operational phase will have been identified prior to final closure and the closure strategy will be implemented based on this information. Should this occur additional earthworks costs would be required to relocate contaminated materials.	None. An allowance has already been made for removal of contaminated material from all-weather pads in the closure cost estimate. Furthermore, at the time of closure there will no longer be any uncertainty with regards to number of locations with contamination since all spills are documented and reported to the relevant regulators as per licence requirements. In addition, all operational spills are remediated as and when they occur as part of regular operations.	None. Continued observation and reporting during operational stage. Such observations are formally documented as part of spill response reporting which is a licensing condition.	Not required.	Yes. An allowance for contaminated material relocation from all-weather pads is included in the cost estimate totaling $791,540.
	Design	Quantity of scaling required on high walls adjacent to pads.	None. No consequence associated with this as there is no pad use post-closure, and hazard is no different than any natural rock cliff prevalent in area. Should this be a concern, additional scaling of rock faces or saftey barriers/singage may be required.	None. Scaling of rock faces would occur during construction and operations for personnel safety requirements. Saftey barriers/singage would be installed at descreation of Mines Inspector at Final Closure.	None. This will be undertaken during the operational or closure phase.	Not required.	Yes. The potential impact on the cost for saftey barriers/singage installation is negligible, and can reasonably be considered under the contingency allowance.

Potential Closure Design and Post Closure (100 Years) Maintenance Uncertainties							
Closure Component	**Closure Design or Closure Performance Issue**	**Uncertainty**	**Consequence of Uncertainty Materializing**	**Likelihood of Uncertainty Materializing**	**Approach to Mitigate Uncertainty**	**Approach to Manage Uncertainty**	**Addressed in Closure and Reclamation Plan and Associated Cost Estimate**
	Design	Geochemistry of construction material.	Onset of acid rock drainage or neutral metal leaching leading to poor quality drainage that may impact water bodies and therefore aquatic, terrestrial or bird life. Poor quality drainage can also cause tundra vegetation dieback which in turn can start onset of long-term thermal erosion. Should this occur additional closure mitigation would be required in the form of relocation or cladding of impacted material.	None. All pads are constructed using geochemically suitable material. Appropriate testing and seep survey sampling are done and reported to the licensing agencies during the construction and operations phase to demonstrate this. Unsuitable material identified are removed.	None. Licensing requirements in place during the construction phase addresses this issue.	Not required.	Yes.
	Performance	Long term active layer deepening resulting in overburden consolidation and settlement of pad.	None. Pads are not required to be used post-closure and therefore undulations are of no consequence.	Low. Pad thicknesses are based on rigorous thermal modeling during design. This is supported by the performance of all Doris mine infrastructure pads that has been on site for approximately 10 years with no signs of deformation confirming the conservativeness in the engineering analysis. Engineering assessment confirm that even considering long term climate change predictions, active layer thickness deepening wont result in road settlement of more than 100 to 200 mm which is of no consequence.	None. Pads are designed based on rigorous thermal analysis which takes the active layer into account.	Not required.	Yes.
Breached Contact Water Ponds (Boston Tailings Management Facility)	Design	Geochemistry and physical make-up of sediment within contact water ponds at time of closure.	Poor quality drainage can impact water bodies and therefore aquatic, terrestrial or bird life. Poor quality drainage can also cause tundra vegetation dieback which in turn can start onset of long-term thermal erosion. Fine sediment, even if geochemically suitable, may result in unacceptable total suspended solids concentrations in downstream water bodies. Should this occur additional closure mitigation would be required in the form of relocation or cladding of sediments.	None. The containment pond design capacity needs to be maintained, and therefore any material quantities of sediment buildup needs to be removed as it occurs. Furthermore, if concentrated flows on the tailings management facility is observed, leading to surface erosion such flow paths will be remediated as part of normal operations.	None. Accumulated material required to be removed during operations, and remedial measures to be implemented to prevent erosion resulting in sedimentation during operations.	Not required.	Yes.
	Design	Thermal erosion along the recreated flow path.	Permanent ponding will result in tundra vegetation dieback which in turn can start onset of long-term thermal erosion. Should this occur additional closure mitigation would be required in the form of additional thermal cover.	None. Prior to design implementation appropriate thermal analysis will be completed to confirm the minimum thermal thickness to preclude long-term ponding. The results of this analysis will be similar to existing thermal analysis, but will be updated based on long-term site specific performance data.	None. Part of routine detailed engineering analysis to be completed at closure which includes appropriate thermal analysis.	Not required.	Yes. Detailed design engineering design is costed as part of the estimate based on 5% of Direct Costs.

Potential Closure Design and Post Closure (100 Years) Maintenance Uncertainties							
Closure Component	**Closure Design or Closure Performance Issue**	**Uncertainty**	**Consequence of Uncertainty Materializing**	**Likelihood of Uncertainty Materializing**	**Approach to Mitigate Uncertainty**	**Approach to Manage Uncertainty**	**Addressed in Closure and Reclamation Plan and Associated Cost Estimate**
Breached Contact Water Ponds (All Ponds except Boston Tailings Management Facility)	Design	Geochemistry and physical make-up of sediment within contact water ponds at time of closure.	Poor quality drainage can impact water bodies and therefore aquatic, terrestrial or bird life. Poor quality drainage can also cause tundra vegetation dieback which in turn can start onset of long-term thermal erosion. Fine sediment, even if geochemically suitable, may result in unacceptable total suspended solids concentrations in downstream water bodies. Should this occur additional closure mitigation would be required in the form of relocation or cladding of sediments.	None. The containment pond design capacity needs to be maintained, and therefore any material quantities of sediment buildup needs to be removed as it occurs. More importantly, ponds are located downstream of non-erodible waste rock and ore stockpiles and therefore sediments loads during operations are expected to be negligible. Current ponds at Doris mine confirms this to be the case with no sediment buildup since construction in 2007.	None. Accumulated material required to be removed during operations.	Not required.	Yes.
	Design	Thermal erosion along the recreated flow path.	Permanent ponding will result in tundra vegetation dieback which in turn can start onset of long-term thermal erosion. Should this occur additional closure mitigation would be required in the form of additional thermal cover.	None. Prior to design implementation appropriate thermal analysis will be completed to confirm the minimum thermal thickness to preclude long-term ponding. The results of this analysis will be similar to existing thermal analysis, but will be updated based on long-term site specific performance data.	None. Part of routine detailed engineering analysis to be completed at closure which includes appropriate thermal analysis.	Not required.	Yes. Detailed design engineering design is costed as part of the estimate based on of 5% of Direct Costs.
Quarries	Design	Quantity of scaling required on vertical faces.	None. No consequence associated with this as there is no quarry use post-closure, and hazard is no different than any natural rock cliff prevalent in area. Should this be a concern, additional scaling of rock faces or saftey barriers/singage may be required.	None. Scaling of rock faces would occur during construction and operations for personnel safety requirements. Saftey barriers/singage would be installed at descreation of Mines Inspector at Final Closure.	None. This will be undertaken during the operational or closure phase.	Not required.	Yes. The potential impact on the cost for saftey barriers/singage installation is negligible, and can reasonably be considered under the contingency allowance.
	Design	Geochemistry of quarry.	Onset of acid rock drainage or neutral metal leaching leading to poor quality drainage that may impact water bodies and therefore aquatic, terrestrial or bird life. Poor quality drainage can also cause tundra vegetation dieback which in turn can start onset of long-term thermal erosion. Should this occur additional closure mitigation would be required in the form of relocation or cladding.	None. All quarries are geochemically characterized prior to development. Geochemically unsuitable quarries are not developed.	None. Operational practices precludes development of unsuitable quarries.	Not required.	Yes.

Potential Closure Design and Post Closure (100 Years) Maintenance Uncertainties							
Closure Component	**Closure Design or Closure Performance Issue**	**Uncertainty**	**Consequence of Uncertainty Materializing**	**Likelihood of Uncertainty Materializing**	**Approach to Mitigate Uncertainty**	**Approach to Manage Uncertainty**	**Addressed in Closure and Reclamation Plan and Associated Cost Estimate**
Non-Hazardous Waste Landfill Cover	Design	Gradation of quarry material not suitable to place design thickness of 0.3 m.	None. The function of the cover is to isolate the non-hazardous waste from occasional land users, large terrestrial mammals and birds. To this end the cover thickness is not material, but given the only viable construction source is quarry rock, a cover thickness of 0.3 m was specified as the minimum practical thickness that can be placed. Actual cover thickness will however be a function of the final gradation of the rock, and the gradation of the rock will be a function of the level of effort extending during drilling and blasting, and/or the decision to crush and screen material.	None. Quarries have been developed at the project since 2007 and the geomechanical properties of the rock is well understood, which in turn means quarry material can easily be manufactured to designated specifications. At time of final closure the site will have approximately 30 years of experience in producing this material.	None. Quarry material consistent with the proposed cover specifications are continuously being produced.	Not required.	Yes. Cover material cost estimate is based on producing materials to the required cover specification. Lower blast loads during quarry development may produce larger rock grading necessitating thicker cover, but that would mean a different (and likely lower) quarry development cost which would offset the larger cover volume. Similarly, higher blast loads, or additional crushing and screening may produce smaller rock grading which could allow the cover thickness to be reduced. The increased cost of cover material in this case could be offset by the need for a smaller volume.
	Design and Performance	Cover settlement.	None. Cover settlement will result in undulations in the covered surface which may lead to localized ponding. Should this occur it does not affect the function of the cover which is to isolate the non-hazardous waste from occasional land users, large terrestrial mammals and birds.	Low. Natural consolidation settlement of landfilled materials over time will manifest as undulations but as stated these are of no consequence.	None. Design and performance not sensitive to settlement.	Not required.	Yes
	Performance	Cover migration into voids	Void space in the non-hazardous waste is inevitable, and over the long term the cover material may ravel through openings into voids. This may result in exposed non-hazardous waste which would mean that the landfill cover is no longer fulfilling its intended purpose of isolating the waste from occasional land users, large terrestrial mammals and birds.	None. The potential for long term cover migration into voids can to a large extent be minimized by adoption of good waste management practices during operations and closure. A dedicated landfill management plan will address waste placement within the landfill prior to landfill operation. This management plan will include placement and compaction requirements to minimize the potential for large voids being left in the landfill mass. The placement methodology at closure will also include the strategic placement of 'sheet' type materials such as geomembranes, sheet metal and cut sections of tanks as the final waste layer to create a layer impenetrable by the overlying rockfill cover. This will eliminate the migration of the rockfill cover material into any significant voids which may have inadvertently been created during the development of the landfill.	None. Operational practices, governed by a dedicated landfill management plan will minimize the risk of significant voids in the landfill during operations or closure. Strategic placement of 'sheet' type materials will create layers which do not allow the migration of rockfill into voids.	Closure cost to reflect the cutting of 'sheet' materials into manageable sections for placement in landfill.	Yes
	Design	Poor quality leachate.	Poor quality drainage that may impact water bodies and therefore aquatic, terrestrial or bird life. Should this occur additional closure mitigation would be required in the form of an infiltration reducing cover.	None. The landfill is licensed for non-hazardous waste only and therefore will not contain any products that can produce poor quality leachate.	None. Operational practices, governed by a dedicated landfill management plan will ensure no unsuitable material can be placed in the landfill during operations or closure. This is a licensing condition.	Not required.	Yes. Additionally, an allowance for contaminated material removal from site at closure is included in the cost estimate and therefore will not be disposed of in the non-hazardous landfill.

Potential Closure Design and Post Closure (100 Years) Maintenance Uncertainties							
Closure Component	**Closure Design or Closure Performance Issue**	**Uncertainty**	**Consequence of Uncertainty Materializing**	**Likelihood of Uncertainty Materializing**	**Approach to Mitigate Uncertainty**	**Approach to Manage Uncertainty**	**Addressed in Closure and Reclamation Plan and Associated Cost Estimate**
Doris Tailings Impoundment Area North Dam	Design	Volume of excavation required to achieve adequate dam breach.	None. If the breach was undersized for any reason it would simply raise the flow level at peak flow. The dam is constructed with coarse-grained, erosion resistant material and therefore no consequence is expected.	None. Suitable engineering analyses and assumptions already considered.	None. Addressed by design.	Not required.	Yes. Detailed design engineering design is costed as part of the estimate based on of 5% of Direct Costs.
	Performance	Unstable breach cut slopes.	Oversteepened breach cut slopes could fail resulting in blockage of the breach which would have to be repaired.	None. Slope design is based on rigorous and extensive geotechnical and thermal analysis supported by considerable data and long term dam performance data (more than 6 years already). Prior to closure this performance data will have a record of more than 20 years allowing for unprecedented certainty.	None. Part of routine detailed engineering analysis to be completed at closure which includes appropriate thermal analysis.	Not required.	Yes. Detailed design engineering design is costed as part of the estimate based on of 5% of Direct Costs.
	Performance	Erosion of structure.	None. Dam is constructed entirely of non-erodible quarry rock. Furthermore the entre dam shell is clad with at least 3 m of run-of quarry rock which is especially erosion resistant.	None. Only non-erosion susceptible materials have been used for dam construction.	None. Addressed by original dam design.	Not required.	Yes.
	Performance	Slope failure	None. Slope failures up- or downstream outside of the breach zone have no consequence to dam performance as the dam no longer fulfills a purpose of retaining either water or tailings solids.	None. Dam slopes have design factors of safety that far exceed minimum long-term requirements. The slope design is not dictated by slope requirements but by long-term deformation requirements. Notwithstanding, the slope design is based on rigorous and extensive geotechnical and thermal analysis supported by considerable data and long term performance data (more than 6 years already). Prior to closure this performance data will have a record of more than 20 years allowing for unprecedented certainty.	None. Part of routine detailed engineering analysis to be completed at closure which includes appropriate thermal analysis.	Not required.	Yes. Detailed design engineering design is costed as part of the estimate based on of 5% of Direct Costs.
	Performance	Long-term deformation of dam	None. Increased deformation would not have any consequence as the dam is no longer impounding water or any other material at closure.	None. Dam slopes have been designed to allow deformation assuming full head of water. Without water, impounded deformation will likely cease or slow down drastically. Notwithstanding, the slope design is based on rigorous and extensive geotechnical and thermal analysis supported by considerable data and long term performance data (more than 6 years already). Prior to closure this performance data will have a record of more than 20 years allowing for extremely high certainty.	None. Part of routine detailed engineering analysis to be completed at closure which includes appropriate thermal analysis.	Not required.	Yes. Detailed design engineering design is costed as part of the estimate based on of 5% of Direct Costs.
	Design	Geochemistry of dam material.	Onset of acid rock drainage or neutral metal leaching leading to poor quality drainage that may impact water bodies and therefore aquatic, terrestrial or bird life. Poor quality drainage can also cause tundra vegetation dieback which in turn can start onset of long-term thermal erosion. Should this occur additional closure mitigation would be required in the form of cladding of dam material.	None. All dams are constructed using geochemically suitable material. Appropriate testing and seep survey sampling are done and reported to the licensing agencies during the construction and operations phase to demonstrate this. Unsuitable material identified are removed.	None. Licensing requirements in place during the construction phase addresses this issue.	Not required.	Yes.

Potential Closure Design and Post Closure (100 Years) Maintenance Uncertainties							
Closure Component	**Closure Design or Closure Performance Issue**	**Uncertainty**	**Consequence of Uncertainty Materializing**	**Likelihood of Uncertainty Materializing**	**Approach to Mitigate Uncertainty**	**Approach to Manage Uncertainty**	**Addressed in Closure and Reclamation Plan and Associated Cost Estimate**
Doris Tailings Impoundment Area South and West Dams	Performance	Slope failure	Downstream slope failures is unlikely to result in release of tailings as permafrost will aggrade into the tailings.	None. Dam slopes have design factors of safety that far exceed minimum long-term requirements. The slope design is not dictated by slope requirements but by long-term deformation requirements. Notwithstanding, the slope design is based on rigorous and extensive geotechnical and thermal analysis supported by considerable data and long term performance data (more than 6 years already). Prior to closure this performance data will have a record of more than 20 years allowing for unprecedented certainty.	None. Part of routine detailed engineering analysis to be completed at closure which includes appropriate thermal analysis.	Not required.	Yes. Detailed design engineering design is costed as part of the estimate based on of 5% of Direct Costs.
	Performance	Long-term deformation of dams	None. Increased deformation would not result in a release of tailings solids and therefore is of no consequence.	None. Dam slopes have been designed to allow deformation assuming tailings operational conditions. Under closure conditions deformation will likely cease or slow down drastically. Notwithstanding, the slope design is based on rigorous and extensive geotechnical and thermal analysis supported by considerable data and long term performance data (more than 6 years already). Prior to closure this performance data will have a record of more than 20 years allowing for unprecedented certainty.	None. Part of routine detailed engineering analysis to be completed at closure which includes appropriate thermal analysis.	Not required.	Yes. Detailed design engineering design is costed as part of the estimate based on of 5% of Direct Costs.
	Design	Geochemistry of dam material.	Onset of acid rock drainage or neutral metal leaching leading to poor quality drainage that may impact water bodies and therefore aquatic, terrestrial or bird life. Poor quality drainage can also cause tundra vegetation dieback which in turn can start onset of long-term thermal erosion. Should this occur additional closure mitigation would be required in the form of cladding of dam material.	None. All dams are constructed using geochemically suitable material. Appropriate testing and seep survey sampling are done and reported to the licensing agencies during the construction and operations phase to demonstrate this. Unsuitable material identified are removed.	None. Licensing requirements in place during the construction phase addresses this issue.	Not required.	Yes.
Overburden Dumps	Design	Extent of regrading required to produce a stable landform.	Insufficient regrading could lead to slope instability within overburden dumps.	None. Overburden dumps are resloped upon construction to conservative slope angle of 3H:1V. Existing overburden dumps have been on site for over 10 years and shown no signs of instability or erosion.	None. Part of routine detailed engineering analysis to be completed at closure.	Not required.	Yes. Detailed design engineering design is costed as part of the estimate based on of 5% of Direct Costs.
	Performance	Erosion	None. Overburden dumps have been constructed at least 31 m away from fish bearing water bodies and have permanent permeable sediment control berm downgradient from them. These mitigations measures has been in operation for over 10 years and have been proven to be effective without ongoing maintenance.	None. Existing overburden dumps have been on site for over 10 years and shown no signs of instability or excessive erosion.	None. Part of routine detailed engineering analysis to be completed at closure.	Not required.	Yes. Detailed design engineering design is costed as part of the estimate based on of 5% of Direct Costs.
	Performance	Vegetation establishment	None. Vegetation is not a closure requirement, nor an objective. Volunteer vegetation will not be precluded but success of the closure plan is not contingent on the vegetation performance.	None. Physical stability is not contingent on vegetation success.	None.	Not required.	Yes.

Potential Closure Design and Post Closure (100 Years) Maintenance Uncertainties							
Closure Component	**Closure Design or Closure Performance Issue**	**Uncertainty**	**Consequence of Uncertainty Materializing**	**Likelihood of Uncertainty Materializing**	**Approach to Mitigate Uncertainty**	**Approach to Manage Uncertainty**	**Addressed in Closure and Reclamation Plan and Associated Cost Estimate**
Doris Tailings Impoundment Area Cover	Design	Depth of mixing zone when placing rock cover on saturated unconsolidated tailings.	None. Closure cover is to prevent dust and minimize direct contact with terrestrial animals (large mammals). The cover thickness is not material, and the 0.3. m thickness specified was based solely on what was deemed practical considering the available material. As long as no tailings are exposed at surface, the presence of a mixing zone is immaterial to the performance of the cover, as is the cover thickness.	Possible. In wet saturated fine tailings areas which is most likely to occur in close proximity of the Reclaim Pond edge at the time of closure. This is expected to be limited to a zone about 100 m wide from the Reclaim Pond shoreline.	Only place tailings cover under frozen conditions when the tailing surface is readily trafficable.	Closure schedule to reflect only winter tailings cover construction.	No. Not the preferred approach.
	Design				Delay cover construction until sufficient tailings consolidation has occurred.	Closure schedule to reflect delayed cover construction.	No. Not the preferred approach.
	Design				Conduct trafficability tests to confirm mixing zone extent and increase cover quantities accordingly.	Closure cost to reflect preliminary allowance for additional material based on best judgement.	Yes. As part of routine operations there will be ample times when the tailings will be required to be accessed to confirm the trafficability. If an allowance for some additional material around the Reclaim Pond shoreline is required based on evidence provided by operational activities on the tailings surface, it can reasonable be assumed that this would be limited to the zone approximately 100 m wide from the Reclaim Pond shoreline, an area approximately 18,000 m2. Should this entire area require am additional 0.5 m of rockfill placement, this would result in an additional closure cost of $404,460. This is equivalent to approximately 2.4% of the closure cost estimate for the TIA cover placement and is therefore well within the 20% contingency allowance. As such this uncertainty is considered adequately covered.
	Design				Include a separation layer such as a geotextile in the cover design.	Closure cost to reflect allowance for additional construction elements.	No. Not the preferred approach.
	Design	Gradation of quarry material not suitable to place design thickness of 0.3 m.		None, the mine has been operating quarries since 2007 and has a well established and refined operational practices to produce ROQ material according to specifications. At time of final closure the site will have approximately 30 years of experience in producing this material.	Continue to implement and refine existing operational procedures. Identify and characterize source material. Specify required grading and design quarry development and material crushing as necessary.	Not required.	Yes.

Potential Closure Design and Post Closure (100 Years) Maintenance Uncertainties							
Closure Component	**Closure Design or Closure Performance Issue**	**Uncertainty**	**Consequence of Uncertainty Materializing**	**Likelihood of Uncertainty Materializing**	**Approach to Mitigate Uncertainty**	**Approach to Manage Uncertainty**	**Addressed in Closure and Reclamation Plan and Associated Cost Estimate**
	Design	Insufficient volume/quantities of cover material available to complete cover system. construction	Complete coverage of the cover is required by design. If insufficient quarry rock has been produced, additional quarry development can be done.	None. Volumes can be calculated in advance and planned for. Volume of material in permitted quarries far exceed the planned quarry rock use.	None. Part of routine detailed engineering analysis to be completed at closure which includes development of absolute quantities.	Not required.	Yes.
	Performance	Development of "boils" resulting in tailings being exposed through cover.	Exposed tailings would be of concern as the function of the cover is to prevent dust and minimize direct contact with terrestrial animals (large mammals). Small areas of exposure is however not of concern. If more than 10% of covered surface has exposed tailings there would be a perception of concern, but actual impact would be negligible as exposure pathway is limited.	Low. Formation of "boil" are considered during the design phase and is most likely to be observed during construction where it can be immediately mitigated.	Eliminate very large permanent ponds on the tailings surface where variable hydraulic gradients can induce boils by managing deposition plan to create shedding surface and breaching North Dam at closure.	None required. Already part of closure design and operational principles.	Yes. Detailed design engineering design is costed as part of the estimate based on 5% of Direct Costs.
	Performance	Differential settlement and/or consolidation of tailings creating undulating surface.	None. The function of the cover is to prevent dust and minimize direct contact with terrestrial animals (large mammals). Ponding is of no concern as infiltration control is not a function of the cover.	Possible, but immaterial.	None.	Not required. However, normal operational practices are in place to eliminate ice buildup to maximize capacity..	Yes.
	Performance	Excessive rill/gully formation due to higher than expected runoff.	Although tailings surface is landscaped to allow free drainage, the tailings are susceptible to hydraulic erosion, which will mobilize tailings towards the Reclaim Pond. Therefore, a tailings cover that functions to prevent wind and water erosion will be constructed.	None. The cover is to be constructed of erosion resistant quarry rock.	Construct cover with demonstrably erosion resistant materials.	Not required.	Yes.
	Performance	Freeze / thaw cycling of the cover system.	Excessive cover deformation resulting from frost heave associated with long-term freeze-thaw cycling can lead to undulations and localized ponding.	Possible. The tailings impoundment area is constructed hydraulically at high moisture content. The facility freezes back as construction progresses. The material is largely homogeneous and is not frost susceptible so there will be negligible freeze/thaw cycling although the high entrained moisture content during placement could cause some discontinuities. Any undulations of the surface is however immaterial as it does not change the function of the cover. Minor cycling that would occur can readily be handled by the normal strain load of the geomembrane liner.	None.	Not required.	Yes.
	Performance	Burrowing animals damage liner.	Terrestrial animals may burrow into the rock cover, ultimately exposing tailings.	Low. Due to geographical area and climate, the likelihood of burrowing animals is considered low. Use of well-graded ROQ, as is planned, will make it difficult for small animals to dig through. Even if animals does make this a habitat the nature of the excavations will be small tunnels and exposure of tailings is unlikely.	None.	Not required.	Yes.
	Performance	Occasional land users damage cover.	None. Although occasional land users will travel through the area they will have no reason the access the closed tailings impoundment area. Access would be limited to foot travel, and potentially snowmobile and all-terrain vehicle travel. The run-of quarry cover can easily withstand those forces without risk of exposure of tailings.	None. The frequency of people accessing the area is low, and the cover is sufficiently robust to withstand access.	None	Not required.	Yes.

Potential Closure Design and Post Closure (100 Years) Maintenance Uncertainties							
Closure Component	**Closure Design or Closure Performance Issue**	**Uncertainty**	**Consequence of Uncertainty Materializing**	**Likelihood of Uncertainty Materializing**	**Approach to Mitigate Uncertainty**	**Approach to Manage Uncertainty**	**Addressed in Closure and Reclamation Plan and Associated Cost Estimate**
	Performance	Climate change leading to wetter conditions than anticipated in design	None. The cover function is not to reduce infiltration and wetter conditions won't alter this function.	Possible, but immaterial.	None.	Not required.	Yes.
Boston TMA Cover	Design	Increased area of cover required due to erosion of side slopes of Tailings Management Area during operations and accumulation of eroded tailings in Contact Water Ponds.	At final closure, small amounts of remnant eroded tailings that may be located within the contact water ponds will be removed and placed on the TMA prior to final cover construction. If it is found that the remnant residual tailings cannot be removed for whatever reason, a cover could be extended over the affected area.	None. The containment pond design capacity needs to be maintained, and therefore any material quantities of sediment buildup needs to be removed as it occurs. More importantly, ponds are located downstream of non-erodible waste rock and ore stockpiles and therefore sediments loads are expected to be negligible. Current ponds at Doris mine confirms this to be the case with no sediment buildup since construction in 2007.	None. Accumulated material required to be removed during operations.	Not required.	Yes.
	Design	Insufficient volume/quantities of cover material available to complete cover system. construction	Complete coverage of the cover is required by design. If insufficient geosynthetics are not available, more material can be produced and shipped to site. If insufficient quarry rock has been produced, additional quarry development can be done.	None. Volumes can be calculated in advance and planned for. Volume of material in permitted quarries far exceed the planned quarry rock use.	None. Part of routine detailed engineering analysis to be completed at closure which includes development of absolute quantities.	Not required.	Yes.
	Design	Geochemistry of tailings.	Onset of acid rock drainage or neutral metal leaching leading to poor quality drainage that may impact water bodies and therefore aquatic, terrestrial or bird life. The amount of infiltration that can be allowed to pass through the cover is dictated by the tailings geochemistry. Should this occur additional closure mitigation would be required in the form of relocation or cladding of impacted material.	None. Worst case geochemical predictions has been used to assess the cover requirements. Furthermore, the lowest conceivable infiltration reduction cover has been selected, with a stated performance far in excess what is required. Technology is proven.	None. Ongoing data collection during operations will confirm design conservatism, possibly leading to reduction of cover requirement.	Not required.	Yes.
	Performance	Localized sloughing of protective cover material.	Local sloughing of cover material can expose, or even tear the geosynthetic liner exposing the underlying tailings which would impact the functionality of the cover. Such damage may have to be repaired. Analysis has however demonstrated that even with 10% of the tailings surface exposed, there would be no environmental effects in the receiving water bodies.	None. The design of the cover has been based on well established geotechnical stability analyses considering infinite slope failure for a geosynthetic covered slope. Industry best practice factors of safety against slope failure have been applied. The materials are well known and seismicity is not a concern.	None. Part of routine detailed engineering analysis.	Not required.	Yes. Detailed design engineering design is costed as part of the estimate based on 5% of Direct Costs.
	Performance	Major slope failure of TMA.	A major slope stability failure of the TMA will tear the geosynthetic liner exposing the underlying tailings which will impact the functionality of the cover. Such damage will have to be repaired. Analysis has however demonstrated that even with 10% of the tailings surface exposed, there would be no environmental effects in the receiving water bodies.	None. The design of the TMA has been based on well established geotechnical analyses methods. Industry best practice factors of safety against slope failure have been applied. The materials are well known and seismicity is not a concern.	None. Part of routine detailed engineering analysis.	Not required.	Yes. Detailed design engineering design is costed as part of the estimate based on 5% of Direct Costs.

Potential Closure Design and Post Closure (100 Years) Maintenance Uncertainties							
Closure Component	**Closure Design or Closure Performance Issue**	**Uncertainty**	**Consequence of Uncertainty Materializing**	**Likelihood of Uncertainty Materializing**	**Approach to Mitigate Uncertainty**	**Approach to Manage Uncertainty**	**Addressed in Closure and Reclamation Plan and Associated Cost Estimate**
	Performance	Degradation of geomembrane liner.	None. The geomembrane liner may systematically break down over time resulting in increased infiltration through the cover. There is strong evidence to show that geomembrane liners installed in similar conditions can be expected to last well beyond 100 years. Analysis has however demonstrated that even with 10% of the tailings surface exposed, there would be no environmental effects in the receiving water bodies.	None. There is strong evidence to show that geomembrane liners installed in similar conditions can be expected to last well beyond 100 years.	None. Proven precedent.	Not required.	Yes.
	Performance	Erosion of protective cover layer	None. The geomembrane cover would still achieve the performance requirements.	None. The material proposed for the upper cover layer is ROQ rock which has demonstrated erosion resistance including at slopes steeper than those proposed for the Tailings Management Area.	None. Part of routine detailed engineering analysis.	Not required.	Yes. Detailed design engineering design is costed as part of the estimate based on 5% of Direct Costs.
	Performance	Deformation of TMA leading to undue cover deformation.	Excessive deformation of the Tailings Management Area can result in tears and ruptures of the liner which would result in the cover function no longer being maintained. Analysis has however demonstrated that even with 10% of the tailings surface exposed, there would be no environmental effects in the receiving water bodies.	None. The Tailings Management Area material is compacted upon placement and settlement within the tailings is expected to be negligible. Creep settlement has been analyzed and demonstrated to be of no concern.	None. Part of routine detailed engineering analysis.	Not required.	Yes. Detailed design engineering design is costed as part of the estimate based on 5% of Direct Costs.
	Performance	Freeze / thaw cycling of the cover system.	Excessive liner deformation resulting from frost heave associated with long-term freeze-thaw cycling can lead to liner rupture. Excessive deformation of the Tailings Management Area can result in tears and ruptures of the liner which would result in the cover function no longer being maintained.	None. The tailings management facility is constructed in lifts at controlled moisture content. The facility freezes back as construction progresses. The material is largely homogeneous and not frost susceptible so there will be negligible freeze/thaw cycling. Any minor cycling that would occur can readily be handled by the normal strain load of the geomembrane liner.	None. Appropriately flexible liner with suitable strain resistance part of design.	Not required.	Yes.
	Performance	Burrowing animals damage liner.	Terrestrial animals may burrow into the protective rock cover, ultimately exposing and damaging the geomembrane liner. Analysis has however demonstrated that even with 10% of the tailings surface exposed, there would be no environmental effects in the receiving water bodies.	Low. Due to geographical area and climate, the likelihood of burrowing animals is considered low. Use of well-graded run-of-quarry, as is planned, will make it difficult for small animals to dig through. Even if animals does make this a habitat the nature of the excavations will be small tunnels and exposure of liner is unlikely.	None.	Not required.	Yes.
	Performance	Occasional land users damage liner.	None. Although occasional land users will travel through the area they will have no reason the access the closed tailings management facility. Access would be limited to foot travel, and potentially snowmobile and all-terrain vehicle travel. The run-of quarry protective cover can easily withstand those forces without damage or risk to the liner.	None. The frequency of people accessing the area is low, and the cover is sufficiently robust to withstand access.	None	Not required.	Yes.
	Performance	Climate change leading to wetter conditions than anticipated in design	None. The geosynthetic cover has very low sensitivity to the volume of precipitation. Analysis has however demonstrated that even with 10% of the tailings surface exposed, there would be no environmental effects in the receiving water bodies.	Possible. The liner performance is however not sensitive to the amount of precipitation. Furthermore, more precipitation would imply greater dilution and as a result the cover performance would not have to be as stringent.	None. Part of routine detailed engineering analysis.	Not required.	Yes. Detailed design engineering design is costed as part of the estimate based on 5% of Direct Costs.

Potential Closure Design and Post Closure (100 Years) Maintenance Uncertainties							
Closure Component	**Closure Design or Closure Performance Issue**	**Uncertainty**	**Consequence of Uncertainty Materializing**	**Likelihood of Uncertainty Materializing**	**Approach to Mitigate Uncertainty**	**Approach to Manage Uncertainty**	**Addressed in Closure and Reclamation Plan and Associated Cost Estimate**
Marine Outfall Pipeline	Design	Complete removal of pipeline at closure or leaving it in place.	None. Local community members are divided on whether the pipeline needs to be removed or left in place. Leaving it in place poses no long term environmental risks as all materials are non-reactive and benign. Over the life of the mine the pipeline is however expected to become a productive habitat for marine life and therefore removal may result in destruction of newly created habitat.	Possible. The project certificate has a condition imposed requiring the proponent to conduct a survey of the pipeline prior to closure to determine the extent of the newly created habitat. Based on that information a determination needs to be made as to whether it should be removed or not.	None. Closure plan in accordance with stipulated Project certificate conditions.	Not required.	Yes. An amount of $50,000 is included in the cost estimate to conduct the survey of the pipeline as required. Should the pipeline be required to be removed the cost is estimated at $200,000 direct costs which is approximately 2.5% of the available contingency.
	Performance	Pipeline floats due to breakdown of ballast system.	Floating pipeline will become possible navigation hazard and generally be seen as littering of Roberts Bay. Should that occur pipeline need to be either re-anchored or removed.	None. Ballast system is a marine grade concrete pipe sleeve, so there are no joins or connections which could break free resulting in release of pipe.	None. Addressed by initial pipeline design.	Not required.	Yes.
	Performance	Pipeline or ballast system degrades and leaches poor quality leachate	None. Pipeline is high density polyethylene with a lifespan far beyond 100 years with no leaching characteristics in the marine environment and the concrete ballast sleeves are marine grade concrete with no leaching characteristics in the marine environment.	None. Pipeline and ballast system are not subject to degradation in the marine environment.	None. Addressed by initial pipeline design.	Not required.	Yes.
Vent Raises	Design	Size of required concrete cap.	Larger openings or poor quality collar rock will require more elaborate concrete cap design with associated higher cost.	None. All mine openings are geomechanically well characterized and understood and are all collared in competent rock. All mine openings have known dimensions and therefore there is absolute certainty regrading the required cap design.	None. Addressed by design.	Not required.	Yes.
	Performance	Concrete cap degrades.	A degraded concrete cap may fail and as such will not preclude inadvertent mine access by occasional land users, large terrestrial mammals or birds. To remedy the situation the cap will have to be repaired or replaced.	None. Concrete caps will be constructed with concrete designed for >100 year performance. Performance of concrete for these conditions is well understood.	None. Addressed by design.	Not required.	Yes.
	Design	Caps not watertight	None. All mine openings are collared in permafrost bedrock and are well above any post-mining reflooding elevations. Therefore there is no possible means for flooded mine to flow out via the vent raises.	None. Vent raises has been designed to physically preclude mine water outflow.	None. Addresses by design.	Not required.	Yes.
	Design	Unidentified openings	Unidentified openings will require unplanned costs for design and implementation of caps.	None. Any new mine vent raise locations are subject to licensing which approval is contingent on posting of a reclamation bond.	None. New mine vent raises may not be developed without appropriate licensing.	Not required.	Yes.
Mine Portals	Design	Under sizing or under design of plug.	An undersized or structurally underdesigned plug will not preclude inadvertent mine access by occasional land users, large terrestrial mammals or birds. To remedy the situation additional closure costs must be incurred.	None. All mine openings are geomechanically well characterized and understood and are all collared in competent rock. All mine openings have known access grades and dimensions and therefore there is absolute certainty regrading the required plug design.	None. Addressed by design.	Not required.	Yes.
	Design	Plugs not watertight	None. All mine openings are collared in permafrost bedrock and well above any post-mining reflooding elevations. Therefore there is no possible means for flooded mine to flow out via the portals.	None. Portal locations has been designed to physically preclude mine water outflow.	None. Addressed by design.	Not required.	Yes.
	Design	Unidentified openings	Unidentified openings will require unplanned costs for design and implementation of plugs.	None. Any new mine portals locations are subject to licensing which approval is contingent on posting of a reclamation bond.	None. New mine portals may not be developed without appropriate licensing.	Not required.	Yes.

Potential Closure Design and Post Closure (100 Years) Maintenance Uncertainties							
Closure Component	**Closure Design or Closure Performance Issue**	**Uncertainty**	**Consequence of Uncertainty Materializing**	**Likelihood of Uncertainty Materializing**	**Approach to Mitigate Uncertainty**	**Approach to Manage Uncertainty**	**Addressed in Closure and Reclamation Plan and Associated Cost Estimate**
	Performance	Collapse or settlement of plug.	A collapsed plug, of a plug that has settled substantially will not preclude inadvertent mine access by occasional land users, large terrestrial mammals or birds. To remedy the situation additional fill needs to be added to plug any openings.	None. Collapse of plugs cannot happen as the geomechanics and geometry of the mine openings are well known and therefore the plug design is based on best possible information long before closure. None. Settlement of plugs can be prevented by ensuring construction is done using appropriate specifications to ensure proper compaction.	None. Appropriate plug design can be done in advance of closure as there is complete certainty regarding portal geomechanics and dimensions.	Not required.	Yes.
Jetty	Design	Depth to which jetty must be removed below water.	None. The depth is dictated by regulatory agencies as part of regulatory approvals process.	None. The depth is dictated as part of the environmental assessment phase.	None.	Not required.	Yes.
Cargo Dock	Design and Performance	Remaining subsea sheet piles corrode and fail.	None. Failure of sheet piles will result in contained rockfill locally spilling out and covering seabed. The cargo dock is below water and has no post-closure use and there are no consequences.	None. Based on the maximum theoretical corrosion rate for carbon steel, the sheet piles will lose less than 1% of their thickness in 100 years.	None.	Not required.	Yes.
	Design	Depth to which dock must be removed below water.	None. The depth is dictated by regulatory agencies as part of regulatory approvals process.	None. The depth is dictated as part of the environmental assessment phase.	None.	Not required.	Yes.

Appendix E

Memo: TMAC Response to INAC-FC-2-Rec-3. June 11, 2018.

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Memo

To:	Oliver Curran, Vice President Environmental Affairs	**Client:**	TMAC Resources
From:	Maritz Rykaart, PhD, PEng	**Project No:**	1CT022.022
Reviewed By:	Lisa Barazzuol, PGeo Andrea Bowie, PEng Mike Henry, PhD (ERM)	**Date:**	June 11, 2018
Subject:	TMAC Response to INAC-FC-2-Rec-3		

1 Context

SRK Consulting (Canada) Inc. has prepared this technical memo to address Indigenous and Northern Affairs Canada's (INAC's) technical comment, INAC-FC-2 Recommendation #3 as discussed at the Phase 2 Hope Bay Belt Project technical meeting on May 15, 2018.
The commitment to provide this response is listed as Item #7 in Appendix A of the Nunavut Water Board memo titled "Phase 2 Hope Bay Belt Project Type 'A' Water Licence Applications: 2AMDOH1323 Amendment No. 2 and 2AM-BOS----; Technical Meeting Issues and Commitments", dated May 29, 2018.

2 INAC-Rec-3: Response

During operations, the arsenic load emanating from the Boston Tailings Management Area (TMA) is from two sources:

1. Runoff from surficial tailings; and
2. Seepage through the 2.5 m thick tailings active layer.

The total annual Base Case arsenic load from the TMA from these sources combined is about 13 kg, and the Upper Case load is about 87 kg, as calculated from the Water and Load Balance (Volume 1 Annex V1-7 P5-4).

The arsenic load during operations is representative of what the load would be without any cover at closure.

At closure, with placement of the high-density polyethylene (HDPE) liner, the arsenic load is again from two sources:

1. Runoff from the quarry rock covering the liner; and
2. Seepage through the liner and then through the 1.7 m thick tailings active layer.

The 1.7 m thick tailings active layer is the thickness predicted to be present in year 2100 beneath the liner cover system (Volume 1 Annex V1-7 P5-26), in addition to the upper 1.0 m of protective rock. The load from the quarry rock runoff is negligible, so it can conservatively be assumed that the total load is from seepage through the liner.

The total annual Base Case, and Upper Case load from the TMA from these sources at closure (in year 2100) considering the conservatively calculated seepage rate through the liner is about 1 kg as calculated from the Water and Load Balance (Volume 1 Annex V1-7 P5-4).

Using a hypothetical and unrealistic upper bound of 10% liner failure at an undetermined time in the future, far beyond the year 2100, the total arsenic load to Section 2b of Aimaokatalok Lake under the Upper Case conditions would be about 9 kg.

An Arsenic load of 9 kg being received by the normal annual throughflow from Trout Lake and Stickleback Lake (approximately 4.1 million m^3/year) and entering Section 2b of Aimaokatalok Lake, would yield arsenic concentrations in Section 2b of Aimaokatalok Lake at least 2.5 times lower than the Canadian Council of Ministers of the Environment (CCME) arsenic guideline of 0.005 mg/L. This therefore will remain protective of aquatic life, including the most sensitive life stages and demonstrates the efficacy of the closure design in the very long term.

Appendix F

Memo: TMAC Response to INAC-TC-7-Rec15. June 4, 2015

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Memo

To:	Oliver Curran, Vice President Environmental Affairs	**Client:**	TMAC Resources
From:	Cameron Hore, PEng	**Project No:**	1CT022.022
Reviewed By:	Maritz Rykaart, PhD, PEng	**Date:**	June 4, 2018
Subject:	TMAC Response to INAC-TC-7-Rec15		

1 Context

SRK Consulting (Canada) Inc. has prepared this technical memo to address Indigenous and Northern Affairs Canada's (INAC's) technical comment, INAC-TC-7 Recommendation #3 as discussed at the Phase 2 Hope Bay Belt Project technical meeting on May 15, 2018. The commitment to provide this response is listed as Item #13 in Appendix A of the Nunavut Water Board memo titled "Phase 2 Hope Bay Belt Project Type 'A' Water Licence Applications: 2AMDOH1323 Amendment No. 2 and 2AM-BOS----; Technical Meeting Issues and Commitments", dated May 29, 2018.

2 INAC-Rec-15: Response

SRK agrees that the permafrost overburden soils in the vicinity of the mining infrastructure are ice-rich. Permafrost degradation in such soils has the potential to compromise their structural integrity and to cause environmental impacts (e.g., erosion, thaw-settlement). However, there is not considered to be any risk that a groundwater (saline mine water) spill would cause permafrost degradation.

Permafrost degradation of the ice-rich overburden soils could potentially occur by two mechanisms:

1. Increased salinity of the porewater within the overburden introduced by a groundwater spill, resulting in a lowering of the thawing point temperature.

2. Accumulation or ponding of spilled groundwater on the surface for a significant period such that the ponded water melts the ice within the overburden due to the large thermal mass and heat storage effects of water.

As stated in Section 2.3.4, Salinity and Freezing Point Depression, of Volume 1 Annex V1-7 P5-5 Hope Bay Project Geotechnical Design Parameters and Overburden Summary Report:

> "*The freezing point of the permafrost overburden on site is depressed due to the high salinity of the overburden porewater."*, and the average site wide salinity is 37 ppt corresponding to an average freezing point depression for the site of −2.1°C.

The peak chloride concentration from the groundwater is expected to be 18 ppt, i.e. less than the average overburden porewater salinity. Therefore, permafrost degradation by a groundwater spill introducing additional salinity is not a concern.

It is recognised that a groundwater spill could potentially occur and as such TMAC has designs and operational controls in place to minimise the risk of a groundwater spill. The methods of transport for groundwater are either trucking or pipeline. Operational controls such as regular inspections and loading and unloading operating procedures are in place to minimise the risk of spills from trucks. Should a groundwater spill occur from a truck the maximum volume of the spill would be the full capacity of the largest water truck, conservatively assumed as 60 m^3.

The proposed pipelines will be designed using best practice and be subject to a rigorous Hazard and Operability study as part of detailed design. For example, a leak detection system will be included, similar to that included for the Roberts Bay Marine Discharge (RBMD) Pipeline, approved under the existing Doris Water License that transports saline mine water (similar to what will be encountered at Madrid) from the Doris mine to Roberts Bay. Should a spill occur from a pipeline, it could be conservatively assumed that it takes up to half an hour to turn off the pumps and respond to the spill following the initiation of a spill. It should be noted that this is considered to be conservative, as the leak detection system automatically triggers an alarm at the control room, which is continuously operated, so the shut-off period should be less than 5 minutes. The pumping rate of the groundwater is designed as 125 m^3/hour. Therefore, assuming it takes up to half an hour to turn off the pumps following the initiation of a spill, the spill volume would be approximately 60 m^3.

Should a spill occur it will be handled as per Volume 1 Annex V1-7 P4-3 Hope Bay Project Spill Contingency Plan. There are two scenarios that could occur following a spill, the spilled groundwater could pond in a local depression and/or disperse across the tundra. Should any of the spilled groundwater pond in a local depression, as per the P4-3 Hope Bay Project Spill Contingency Plan it will be recovered using a pump or vacuum truck. Therefore, the pond will be removed and not act to thermally disturb the permafrost or melt ice within the overburden soil. Should any of the spilled groundwater disperse across the tundra, it will not act as a heat 'source' as it will not be accumulated in any sufficient mass.

Therefore, there is not a risk that a groundwater (saline mine water) spill would cause permafrost degradation.

Appendix G

TMAC Resources. Hope Bay Project Groundwater Management Plan. May 2018

HOPE BAY PROJECT
GROUNDWATER MANAGEMENT PLAN

HOPE BAY, NUNAVUT

MAY 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

Publication Date: May 2018

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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			
04	May 2018	Section 1	Updated to specifically mention trucking as a groundwater transport option.	SRK	TMAC

Contents

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, where it will be transported by pumping and/or trucking and ultimately 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, pipelines, trucks, 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. The additional groundwater 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 discharge 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

HOPE BAY, NUNAVUT

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%: o From 0 to 60 mbgs: [Predicted Cl in mg/L] = 0.5012 + [vertical depth in mbgs] / 0.0043 o 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 • Discharge mine water to Doris TIA

HOPE BAY PROJECT GROUNDWATER MANAGEMENT PLAN

HOPE BAY, NUNAVUT

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%: o From 0 to 60 mbgs: [Predicted Cl in mg/L] = 0.5012 + [vertical depth in mbgs] / 0.0043 o 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 • Discharge 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 m^3/day • Point source chloride concentration exceeds the predicted chloride concentration profile by more than 20%: o From 0 to 60 mbgs: [Predicted Cl in mg/L] = 0.5012 + [vertical depth in mbgs] / 0.0043 o 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 m^3/day (~0.6 Lps) for > 3 days • Total mine pumping rate exceeds 180 m^3/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 m^3/day (~4.2 Lps) is observed in a new development • Total mine pumping rate exceeds 360 m^3/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. • Discharge mine water to Doris TIA • If groundwater pumping exceeds 360 m^3/day for a period of 30 days, the Nunavut Water Board will be notified and mining of the area concerned will stop.