Natural Resources Canada | Ressources naturelles Canada

June 1, 2018
NWB File #: 2AM-DOH1323 Amendment No. 2 and 2AM-BOS----
NRCan File #: NT-088

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

Sent via email: karen.kharatyan@nwb-oen.ca

Dear Karén,

Re: Hope Bay Phase 2 Water Licence – Natural Resources Canada's Submission

Further to the Nunavut Water Board's correspondence posted on May 29, 2018, please find attached Natural Resources Canada's Final Written Submission submitted to the Nunavut Impact Review Board (NIRB) as part of the environmental assessment of TMAC's Hope Bay Phase 2 Project. Natural Resources Canada (NRCan) would like to submit this directly to the Nunavut Water Board as a submission in the Water Licence process.

As indicated during the Final Hearing of the NIRB process, NRCan maintains expertise in permafrost and hydrogeology for its research activities. As such, the advice provided by NRCan comes from research scientists who are experts in their field, but are not regulators. As a result, NRCan provides technical advice stemming from extensive in-house expertise, but is not able to provide recommendations relating to specific regulatory processes in these areas.

With respect to Commitment No. 15 in *Appendix A: Draft List of Commitments Resulting from the Technical Meeting, May 14 and 15, 2018, regarding Water Licence 2AM-DOH1323 Amendment No. 2 and Water Licence 2AM-BOS*, the advice provided by NRCan does not appear to impact this commitment. NRCan presented comments in our Final Written Submission on uncertainties related to groundwater modelling, including groundwater salinity and its management. NRCan made suggestions related to the Groundwater Management Plan, and TMAC indicated acceptance of the majority of those suggestions. NRCan confirmed at the NIRB's hearings that it is generally satisfied with TMAC's responses. Although the advice provided by NRCan does not appear to affect Commitment # 15, we would be able to review the updated Groundwater Management Plan when submitted, in consideration of our advice to the NIRB.

Natural Resources Canada | Ressources naturelles Canada

Should you have any questions related to NRCan's submission, please do not hesitate to contact me at peter.unger@canada.ca.

Sincerely,

Peter Unger

Senior Environmental Assessment Officer/Agent principal d'évaluation environnementale
Office of the Chief Scientist/Bureau de la scientifique principale
Natural Resources Canada / Ressources naturelles Canada
(613) 558-4854
peter.unger@canada.ca
588 Booth Street
Ottawa, Ontario, K1A 0Y7

Natural Resources Canada | Ressources naturelles Canada

Final Written Submission

Phase 2 Hope Bay Belt Project (NIRB File No. 12MN001)

Natural Resources Canada

Submission to the Nunavut Impact Review Board

March 19, 2018

Executive Summary

Natural Resources Canada (NRCan) conducted a technical review related to permafrost and hydrogeology to assess the completeness and technical merit of the information presented in TMAC Resources Inc. proposed Phase 2 Hope Bay Belt Project Final Environmental Impact Statement, submitted to the Nunavut Impact Review Board (NIRB) on December 21, 2017. NRCan also considered the additional information provided by the Proponent submitted June 6, 2017 in response to the technical submissions received from Parties, including NRCan.

Permafrost

Permafrost is found throughout the project area and will provide a foundation for project components such as the all weather road (AWR) and facilities at the Madrid and Boston mining sites. Adequate baseline knowledge of permafrost and terrain conditions is required for appropriate design of project infrastructure and to assess and mitigate potential impacts to the environment.

Baseline Permafrost and ground ice conditions in the Madrid and Boston mining sites and along the All Weather Road

The Proponent has summarized the geotechnical conditions at the project site and provided terrain maps for the project area. Additional geotechnical investigations will be conducted by the Proponent in the project area, including along the AWR, prior to detailed design. The Proponent has indicated they will conduct further site specific investigations to better characterize ground ice conditions and identify sensitive terrain in the project area. NRCan agrees that for this stage of design the terrain mapping and geotechnical investigations are sufficient.

Design of Doris Tailings Impoundment Area

The proposed Project will require expansion of the approved Doris North Tailings Impoundment Area for disposal of tailings resulting from the Madrid North and Madrid South mining sites. An understanding of the subsurface materials that will underlie the expanded Tailings Impoundment Area is required to ensure the facility operates as intended and to ensure impacts on the environment will be minimised. Freezing of the tailings will enhance performance of the facility and this will require an assessment of the thermal evolution of the pile. NRCan agrees with the Proponent's approach and recommends further site investigations and thermal analysis be done to support detailed design.

Configuration of Taliks and Permafrost in the Project Areas

Unfrozen ground or taliks may be found beneath large water bodies, providing a hydraulic connection between surface and ground water. In response to NRCan's comment regarding the potential for the Boston underground mine to intersect a talik beneath Aimokatalok Lake, the Proponent indicated that the Boston mine is expected to be entirely within permafrost and no groundwater flow is expected. Measures will be implemented to ensure mining stays within the

permafrost zone. In addition, a Groundwater Management Plan will be prepared for the Boston Mine that is consistent with those to be developed for other Phase 2 mines. NRCan agrees that these plans are sufficient to deal with potential uncertainties regarding the configuration of taliks and permafrost zones in the Boston mine area and has no further recommendations with respect to this issue.

Design of the Boston Tailings Management Area and Associated Contact Water Pond

The Boston mine will include a tailings management facility for dry stack tailings that are expected to freeze following deposition. The tailing management facility and an associated contact water pond must be designed to limit seepage to the environment, and an understanding of the subsurface materials that underlie the facilities is required to inform the design and stability assessments. The Proponent has committed to conduct further site investigations to support the final design of this facility. NRCan agrees with the Proponent's proposed approach to conduct additional site investigations to support detailed design and final closure plans for the tailings management facility to ensure long-term physical stability of the facility.

Hydrogeology

NRCan's review focused on groundwater flows and salinity. NRCan is generally in agreement with the Proponent's assessment of the hydrogeological conditions, noting that the conditions that will be encountered during mining may differ from those on which the assessment is based.

Mine inflow salinity

Several interconnected aspects of water management across the site, including discharge of mine inflow waters to Roberts Bay or the Doris Tailings Impoundment Area, could be affected by the presence of higher salinity groundwater flowing into the mines. Although higher salinity groundwater is not necessarily anticipated, there is enough uncertainty in the characterization and modelling that it is a possibility. NRCan has made specific recommendations for the Groundwater Management Plan that would address this issue, including specific water chemistry indicators, review of monitoring programs, and additional and revised specific performance thresholds.

Uncertainties of groundwater model predictions

Key predictions from the groundwater models include mine inflows, groundwater salinity and surface water flows to and from lakes. Groundwater modelling in a permafrost setting is a difficult task and requires several simplifying assumptions. Although it may be possible to improve the groundwater models for the project with additional data, unexpected conditions are possible and mitigation measures may be required to reduce the inflow of saline groundwater to the mine sites. NRCan recommends that the best way to address the uncertainty in the groundwater models is through revision and implementation of the Groundwater Management Plan based on the recommendations mentioned above.

ᓇᐃᓕᒋᐊᖅᓯᒪᔪᑦ ᐅᓂᑉᑳᖅᓯᒪᔪᑦ ᐱᓕᕆᐊᖑᓂᐊᖅᑐᒥᒃ

ᓄᓇᕗᒻᒥ ᐊᕙᑎᓕᕆᔨᒃᑯᑦ ᑲᑎᒪᔨᖏᑦᑦ (NRCan) ᖃᐅᔨᓴᓚᐅᕐᒪᑕ ᓄᓇᐅᑉ ᕿᕿᓂᖓᓐᓂᒃ ᐊᒻᒪ ᑕᕆᐅᓕᕆᓂᕐᒥᒃ ᖃᐅᔨᓴᕐᓂᑯᑦ ᓇᒻᒪᑎᐊᕐᒪᖓᑕ ᑐᓂᔭᐅᓯᒪᔪᑦ TMAC ᐅᔾᕈᖕᓂᐊᖅᑎᑦ ᑐᒃᓯᕋᐅᑎᖓᓐᓂ ᐱᓕᕆᐊᑉ ᑐᓪᓕᐊᓂ Hᐅᑉ ᐱᐃᒻᒥ ᐱᓕᕆᐊᖑᔪᒻᒥ ᑭᖑᓪᓕᕐᒥ ᐊᕙᑎᐅᑉ ᐊᒃᑐᒐᐅᓂᖓᑕ ᑎᑎᖅᑲᖏᓐᓂ, ᑐᓂᓯᒪᔭᖓᑦ ᓄᓇᕗᒻᒥ ᐊᕙᑎᓕᕆᔨᒃᑯᑦ ᑲᑎᒪᔨᖏᑦ (NIRB) ᑎᓯᒻᐱᕆ 21, 2017. ᑲᓇᑕᒥ ᓄᓇᒥᐅᑕᓕᕆᔩᑦ ᐃᓱᒪᑲᓂᕐᓯᒪᖓᑕ ᑐᑭᓯᑲᓂᕈᑎᒃᓴᑲᓐᓂᕐᓂᒃ ᑐᓂᔭᐅᓯᒪᔪᓐᓂᒃ ᐱᓕᕆᓱᐊᖅᑐᒥᑦ ᔪᓐ 6, 2017 ᑭᐅᔪᑕᐅᓚᐅᖅᑐᓂᒃ ᖃᓄᐃᓕᐅᕈᑎᑦ ᐱᓕᕆᐊᖏᓐᓄᑦ ᑎᒥᐅᔪᑦ ᐱᓚᐅᖅᑕᖏᓐᓂᒃ, ᐃᓚᐅᑉᐳᑎᒃ ᑲᓇᑕᒥ ᓄᓇᒥᐅᑕᓕᕆᔩᑦ.

ᓄᓇᐅᑉ ᕿᕿᓂᖓ

ᓄᓇᐅᑉ ᕿᕿᓂᖓ ᓇᓂᔭᐅᓯᒪᕗᖅ ᐱᓕᕆᕝᕕᐅᓐᓂᐊᖅᑐᒻᒥ ᐊᒻᒪ ᑐᖓᕕᐅᑉᐳᓐᓂ ᐱᓕᕆᐊᑉ ᐃᓗᓕᖏᓐᓄᑦ ᐃᓚᐅᑉᐳᓐᓂ ᐅᑭᐅᒥ ᖃᖓᒥᐊ ᐊᑐᕈᖕᓇᖅᑐᒻᒥ ᐊᑉᕿᒧᒥ, ᐊᒻᒪ ᐱᕐᑯᑎᖏᓐᓂ ᒪᑐᓇᑦ ᐊᒻᒪ ᐸᓯᑕᓐ ᐅᔾᕈᖕᓂᐊᕐᕕᖏᓐᓂ. ᑐᖓᕕᖃᑎᐊᖅᑐᑦ ᖃᐅᔨᒪᔪᑕᐅᓂᐊᖅᑐᑦ ᓄᓇᐅᑉ ᕿᕿᓂᖓᓐᓂᒃ ᒪᓂᕋᕐᒦᓪᓗ ᐊᑐᕐᑯᔭᐅᓯᒪᕗᑦ ᐃᓱᒪᓕᐅᕐᓂᐊᕐᓗᓐᓂ ᐱᓕᕆᐊᕐᒍᑦ ᐱᕐᑯᑎᓂᒃ ᓴᓇᓂᐊᕐᓗᓐᓂ ᖃᐅᔨᓴᕐᓗᒋᑦᓗ ᐊᒃᑐᐃᓂᐅᔪᑦ ᐊᕙᑎᒻᒥᒃ.

<u>ᑐᖃᕕᖃᑎᐊᖅᑐᑦ ᓄᓇᐅᑉ ᕿᕿᓂᖓᓄᑦ ᓯᑯᑉᐳ ᖃᓄᐃᓂᖏᓐᓄᑦ ᒪᑐᓇᑦ ᐊᒻᒪ ᐸᓯᑕᓐ ᐅᔾᕈᖕᓂᐊᕐᕕᖏᓐᓂ ᐊᒻᒪ ᖃᖓᑐᐃᓐᓇᖅ ᐊᑐᓚᐅᓱᖅᑐᒻᒥ</u>

ᐱᓕᕆᓂᐊᖅᑐᖅ ᓇᓗᓇᐃᕐᓂᒃᓯᒪᖕᒪᑦ ᐅᔾᕈᐃᑦ ᖃᓄᐃᓐᓂᖏᓐᓂᒃ ᐱᓕᕆᕝᕕᖕᒥ ᐊᒻᒪ ᓄᓇᒥᒃ ᓄᓇᖑᐊᒃᑯᑦ ᐱᓕᕆᕝᕕᐅᑉ ᓄᓇᕐᑯᑎᖓᓐᓂ. ᐅᔾᕈᓕᕆᓂᕐᒧᑦ ᖃᐅᔨᒪᔪᑎᒃᑲᓂᑦ ᐱᓕᕆᐊᖑᓂᐊᖅᐳᑦ ᐱᓕᕆᓂᐊᖅᑐᒧᑦ ᐱᓕᕆᕝᕕᖕᒥ, ᐃᓚᖅᑲᕐᓗᒍ ᖃᖓᒥᐊ ᐊᑐᕈᖕᓇᖅᑐᒻᒥ ᐊᑉᕿᒧᒥ, ᐃᓱᒪᓕᐅᕐᓂᐅᑉ ᓯᕗᓂᖓᓐᓂ. ᐱᓕᕆᓂᐊᖅᑐᖅ ᓇᓗᓇᐃᖅᓯᒪᕗᖅ ᖃᐅᔨᓴᒃᑲᓐᓂᕐᓂᐊᕐᒪᑕ ᖃᓄᐃᑐᓂᖏᓐᓂᒃ ᓯᑯᑉ ᐊᒻᒪ ᓄᓇᐅᑉ ᐃᑉᐸᓕᕐᓇᕐᓂᖓᓐᓂᒃ ᐱᓕᕆᕝᕕᐅᑉ ᓄᓇᕐᑯᑎᖓᓐᓂ. ᑲᓇᑕᒥ ᓄᓇᒥᐅᑕᓕᕆᔩᑦ ᐊᖏᖅᓯᒪᖕᒪᑕ ᐱᓕᕆᐊᕐᒥ ᐊᕐᑭᒃᑕᐅᓂᖓᓄᑦ ᓄᓇᖑᐊᓕᐅᖅᑕᐅᓂᖓᓄᑦ ᐊᒻᒪ ᐅᔾᕈᐃᑦ ᖃᐅᔨᓴᖅᑕᐅᓂᖏᓐᓄᑦ ᓇᒻᒪᖕᒪᑕ.

<u>ᐃᓱᒪᓕᐅᖅᑕᐅᓂᖓ ᑐᐊᓇᔅ ᐅᔾᕈᖕᓂᐊᕐᓂᑯᑦ ᐃᓂᖃᕐᕕᖓᓄᑦ</u>

ᑑᒃᓯᕋᖅᑕᐅᓯᒪᔪᖅ ᐱᓕᕆᓂᐊᖅᑐᒥᑦ ᐊᓪᓕᒋᐊᕐᓂᖅ ᐊᖏᖅᑕᐅᓯᒪᔪᖕᓄᑦ ᑐᐊᓇᔅ ᑲᓇᖕᓇᒻᒥ ᐅᔾᕈᖕᓂᐊᕐᓂᑯᑦ ᐃᓂᖃᕐᕕᖓᑦ ᒪᑐᓇᑦ ᑲᓇᖕᓇᒻᒥ ᐊᒻᒪ ᒪᑐᓇᑦ ᓂᒋᐊᓐᓂ ᐅᔾᕈᖕᓂᐊᕐᕕᖕᓄᑦ. ᑐᑭᓯᐅᒪᓐᓇᖅᐳᖅ ᓄᓇᐅᑉ ᖃᖓᓐᓂ ᐃᓕᓯᒪᓂᐊᖅᑐᑦ ᐊᓪᖕᒋᓕᒋᐊᖅᓯᒪᑉᐳᑎᒃ ᐅᔾᕈᖕᓂᐊᕐᓂᑯᑦ ᐃᓂᖃᕐᕕᖓᓐᓄᑦ ᐊᑐᓇᐊᖃᖅᐳᑦ ᐅᔾᕈᖕᓂᐊᕐᕕᒃ ᐃᖏᕋᑎᐊᕐᑯᑉᐳᒍ ᐊᒻᒪ ᐊᒃᑐᐃᓂᐅᔪᑦ ᓄᓇᓗᑦ ᒥᑭᓂᖅᓴᐅᕐᑯᑉᐳᕆᑦ. ᕿᑭᓕᖅᑎᑕᐅᓂᖓ ᐅᔾᕈᖕᓂᐊᕐᓂᑯᑦ ᐃᓂᖃᕐᕕᖓᑕ

ᐊᕿᓯᒪᔪᑕᐅᑲᓂᕋᔭᖅᐳᖅ ᐊᒻᒪ ᖃᐅᔨᓴᒐᐅᓗᓐᓂ ᕿᑭᓕᖅᐸᓕᐊᓂᖓᓄᑦ ᖃᓄᐃᓕᕙᓕᐊᓂᖏᑦ ᑲᑎᑕᐅᓯᒪᔪᑦ. ᑲᓇᑕᒥ ᓄᓇᒥᐅᑕᓕᕆᔩᑦ ᐊᖏᖅᓯᒪᖕᒪᑦ ᐱᓕᕆᓂᐊᖅᑐᑉ ᐃᓱᒪᒋᔭᖓᓐᓂᒃ ᐊᑐᖅᑯᔭᐅᓯᒪᔪᓂᒡᒍ ᐅᔭᕋᖕᓂᐊᕐᕕᐅᑉ ᖃᐅᔨᓴᖅᑕᐅᓂᖓᓂᒃ ᐊᒻᒪ ᓄᓇᐅᑉ ᕿᑭᑕᕐᓂᖓᑕ ᖃᐅᔨᓴᒐᐅᓂᖓᓐᓂᒃ ᐊᑐᒐᐅᕐᑯᐸᑐᒋᑦ ᖃᓄᐃᓇᔭᕐᓂᖓᓂᒃ ᐊᕿᒃᓯᒪᓂᕐᒧᑦ.

ᐊᓯᐊᖑᖅᑎᑕᐅᓂᖓ ᑕᓕᒃᔅ ᐊᒻᒪ ᓄᓇᐅᑉ ᕿᑭᓂᖓ ᐱᓕᕆᕝᕕᖕᒥ

ᕿᑭᓯᒪᖏᑐᖅ ᓄᓐᓇ ᐅᕙᓗᕙ ᑕᓕᒃ ᓇᓂᔭᐅᔪᖕᓇᖅᐳᑦ ᑕᓯᕐᓂ ᐊᖏᔪᓐᓂ, ᓄᖃᖓᑎᕐᓯᔪᖕᓇᕐᒪᑕ ᓄᓇᒥᒃ ᐊᒻᒪ ᑕᓯᐅᑉ ᐊᑐᐊᓐᓂ ᓄᓇᒥᒃ. ᑭᐅᔪᑕᐅᑉᑐᓂ ᐅᑯᓄᖓ ᑲᓇᑕᒥ ᓄᓇᒥᐅᑕᓕᕆᔩᑦ ᐅᖃᐅᓯᖏᓐᓄᑦ ᐸᔅᑕᓐ ᓄᓇᐅᑉ ᐊᑕᓐᓂ ᐅᔭᕋᖕᓂᐊᕐᕕᒃᔅᒻᒧᑦ ᑲᑎᑕᐅᓯᒪᓂᐊᕐᓗᓐᓂ ᐊᐃᒧᑲᑕᓕᐅᑉ ᑕᓯᖓᓐᓄᑦ, ᐱᓕᕆᓯᐊᖅᑐᖅ ᓇᓗᓇᐃᓚᐅᕐᒪᑦ ᐸᔅᑕᓐ ᐅᔭᕋᖕᓂᐊᕐᕕᖓ ᓄᓇᐅᑉ ᕿᑭᓂᖓᑕ ᐃᓗᐊᓂᓯᐅᕐᓂᐊᕐᒪᑦ ᐊᒻᒪ ᑯᒃᑐᖅᑲᓚᖏᓗᓐᓂ ᐃᒪᕐᒥᒃ. ᖃᓄᐃᓕᐅᕈᑎᒃᓴᑦ ᐊᕿᒃᑕᐅᓯᒪᓂᐊᖅᑐᑦ ᐊᑐᓕᖅᑎᑕᐅᓂᖏᓐᓄᑦ ᐅᔭᕋᖕᓂᐊᕐᕕᒃ ᓄᓇᐅᑉ ᐃᓗᐊᓐᓂ ᐱᓕᕆᐊᖑᓂᐊᕐᓗᓐᓂ. ᐃᓚᑲᓂᕐᓗᒍ, ᓄᓇᐅᑉ ᐊᑕᓐᓂ ᐃᒪᕐᒥᒃ ᒥᐊᓂᖅᓯᓂᐅᑉ ᐸᕐᓇᐅᑎᖓ ᐊᕿᒃᑕᐅᓂᐊᖅᐳᖅ ᐸᔅᑕᓐ ᐅᔭᕋᖕᓂᐊᕐᕕᖓᓄᑦ ᐊᑐᖅᑕᐅᓚᐅᖅᓯᒪᔪᑦ ᐊᓯᖏᓐᓂ ᐱᓕᕆᐊᑉ ᑐᓪᓕᐊᓂ ᐅᔭᕋᖕᓂᐊᕐᕕᖕᓂ. ᑲᓇᑕᒥ ᓄᓇᒥᐅᑕᓕᕆᔩᑦ ᐊᖏᖅᓯᒪᖕᒪᑦ ᐸᕐᓇᐅᑎᑦ ᓇᒻᒪᖕᒪᑕ ᓇᓗᓇᖅᑐᓂᒃ ᐱᓕᕆᐊᖃᕈᖕᓇᕐᒪᑎᒃ ᐊᕿᒃᑕᐅᓯᒪᓂᖏᓐᓂᒃ ᑕᓕᒃ ᐊᒻᒪ ᓄᓇᐅᑉ ᕿᑭᓂᖓᑕ ᐸᔅᑕᓐ ᐅᔭᕋᖕᓂᐊᕐᕕᖑᓐᓂ ᐊᑐᓕᕈᑎᒃᓴᓂᒃ ᐱᑕᖃᕐᓇᖅᑲᐅᖏᒻᒪᑦ ᐃᓱᒪᑐᑕᐅᔪᒻᒪᑦ.

ᐊᕿᒃᑕᐅᓯᒪᓂᖓ ᐸᔅᑕᓐ ᐅᔭᕋᖕᓂᐊᕐᓂᑯᑦ ᐃᓂᖃᕐᕕᖓᑕ ᒥᐊᓂᕆᔭᐅᓂᖓ ᐊᒻᒪ ᐃᓚᖏᑦ ᐃᒥᐅᑉ ᑕᓯᖓ

ᐸᔅᑕᓐ ᐅᔭᕋᖕᓂᐊᕐᕕᖓ ᐃᓚᖃᕐᓂᐊᖅᐳᖅ ᐅᔭᕋᖕᓂᐊᕐᓂᑯᑦ ᐃᓂᖃᕐᕕᒃᓴᖑᓂᒃ ᐸᓂᖅᓯᒐᐅᕐᑯᐸᑐᒋᑦ ᑭᖓᓂᖓᒍᑦ ᕿᑭᓕᖅᑎᑕᐅᓂᐊᕐᑐᑎᒃ. ᐅᔭᕋᖕᓂᐊᕐᓂᑯᑦ ᐃᓂᖃᕐᕕᒃᔅᖓᑕ ᒥᐊᓂᕆᔭᐅᓂᖓ ᐊᒻᒪ ᐃᒥᖅ ᐊᑐᓕᐅᑕᖅᑐᖅ ᐊᕿᒃᓯᒪᓗᓐᓂ ᓄᓇᒧᑦ ᑯᒃᑕᓗᐊᖏᓗᓐᓂ, ᐊᒻᒪ ᑐᑭᓯᐅᒪᑎᐊᕐᑯᑉᑐᒍ ᓄᓇᐅᑉ ᖃᖅᒐᓂ ᐱᕐᑯᑎᑦ ᑐᖑᑎᐊᕐᓂᕐᓗ ᖃᐅᔨᓴᒐᐅᒪᑐᑎᒃ. ᐱᓕᕆᓂᐊᖅᑐᖅ ᐊᖏᖅᓯᒪᖕᒪᑦ ᖃᐅᔨᓴᑲᓂᕐᓂᕐᒥᒃ ᐅᔭᕋᖕᓂᐊᕐᕕᖕᒥᒃ ᐊᕿᒃᑕᐅᓯᒪᓂᖓ ᓇᒻᒪᑎᐊᕐᑯᑉᑐᒍ ᐊᑐᖅᑕᐅᓂᐊᖅᑐᑉ. ᑲᓇᑕᒥ ᓄᓇᒥᐅᑕᓕᕆᔩᑦ ᐊᖏᖅᓯᒪᖕᒪᑦ ᐱᓕᕆᓯᐊᖅᑐᑉ ᐊᑐᕈᒪᔭᕐᓚᓐᓂᒃ ᖃᐅᔨᓴᑲᓂᕐᓂᕐᒥᒃ ᐱᓕᕆᕕᐅᓂᐊᖅᑐᒻᒥᒃ ᐊᕿᐅᒪᔪᑎᒃᓴᓚᓐᓂᒃ ᐅᑯᐊᑕᐅᓂᖓᓚᑕᑐ ᐸᕐᓇᐅᑎᒃᓴᖓᓐᓂᒃ ᐅᔭᕋᖕᓂᐊᕐᓂᑯᑦ ᒥᐊᓂᕆᔭᐅᓂᖓᓐᓄᑦ ᐅᑭᐅᓐᓄᑦ ᐊᒥᓱᓄᑦ ᓇᒻᒪᑎᐊᕐᑯᑉᑐᒍ ᐅᔭᕋᖕᓂᐊᕐᕕᒃ.

ᐃᒥᕐᒥᒃ ᖃᐅᔨᓴᕐᓂᖅ ᓄᓇᐅᑉ ᐊᑕᓐᓂ

ᑲᓇᑕᒥ ᓄᓇᒥᐅᑕᓕᕆᔩᑦ ᖃᐅᔨᓴᕐᓗᓐᓂ ᓄᓇᒻᒥᑦ ᑯᒃᑕᕐᓂᑯ ᑕᓇᐅᖃᕐᓂᖓᑐ ᖃᐅᔨᓴᒐᐅᓗᓐᓂ. ᑲᓇᑕᒥ ᓄᓇᒥᐅᑕᓕᕆᔩᑦ ᐊᖏᖅᓯᒪᕗᖅ ᐱᓕᕆᓂᐊᖅᑐᑉ ᖃᐅᔨᓴᐅᓂᖏᓐᓂᒃ ᐅᔭᕋᐃᑦ ᓄᓇᐅᑉ ᐊᑕᓐᓂᑦᑐᑦ ᖃᐅᔨᓴᒐᐅᓂᖏᓐᓂᒃ, ᐅᐳᕈᐱᒃᑐᑎᒃ ᖃᓄᐃᑐᓂᖏᑦ ᐊᐳᖅᑕᐅᑕᕐᓂᐊᕐᒪᑕ ᐅᔭᕋᖕᓂᐊᕐᕕᖕᒥ ᐊᐳᐅᓚᖅᑭᒻᒪᑕ ᖃᐅᔨᓴᒐᐅᓯᒪᔪᑦᑐᑦ ᑐᐊᕕᕆᔭᐅᑉᑐᑎᒃ.

ᐅᔭᕋᖕᓂᐊᕐᕕᖕᒧᑦ ᑯᒃᐸᓕᐊᔪᖅ ᐃᒥᖅ ᑕᕆᐅᖃᖅᑐᖅ

ᐊᓯᖏᑦ ᐃᓚᒋᔭᐅᔪᑦ ᐃᒥᐅᑉ ᒥᐊᓂᕆᔭᐅᓂᖓᓄᑦ ᐅᔭᕋᒃᑕᕆᐊᕐᕕᖕᒥ, ᐊᒻᒪ ᐃᒥᐅᑉ ᑯᕙᔭᐅᓂᖓ ᐅᔭᕋᖕᓂᐊᕐᕕᖕᒥᑦ ᕋᐳᑦᔅ ᑕᕆᐅᖓᓄᑦ ᐅᕙᓗᕙ ᑐᐊᕆᔅ ᐅᔭᕋᖕᓂᐊᕐᓂᑯᑦ ᐃᓂᖃᕐᕕᖓᓄᑦ, ᐊᒃᑐᒐᐅᔪᖕᓇᖅᐳᑦ ᑕᕆᐅᖃᕐᓂᖓᓄᑦ ᐃᒥᖅᒧᑦ ᐅᔭᕋᖕᓂᐊᕐᕕᖕᓄᑦ ᑯᒃᐸᓕᐊᔪᒧᑦ. ᑕᕆᐅᖃᕐᓂᖓ ᐊᖏᓂᖅᓴᐅᒐᓗᐊᖅᑎᓪᓗᒍ ᐃᓱᒪᓇᖏᑐᖅ, ᑭᓯᐊᓐᓂ ᓇᓗᓇᖅᐳᖅ ᖃᓄᐃᓕᑎᑦᓯᓂᖏ ᐊᒻᒪ ᐊᕿᐅᒪᓂᖓ ᖃᓄᐃᓇᔭᕐᒪᖏᑦ ᓂᕆᐅᓇᖅᑐᖅ. ᑲᓇᑕᒥ ᓄᓇᒥᐅᑕᓕᕆᔩᑦ ᐊᑐᓕᖅᑯᔭᐅᔪᓐᓂᒃ ᐊᕿᒃᓯᓯᒪᖕᒪᑦ ᓄᓇᒥᑦ ᐃᒪᐅᑉ ᑯᒃᑕᕐᓂᖓᑕ ᒥᐊᓂᖅᓯᔪᑎᒃᓴᖓᓄᑦ ᐃᓱᒪᓗᑕᐅᔪᖅ ᐱᑉᓗᒍ, ᐊᒻᒪ ᐃᒥᐅᑉ ᐃᖏᕋᑕᕐᓂᖓᓄᑦ, ᐃᖏᕋᓂᖓᓄᑦ ᖃᐅᔨᓴᕈᑕᐅᓇᔭᖅᑐᑦ, ᐃᓚᖁᑎᑲᓂᓪᓗ ᐊᕿᒃᑕᐅᓯᒪᔪᑦ ᐃᖏᕋᓂᖓᓄᑦ ᓇᒻᒪᑎᐊᕈᑕᐅᓂᐊᖅᑐᑦ.

ᓇᓗᓇᕐᓂᖏᑦ ᓄᓇᐅᑉ ᐊᑕᓐᓂ ᐃᒥᐅᑉ ᐃᓱᒪᒋᔭᐅᔪᑦ

ᖃᐅᔾᒪᔪᑎᒃᓴᐅᔪᑦ ᓄᓇᐅᑉ ᐊᑕᓐᓂᑦ ᐃᒥᖅᒧᑦ ᐅᒃᑐᕋᐅᑕᐅᔪᑦ ᐃᓚᖃᖅᑐᑦ ᐅᔭᕋᖕᓂᐊᕐᕕᖕᒥᑦ ᐃᒥᖅ, ᓄᓇᐅᑉ ᐊᑕᓐᓂᑦ ᑯᖕᓂᑯ ᐊᒻᒪ ᓄᓇᐅᑉ ᖃᖓᓂᑦ ᑕᓯᕐᓂᓪᓗ. ᓄᓇᐅᑉ ᐃᓗᐊᓐᓂ ᐃᒥᐅᑉ ᐊᕿᒃᑕᐅᓯᒪᓂᖓ ᕿᕿᓂᕐᒥᓯᐅᖅᑐᖅ ᐊᔪᕐᓇᕈᑎᖃᕐᒪᑦ ᐊᒥᓱᓂᒃ ᐊᔾᔨᖏᖏᑐᓂᒃ ᐱᓕᕆᐊᖑᔭᕆᐊᖃᖅᐳᖅ ᐊᑐᕐᓗᓐᓂ. ᐊᔪᕐᓇᖏᑲᓗᐊᖅᑎᓪᓗᒍ ᐊᕿᒃᓯᓂᕐᒥᒃ ᓄᓇᐅᑉ ᐊᑕᓐᓂᑦ ᑯᖕᓂᖓᓂᒃ ᐱᓕᕆᐊᕐᒧᑦ ᖃᐅᔾᔭᑲᓂᕐᓗᓂ, ᓂᕆᐅᓇᖏᑐᑦ, ᖃᓄᐃᑐᖃᕈᖕᓇᕐᒪᑕ ᐊᒻᒪ ᐊᒃᑐᐃᑕᐃᓕᔪᑕᐅᔪᑦ ᐊᑐᓇᐊᖃᕋᔭᕐᒪᑕ ᑯᒃᑕᐅᓂᖏ ᓯᐅᕋᖃᖅᑐᑦ ᑯᒃᑕᐅᓂᖏ ᐅᔭᕋᖕᓂᐊᕐᕕᖕᓄᑦ. ᑲᓇᑕᒥ ᓄᓇᒥᐅᑕᓕᕆᔩᑦ ᐊᑐᓕᖁᔨᓯᒪᖕᒪᑦ ᐱᐅᓂᖅᓴᒻᒥᒃ ᓇᓗᓇᐃᕐᓯᒪᔪᓄᑦ ᓄᓇᐅᑉ ᐊᑕᓐᓂᑦ ᑯᒃᑕᕐᓂᕐᒥᒃ ᐊᕿᒋᐊᕈᑎᑎᒍᑦ ᐊᑐᓕᖅᑎᑕᐅᓂᖏᓐᓄᑦ ᓄᓇᐅᑉ ᐊᑕᓐᓂᑦ ᑯᒃᑕᕐᓂᖏᑕ ᒥᐊᓂᕆᔭᐅᓂᖏᓐᓇ ᐸᕐᓇᐅᓪᒥᒃ ᐊᑐᓕᖅᑯᔭᐅᓯᒪᔪᑦ ᒪᓕᒃᓗᒋᑦ ᖁᓚᓐᓂ.

Natural Resources Canada | Ressources naturelles Canada

Ihumaliurutaanut Nainaaqhimayuq

Nunamiingaqhimayut Maniliurahuarutit Kaanatami (NRCan) piyut ilitariyauyut ihivriuqniq piyuq uumunnga qiqiniq nuna nunap imangalu naunaiyaiyaat iniqtirninnganik unalu ilitariyauyut qanuriliurninnga naunaitkutanga tuniyauyuq TMAC-kut Resources Havakvinganit piumayanginnik Ilangani 2 Hope Bay Nunanga Havauhikhaq Kingulliqpaanga Avatiliriniqmut Pilaqutauyuq Naunaitkutaq, tuniyauyuq ukununnga Nunavut Avatilirinirmut Katimayiinut (NIRB) December 21mi, 2017. NRCan ihumaliqpakhutik ilaqaqhutik ilitturnikhainit ilaliutauhimayuqHavaakhaliuqtunut turaaqtauhimayuq uvani June 6, 2017 mi kiuvluniuk qauyiharnikhainnut turaarutaa Ikayuqtigiyainnit, ilaliutauvluniuk NRCannit.

Qiqiniq

Qiqiniq nuna takunnaqtuq tamainni havauhikhami tuniniaqtuqlu tunngavikhaq havauhikhamut ukunatitut tamaita tamaat ukiuq apqut (AWR) igluqpangillu Madrid-mi Boston-milu uyarakhiurvinganit. Piqaqtumik kiklinga ilihimaniq uuminnga qiqiniq nuna maniqqangalu qanurittaakhaanik ihariagiyauyuq ihuaqtumik piliurninnga uuminnga havauhikhaq aulapkaitjutikhanik naunaiyariami mikhigiamillu pilaqutiniaqtut avatimut.

Kiklinga Qiqiniq nuna nunamilu hikunga qanurittaakhaanik Madrid-mi Boston-milu uyarakhiurvingit tamainnilu Ukiuq Tamaat Apqutauyuni

Ikayuqtiuyuq naigliyaa munariyuq nunanganik qaiqtuniklu qanurittaakhaanik havauhikhami tuniyullu maniqqamut nunauyanga havauhikhamut. Aadlat munariyuq nunanganik qaiqtuniklu ihivriuqtauniaqtait Ikayuqtiuyumit havauhikhami, unalu AWR-kunnit, naunaiyaqtinnagit. Ikayuqtiuyuq naunaiqtaa havaariniaqtait aadlat uyarakhiurviuyut ihuaqtuq ihivriuqniq nakuutqiamik pigiamikni nuna hikunganik qanurittaakhaanik ilitarilugillu qayagiyauyut maniqqa havauhikhami. NRCan angiqtut uumunnga pidjutinganik piliurninnga maniqqami nunauyaliurniq unalu munariyuq nunanganik qaiqtuniklu ihivriuqninngit nakuuyut.

Piliurninnga Doris Uyarakhiurviup piluryangit Pihimayanginnit

Piumayanganik Havauhikhaq ihariaginiaqtaat angikliyuumiutinga angiqtauninnganik Doris Tununngani Uyarakhiurviup piluryangit Pihimayanginnit igitakhanginnik uyarakhiurviup piluryangit piyut ukunannga Madrid Tununngani uumanilu Madrid Hivuraani uyarakhiurvinganit. Kangirhiyakhaq qaanganit hunavaluit pipkaidjutigiyaa angikliyuumiqhimayuq Uyarakhiurviup piluryangit Pihimayanginnit ihariagiyauyuq naunairiami igluqpanga aulapkaiyuq pipkaidjutiyumik naunairiami pilaqutingit avatinganut ikikliyuumiqniaqtuq. Qiqimayunik uyarakhiurviup piluryangit ihuarhiniaqtaa havaanga igluqpanganik unalu ihariaginiaqtaat naunaiyainiq piliurninnga angikliyuumiutihimayanganit. NRCan angiqtut ukununnga Ikayuqtiuyut hivumuuqninnga pitquyaillu aadlat uyarakhiuvingit ihivriuqninngit ihivriuqninngalu piyakhaq ikayuriami naunaittut piliurninnga.

Piliurninnga Taliknik unalu Qiqiniq nuna Havauhikhangani

Qiqihimangittuq nuna taliklu takunnaqtut ataani angiyut imaqmi, tuniyuq aulapkaihimayuq atayuq qaanganit imaqmillu. Kiuvluniuk uvunga NRCan'ip nipliqtangit haffumani ihumagiyauvluniuk haffumanit Boston nunaup iluaniittumi uyaraqtarviuyuq qaliriiqtukhaq talik ataaniittuni Aimokatalok Tahia, una Havaakhaliuqtuq tikkuaqhimayaa unaguuq Boston uyaraqtarvik ilitturiyauyuq iluaniittuni nunaup puvitquumannganiittuni nunaup imanga qurlualaittuni ittukhauyuq. Maliguutiqaqhutik pilimmakhaivluni pidjarikhiyukhat uyaraqrarviuniarumik iluaniittukhauyuq nunaup puvitquumannga kiglingani. Ilagiyangit, una Nunaup imangit Munaqhiivikhat Upalungaiyautit upalungaiqhimayukhaq haffumani Boston Uyaraqtarvik atuinnaqhimayuq pivalliayukhaq aahiit Ilanganit 2 uyaraqtarviit. NRCan angiqhimayut tahapkuat upalungaiyautit ihuaqtuuvlutik ihumagikhaqarumik nalunaqtumik haffumani tiliutaanit haffumani taliit nunaup puvitquumanngat kigliit iluani Boston Uyaraqtarviuyuq nunangani tukhiutigiyakhaitpat ihumagivlugu haffumani akihautaanit.

Piliurninnga Boston-mi Uyarakhiurviup piluryangit Munarininngani Piyunullu Imaqmik Tahiraq

Tamna Boston uyarakhiurvinga ilaliutihimaniaqtuq uyarakhiuvriup ilakunganik munarivikhanganik paniupayumut qaliriikhimayut uyarakhiurviup piluryangit ihumagiyauyuq qiqiniaqtuq talvannga piiyaqtaukpat. Uyarakhiuvriup piluryanganik munarivikhanganik piyunullu imaqmi tahiranga piliurhimayuq kikliqariami kuvininnga avatinganut, kangirhilunilu qaangani hunavaluit pipkaidjutigiyuq igluqpingit ihariagiyauyuq naunaipkariami piliurninnga hakugikninnga naunaiyainiq. Una Havaakhaliuqtuq malittiaqhimayangit aulattiyakhaat nayugaanit ihivriurnikhainut ikayuqtakhaat iniqpiaqtumik tiliugainit havagvianit. NRCan angiqatigiikhimayangit Havaakhaliuqtu'm tukhiutigiyangit ininganit havaarilugu ilagiyainnit nayugaani ihivriuqtakhaat ikayuqhimayakhaat tiliuyauhimayut iniqhimayaanit attarvingit munaqhiivikhaat aturaaqhimayaamingnit qaanganit ayurnaiqtumik havagviqaqhutik.

Imanga nunami naunaiyainiq

NRCan-kut ihivriuqniq ihumagilluaqtait nunapimanga kuvininnga tariuqarninngalu. NRCan angirutihimayut Ikayuqtiup naunaiyaininnganut uuminnga imanganik nunami naunaiyainiq qanurittaakhaanik, naunaiqhugu qanurittaakhaanik piniaqtut uyarakhiuqtillugit aadlanganiaqtuq tahapkunannga naunaiyaininnganik piyuq.

Uyarakhiuviup iluanut kuviyuq tariuq

Qaffiuyut ilaliutihimayut qanuriliurninngit imanganik munarinniq tamainni uyarakhiuvrikmi, unalu kuvininnga uyarakhiuvriup iluanut kuviyuq imaq Roberts Bay-mut uumunngaluuniit Doris Uyarakhiurviup piluryangit Pihimayanginnit, ayurhapkainiaqtuq piqarmat amigaitpiaqtumik tariulik nunanga imanga kuviyuq uyarakhiurvikmut. Amigaittuq tariulik nunanga imalik ihumagiyaungittuq, piqarmat naunaqtuq qanurittaakhaanik uuktuutiliriniqlu taimainniaruknaqhiuq. NRCan tukhiutikhanit kiuvikhaliuqhimayauyut haffumani Nunaup imangit Munaqhiivikhat Upalungaiyaut kiuyaamingni ihumaaluutainnit, ilaliutauhimayurlu aallat

imat ilaurutikhaqarumik nalunaiyaiyut, qimilrurlugillu munariyangit piliriakhait, ilagiyauyullu ihuaqhaihimayut ilitturnaqtumik ilitquhiriyunnaiqtaat.

Ilihimangitanginnik nunap imanganik uuktuutingit itqurnarutait

Akhuurutaulluaqtut itqurnarutait nunap imanganik uuktuutingit ilaliutihimayut uyarakhiurvikmi iluanut kuviyuq, nunap imanga tariulik qaanganilu imanga kuviyuq talvunga talvanngalu tahiqnit. Nunap imanga uuktuutiniq uumani qiqiniq nuna piyuq ayurnaqtuq havaaq ihariagiyuq qaffinik naigligiyuq ihumaliurniq. Pilimaittutut iliugaluaq ihuarhigiami nunap imanga uuktuutingit havauhikhamut aadlamik naunaitkutanik, ihumagingitanginnik qanurittaakhaanik pittaaqtuq ikikliyuummiriami qanuriliurutingit ihariagiyauniaqtut ikikliyuumiriami kuvininnga tariuq nunap imanga uyarakhiurvikmut. NRCan tukhiutigiyangit nakuuqpiaqtumik kiunnaqtumik nalunaqtumik nunaup imangit ilitquhiita uuminngat ihuaqhaiffaarningit pilimmakhainingillu haffumani Nunaup imangit Munaqhiivikhat Upalungaiyaut tikkuaqhugit tukhiutigiyauyut niplautigiyauyut qulaanit.

Résumé

Ressources naturelles Canada (RNCan) a procédé à un examen technique lié au pergélisol et à l'hydrogéologie afin d'évaluer l'exhaustivité et le mérite technique des informations présentées dans l'étude d'impact environnemental de la phase 2 du projet visant la ceinture de la baie Hope de TMAC Resources Inc., présenté à la Commission du Nunavut chargée de l'examen des répercussions (CNER) le 21 décembre 2017. RNCan a également tenu compte des renseignements additionnels fournis par le promoteur le 6 juin 2017 en réponse aux présentations techniques (DR) des parties, notamment RNCan.

Pergélisol

Le pergélisol est présent dans toute la zone du projet et servira de base aux composantes du projet telles que la route praticable en tout temps et les installations aux sites d'exploitation minière Madrid et Boston. Des connaissances de référence adéquates concernant les conditions liées au pergélisol et au terrain sont requises pour concevoir de manière appropriée une infrastructure de projet et évaluer et atténuer les répercussions potentielles sur l'environnement.

Conditions de référence liées au pergélisol et à la glace au sol dans les sites d'exploitation minière de Madrid et de Boston et le long de la route praticable en tout temps

Le promoteur a résumé les conditions géotechniques au site du projet et a fourni une cartographie du terrain pour la zone du projet. D'autres études géotechniques seront dirigées par le promoteur dans la zone du projet, notamment le long de la route praticable en tout temps, préalablement à la conception détaillée. Le promoteur a indiqué que d'autres études propres au site seraient exécutées pour mieux caractériser les conditions liées à la glace au sol et pour déterminer quel est le terrain sensible dans la zone du projet. RNCan reconnaît qu'à ce stade de la conception, la cartographie du terrain et les études géotechniques sont suffisantes.

Conception du dépôt de résidus miniers Doris

Le projet proposé nécessitera l'agrandissement du dépôt de résidus miniers Doris North aux fins d'élimination des résidus provenant des sites d'exploitation minière Madrid North et Madrid South.
La compréhension des matières sous la surface qui sous-tendront la zone élargie de conservation des résidus sera nécessaire pour s'assurer que l'installation fonctionne comme prévu et pour minimiser les impacts sur l'environnement. Le gel des résidus améliorera la performance de l'installation, ce qui nécessitera une évaluation de l'évolution thermique de la pile. RNCan est d'accord avec l'approche du promoteur et recommande d'effectuer d'autres études de site et d'effectuer des analyses thermiques pour appuyer la conception détaillée.

Configuration des taliks et du pergélisol dans les zones du projet

Sous de grands plans d'eau peut se trouver un sol non gelé, ou talik, qui constitue un lien hydraulique entre la surface et l'eau souterraine. En réponse au commentaire de RNCan concernant la possibilité que la mine souterraine Boston intersecte un talik sous le lac Aimokatalok, le promoteur a indiqué que la mine Boston devrait se trouver entièrement dans le pergélisol et qu'aucun écoulement d'eau souterraine n'est prévu. Des mesures seront mises en œuvre pour assurer que les mines restent dans la zone de pergélisol. De plus, un plan de gestion des eaux souterraines sera préparé pour la mine Boston et sera conforme à ceux qui seront élaborés pour les autres mines de la phase 2. RNCan convient que ces plans sont suffisants pour faire face aux incertitudes potentielles concernant la configuration des taliks et des zones de pergélisol dans la région de la mine Boston et n'a pas d'autres recommandations à ce sujet.

Conception de la zone de gestion des résidus Boston et du bassin d'eau de contact connexe

La mine Boston comprendra un parc à résidus miniers destiné aux résidus secs empilés qui doivent geler après le dépôt. Le parc à résidus miniers et un bassin d'eau de contact associé doivent être conçus pour limiter l'infiltration dans l'environnement. Par ailleurs, il est nécessaire de comprendre les matières sous la surface situées sous les installations pour guider la conception et les évaluations de la stabilité. Le promoteur s'est engagé à mener d'autres études de site pour appuyer la conception finale de cette installation. RNcan est d'accord avec l'approche proposée du promoteur qui consiste à effectuer d'autres études à l'appui d'une conception détaillée et de plans de fermeture définitive de la zone de gestion des résidus en vue d'assurer une stabilité physique à long terme de l'installation.

Hydrogéologie

L'examen réalisé par RNCan était axé sur les débits et la salinité des eaux souterraines. D'une manière générale, RNCan est d'accord avec l'évaluation du promoteur concernant les conditions hydrogéologiques, et tient compte du fait que les conditions rencontrées au cours de l'exploitation minière peuvent différer de celles sur lesquelles l'évaluation est fondée.

Salinité des débits entrants de la mine

Plusieurs aspects liés de la gestion des eaux à l'échelle du site, notamment le rejet des débits entrants de la mine dans la baie Robert ou dans le dépôt de résidus miniers de Doris, pourraient être touchés par la présence d'une plus grande salinité des eaux souterraines qui s'écoulent dans les mines. Bien que l'on n'anticipe pas nécessairement une salinité plus élevée des eaux souterraines, l'incertitude touchant la caractérisation et la modélisation est suffisante pour que cela soit une possibilité. RNCan a formulé des recommandations précises pour le plan de gestion des eaux souterraines qui traiteraient de ce problème, y compris des indicateurs spécifiques de la chimie de l'eau, l'examen des programmes de surveillance et des seuils de rendement spécifiques additionnels et révisés.

Incertitudes des prédictions réalisées avec un modèle des eaux souterraines

Les principales prédictions résultant des modèles des eaux souterraines comprennent les apports de la mine, la salinité des eaux souterraines et les flux d'eau de surface à destination et en provenance des lacs. La modélisation des eaux souterraines dans un environnement où se trouve du pergélisol est une tâche difficile et requiert plusieurs hypothèses de simplification. Bien qu'il soit possible d'améliorer les modèles d'eau souterraine pour le projet avec des données supplémentaires, des conditions imprévues peuvent se présenter et des mesures d'atténuation peuvent être requises pour réduire le débit entrant des eaux souterraines salines dans les sites miniers. RNCan recommande que l'on aborde l'incertitude liées aux modèles des eaux souterraines en révisant et en mettant en œuvre le plan de gestion des eaux souterraines en fonction des recommandations mentionnées ci-dessus.

Table of Contents

Executive Summary 1
1. Introduction 14
1.1. NRCan's Mandate 14
1.2. NRCan's Participation in the review of the Phase 2 Hope Bay Belt Project 14
2. Specific Comments 15
2.1. Permafrost and Terrain Stability 15
2.1.1. Introduction 15
2.1.2. Issue 1: Baseline Permafrost and ground ice conditions in the Madrid and Boston project areas and along the All Weather Road 15
2.1.2.1. Summary of NRCan's Review 15
2.1.2.2. Proponent's Initial Conclusions 16
2.1.2.3. NRCan's Initial Conclusions 16
2.1.2.4. NRCan's Initial Recommendations 17
2.1.2.5. NRCan's Final Conclusions 17
2.1.2.6. NRCan's Final Recommendation 17
2.1.3. Issue 2: Design of Doris Tailings Impoundment Area 17
2.1.3.1. Summary of NRCan's Review 17
2.1.3.2. Proponent's Initial Conclusions 18
2.1.3.3. NRCan's Initial Conclusions 18
2.1.3.4. NRCan's Initial Recommendations 19
2.1.3.5. NRCan's Final Conclusion 20
2.1.3.6. NRCan's Final Recommendations 20
2.1.4. Issue 3: Configuration of Taliks and Permafrost in the Project Areas 20
2.1.4.1. Summary of NRCan's Review 21
2.1.4.2. Proponent's Initial Conclusions 21
2.1.4.3. NRCan's Initial Conclusions 21
2.1.4.4. NRCan's Initial Recommendations 22
2.1.4.5. NRCan's Final Conclusions 22
2.1.4.6. NRCan's Final Recommendations 23
2.1.5. Issue 4: Design of the Boston Tailings Management Area and Associated Contact Water Pond 23

2.1.5.1. Summary of NRCan's Review 23
2.1.5.2. Proponent's Initial Conclusions 24
2.1.5.3. NRCan's Initial Conclusions 24
2.1.5.4. NRCan's Initial Recommendations 25
2.1.5.5. NRCan's Final Conclusions 25
2.1.5.6. NRCan's Final Recommendations 25
2.2. Hydrogeology 25
2.2.1. Introduction 25
2.2.2. Issue 1: Mine inflow salinity 26
2.2.2.1. Summary of NRCan's Review 26
2.2.2.2. Proponent's Initial Conclusions 27
2.2.2.3. NRCan's Initial Conclusions 28
2.2.2.4. NRCan's Initial Recommendations 29
2.2.2.5. NRCan's Final Conclusions 29
2.2.2.6. NRCan's Final Recommendations 31
2.2.3. Issue 2: Uncertainties of groundwater model predictions 32
2.2.3.1. Summary of NRCan's Review 32
2.2.3.2. Proponent's Initial Conclusions 32
2.2.3.3. NRCan's Initial Conclusions 32
2.2.3.4. NRCan's Initial Recommendations 33
2.2.3.5. NRCan's Final Conclusions 33
2.2.3.6. NRCan's Final Recommendations 33
2.2.4. Issue 3: Groundwater management plans 34
2.2.4.1. Summary of NRCan's Review 34
2.2.4.2. Proponent's Initial Conclusions 34
2.2.4.3. NRCan's Initial Conclusions 34
2.2.4.4. NRCan's Initial Recommendations 35
2.2.4.5. NRCan's Final Conclusions 35
2.2.4.6. NRCan's Final Recommendation 35
3. Overall Conclusion 36
4. Summary of NRCan's Recommendations for TMAC Resources Inc. 37

1. Introduction

Natural Resources Canada (NRCan) conducted a technical review to assess the completeness and technical merit of the information presented in TMAC's Draft Environmental Impact Statement for the Hope Bay Phase 2 Project submitted to the Nunavut Impact Review Board (NIRB) on December 28, 2016. NRCan also considered the additional information provided by the proponent on March 20, 2017 in response to the information requests (IR) received from Parties regarding the Hope Bay Belt Phase 2 project. NRCan provided fourteen information requests for the NIRB's consideration.

1.1. NRCan's Mandate

NRCan seeks to enhance the responsible development and use of Canada's natural resources and the competitiveness of Canada's natural resources products. We are an established leader in science and technology in the fields of energy, forests, and minerals and metals and use our expertise in earth sciences to build and maintain an up-to-date knowledge base of our landmass. NRCan develops policies and programs that enhance the contribution of the natural resources sector to the economy and improve the quality of life for all Canadians. We conduct innovative science in facilities across Canada to generate ideas and transfer technologies. We also represent Canada at the international level to meet the country's global commitments related to the sustainable development of natural resources.

1.2. NRCan's Participation in the review of the Phase 2 Hope Bay Belt Project

NRCan has been participating in the review of the proposed Phase 2 Hope Bay Belt Project in the context of our role as a federal department with expertise in permafrost and hydrogeology.

NRCan has participated throughout the review process and has reviewed the Final Environmental Impact Statement (FEIS) and the Proponent's responses to Information Requests (IR) and technical comments. NRCan has conducted its review of the FEIS to assess whether impacts related to NRCan's mandate and areas of expertise have been adequately identified and evaluated.

2. Specific Comments

2.1. Permafrost and Terrain Stability

2.1.1. Introduction

The Draft Environmental Impact Statement (DEIS) was initially reviewed to determine if any additional information was required to complete the technical review. The review focussed on the terrain sensitivity and permafrost issues and design of project components for which these aspects of the physical environment are important. NRCan submitted Information Requests (IRs) in February 2017 for further clarifications regarding baseline data in the project area including ground ice conditions and permafrost distribution beneath lakes in the project area. Information was also requested regarding analysis to support project facility design such as the Doris Tailing Impoundment Area (TIA). The responses from TMAC were helpful in providing NRCan with the information required to complete the technical review.

NRCan provided comments and recommendations with respect to the analysis included in the DEIS to support design of major project components. These recommendations were for consideration by the Proponent and NIRB to support the detailed design stage or development of environmental monitoring and management programs to ensure that project facilities are operating as predicted and environmental effects are minimized.

TMAC provided a response to NRCan's comments and recommendations and also made a number of commitments. NRCan has reviewed TMAC's responses and commitments as well as new information provided in the Final Environmental Impact Statement (FEIS). TMAC generally agreed with NRCan's comments and indicated it would consider the recommendations during later design stages and in the development of environmental monitoring and management plans. The results of NRCan's review of the FEIS and other post DEIS documentation is provided below, following NRCan's initial review of the DEIS for each issue. NRCan has a few additional comments as well as recommendations with respect to the advanced design stages for the project.

2.1.2. Issue 1: Baseline Permafrost and ground ice conditions in the Madrid and Boston project areas and along the All Weather Road

2.1.2.1. *Summary of NRCan's Review*

Guidelines for the Preparation of an Environmental Impact Statement for Hope Bay Mining Ltd.'s Phase 2 Hope Bay Belt Project (NIRB File No. 12MN001), December 2012, Sections 6.1, 6.6, 7.6,7.10, 8.1.4

Documents Reviewed

Phase 2 of the Hope Bay Project: Draft Environmental Impact Statement, December 2016, Vol. 1 (sec 4.2.3), Vol. 3 (sec. 3, App. V3-2C,2E,2F,3H,3I,3J), Vol 4 (Ch. 4,6,7, App. V4-7A)
Information Requests for the Madrid-Boston Project: NRCan IR 1, INAC IR 34(2), KIA IR175
FEIS Vol. 1 Main Volume, Annex V1-7 Packages P5-3,11,14,16,17,17,22,26,28
TMAC response to NRCan's technical review comments NRCan 2.1.2
Final Commitment Table

Issue
Permafrost is found throughout the project area and will provide a foundation of project components such as the all weather road (AWR) and facilities at the Madrid and Boston sites. Surface disturbance associated with infrastructure construction or extraction of borrow resources can lead to alterations of the ground thermal regime which can lead to thawing of permafrost. Where sediments are ice-rich, ground instability, ponding of water and changes in drainage can occur which can have implications for infrastructure performance and the surrounding terrain. Adequate knowledge of baseline permafrost and terrain conditions is therefore required for appropriate design of project infrastructure and to also assess the impacts on the environment.

2.1.2.2. *Proponent's Initial Conclusions*

The Proponent has summarized the geotechnical conditions at the project site in Appendix V3-2E of the DEIS, and provides terrain maps for the project area in App. V4-7A (App. 1) of the DEIS. Geotechnical boreholes have provided information such as ground ice conditions for the mine sites (Vol. 4, sec. 6.3.2 Figure 6.3-1 to 6.3-3, Table 6.3-4). There have however, been no detailed geotechnical investigations along the AWR (response to NRCan IR 1). Additional geotechnical investigations will be conducted in the project area prior to detailed design that will provide further characterization of foundation conditions and ensure environmental effects will be minimized.

2.1.2.3. *NRCan's Initial Conclusions*

Limited site-specific geotechnical investigations have been conducted particularly along the proposed AWR. However, NRCan agrees that for this stage of design the terrain mapping and geotechnical investigations are generally sufficient. However, additional geotechnical investigations including information on ground thermal and ground ice conditions will be required to support detailed engineering. NRCan agrees with the approach outlined by the Proponent in response to NRCan IR 1 and 2, which includes additional geotechnical investigations at all sites prior to detailed engineering to further characterise the foundation conditions and to collect information on ground thermal conditions. With respect to the AWR, additional geotechnical investigations and thermal monitoring will focus on bridge abutments only (particularly where not founded on bedrock) in order to update the engineering analysis and confirm bridge performance (Response to NRCan IR1, INAC IR34(2), KIA IR 175). For other sections of the AWR, more detailed air photo interpretations will be done to confirm terrain conditions. This approach appears to be reasonable and is similar to that used for other roads on the site as well as other projects.

2.1.2.4. *NRCan's Initial Recommendations*

NRCan recommends that the Proponent conduct further site specific investigations (such as geotechnical boreholes indicated in response to NRCan IR 1), to better characterize ground ice conditions and identify sensitive terrain in the project area.

2.1.2.5. *NRCan's Final Conclusions*

In its response to NRCan's technical comment 2.1.2, TMAC acknowledged agreement with their proposed approach. TMAC also indicated that the proposed additional work to better characterize ground ice conditions would be conducted during detailed design. Commitments made in response to NRCan's recommendation (and also commitments in response to KIA-DEIS-55,56,57,58) further indicate that the Proponent will be conducting additional geotechnical site characterization after completion of FEIS stage (post-water licencee) to support detailed engineering. The data acquired from these investigations would be used to update any engineering design analysis. NRCan is in agreement with TMAC's approach and recommends that they follow through on their commitments.

2.1.2.6. *NRCan's Final Recommendation*

NRCan recommends that the Proponent conduct the additional site investigations and geotechnical site characterization, as outlined in their commitments, to support detailed design of project infrastructure and facilities.

2.1.3. Issue 2: Design of Doris Tailings Impoundment Area

2.1.3.1. *Summary of NRCan's Review*

Documents Reviewed

Guidelines for the Preparation of an Environmental Impact Statement for Hope Bay Mining Ltd.'s Phase 2 Hope Bay Belt Project (NIRB File No. 12MN001), December 2012, 6.6.3.2, 7.6.1, 8.1.5, 9.4.6

Phase 2 of the Hope Bay Project: Draft Environmental Impact Statement, December 2016, Vol 3 (App. V3-2D,2F,2E,3F);

Information Requests for the Madrid-Boston Project: NRCan IR 3, 4, KIA IR 168, 169, 172, 172, 181

FEIS Vol. 1 Main Volume, Annex V1-7 Package P4-9

TMAC response to NRCan's technical review comments NRCan 2.1.3

Final Commitment Table

Issue

The Phase 2 project will make use of the approved Doris North Tailings Impoundment Area (TIA) for disposal of tailings resulting from development of the Madrid North and South mines. However, to accommodate the substantial increase in the volume of tailings, the facility will

need to be expanded. An understanding of the characteristics of the subsurface materials that will underlie all structures required for the expanded facility is required to inform the design and stability assessments required to ensure the facility operates as intended and to ensure impacts on the environment will be minimised. Freezing of the tailings will enhance performance of the facility and this will require an assessment of the thermal evolution of the pile.

2.1.3.2. *Proponent's Initial Conclusions*

The expansion of the Doris TIA will require a modification to dams, including enlargement and raising of the South Dam and construction of the West Dam (Vol. 3, sec. 4.4.4.1, App. V3-3F). While there is adequate knowledge of foundation conditions for the North and South Dams that were part of the approved facility, the Proponent indicates that the foundation conditions for the West Dam are less understood due to the minimal subsurface investigations (App. V3-2D, 3F). For the new or enhanced structures that will be required, foundation conditions are assumed to be similar to the foundation conditions beneath the approved structures. Based on their analysis, the Proponent expects that the North Dam will stay frozen over its extended life to 2050 and the South and West Dam liners will stay frozen in perpetuity (App. V3-2F, sec. 4.8, App, C, H). They have also determined that tailings freeze-back will occur in 2-13 years depending on the thickness of the tailings (App. V3-2F, sec. 4.8, App. H). Little deformation of the tailings pile is expected so there should be no issues with respect to deformation and performance of the tailings cover (App. V3-2F, sec. 4.9, App. I).

2.1.3.3. *NRCan's Initial Conclusions*

Although the Proponent has conducted detailed site investigations to support the Phase 1 TIA design, NRCan notes that these investigations such as those for the North Dam occurred at a more advanced design stage. For the new components such as the West Dam, information on foundation conditions comes from one borehole and design is largely supported by the information collected for the North Dam. In 2006, the Proponent conducted ground-penetrating radar (GPR) surveys around the lake but the survey line is located about 200 m to the east of the West Dam (App. V3-2F, sec. 4). For the South Dam raise, there is also lack of geotechnical data (App. V3-2F, App. B). In response to NRCan IR3 and KIA IR169, the Proponent has indicated that additional geotechnical investigations will be conducted prior to detailed engineering to characterize foundation conditions and to update the engineering analyses (thermal, seepage, stability) required for the Phase 2 TIA. NRCan agrees with this approach.

The Proponent has conducted a thermal analysis for the Phase 2 TIA including the West and South Dams and their foundations and also for the extended life time for the North Dam (App. V3-2F, App. C and H). The analysis is similar to that conducted for the Phase 1 project and also incorporates thermal monitoring data collected for the core and foundation of the already constructed North Dam (App. V3-2F, App. C). The results of these analyses also support the stability and seepage analysis (e.g., App. V3-2F, App. B, D, I). The Proponent has been fairly conservative in their approach. For the North Dam the analysis indicates that the core and the foundation temperatures will remain below the design values of -2 and -8°C respectively over the 40 year lifetime. The ground temperature data collected in 2014-15 indicates that the observed

thermal conditions are in agreement with those predicted (App. V3-2F, App. C). For the West and South Dams, which will not be water retaining at closure, the thermal analysis also indicates that the critical part of the dams (the liner in the key trench) will remain frozen and tailings are expected to freeze-back (App. V3-2F, App. H).

NRCan agrees that the Proponent has conducted an adequate thermal analysis for this stage of the project design. NRCan suggests that the Proponent continues to update this analysis as additional data is generated through the monitoring program for the North Dam. Since the thermal response of the North Dam and foundation will be slow, any variance from predicted response can be identified through analysis of the monitoring data. NRCan suggests that a similar approach can be followed for the other components of the Phase 2 TIA to ensure that the facility maintains its integrity over its intended life time.

During its review of the amended Phase 1 Doris project and in NRCan IR4, NRCan expressed some concern regarding the potential for warmer conditions at the north end of the tailings pile, both within the tailings and foundation, due to the presence of the reclaim pond. This could result in variable thermal conditions and potential for differential heave or settlement and deformation of the cover. Freeze-back of the foundation beneath the tailings pile would generally be expected to be slow with a potential for ice lens formation and frost heave and would occur at variable rates given the warmer conditions at the north end of the pile. NRCan had recommended in its review of the amended Phase 1 project that 2D thermal modelling might be considered for the assessment of differential movements and potential effects on the tailings cover integrity. The Proponent indicated that the thermal analysis would be re-visited as design advances but that it was premature at the preliminary stage to suggest 2D thermal analysis is the appropriate approach. For the Phase 2 project the Proponent presents a similar thermal analysis and qualitative analysis with respect to frost heave potential. In response to NRCan IR 4, the Proponent indicated that there has been no sensitivity analysis regarding the thermal conditions in the tailings pile. Thermal monitoring during operation would provide data to confirm the closure design and the post-closure monitoring plans will be provided in detail in an updated tailings operation, maintenance and surveillance manual. Further stability analysis will be done prior to final closure. NRCan agrees that further thermal analysis can be revisited during detailed design.

2.1.3.4. *NRCan's Initial Recommendations*

With respect to the Doris TIA, NRCan recommends that the Proponent:

- Continue to utilize the data generated through the North Dam monitoring program to update thermal analysis, to improve characterization of the thermal evolution of the dam and its foundation, and to determine if mitigation is required should actual conditions deviate from those predicted.
- Conduct the additional site investigations, as outlined by the Proponent in response to NRCan IR3, to better characterize foundation conditions for structures required for the Phase 2 TIA (West Dam and South Dam raise) and to support the thermal, seepage and stability analysis required for their detailed design.

- Revisit the thermal modelling for the tailings during detailed design to confirm the potential for differential movements that may have impacts on the cover integrity.
- Adopt an approach similar to that taken for the North Dam with respect to monitoring of the dams required for the Phase 2 TIA, and use the data collected to update the thermal analysis and to determine if mitigation is required should actual thermal conditions deviate from those predicted.

2.1.3.5. *NRCan's Final Conclusion*

In its response to NRCan's comments, TMAC acknowledged NRCan's general agreement with their approach. TMAC also acknowledged NRCan's recommendations and indicated that they would consider these in future design and monitoring stages. TMAC's commitment in response to NRCan-2.1.3 states that they will be conducting additional geotechnical site characterization studies after completion of the FEIS as part of detailed engineering (post water licence). Data collected as part of these characterization studies will be used to update any engineering design analysis. NRCan agrees with the approach with respect to geotechnical site investigations and incorporation of the data acquired into the engineering analysis and recommends they follow through on these commitments. NRCan also agrees that TMAC should consider other NRCan recommendations in future design stages and also in the development of monitoring and management plans for the Phase 2 TIA to determine if it is performing as intended and to guide the implementation of mitigation measures if required. NRCan also suggests that this may include more detailed thermal modelling for the tailings, such as 2-D modelling, to support stability assessments and potential for differential movements of the tailings. NRCan also suggests that TMAC consider adopting an approach similar to the North Dam with respect to the monitoring of the Phase 2 TIA dams.

2.1.3.6. *NRCan's Final Recommendations*

With respect to the Doris Phase 2 TIA, NRCan recommends the following to support final design and development of environmental monitoring and management plans:

- The Proponent follow through on commitments for additional site investigations to better characterize foundation conditions for structures required for the Phase 2 TIA (including West Dam and South Dam raise) to support and update their engineering analysis.
- The Proponent consider revisiting the thermal analysis to confirm potential for differential movements that may have an impact on tailings cover integrity.
- Continuing monitoring of the North Dam and utilize these data to update thermal analysis and also adopt a similar approach with respect to the development of monitoring plans for Phase 2 TIA dams.

2.1.4. Issue 3: Configuration of Taliks and Permafrost in the Project Areas

2.1.4.1. *Summary of NRCan's Review*

Documents Reviewed

Guidelines for the Preparation of an Environmental Impact Statement for Hope Bay Mining Ltd.'s Phase 2 Hope Bay Belt Project (NIRB File No. 12MN001), December 2012, Sections 7.3, 7.6.1, 8.1.4, 8.1.6

Phase 2 of the Hope Bay Project: Draft Environmental Impact Statement, December 2016, Vol 3 (App. V3-4B, Vol. 4 (sec. 6.3.4)

Hope Bay 2010 West Bay Program Report; Geotechnical and Hydrogeological Assessment for the Boston Open Pit and Madrid Open Pit and Underground

Information Requests for the Madrid-Boston Project: Response to NRCan IR5, IR6

FEIS Volume 1 Main Volume, Annex V1-7 Package P5-13

TMAC response to NRCan's technical review comments NRCan 2.1.4

Final Commitment Table

Issue

Although permafrost is continuous in the region, unfrozen ground or taliks may be found beneath large water bodies that do not freeze to the bottom during the winter. Where lakes exceed a critical size, taliks may be open and provide a hydraulic connection between surface and ground water. Knowledge of the extent of taliks is important to determine whether mining will take place in frozen or unfrozen conditions and to determine mine inflows and whether mining operations will have an effect on water quantity and quality in the project area.

2.1.4.2. *Proponent's Initial Conclusions*

The Proponent has conducted an analysis to determine lakes in the project area that are likely to have open taliks (App. V3-4B, Figure 20, App. A, sec. 4, Table 4 and 5). For the underground mine sites, a more detailed thermal analysis has been conducted (App. V3-4B, App. A). The Proponent has determined that the Boston underground mine will be entirely in permafrost (App. V3-4B, Figure 21). At Madrid North, the Suluk and Rand underground mines will be within an open talik beneath Patch Lake (App. V3-4B, Figure 22). The lower portion of the Naarotok mine, below 430 m depth will be below the permafrost (App. V3-4B, Figure 22). The Madrid South mine will also intercept unfrozen ground at the edge of an open talik formed by Wolverine and Patch Lake (App. V3-4B, Figure 23).

2.1.4.3. *NRCan's Initial Conclusions*

The Proponent has utilized acceptable methods to delineate lakes likely to have open taliks (App. V3-4B). NRCan requested clarification regarding whether consideration of warmer ground conditions would lead to identification of additional lakes potentially having open taliks (NRCan IR5). In their response to NRCan IR5, the Proponent indicated that while it is possible that additional lakes might have open taliks, they were outside the hydrogeological domain for the project. NRCan agrees that the Proponent has adequately identified lakes potentially having open taliks to support their groundwater modelling.

The Proponent has utilized observed ground temperatures and thermal modelling to determine the extent of taliks at the mine sites to determine whether the underground mines will be in frozen or unfrozen ground (App.V3-4B). The Proponent's approach is reasonable. NRCan does, however, offer a few observations regarding the analysis for consideration by the Proponent.

For the Madrid and Boston mine sites, information on deep ground temperatures has been acquired from inclined boreholes drilled at these sites (Vol 4, Figure 6.3.2, 6.3.3). The Proponent has presented ground temperature profiles derived from the data collected at these boreholes (App. V3-4B, App. A Figure 7 and 15). NRCan would note that the reconstruction of vertical temperature profiles based on data from inclined holes may not provide a true picture of the ground thermal regime beneath a specific point, especially where there is a significant variation in the surface conditions above the area traversed by the borehole (i.e. in some cases the shallow temperatures were measured beneath the land surface while the deeper temperatures in the borehole were measured beneath the water body).

For the Boston site, there are three deep inclined wells that extend beneath Aimokatalok Lake. Temperatures are cold (<-5°C) at depths of 241-247 m below the ground surface (App. V3-4B, App. A Figure 6 and 7). Below the lake the -2°C isotherm occurs between 201 and 224 m depth between 17 and 115 m from the shore (App. V3-4B, App. A). The Proponent concludes that these low temperatures cannot be explained by the present day lake configuration and suggest there has been a more recent submergence of this area and temperatures are still warming at depth. This has been incorporated in the talik modelling and they have concluded that the underground mine, which for the most part is beneath the land surface, will be entirely within permafrost. NRCan notes that a small portion of the mine will extend a short distance offshore (App. V3-4B, App. A, Figure 6). Although ground temperatures a short distance offshore are about -2°C at depths of about 200 m, NRCan suggests that above this altitude, temperatures may be warmer due to ground warming at depth following submergence of this area. Temperatures at the lake bed could be close to or above 0°C and it is possible that a small portion of the mine may occur within an unfrozen zone, based on a freezing point depression of -2°C. At the detailed design stage the Proponent may want to give further consideration to the potential for a portion of the mine to intersect a talik. NRCan also notes that one of the recommendations made by SRK (2009 Assessment Report for the Boston Open Pit) was for consideration of additional thermistor installations to better characterize the thermal regime under the lake and to confirm whether the lake freezes to the bottom.

2.1.4.4. *NRCan's Initial Recommendations*

NRCan recommends that during final design, further considerations be given for the potential of a portion of the Boston underground mine to intersect a talik beneath the Aimokatalok Lake.

2.1.4.5. *NRCan's Final Conclusions*

In response to NRCan's comment regarding the potential for the Boston underground mine to intersect a talik beneath Aimokatalok Lake, TMAC acknowledged NRCan's comment regarding the analysis and indicated they would consider this in detailed design. TMAC indicates in their

response to ECCC 4.9, that the Boston mine is expected to be entirely within permafrost and no groundwater flow is expected. Measures such as pilot drilling and risk zone mapping, as undertaken at Doris, will be used to ensure mining stays within the permafrost zone, and their assessment does not consider any mining at Boston outside of permafrost. In FEIS Annex V1-7 package P4-6, TMAC states (sec. 1.1) that an objective is to avoid taliks or unfrozen zones beneath permafrost in areas where mining is planned to remain encapsulated in permafrost. Regardless of this objective, TMAC has indicated (response to ECCC 4.9 and commitment to NRCan 2.1.4) a groundwater management plan will be prepared for the Boston Mine that is consistent with those to be developed for other Phase 2 mines. Contingency measures for small quantities of water will be in place that can be handled within the existing water management structures and framework at Boston. However if larger quantities should be encountered, TMAC plans include temporary isolation and cessation of specific mining areas until suitable water management strategies can be put in place. As indicated in commitments to NRCan 2.1.4 and ECCC 4.9, a ground water management plan for Boston was provided in the FEIS (P4-6 Module C). This plan includes triggers and mitigation measures (Table C-1) and also outlines specific responses, such as reviewing thermal measurements and permafrost models to assess correlation between modeled and observed inflow. NRCan agrees that the Proponent has presented a reasonable approach to deal with uncertainty with respect to delineation of permafrost and taliks at the Boston mine and the potential for any groundwater flow should mining intersect the talik.

2.1.4.6. *NRCan's Final Recommendations*

NRCan agrees with the plans and approach outlined in their response to NRCan's technical comments, commitments made and also in the groundwater management plans provided in the FEIS. NRCan agrees that these plans are sufficient to deal with potential uncertainties regarding the configuration of taliks and permafrost zones in the Boston Mine area and has no further recommendations with respect to this issue.

2.1.5. Issue 4: Design of the Boston Tailings Management Area and Associated Contact Water Pond

2.1.5.1. *Summary of NRCan's Review*

Documents Reviewed

Guidelines for the Preparation of an Environmental Impact Statement for Hope Bay Mining Ltd.'s Phase 2 Hope Bay Belt Project (NIRB File No. 12MN001), December 2012, Sections 6.1,6.6.1, 6.6.3.2, 7.3, 8.1, 9.4.6

Phase 2 of the Hope Bay Project: Draft Environmental Impact Statement, December 2016, Vol 1, Vol 3 (App. V3-2A,2C,2E,2F,3J), Vol 7 (Ch. 2), Vol 8 (Appendix 27)

Information Requests for the Madrid-Boston Project: Response to INAC IR 36,39; KIA IR 165

FEIS Volume 1 Main Volume, Annex V1-7 Package P5-3

TMAC response to NRCan's technical review comments NRCan 2.1.5

Final Commitment Table

Issue
The Boston tailing management facility (TMA) will be a dry stack tailing facility. The TMA and associated contact water pond must be designed to limit seepage of contact water to the surrounding environment. Adequate knowledge of foundation materials is required to ensure stability of the facility, including contact water pond berms, during operation. Long-term physical stability of the TMA is required to meet closure objectives and to ensure that long-term water management is not required. A key to ensuring these objectives are met is the stability of the TMA cover system in order to limit potential for seepage through tailings and potential leaching.

2.1.5.2. *Proponent's Initial Conclusions*

The Boston TMA will be a dry stack tailing facility that will be built on permafrost and the facility is expected to freeze following deposition (V1, sec. 3.3; V3, sec. 3.8.11). The closure plans will include a low permeability cover (consisting of a geomembrane with crushed rock on top) that will mitigate against long-term water quality concerns associated with metal leaching (App. V3-2F). Although water management, including a contact water pond will be required during operation, there will be no need for water management under the proposed closure plans (V8 Appendix 27).

2.1.5.3. *NRCan's Initial Conclusions*

The Proponent has presented a detailed analysis to support their conclusions regarding the proposed Boston TMA. This includes thermal analysis and stability analysis for the dry stack, including the geosynthetic closure cover (V3 sec 3.1.11, App. V3-27 App. A, B; V7 sec. 2.9). Although there is potential for heave or settlement of the dry stack which could lead to deformation of the cover, the analysis indicates that stability of the cover will be maintained over the long-term (App. V3-2E, 2F App. A). The design for the contact water pond includes thermal modelling for the berms over a 20 year operating period, including climate change, to ensure that thawing does not occur that could have an impact on the performance of the berms (V3 sec, 3.8.5; App. V3-2C). The analysis conducted by the Proponent is reasonable for this stage of the design. NRCan notes that there is currently a lack of geotechnical site investigations to support the design of the Boston TMA and contact water pond. The analysis utilized foundation properties based on site-wide geotechnical properties (App. V3-2F App. A). The Proponent has indicated in response to KIA IR165, that additional site investigations will be conducted to support detailed design and to refine the engineering analysis. NRCan agrees with the approach proposed by the Proponent. The monitoring plan outlined in Appendix V3-2F, including temperature cables installed beneath and along containment berms and monitoring of deformation of dry stack facility, will facilitate assessments of facility performance and inform final closure plans.

2.1.5.4. *NRCan's Initial Recommendations*

NRCan recommends that additional site investigations, as suggested in response to KIA IR165, be conducted to support detailed design and final closure plans for the Boston tailings management area.

2.1.5.5. *NRCan's Final Conclusions*

In its response to NRCan's comments and recommendations, TMAC acknowledged NRCan has confirmed agreement with the approach proposed by TMAC. TMAC's commitment with respect to NRCan 2.1.5, states that TMAC will be conducting additional geotechnical site characterization studies as part of detailed engineering (post water licence) and data collected will be used to update any engineering design analysis for the Boston TMA. In addition, the Proponent has indicated in Annex V1-7, Package P5-3 (sec. 2.3) that additional geotechnical site investigations will be carried out prior to final design to better characterize conditions of foundations for berms required for the contact water ponds. NRCan also notes that additional thermal modelling has been completed to support design of the berms for the contact water ponds (Attachment 1, P5-3 and response to KIA-DEIS-54) in which a conservative approach has been taken with respect to pond water temperatures. NRCan assumes that based on TMAC's response, this analysis will be updated with information obtained in future geotechnical site investigations.

2.1.5.6. *NRCan's Final Recommendations*

NRCan is agreement with the approach TMAC has outlined for its detailed and final design of the Boston TMA and associated contact water ponds, and also the commitments made in response to NRCan's review of the DEIS. NRCan therefore recommends that the Proponent follow through on commitments for additional geotechnical site investigations to support final design and use data collected to update the engineering analysis associated with the Boston TMA and associated contact water ponds.

2.2. Hydrogeology

2.2.1. Introduction

This review focuses on hydrogeology issues with respect to groundwater flow and salinity; NRCan has not reviewed groundwater quality issues with respect to water quality parameters. Although Table 6.1-1 (TMAC Resources, 2016, Volume 1) identifies hydrogeology and groundwater quality as potential VECs, there are no identified potential effects to groundwater or groundwater quality (Table 6.1-4). However, groundwater has the potential to affect other VECs such as surface water quantity, surface water quality, marine water quality and fish habitat (Table 6.1-4). The assessment for these VECs determined that there are either no residual effects predicted or that the residual effects are not significant (Table 6.1-4).

Overall, NRCan is in general agreement with the proponent's assessment of groundwater issues given the hydrogeological information considered in this review. However, it is important to note that the hydrogeological conditions that will be encountered during mining may differ from those on which the assessment is based as is acknowledged by the Proponent. For example, zones of higher permeability could be encountered leading to increased groundwater inflow to the mines. The Proponent has stated that:

> "TMAC is fully aware of the uncertainty related to fault zones and exploration holes and plans to safely and appropriately manage groundwater inflows. In advance of starting mine development in the talik zones, TMAC will develop operational measures in the appropriate SOPs to address these uncertainties. These operational measures will be functional and with concise instructions that will allow the relevant mine operations staff to manage responses to groundwater inflows. It will describe actions to be taken to routinely manage expected amounts of groundwater inflow, and actions to be taken when high permeability formations are encountered." (TMAC, 2017, Appendix V3-4B, p. 33)

Therefore, mine inflows will be limited using management plans and an adaptive approach as required. Consequently, NRCan emphasizes the importance of the development of appropriate groundwater management plans.

2.2.2. Issue 1: Mine inflow salinity

2.2.2.1. *Summary of NRCan's Review*

Documents Reviewed

Phase 2 of the Hope Bay Project: Draft Environmental Impact Statement, December 2016, Vol. 1 (sec. 3, sec. 4.3.2, 4.4.1), Vol.3 (sec. 4.3.2, 4.4.5, 7.3.10, App. V3-2D,4B), Vol. 5 (sec. 2, App. V5-8A,8B)

Information Requests for the Madrid-Boston Project: Responses to NRCan-IR10,-IR12,-IR13, ECCC-IR5

Hope Bay 2010 Westbay Program Data and Installation Report – SRK Feb. 2011

Hope Bay 2011 Groundwater Quality Report – SRK April 2014

FEIS Vol. 1 Main Volume; Vol. 3, Sect. 4.4.5; Vol. 4, Sect. 4; Vol. 5, Sect. 2; Annex V1-7 Packages P1, P2, P4, P4-6, P4-7, P4-8, P4-9, P4-11, P5-4, and P5-24.

TMAC. 2017. Hope Bay Project: Proponent's Response to Technical Comments on the Draft Environmental Impact Statement for the Madrid-Boston (Phase 2) Proposal: Toronto, Ontario. Response to comment NRCan 2.2.2

Final List of Commitments for the Madrid-Boston Proposal.

Issue

If groundwater salinity is higher than expected, discharge of mine waters to Roberts Bay via the marine outflow mixing box (MOMB) or to the Doris Tailings Impoundment Area (TIA) may be problematic and require careful management.

The salinity of groundwater inflow into the mine is important for two reasons. First, saline mine inflow will be discharged primarily to the marine environment in Roberts Bay via the MOMB. Secondly, saline mine inflow could be diverted to the TIA if discharge of mine water via the MOMB is not possible due to high salinity.

The salinity of the water discharged from the MOMB to Roberts Bay is important because discharge to the marine environment relies upon its buoyancy for appropriate mixing. Consequently, there is a maximum limit to the salinity that can be discharged to Roberts Bay and "all groundwater that have salinities above 27 ppt (15,000 mg chloride/l) will be conveyed to the TIA" (App. V5-8A, sec. 3.3.2.2). The MOMB mixes water from the TIA and the intercepted groundwater. However, the plan is to discharge TIA water to the MOMB only during the open water season (App. V3-2D, Sec 6.3.1). Therefore, mine water is the only source of water to the MOMB and Roberts Bay during the ice-covered season. So, if the mine water salinity is above the MOMB discharge concentration, it will be discharged to the TIA. However, as noted in the water and load balance sensitivity analysis, the high salinity of mine inflow would impact the performance of the TIA (App. V3-2D, sec. 8) "the 180 day pumping duration resulted in a significant increase to the chloride predictions, excluding Madrid North intercepted groundwater, which could have a significant impact on process performance." This section also stated that "prolonged use of the Doris TIA for storage of intercepted groundwater should be avoided for the Doris and Madrid South mines."

2.2.2.2. *Proponent's Initial Conclusions*

The mixing modelling (of MOMB water and marine water) in Roberts Bay (App. V5-8A, 8B) uses the groundwater modelling results (App. V3-4B) as inputs to their modelling and include both high salinity (25.3 ppt) and a low salinity (15.3 ppt) scenarios. Although the water and load balances for the Hope Bay project (App. V3-2D) can include groundwater inflows to the TIA, it appears that the balance and load results do not include any groundwater input to the TIA (except for the sensitivity analysis discussed above) since intercepted groundwater is assumed to be pumped directly to the MOMB. Therefore, the models on which the water management is planned rely on the predicted groundwater fluxes and concentrations results from the groundwater models.

The proponent recognizes the potential limitations of the groundwater modelling (App. V3-4B, sec. 4.2.7) and addresses the models' sensitivities by comparing the model results of various scenarios (App. V3-4B, sec. 5.4). All scenarios predict that intercepted groundwater concentrations are below the 15 000 mg/l chloride discharge limit, except for Madrid North in 2019-20 for all scenarios.

In response to ECCC-IR5, the proponent states that "the rationale for using Doris groundwater samples (10WBW001) is driven by the extreme difficulty of obtaining good quality groundwater

quality samples in a low K and frozen environment that would be representative of the true formation water" and adds "salinity which is not expected to differ between the sites because it is not a function of the mineralogical make-up".

2.2.2.3. *NRCan's Initial Conclusions*

NRCan recognizes the significant challenges and costs involved in collecting hydrogeological data from sub-permafrost groundwater environments such as for the Hope Bay Project. As a result, there is necessarily more uncertainty in any hydrogeological modelling and assessment than might be expected for more accessible non-permafrost sites. The goal of the following comments is not to request additional sample collection or modelling. Rather, it is to illustrate the nature of the uncertainties in mine inflow salinity (as measured by groundwater chloride or total dissolved solids (TDS)).

Intercepted groundwater could have chloride concentrations that are higher than predicted for several reasons. First, the characterization of groundwater chloride concentrations with depth is based on the results from one multilevel piezometer (3 depths) located at the Doris site (ECCC-IR5). Despite the Proponent's claim that salinity is not expected to differ between the sites, there is no data to support this claim. Data compiled from other sites (Figure 17, V3-4B) show that total dissolved solids (TDS) concentrations (chloride being the dominant ion in most cases) can vary widely at any given depth. Chloride (and TDS) concentrations could be higher (or lower) at the Madrid sites.

Second, the groundwater models may underestimate chloride. As noted above, the chloride concentrations vs. depth profiles used in the groundwater modelling are based on the characterization from one location at the Doris site (Figure 18, App. V3-4B). The groundwater models have both initial and boundary conditions based on this profile (Figure 18, App. V3-4B; NRCan-IR10). The resulting vertical stratification of initial chloride concentrations (Figures 26 and 27 in V3-4B and Figures IR-10-1 and -2) may not be appropriate. For example, the TDS concentrations from the Hope Bay site are much higher than those at comparable depths at other sites (Figure 17, V3-4B) which may suggest that the proximity of the Hope Bay site to the ocean (on a regional scale) may result in regional groundwater upwelling and higher chloride concentrations originating from deeper groundwater flow. Higher groundwater chloride concentrations at shallower depths could produce higher concentrations in mine inflow, particularly at early times when most groundwater originates from storage.

Finally, the goal of the groundwater model sensitivity analysis was to put emphasis (V3-4B sec. 5.4) "on scenarios that could result in increased inflow to the underground mine compared to the base model." Consequently, these scenarios often produced greater flows of fresh water towards the mine with resulting lower chloride concentrations. A high permeability zone that intercepts the mine at depth could result in higher inflows of more saline water.

In conclusion, several interconnected aspects of water management across the site could be affected by the presence of higher salinity groundwater flowing into the mine. Although higher

salinity groundwater is not necessarily anticipated, there is enough uncertainty in the characterization and modelling that it is nonetheless a possibility.

2.2.2.4. *NRCan's Initial Recommendations*

NRCan recommends that water management plans should consider how groundwater would be managed if mine water chloride concentrations (i.e. salinity) were consistently in excess of the limits for discharge to Roberts Bay via the marine outflow mixing box.

Although some statements in the DEIS suggest that saline groundwater inflow to the TIA is not desirable beyond a short term diversion, it is not clear if there are the potential consequences to the operation of the TIA should longer term groundwater flow to the TIA be necessary. NRCan recommends that potential effects of higher groundwater salinity should be assessed across the water management system and assessed for significance if necessary.

2.2.2.5. *NRCan's Final Conclusions*

In its response to NRCan's technical comment 2.2.2, TMAC acknowledged the possibility of higher mine water chloride concentrations (i.e. salinity). However, they consider it "very unlikely that high concentrations would be associated with consistently high mine inflows" claiming that the source of the high salinity water is storage in the fractured rock. TMAC indicates (TMAC, 2017, p. 308) that "groundwater management and monitoring plans are in place and will be further refined as the Project moves through the review and water licensing process. Where appropriate, groundwater management plans may consider mine water salinity trigger levels and thresholds."

NRCan's assertion is that groundwater chloride concentrations (and by extension salinity and density) could be above the marine discharge limits. As noted above, dealing with this discharge could become an issue during the ice-covered season when mine water is the only source of discharge to the MOMB. This issue does not necessarily require the Proponent's scenario of high inflow of intercepted lake water that makes its way into mine drainage. A deep, extensive enhanced permeability zone could contribute moderate water fluxes with high salinity.

Although it is beyond the scope of NRCan's review to assess the potential effects of saline mine water inputs to the functioning of the TIA, NRCan does note that the DEIS responses (TMAC, 2017) and the FEIS (both the GWMP and the Water Management Plan; Annex V1-7, P4-6, P4-7) do not seem to address these potential effects. NRCan recommends to the NIRB to follow up on this potential issue with the Nunavut Water Board.

A Groundwater Management Plan (GWMP) for the Hope Bay Project has been developed with specific Mine Inflow Management Programs (MIMP) for the Doris, Madrid and Boston mine sites as part of the Water Licence Application (P4-6). The specific MIMPs for the Madrid and Boston Mines have not been subject to peer review as they have recently been added to the Water Licence Applications' GWMP (Annex V1-7, P4-6). The following comments pertain to the GWMP and the included MIMPs:

1) Although the GWMP recognizes the mine inflow chemistry (section 2.2) as a groundwater management issue and includes mine inflow quality monitoring (section 5.2), the MIMPs do not seem to include any considerations related to mine inflow chemistry. No Specific Performance Thresholds (SPT) are specified for chloride concentrations or salinity although TMAC acknowledges that these could be considered.

2) The Boston mine is being developed on the premise that it will be entirely contained in the permafrost and there will be no discharge of (mostly saline) groundwater to the environment. The GWMP and the MIMP for the Boston mine are designed to limit groundwater inflow to the Boston mine but implicitly acknowledge that some mine inflow from groundwater may occur. In contrast to the MIMPs for the Doris and Madrid mine sites, no SPTs are specified for the total mine pumping rate from the Boston mine (Annex V1-7, Package P4-6, Module C). Consequently, there is no stated limit on total groundwater inflow to the mine. Numerous small point sources and/or larger point sources that cannot be fully sealed with grout could add up. The potential impacts of this source of saline water (e.g. to the Boston contact water ponds) do not appear to have been considered (see next comment).

3) The Water Management Plan for the Boston mine (Annex V1-7, Package P4-8, Section 2.3.3) states that "The management of any unplanned groundwater interception is presented in the Hope Bay Groundwater Management Plan." However, the GWMP does not discuss how intercepted groundwater from the Boston mine would be managed. The action in the MIMP specified in response to a groundwater inflow in excess of 360 m^3/day for the Boston mine (Annex V1-7, Package P4-6, Table C1) indicates pumping "excess groundwater to surface water contact ponds or directly to water truck for transport to Doris Marine Mixing Box." This source of water does not appear in the Boston conceptual water balance (Annex V1-7, Package P5-4, figure 2-4) nor in the water and load calculations to Aimaokatalok Lake (Annex V1-7, Package P5-4, section 7.1.3 and TMAC, 2017, response to ECCC-4.15). The potential implications of the discharge of unplanned intercepted saline groundwater to the contact water ponds (and ultimately to Aimaokatalok Lake) do not appear to have been considered. Furthermore, the treatment process for water contact ponds will not affect chloride concentrations (Annex V1-7, Package P5-4, section 3.7.6). Combined effluent to Aimaokatalok Lake is already predicted (Annex V1-7, Package P5-4, Table 7-3) to be above the CCME guidelines (Annex V1-7, Package P5-4, Table 4-3) without including any saline groundwater discharge to the contact water ponds (and ultimately to Aimaokatalok Lake).

4) Although the Boston mine is expected to have no groundwater inflow, a threshold value of 360 m^3/day for 30 days (Annex V1-7, Package P4-6, Table C1) must be exceeded before mining of the concerned area should stop. This threshold is not supported by any justification and seems excessive, particularly since there does not appear to be a clear management action for groundwater inflows to the Boston mine (see previous comment).

NRCan is of the opinion that the GWMP can provide an effective means to ensure proper management and monitoring of mine inflows and water chemistry subject to the resolution of comments provided above.

2.2.2.6. *NRCan's Final Recommendations*

NRCan provides the following recommendations for the Groundwater Management Plan (GWMP):

1a) the adaptive management (section 6) within the GWMP should also include consideration of water chemistry indicators and related specific performance thresholds (SPTs) and specific responses (numbering in relation to comments above);

1b) the MIMPs could also include the re-assessment of flow and water chemistry monitoring programs (e.g. frequency, locations, water chemistry parameters) under the "Evaluation" heading of the Specific Performance Threshold, SPT-2;

2a) the Boston mine MIMP should include the review of records of mine pumping rates and discharge chemistry under the "Review" heading of SPT-1 as is the case for the Doris and Madrid MIMPs (this is only applicable if there is groundwater pumped from the mine but ensures that records are kept and reviewed);

2b) the Boston mine MIMP could also include SPTs for total mine inflow (SPT-2 and SPT-3);

3a) the GWMP should explicitly state how any groundwater inflows into the Boston mine would be managed (e.g. discharge locations, treatment, discharge criteria, monitoring) to ensure that they do not impact receiving water bodies;

3b) if warranted, the NIRB and Nunavut Water Board may request the Proponent to consider the potential impacts of discharging saline groundwater to the Boston contact water ponds (and ultimately to Aimaokatalok Lake) at the rates identified in the MIMP;

4) the Proponent and Nunavut Water Board should reconsider and justify the 360 m^3/day threshold (SPT-3) for point source inflow for the Boston mine MIMP.

The Proponent's final commitment for the groundwater salinity issue is the implementation of the GWMP. Notwithstanding the assessment of potential issues related to the discharge of saline water to the MOMB, TIA or Aimaokatalok Lake which are beyond the scope of NRCan's review, NRCan is of the opinion that the GWMP (subject to the resolution of comments discussed above) should provide an effective means to ensure proper control and monitoring of saline mine inflows. The success of the GWMP to manage uncertain groundwater inflows and groundwater chemistry conditions will require the responsible employees (GWMP, Table 1.3) to implement all the monitoring and measures specified in the plan vigilantly and use adaptive management to update the GWMP as new information emerges and reduces the uncertainty. NRCan recommends to the NIRB that the Proponent revise and implement the GWMP; we expect that this would be done under the authority of the Nunavut Water Board.

2.2.3. Issue 2: Uncertainties of groundwater model predictions

2.2.3.1. *Summary of NRCan's Review*

Documents Reviewed

Phase 2 of the Hope Bay Project: Draft Environmental Impact Statement, December 2016, Vol. 1 (sec. 4.3.2), App. V3-4B, Vol. 5 (sec. 2)
Information Requests for the Madrid-Boston Project: Responses to NRCan-IR7,-IR8,-IR9,IR10,-IR11,-IR12,-IR13
Hope Bay 2010 Westbay Program Data and Installation Report – SRK Feb. 2011
Hope Bay 2011 Groundwater Quality Report – SRK April 2014

FEIS Vol. 1 Main Volume; Vol. 3, Sect. 4.4.5; Vol. 4, Sect. 4; Vol. 5, Sect. 2; Annex V1-7 Packages P1, P2, P4, P4-6, P4-7, P4-8, P4-9, P4-11, P5-4, and P5-24.

TMAC. 2017. Hope Bay Project: Proponent's Response to Technical Comments on the Draft Environmental Impact Statement for the Madrid-Boston (Phase 2) Proposal: Toronto, Ontario. Response to comment NRCan 2.2.3.

Final List of Commitments for the Madrid-Boston Proposal.

Issue

Key predictions from the groundwater models include i) mine inflows, ii) chloride concentrations (as a measure of salinity) and iii) surface water flows to and from lakes. These predictions are used as inputs to the water balance and load model so that it can ultimately influence the assessment of potential and residual effects and the development of water management plans.

Groundwater flow and transport modelling of a complex hydrogeological environment in a permafrost setting is a difficult task and requires several simplifying assumptions. The difficulty of obtaining data for model parameters further complicates groundwater modelling. Consequently, uncertainty in the model results is expected and it is difficult to assess this uncertainty. Because of the limited number of hydraulic head measurements and chloride (salinity/density) measurements, it is difficult to calibrate the model or validate the model results.

2.2.3.2. *Proponent's Initial Conclusions*

The groundwater modelling report (App. V3-4B) describes the model input, the conceptual model, the implementation of the numerical model, the modelling results as well as a sensitivity analysis to address some of the uncertainty in model parameters. Results of sensitivity analyses suggest groundwater flows typically vary by a factor of about 2-4 and mine inflow chloride concentrations by a factor of about 2.

2.2.3.3. *NRCan's Initial Conclusions*

NRCan is generally satisfied with the groundwater modelling provided by the proponent. The conceptual model appears to be reasonable as well the numerical implementation of the model. However, the data support for the model in the form of groundwater level and chloride

measurements is weak. Therefore, it is not possible to validate the conceptual and numerical models in terms of flow directions and concentration profiles. Similarly, the model is not truly calibrated as there is no comparison of modelled and measured heads or concentrations. Consequently, there is uncertainty in the model results beyond just the uncertainty inherent in the values of the model parameters (e.g., hydraulic conductivity and storage coefficient) and it is difficult to assess this additional uncertainty.

As noted in the previous comment, NRCan recognizes the significant challenges and costs involved in collecting hydrogeological data from sub-permafrost groundwater environments such as for the Hope Bay Project. Groundwater models sometimes provide the public and users of the results with the impression that the groundwater system is better characterized and understood than it really is. It is NRCan's opinion that although the groundwater modelling appears to be reasonable, the actual mine inflows, water flows to and from lakes and chloride concentrations may still be outside the range of values predicted in the sensitivity models. However, it does appear that the model results are within a range of conditions that can be managed with the proposed mitigation measures.

2.2.3.4. *NRCan's Initial Recommendations*

Although it may be possible to improve the model and reduce the uncertainty with additional data, it is nonetheless a complex hydrogeological system in which unexpected groundwater (and permafrost) conditions are possible and mitigation measures may be required at times to reduce the mine inflow of saline groundwater. NRCan recommends that the best way to deal with the uncertainty in the groundwater models is to ensure that groundwater management plans are in place with appropriate mitigation measures to ensure that excessive saline groundwater mine inflows are promptly reduced (further addressed in next comment).

2.2.3.5. *NRCan's Final Conclusions*

TMAC's response to NRCan's technical comments 2.2.3 and 2.2.4 refers to the groundwater management and monitoring plans that are in place and will be further refined as the Project moves through the review and licensing process. NRCan supports this approach and believes that the uncertainty inherent in the groundwater modelling is best managed through careful implementation of a groundwater management plan (GWMP). NRCan discussed its comments and conclusions on the GWMP in response to technical comment 2.2.2 above. NRCan notes that there may be practical value in a future update to the groundwater models as data become available with respect to groundwater inflows and groundwater chemistry.

2.2.3.6. *NRCan's Final Recommendations*

The Proponent's final commitment for addressing the uncertainties of groundwater model predictions is the implementation of the GWMP. NRCan is of the opinion that the GWMP should provide an effective means to address the consequences related to the uncertainties of groundwater model predictions. NRCan recommends to the NIRB that the Proponent revises and

implements the GWMP under the authority of the Nunavut Water Board as discussed in technical comment 2.2.2.

2.2.4. Issue 3: Groundwater management plans

2.2.4.1. *Summary of NRCan's Review*

Documents Reviewed

Phase 2 of the Hope Bay Project: Draft Environmental Impact Statement, December 2016, Vol. 1 (sec. 10), Vol.8 (App. 6 and 8).
Information Requests for the Madrid-Boston Project: NRCan-IR14

FEIS Vol. 1 Main Volume; Vol. 3, Sect. 4.4.5; Vol. 4, Sect. 4; Vol. 5, Sect. 2; Annex V1-7 Packages P1, P2, P4, P4-6, P4-7, P4-8, P4-9, P4-11, P5-4, and P5-24.

TMAC. 2017. Hope Bay Project: Proponent's Response to Technical Comments on the Draft Environmental Impact Statement for the Madrid-Boston (Phase 2) Proposal: Toronto, Ontario. Response to comment NRCan 2.2.4.

Issue

As noted above (Issue 2), there is uncertainty in groundwater flow and salinity predictions from groundwater modelling. Consequently, groundwater flow and/or salinity could be higher than expected. Appropriate monitoring, groundwater management plans (with mitigation measures) and follow-up needs to be in place to ensure that potentially problematic groundwater conditions can be avoided, promptly identified and addressed. Groundwater management plans for Doris mine were presented in Appendix 6 of Volume 8. Specific plans for the Madrid North, Madrid South and Boston mines have yet to be developed.

2.2.4.2. *Proponent's Initial Conclusions*

In response to NRCan-IR14, the proponent has indicated that groundwater management plans would be developed for the Madrid North, Madrid South, and Boston mines in the same manner as those proposed for the Doris mine. These plans will be updated for the water licensing process (Table 10.2-1).

2.2.4.3. *NRCan's Initial Conclusions*

NRCan is satisfied with the proponent's response to NRCan-IR14. The monitoring and mitigation measures in Appendix 6 of the DEIS would help manage and control the inflow rates. The water quality issues are addressed in Appendix 8 of the DEIS. NRCan notes the importance of the development and implementation of groundwater management plans as well as monitoring given the uncertainty in the groundwater modelling results.

2.2.4.4. *NRCan's Initial Recommendations*

NRCan recommends that groundwater management plans (with well-defined mitigation measures and monitoring) should be developed for the Madrid North, Madrid South, and Boston mines with appropriate thresholds for each mine. If appropriate, groundwater management plans should consider mine water salinity thresholds (as discussed in a previous comment). Implementation and regular updating of these plans for the specific conditions observed in each mine will help ensure workers health, safety, and environmental protection.

2.2.4.5. *NRCan's Final Conclusions*

TMAC's response to technical comment 2.2.4 refers to the groundwater management and monitoring plans that are in place and will be further refined as the Project moves through the review and licensing process. The Groundwater Management Plan (GWMP) for the Hope Bay Project has been revised since the DEIS with specific Mine Inflow Management Programs (MIMP) for the Doris, Madrid and Boston mine sites as part of the Water Licence Application. The specific MIMPs for the Madrid and Boston Mines have not yet been subject to peer review as they have recently been added to the Water Licence Applications' GWMP (Annex V1-7, P4-6). NRCan comment 2.2.2 provides review comments and recommendations for further refinements of the GWMP and the related MIMPs.

2.2.4.6. *NRCan's Final Recommendation*

The Proponent is committed to the implementation of the GWMP. NRCan considers the GWMP to provide an effective means to address the considerable uncertainties related to groundwater inflow into the proposed mines. NRCan recommends that the Proponent revises and implements the GWMP under the authority of the Nunavut Water Board as discussed in technical comment 2.2.2.

3. Overall Conclusion

NRCan is generally satisfied with the information provided. Within the context of the department's areas of expertise, NRCan finds the conclusions presented in the final EIS to be reasonable. NRCan appreciates the Proponent's responses to NRCan's technical comments and has provided a revised set of recommendations for the proponent and the NIRB.

NRCan appreciates the opportunity provided by the Nunavut Impact Review Board to participate in this review. We would be pleased to answer any questions regarding our comments from the Board, its staff, the Proponent, or other Parties to this review.

4. Summary of NRCan's Recommendations for TMAC Resources Inc.

4.1 Permafrost and Terrain Stability

NRCan recommends that the Proponent conduct the additional site investigations and geotechnical site characterization, as outlined in their commitments, to support detailed design of project infrastructure and facilities.

With respect to the Doris Phase 2Tailings Impoundment Area (TIA), NRCan recommends the following to support final design and development of environmental monitoring and management plans:

- The Proponent follow through on commitments for additional site investigations to better characterize foundation conditions for structures required for the Phase 2 TIA (including West Dam and South Dam raise) to support and update their engineering analysis.
- The Proponent consider revisiting the thermal analysis to confirm potential for differential movements that may have an impact on tailings cover integrity.
- Continuing monitoring of the North Dam and utilize these data to update thermal analysis and also adopt a similar approach with respect to the development of monitoring plans for Phase 2 TIA dams.

NRCan recommends that the Proponent follow through on commitments for additional geotechnical site investigations to support final design and use data collected to update the engineering analysis associated with the Boston TMA and associated contact water ponds.

4.2 Hydrogeology

NRCan provides the following recommendations for the Groundwater Management Plan (GWMP):

1a) the adaptive management (section 6) within the GWMP should also include consideration of water chemistry indicators and related specific performance thresholds (SPTs) and specific responses (numbering in relation to comments above);

1b) the MIMPs could also include the re-assessment of flow and water chemistry monitoring programs (e.g. frequency, locations, water chemistry parameters) under the "Evaluation" heading of the Specific Performance Threshold, SPT-2;

2a) the Boston mine MIMP should include the review of records of mine pumping rates and discharge chemistry under the "Review" heading of SPT-1 as is the case for the Doris and Madrid MIMPs (this is only applicable if there is groundwater pumped from the mine but ensures that records are kept and reviewed);

2b) the Boston mine MIMP could also include SPTs for total mine inflow (SPT-2 and SPT-3);

3a) the GWMP should explicitly state how any groundwater inflows into the Boston mine would be managed (e.g. discharge locations, treatment, discharge criteria, monitoring) to ensure that they do no impact receiving water bodies;

3b) if warranted, the NIRB and Nunavut Water Board may request the Proponent to consider the potential impacts of discharging saline groundwater to the Boston contact water ponds (and ultimately to Aimaokatalok Lake) at the rates identified in the MIMP;

4) the Proponent and Nunavut Water Board should reconsider and justify the 360 m^3/day threshold (SPT-3) for point source inflow for the Boston mine MIMP.

The Proponent's final commitment for the groundwater salinity issue is the implementation of the GWMP. Notwithstanding the assessment of potential issues related to the discharge of saline water to the MOMB, TIA or Aimaokatalok Lake - which are beyond the scope of NRCan's review - NRCan is of the opinion that the GWMP (subject to the resolution of comments discussed above) should provide an effective means to ensure proper control and monitoring of saline mine inflows. The success of the GWMP to manage uncertain groundwater inflows and groundwater chemistry conditions will require the responsible employees (GWMP, Table 1.3) to implement all the monitoring and measures specified in the plan vigilantly and use adaptive management to update the GWMP as new information emerges and reduces the uncertainty. NRCan recommends to the NIRB that the Proponent revise and implement the GWMP; we expect that this would be done under the authority of the Nunavut Water Board.