Natural Resources Canada | Ressources naturelles Canada

For the Reconsideration Process of Agnico Eagle Mines Limited's "Meliadine Extension" Project Proposal

ᐃᓱᒪᒃᓴᖅᓱᐅᓇᒃᑲᓐᓂᕐᓂᕐᒧᑦ ᐱᕙᓪᓕᐊᓂᕐᒧᑦ ᐊᒡᓂᑰ ᐄᒍ ᐅᔭᕋᒃᑕᓇᐊᓕᓇᐃᒃᑯᑦ "ᑕᓯᕐᔪᐊᕐᒥᑦ ᐅᐃᑐᒋᐊᖅᓯᓂᕐᒧᑦ" ᐱᓕᕆᐊᕐᒧᑦ ᑐᒃᓯᕋᐅᑕᐅᔪᒥᑦ

Prepared for the Nunavut Impact Review Board

ᐱᓕᕆᐊᖑᔪᖅ ᓄᓇᕗᒻᒥ ᐊᕙᑎᓕᕆᓂᒃᑯᑦ ᑲᑎᒪᔨᖏᓐᓄᐊᖅᑕᐅᓂᐊᖅᑐᓂ

September 2023

ᐊᒥᕋᐃᔭᕐᕕᒃ 2023

Canada

Outline

- Mandate
- Relevant Acts and Scope of Review
- Technical Review and Recommendations
  - Groundwater Quantity
  - Permafrost
  - Mine Waste Management

ᓇᓗᓇᐃᔭᖅᓯᒪᔪᖅ

- ᐱᓕᕆᐊᒃᓴᖏᑦ
- ᐊᑐᖅᑐᑦ ᐱᖁᔭᐃᑦ ᐊᒻᒪᓗ ᖃᓄᐃᙵᓂᙵᑕ ᕿᒥᕐᕈᓂᐅᑉ
- ᐱᓕᕆᐊᕐᒥᑦ ᕿᒥᕐᕈᓂᖅ ᐊᒻᒪᓗ ᐃᒪᓐᓈᖅᑑᑕᐅᔪᑦ
  - ᒪᓂᕋᕐᒥᑦ ᐃᒪᖅ ᐊᖏᑎᒋᓂᖓ
  - ᖁᐊᙳᐃᓐᓇᐅᔭᖅᑐᖅ
  - ᐅᔭᕋᒃᑕᓇᐊᕐᒥᑦ ᐊᒃᑕᑯᓂᒃ ᐊᐅᓚᑦᑎᓂᖅ

Mandate

- Natural Resources Canada is a federal department responsible for ensuring the country's natural resources are developed sustainably, competitively and inclusively.
- Natural Resources Canada is a science-based department, with nearly half of its employees being scientists, engineers or technicians.
- Natural Resources Canada scientists are conducting research on permafrost, groundwater, mine waste characterisation and management as well as environmental dispersal and effects associated with acid rock drainage and/or metal leaching.
- Natural Resources Canada also provides scientific support to organizations that advance knowledge in mine waste management, including in areas such as prevention and control of acid rock drainage and metal leaching, disposal technologies, mine water treatment.

ᐱᓕᕆᐊᒃᓴᖏᑦ

- ᑲᓇᑕᒥᑦ ᓄᓇᒥᑦ ᐱᕝᕙᐅᖅᑲᑦᑕᖅᑐᓕᕆᔨᒃᑯᑦ ᒐᕙᒪᑐᖅᑲᒃᑯᓐᓂᑦ ᐱᔭᒃᓴᐅᑎᖃᖅᑐᑦ ᑲᓇᑕᐅᑉ ᓄᓇᒥᑦ ᐱᕝᕙᐅᖅᑲᑦᑕᖅᑐᖏᑦ ᐊᔪᙱᓐᓂᒃᑯᑦ ᐱᕙᓪᓕᐊᔭᐅᓂᖅᑲᕐᓂᐊᕐᓗᑎᒃ, ᐱᒡᒎᖕᓂᖅᑲᕐᓂᒃᑯᑦ ᐊᒻᒪᓗ ᐃᓚᐅᑎᑦᑎᓂᒃᑯᑦ.
- ᑲᓇᑕᒥᑦ ᓄᓇᒥᑦ ᐱᕝᕙᐅᖅᑲᑦᑕᖅᑐᓕᕆᔨᒃᑯᑦ ᒐᕙᒪᑐᖅᑲᑯᑦ ᖃᐅᔨᒋᐊᖅᑎᖕᒐᑦ, ᓇᑉᐸᕐᓗᐊᖏᑦ ᐱᓕᕆᔨᑦ ᖃᐅᔨᒋᐊᑎᐅᒪᑕ, ᑎᑎᕋᐅᔭᖅᓯᒪᔪᓯᕐᒥᑦ ᑲᒪᔨᑦ ᐅᕝᕙᓘᓐᓃᑦ ᓴᓇᔭᐅᓯᒪᔪᓯᕐᒥᑦ ᑲᒪᔨᑦ.
- ᑲᓇᑕᒥᑦ ᓄᓇᒥᑦ ᐱᕝᕙᐅᖅᑲᑦᑕᖅᑐᓕᕆᔨᒃᑯᑦ ᖃᐅᔨᒪᓂᖅᑲᖅᑐᑦ ᖃᐅᔨᓇᓱᒃᑎᐅᑉᓗᑎᒃ ᖃᐅᔨᓴᐃᖅᑲᑦᑕᖅᑐᑦ ᖁᐊᙳᐃᓐᓇᐅᔭᖅᑐᒥᒃ, ᒪᓂᕋᕐᒥᑦ ᐃᒪᕐᒥᑦ, ᐅᔭᕋᒃᑕᓇᐊᕐᒥᑦ ᐊᒃᑰᖅᑕᐅᔦᑦ ᖃᓄᐃᓕᐅᕐᓂᖏᓐᓂᒃ ᐊᒻᒪᓗ ᐊᐅᓚᑦᑎᓂᕐᒥᒃ ᐊᒻᒪᓗ ᐊᕕᑎᒍᐊᖅᑐᓂᒃ ᐊᒻᒪᓗ ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓂᐅᔪᓂᒃ ᐱᔪᓂᒃ ᐋᓯᑦᑏᑦ ᐅᔭᕋᐃᑦ ᑯᕙᔪᓂᑦ ᐊᒻᒪᓗ/ᐅᕝᕙᓘᓐᓃᑦ ᓴᕙᖕᓂᑦ ᑯᕙᓂᖅᑲᖅᑐᓂᒃ.
- ᑲᓇᑕᒥᑦ ᓄᓇᒥᑦ ᐱᕝᕙᐅᖅᑲᑦᑕᖅᑐᓕᕆᔨᒃᑯᑦ ᖃᐅᔨᒪᓂᖅᑲᖅᑐᑦ ᖃᐅᔨᓇᓱᖕᓂᒃᑯᑦ ᐃᑲᔪᐃᖅᑲᑦᑕᕐᒥᔪᑦ ᐊᐅᓚᑦᑎᔨᐅᔪᓄᑦ ᓯᕗᒻᒧᒃᓯᔪᓂᒃ ᖃᐅᔨᒪᓂᕐᒥᒃ ᐅᔭᕋᒃᑕᓇᐊᕐᒥᑦ ᐊᒃᑕᑯᓂᒃ ᐊᐅᓚᑦᑎᓂᕐᒧᑦ, ᐃᓚᐅᑉᓗᑎᒃ ᐱᑕᖅᑲᖅᑎᑦᑎᑕᐃᓕᓃᑦ ᐊᒻᒪᓗ ᐊᐅᓚᑦᑎᓂᖅ ᐋᓯᑦᑏᑦ ᐅᔭᕋᐃᑦ ᑯᕙᔪᓂᒃ ᐊᒻᒪᓗ ᓴᕙᖕᓂᑦ ᑯᕙᓂᖅᑲᖅᑐᓂᒃ, ᐊᒃᑰᓇᓂᕐᒧᑦ ᐊᑐᖅᑕᐅᔪᓂᒃ, ᐅᔭᕋᒃᑕᓇᐊᕐᒥᑦ ᐃᓚᓕᓇᕝᕕᖏᑦ.

Relevant Acts and Scope of Review

- Regulator for the *Explosives Act*:
  - Provision of licenses for the storage and manufacture of explosives

- Scientific Analysis Provided:
  - Groundwater Quantity/flow (hydrogeology)
  - Permafrost
  - Mine Waste Management

ᐊᑐᖅᑐᑦ ᐱᕐᑯᓯᐃᑦ ᐊᒻᒪᓗ ᖃᓄᐃᖕᒐᓂᖕᒐᑕ ᕿᒥᕐᕈᓂᐅᑉ

- ᐊᐅᓚᑦᑎᓂᖅᑲᖅᑐᖅ ᖄᖅᑕᖅᑐᓄᑦ ᐱᕐᑯᓯᕐᔪᕐ:
  - ᒪᓕᒐᐅᔪᑦ ᓚᐃᓴᓐᓯᓄᑦ ᑐᖅᑯᖅᓯᓂᐊᕐᓗᓂ ᐊᒻᒪᓗ ᓴᓇᔭᐅᓂᖏᓐᓄᑦ ᖄᖅᑕᖅᑐᐃᑦ

- ᒪᓕᒐᐅᔪᑦ ᐊᔨᖖᒋᓐᓂᕐᑲᕐᓂᕐᒥᒃ ᖃᐅᔨᒪᔭᕐᑲᕐᓂᕐᔪᑦ:
  - ᒪᓂᕋᕐᒥᑦ ᐃᒪᖅ ᐊᖏᑎᒋᓂᖓ/ᑯᕕᓂᖓ (ᐃᒪᓕᓇᓂᖅ)
  - ᖁᐊᖑᐃᓐᓇᐅᔭᖅᑐᖅ
  - ᐅᔭᕋᒃᑕᓇᐊᕐᒥᑦ ᐊᒃᑕᑯᓂᒃ ᐊᐅᓚᑦᑎᓂᖅ

Technical Review: Groundwater Quantity

- Hydrogeological data are collected to characterize subsurface properties and groundwater conditions in order to develop an understanding of groundwater flow and interactions with surface waters.
- Groundwater models are used to help quantify and assess current groundwater conditions and predict those expected to develop as a result of mining and closure activities.
- Groundwater data and knowledge are essential for assessing impacts on groundwater quantity and quality, and groundwater interactions with surface waters.

Specific Issues Considered:

- Complexity of vertical groundwater flow through taliks and their monitoring
- Assessment of tailings and waste rock disposal in exhausted pits
- Assessment of closure and post-closure phases
- Effect of saline water storage in B7
- Groundwater flow basin near the Discovery underground mine
- Inclusion of grouting in hydrogeology model and groundwater inflow estimates

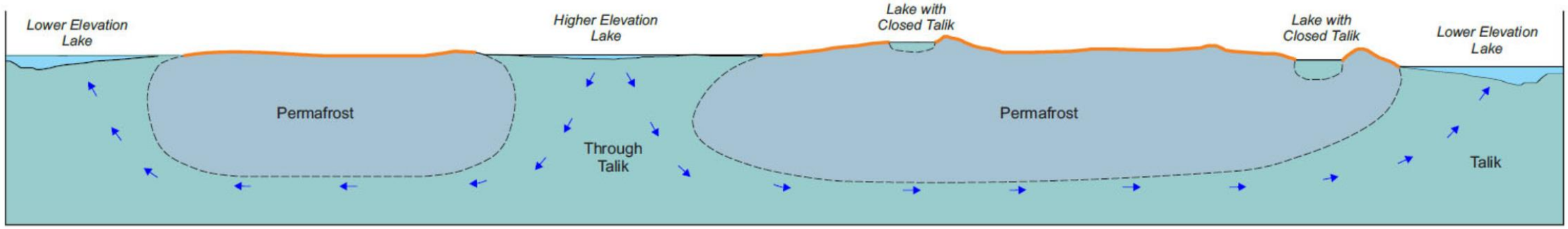
ᐱᓕᕆᐊᕐᒥᑦ ᕿᒥᕐᕈᓂᖅ: ᒪᓂᕋᕐᒥᑦ ᐃᒪᖅ ᐊᖏᑎᒋᓂᖓ

- ᐃᒪᓕᕆᓂᕐᒧᑦ ᓈᓴᐅᑏᑦ/ᑎᑎᕐᕿᐃᑦ ᑲᑎᑕᐅᕐᑲᑦᑕᕐᑐᑦ ᖃᓄᐃᓐᓂᖏᓐᓅᕐᓂᐊᕐᓗᒋᑦ ᐃᒪᐅᑉ ᐃᓗᐊᓃᑦᑐᑦ ᐊᒻᒪᓗ ᒪᓂᕋᕐᒥᑦ ᐃᒪᐅᑉ ᖃᓄᐃᓐᓂᖏᓐᓄᑦ ᑐᑭᓯᐅᓕᕈᒪᑉᓗᒋᑦ ᒪᓂᕋᕐᒥᑦ ᐃᒪᖅ ᑯᕕᓂᖓ ᐊᒻᒪᓗ ᖃᓄᐃᓕᐅᕈᑎᓂᖏᑦ ᖄᖓᓃᑦᑐᑦ ᐃᒪᕐᒧᑦ.
- ᒪᓂᕋᕐᒥᑦ ᐃᒪᕐᒧᑦ ᐋᕐᕿᐅᒪᔪᖅ ᐊᑐᖅᑕᐅᕐᑲᑦᑕᕐᑐᖅ ᐊᒥᓱᙳᓇᐊᖅᑎᓐᓂᐊᕐᓗᒋᑦ ᐊᒻᒪᓗ ᖃᐅᔨᓴᕐᓗᒋᑦ ᒫᓐᓇᐅᔪᖅ ᒪᓂᕋᕐᒥᑦ ᐃᒪᐅᑉ ᖃᓄᐃᓐᓂᓇᔭᖏᑦ ᐊᒻᒪᓗ ᓇᓚᐅᑦᑖᕐᓗᒋᑦ ᓂᓇᐅᒋᔭᐅᔪᑦ ᐋᕐᕿᒃᓯᓂᐊᕐᓗᓂ ᖃᓄᐃᖓᓂᐅᔪᓂᒃ ᐅᔭᕋᒃᑕᓇᐊᓕᓇᓂᕐᒥᑦ ᐱᔪᑦ ᐊᒻᒪᓗ ᐅᒃᑯᐊᖅᐸᓪᓕᐊᓂᕐᒧᑦ ᖃᓄᐃᓕᐅᕈᑕᐅᔪᓂᑦ.
- ᒪᓂᕋᕐᒥᑦ ᐃᒪᕐᒧᑦ ᓈᓴᐅᑏᑦ/ᑎᑎᕐᕿᐃᑦ ᐊᒻᒪᓗ ᖃᐅᔨᒪᓂᓇᔭᐅᔪᑦ ᐱᒻᒪᕆᐅᔪᑦ ᖃᐅᔨᓴᐃᓂᕐᒧᑦ ᐊᒃᑐᖅᓯᓂᐅᔪᓂᒃ ᒪᓂᕋᕐᒥᑦ ᐃᒪᐅᑉ ᐊᖏᑎᒋᓂᖓᓂᑦ ᐊᒻᒪᓗ ᖃᓄᐃᓐᓂᖓᓂᑦ, ᐊᒻᒪᓗ ᒪᓂᕋᕐᒥᑦ ᐃᒪᐃᑦ ᖃᓄᐃᓕᐅᕈᑎᓂᖏᑦ ᖄᖓᓃᑦᑐᑦ ᐃᒪᕐᓂᑦ.

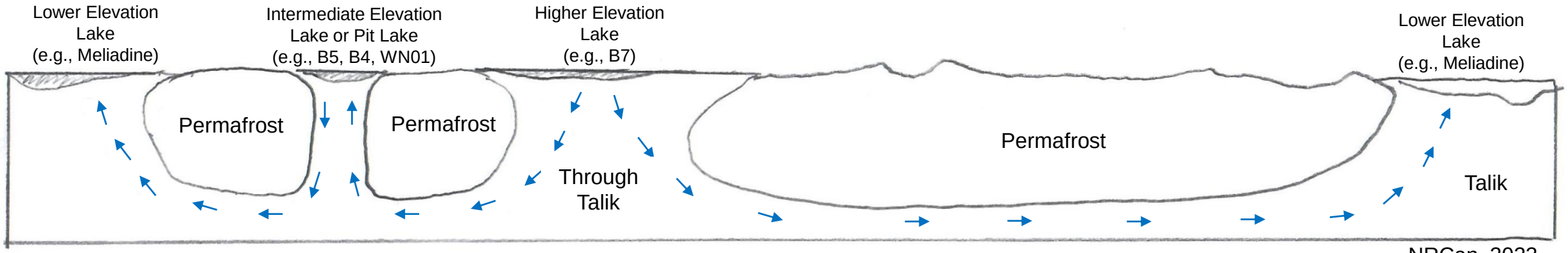
<u>ᐱᔾᔪᑕᐅᔪᑦ ᐃᓱᒪᒃᓴᖅᓯᐅᕈᑎᒋᔭᐅᔪᑦ:</u>

- ᐊᖏᑎᒋᓂᖓ ᕐᑯᒻᒧᙵᔪᖅ ᒪᓂᕋᕐᒥᑦ ᐃᒪᐅᑉ ᐃᓗᐊᓂᑦ ᑯᕕᓂᖓ ᐅᑭᐅᓗᒃᑖᖅ ᐃᒪᐅᖏᓐᓇᖅᑐᓂᑦ ᐊᒻᒪᓗ ᖃᐅᔨᓴᖅᑕᐅᓂᖏᑦ
- ᖃᐅᔨᓴᐃᓂᖅ ᕿᒪᒃᑎᑦᑐᓄᑦ ᐊᒻᒪᓗ ᐊᒃᑕᑰᖅᑕᐅᔪᖅ ᐅᔭᖅᕿᐃᑦ ᐃᓕᔭᐅᓂᖏᑦ ᐃᓘᕈᑎᓯᒪᔪᓂᑦ ᓄᓇᒥᑦ ᐃᓗᑦᑐᖅᓯᒪᔪᓂᑦ
- ᖃᐅᔨᓴᐃᓂᖅ ᐅᒃᑯᐊᖅᐸᓪᓕᐊᓂᕐᒥᑦ ᐊᒻᒪᓗ ᐅᒃᑯᐊᖅᓯᒪᓕᖅᑎᓪᓗᒍ
- ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓂᖅ ᑕᓇᐅᓕᒃ ᐃᒪᖅ ᑐᖅᑯᖅᑕᐅᓯᒪᓂᖓᓄᑦ B7-ᒥᑦ
- ᒪᓂᕋᕐᒥᑦ ᐃᒪᖅ ᑯᕚᕕᐅᔪᖅ ᖃᓂᑕᖓᓂᑦ ᑎᔅᑲᕗᓇᒥᑦ ᓄᓇᐅᑉ ᐃᓗᐊᓂᑦ ᐅᔭᕋᒃᑕᓇᐊᒥᑦ
- ᐃᓚᐅᑎᑕᐅᓂᖓ ᐃᓗᓪᓕᖅᑐᐃᓂᖅ ᐃᒪᓕᕆᓂᕐᒧᑦ ᐋᕐᕿᐅᒪᔪᒥᑦ ᐊᒻᒪᓗ ᒪᓂᕋᕐᒥᑦ ᐃᒪᖅ ᐃᓗᐊᓄᑦ ᑯᕕᓂᐅᔪᓂᒃ ᓇᓚᐅᑦᑖᕆᓃᑦ

Conceptual permafrost and groundwater flow model



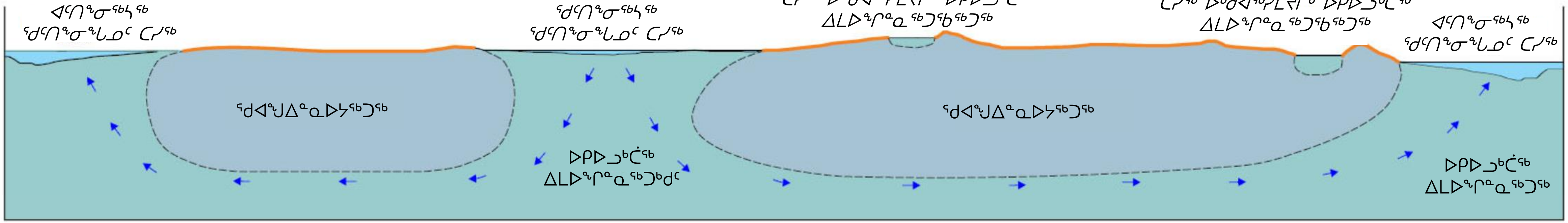
Source: Appendix G5, Summary of Hydrogeology Existing Conditions, Dec 2021



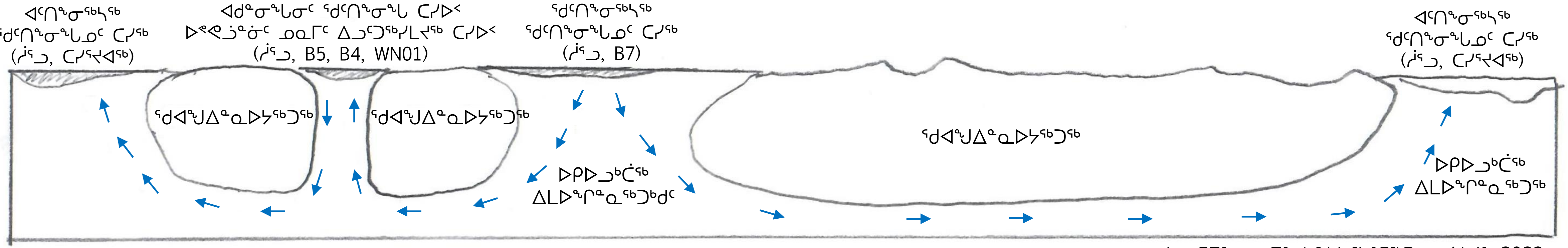
NRCan, 2023

- Intermediate elevation lakes with through talik can receive groundwater flow from upslope lakes *and/or* provide groundwater flow to downslope lakes, with implications for in-pit disposal

ᑕᐅᑐᒐᐅᔪᖅ ᖁᐊᙳᐃᓐᓇᐅᓴᖅᑐᖅ ᐊᒻᒪᓗ ᒪᓂᕋᕐᒥᑦ ᐃᒪᕐᒥᑦ ᑯᕕᔪᒧᑦ ᐋᖅᑭᐅᒪᔪᖅ



ᐱᖕᖑᐅᔪᖅ: ᑎᑎᖅᑲᒧᑦ ᐃᓚᓕᐅᑎᓯᒪᔪᖅ G5, ᓇᐃᓈᖅᓯᒪᔪᖅ ᐃᒪᓕᕆᓂᕐᒧᑦ ᑕᐃᒪᐅᔪᑦ ᖃᓄᐃᓐᓂᖏᓐᓄᑦ, ᐋᓪᔪᓕᕐᕕᒃ 2021



ᑲᓇᑕᒥᑦ ᓄᓇᒥᑦ ᐱᖕᖑᐅᖃᑦᑕᖅᑐᓕᕆᔨᒃᑯᑦ, 2023

- ᐊᑯᓐᓂᖓᓂᑦ ᖁᑦᑎᖕᓂᖓ ᑕᓯᑦ ᐅᑭᐅᓪᓚᒃᑖᖅ ᐃᒪᐅᕐᕿᓐᓇᖅᑐᒃᑯᑦ ᒪᓂᕋᕐᒥᑦ ᐃᒪᕐᒥᑦ ᑯᕕᔭᕐᒥᑦ ᐱᔭᕐᓇᖅᑐᑦ ᖁᓪᓗᑦ ᐅᕙᖓᓂᖅᑲᖅᑐᓂᑦ ᑕᓯᕐᓂᑦ ᐊᒻᒪᓗ/ᐅᕝᕙᓘᓐᓃᑦ ᒪᓂᕋᕐᒥᑦ ᐃᒪᕐᒥᑦ ᑯᕕᔭᖅᑲᕐᓗᓂ ᑕᐅᓄᖓᖓᔪᖅ ᐅᕙᖓᓂᖅᑲᖅᑐᑦ ᑕᓯᕐᓄᑦ, ᓄᓇᒥᑦ ᐃᓗᑦᑐᖅᓯᒪᔪᓄᐊᕐᓂᖅᑲᕐᓗᑎᒃ

Seepage from/to in-filled pits/pit lakes

Table 2: Predict Contact Seepage Discharge from In-filled Pits to Downgradient Surface Water Lakes and Pit Lakes

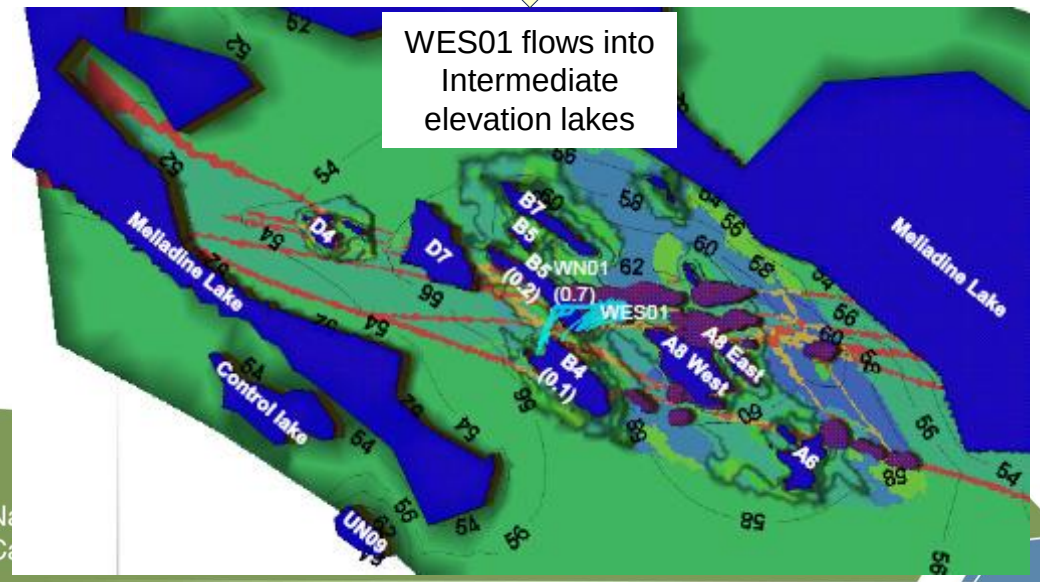
Value	Unit	WES01	WES04	WES05	WN01	PUM01	PUM03	DISC
Pit Bottom Elevation	m asl	-10	30	-45	-65	25	-5	-75
Backfill Material[a]	-	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Waste Rock
Backfill Elevation[a]	m asl	50	54	47	44	47	49	16
Underlying Underground	-	present	not present	not present	present	present	present	present
Post-closure Pit Lake Elevation[b]	m asl	62.5	63	63.6	58.3	58.7	60.3	67
Receptor and Predicted Contact Water Flux using Numerical Groundwater Model	m³/day	Lake B4 – 0.1 Pit Lake WN01 – 0.7 Lake B5 – 0.2 (total contact water seepage – 1)	Meliadine Lake – 0.2	Meliadine Lake – 4.1	No Pit Lake Discharge. Groundwater discharges to Pit Lake. Total Discharge to Pit Lake – 93.7.	Lake B4 – 0.02	No Pit Lake Discharge. Groundwater discharges to Pit Lake. Total Discharge to Pit Lake – 2.0.	Meliadine Lake – 0.6 Lake UN1 – 0.8 Lake CH1 – 1.0 Lake CH5 – 0.4 Lake UN3 – 0.03 (total contact water seepage 2.8)
Travel Time (first arrival of contact water seepage) Using Numerical Groundwater Model[b]	Years	Lake B4 – 450 Lake WN01 – 70 Lake B5 – 70	Meliadine Lake – >1000	Meliadine Lake – 275	not applicable	Lake B4 – 650	not applicable	Meliadine Lake – >1000 Lake UN1 – >1000 Lake CH1 – >1000 Lake CH5 – >1000 Lake UN3 – >1000

(a) From Lorax 2022.

(b) Travel times do not include time to develop open talik conditions below the pits. Actual travels times may be faster than predicted as a result of how the faults are incorporated in the model (see Section 3.0).

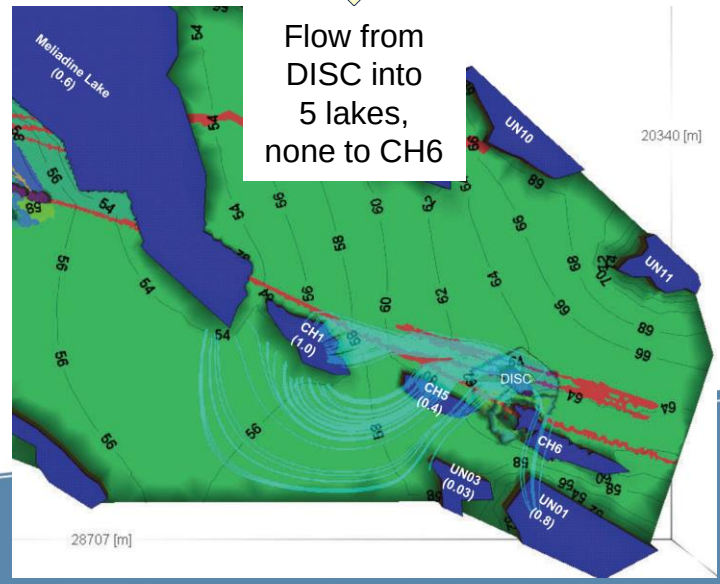
Source: WSP Technical Memo, Reference no. 22524250-972-TM-Rev1-6000, May 05, 2023

WES01 flows into Intermediate elevation lakes



Flow into Pit Lake WN01, an in-filled pit with an intermediate elevation

Flow from DISC into 5 lakes, none to CH6



ᑯᕕᓂᖃᖅᑐᖅ ᓄᓇᒥᑦ ᐃᓗᑦᑐᖅᓯᒪᔪᑦ ᐃᓗᓪᓕᖅᑐᖅᓯᒪᔪᓂᑦ/ᓄᑦ ᓄᓇᒥᑦ ᐃᓗᑦᑐᖅᓯᒪᔪᓄᑦ/ᓂᑦ

ᑎᑎᕋᐅᓯᖅᓯᒪᔪᖅ 2: ᓇᓚᐅᑦᑖᖅᑕᐅᔪᖅ ᐊᒃᑐᖅᑕᐅᓯᒪᔪᖅ ᑯᕕᓂᖃᖅᑐᖅ ᑯᕕᑎᑕᐅᓂᖓ ᐃᓗᓪᓕᖅᑐᖅᓯᒪᔪᓂᒃ ᓄᓇᒥᑦ ᐃᓗᑦᑐᖅᓯᒪᔪᓂᑦ ᐅᕕᖓᓂᖓᓂᑦ ᑕᐅᓄᙵᐅᖓᔪᒥᑦ ᐃᒪᐅᑉ ᖃᖓᓂᑦ ᑕᓯᕐᓄᑦ ᐊᒻᒪᓗ ᐃᓗᑦᑐᖅᓯᒪᔫ ᑕᓯᕐᓄᑦ

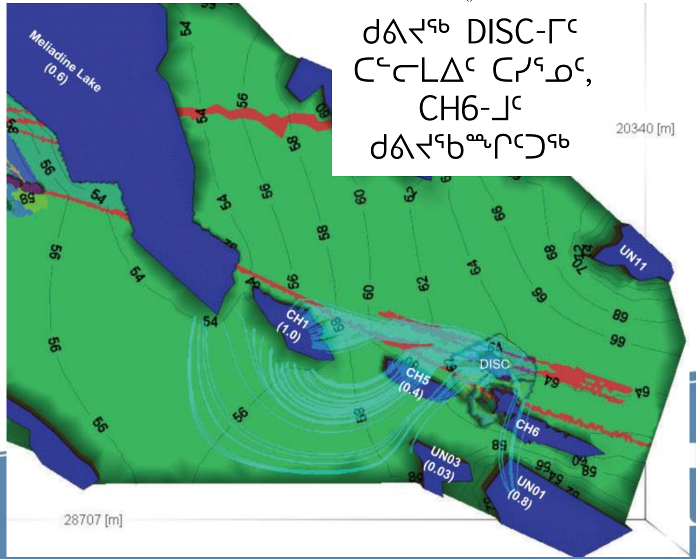
ᓈᓴᐅᑎ	ᐊᕕᒃᑐᖅᓯᒪᓂᖅ	WES01	WES04	WES05	WN01	PUM01	PUM03	DISC
ᐃᓗᑦᑐᖅᓯᒪᔫᑉ ᐊᑖᑕ ᖁᑦᑎᖓᓂᖓ	ᒥᑕᐅᔪᑦ ᑕᕆᐅᑉ ᖁᑦᑎᖓᓂᕆᔭᖓᑕ ᖁᑖᓃᑦᑐᑦ	-10	30	-45	-65	25	-5	-75
ᐃᓗᓪᓕᖅᑐᕈᑕᐅᔪᑦ(a)	-	ᕿᒪᒃᑎᑦᑐᑦ	ᕿᒪᒃᑎᑦᑐᑦ	ᕿᒪᒃᑎᑦᑐᑦ	ᕿᒪᒃᑎᑦᑐᑦ	ᕿᒪᒃᑎᑦᑐᑦ	ᕿᒪᒃᑎᑦᑐᑦ	ᐊᒃᑕᖁᖅᑕᐅᔪᑦ ᐅᔾᔭᖅᑲᐃᑦ
ᐃᓗᓪᓕᖅᑐᕈᑕᐅᔪᑦ ᖁᑦᑎᖓᓂᖓ(a)	ᒥᑕᐅᔪᑦ ᑕᕆᐅᑉ ᖁᑦᑎᖓᓂᕆᔭᖓᑕ ᖁᑖᓃᑦᑐᑦ	50	54	47	44	47	49	16
ᐊᑖᓃᑦᑐᖅ ᓄᓇᐅᑉ ᐃᓗᐊᓂᑦ	-	ᐱᑕᖃᖅᑐᖅ	ᐱᑕᖃᙱᑦᑐᖅ	ᐱᑕᖃᙱᑦᑐᖅ	ᐱᑕᖃᖅᑐᖅ	ᐱᑕᖃᖅᑐᖅ	ᐱᑕᖃᖅᑐᖅ	ᐱᑕᖃᖅᑐᖅ
ᐅᒃᑯᐊᖅᓯᒪᓕᖅᑎᓪᓗᒍ ᓄᓇᒥᑦ ᐃᓗᑦᑐᖅᓯᒪᔫᑉ ᖁᑦᑎᖓᓂᖓ(b)	ᒥᑕᐅᔪᑦ ᑕᕆᐅᑉ ᖁᑦᑎᖓᓂᕆᔭᖓᑕ ᖁᑖᓃᑦᑐᑦ	62.5	63	63.6	58.3	58.7	60.3	67
ᐱᔪᓄᑦ ᐊᒻᒪᓗ ᓇᓚᐅᑦᑖᖅᑕᐅᔪᖅ ᐊᒃᑐᖅᑕᐅᓯᒪᔪᖅ ᐃᒪᕐᒥᑦ ᐱᔪᓂᒃ ᐊᑐᖅᓱᑎᒃ ᓈᓴᐅᓯᕆᔾᔭᑕᐅᔪᓂᒃ ᒪᓂᕋᕐᒥᑦ ᐃᒪᕐᒧᑦ ᐋᖅᑮᐅᒪᔪᖅ	m³/ᐅᓐᓄᑕᒦᑦ	ᑕᓯᖅ B4 – 0.1 ᓄᓇᒥᑦ ᐃᓗᑦᑐᖅᓯᒪᔪᖅ ᑕᓯᖅ WN01 – 0.7 ᑕᓯᖅ B5 – 0.2 (ᑲᑎᖓᓗᒥᑦ ᐊᒃᑐᖅᑕᐅᓯᒪᔪᖅ ᐊᒻᒪᕐᒥᑦ ᑯᕕᓂᖅ – 1)	ᑕᓯᕐᔪᐊᖅ – 0.2	ᑕᓯᕐᔪᐊᖅ – 4.1	ᓄᓇᒥᑦ ᐃᓗᑦᑐᖅᓯᒪᔪᖅ ᑕᓯᕐᒧᑦ ᑯᕕᑦᑎᓂᖃᙱᑦᑐᖅ. ᒪᓂᕋᕐᒥᑦ ᐃᒪᖅ ᑯᕕᑎᑕᐅᔪᖅ ᓄᓇᒥᑦ ᐃᓗᑦᑐᖅᓯᒪᔪᖅ ᑕᓯᕐᒧᑦ. ᑲᑎᖓᓗ ᑯᕕᑎᑕᐅᔪᖅ ᓄᓇᒥᑦ ᐃᓗᑦᑐᖅᓯᒪᔪᖅ ᑕᓯᕐᒧᑦ – 93.7.	ᑕᓯᖅ B4 – 0.02	ᓄᓇᒥᑦ ᐃᓗᑦᑐᖅᓯᒪᔪᖅ ᑕᓯᕐᒧᑦ ᑯᕕᑦᑎᓂᖃᙱᑦᑐᖅ. ᒪᓂᕋᕐᒥᑦ ᐃᒪᖅ ᑯᕕᑎᑕᐅᔪᖅ ᓄᓇᒥᑦ ᐃᓗᑦᑐᖅᓯᒪᔪᖅ ᑕᓯᕐᒧᑦ. ᑲᑎᖓᓗ ᑯᕕᑎᑕᐅᔪᖅ ᓄᓇᒥᑦ ᐃᓗᑦᑐᖅᓯᒪᔪᖅ ᑕᓯᕐᒧᑦ – 2.0.	ᑕᓯᕐᔪᐊᖅ – 0.6 ᑕᓯᖅ UN1 – 0.8 ᑕᓯᖅ CH1 – 1.0 ᑕᓯᖅ CH5 – 0.4 ᑕᓯᖅ UN3 – 0.03 (ᑲᑎᖓᓗᒥᑦ ᐊᒃᑐᖅᑕᐅᓯᒪᔪᖅ ᐊᒻᒪᕐᒥᑦ ᑯᕕᓂᖅ – 2.8)
ᐃᖏᕐᕋᔭᖕᓂᖅ (ᓱᕝᕙᓪᓕᖅᐹᕐᒥᑦ ᑎᑭᑕᐅᔪᖅ ᐊᒃᑐᖅᑕᐅᓯᒪᔪᖅ ᐃᒪᖅ ᑯᕕᓂᖃᖅᑐᖅ) ᐊᑐᖅᓱᑎᒃ ᒪᓂᕋᕐᒥᑦ ᐃᒪᕐᒧᑦ ᐋᖅᑮᐅᒪᔪᕐᒥᑦ(b)	ᐅᑭᐅᑦ	ᑕᓯᖅ B4 – 450 ᑕᓯᖅ WN01 – 70 ᑕᓯᖅ B5 – 70	ᑕᓯᕐᔪᐊᖅ – >1000	ᑕᓯᕐᔪᐊᖅ – 275	ᐊᑐᙱᑦᑐᖅ	ᑕᓯᖅ B4 – 650	ᐊᑐᙱᑦᑐᖅ	ᑕᓯᕐᔪᐊᖅ – >1000 ᑕᓯᖅ UN1 – >1000 ᑕᓯᖅ CH1 – >1000 ᑕᓯᖅ CH5 – >1000 ᑕᓯᖅ UN3 – >1000

(a) ᓘᖕᒃᔅ-ᒥᑦ ᐱᔭᐅᔪᖅ 2022.
(b) ᐃᖏᕐᕋᔭᕐᓂᕐᒥᑦ ᐃᓚᐅᖏᑦᑐᑦ ᐱᕙᓪᓕᐊᓂᖃᕐᓂᖏᑦ ᐅᒃᑯᐃᖓᔪᖅ ᐅᑭᐅᓗᒃᑖᖅ ᐃᒪᐅᖏᓐᓇᖅᑑᑉ ᖃᓄᐃᓐᓂᖏᓐᓂᑦ ᐊᑖᓂᑦ ᐃᓗᑦᑐᖅᓯᒪᔪᐃᑦ. ᐊᑐᖅᑕᐅᔪᑦ ᐃᖏᕐᕋᓂᕐᓄᑦ ᐱᐊᓗᓂᖅᓴᐅᔪᓐᓇᖅᑐᑦ ᓇᓚᐅᑦᑖᖅᑕᐅᔪᓂᐅᓚᓂᑦ ᓱᖁᒥᓯᒪᓃᑦ ᐃᓚᔭᐅᓯᒪᓂᕆᓐᓂᑦ ᐋᖅᑮᐅᒪᔪᒥᑦ (ᑕᖁᓗ ᐃᓚᒋᔭᐅᔪᖅ 3.0).

ᐱᕝᕕᐅᔪᖅ: WSP ᐱᓕᕆᐊᑉ ᒥᒃᓵᓄᑦ ᑎᑎᖅᖃᖅ, ᐱᔾᔪᑕᐅᔪᒧᑦ ᓈᓴᐅᑎ 22524250-972-TM-Rev1-6000, ᓄᕖᐃᑦ 05, 2023

WES01 ᑯᕕᔪᑦ ᐊᑯᓐᓂᖓᓂᑦ ᖁᑦᑎᖕᓂᖓ ᑕᓯᕐᓄᑦ

ᑯᕕᔪᖅ ᓄᓇᒥᑦ ᐃᓗᑦᑐᖅᓯᒪᔪᖅ WN01-ᒧᑦ, ᐃᓗᓪᓕᖅᓯᒪᔪᖅ ᓄᓇᒥᑦ ᐃᓗᑦᑐᖅᓯᒪᔪᖅ ᐊᑯᓐᓂᖓᓂᑦ ᖁᑦᑎᒃᓯᓯᒪᐸᓗᓂ



ᑯᕕᔪᖅ DISC-ᒥᑦ ᑖᓪᓕᒪᐃᑦ ᑕᓯᕐᓄᑦ, CH6-ᒧᑦ ᑯᕕᔪᖃᙱᑦᑐᖅ

Technical Review: Permafrost

- Knowledge of permafrost is required to minimize the impacts of the project on the environment, and the impacts of the environment on the project.
- Knowledge of distribution of permafrost and unfrozen ground (talik) is essential for determining groundwater flow pathways.

<u>Specific Issues Considered:</u>

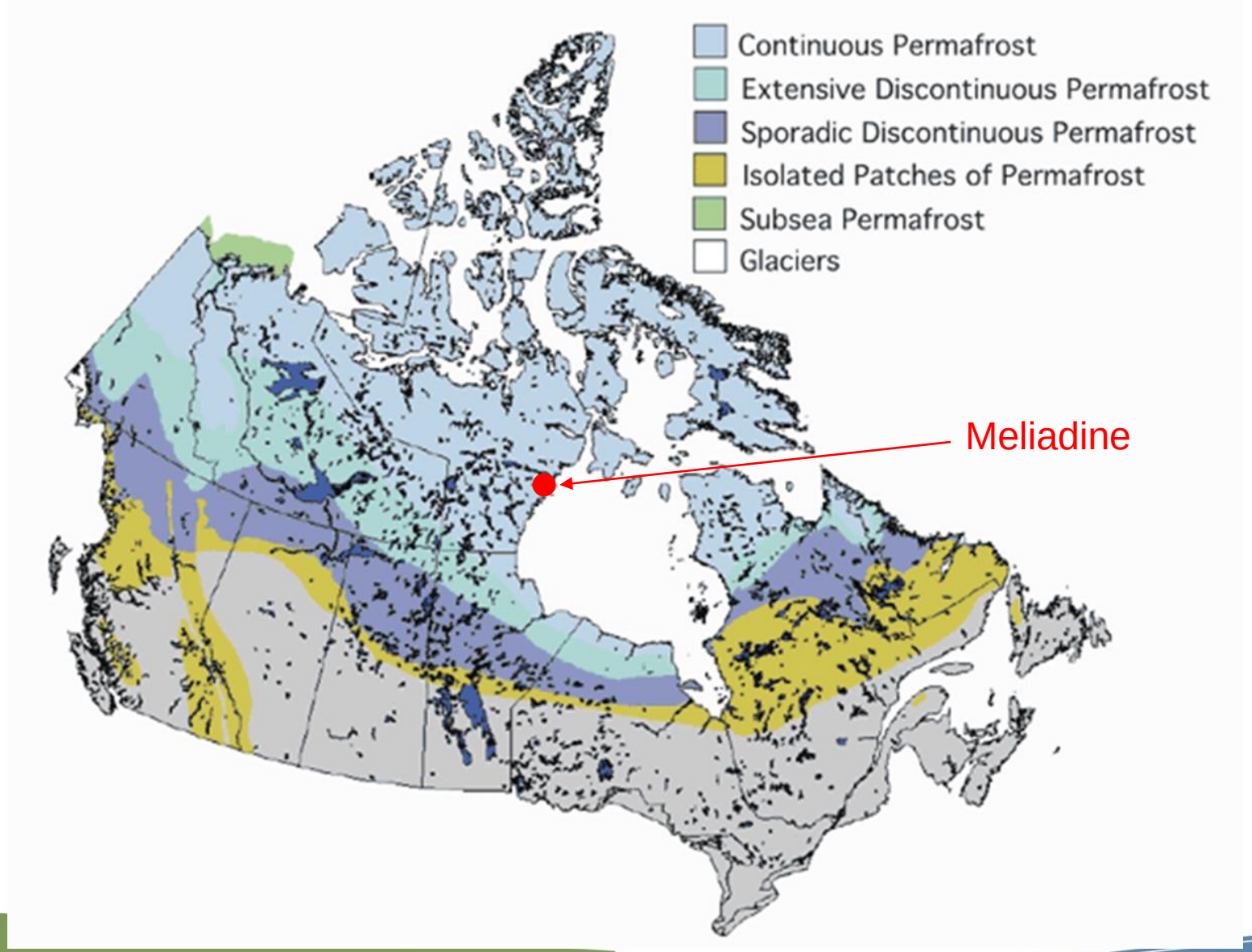
- Thermal modelling- To support design of Mine Waste Storage Facilities
- Ground thermal regime in the project area
- AEM response to Commitment 19 (Thermal modelling of temporary water storage in pits)
- AEM response to Commitment 42 (In-pit deposition alternative and disposal study)

ᐱᓕᕆᐊᕐᒥᑦ ᕿᒥᕐᕈᓂᖅ: ᖁᐊᖑᐃᓐᓇᐅᔭᖅᑐᖅ

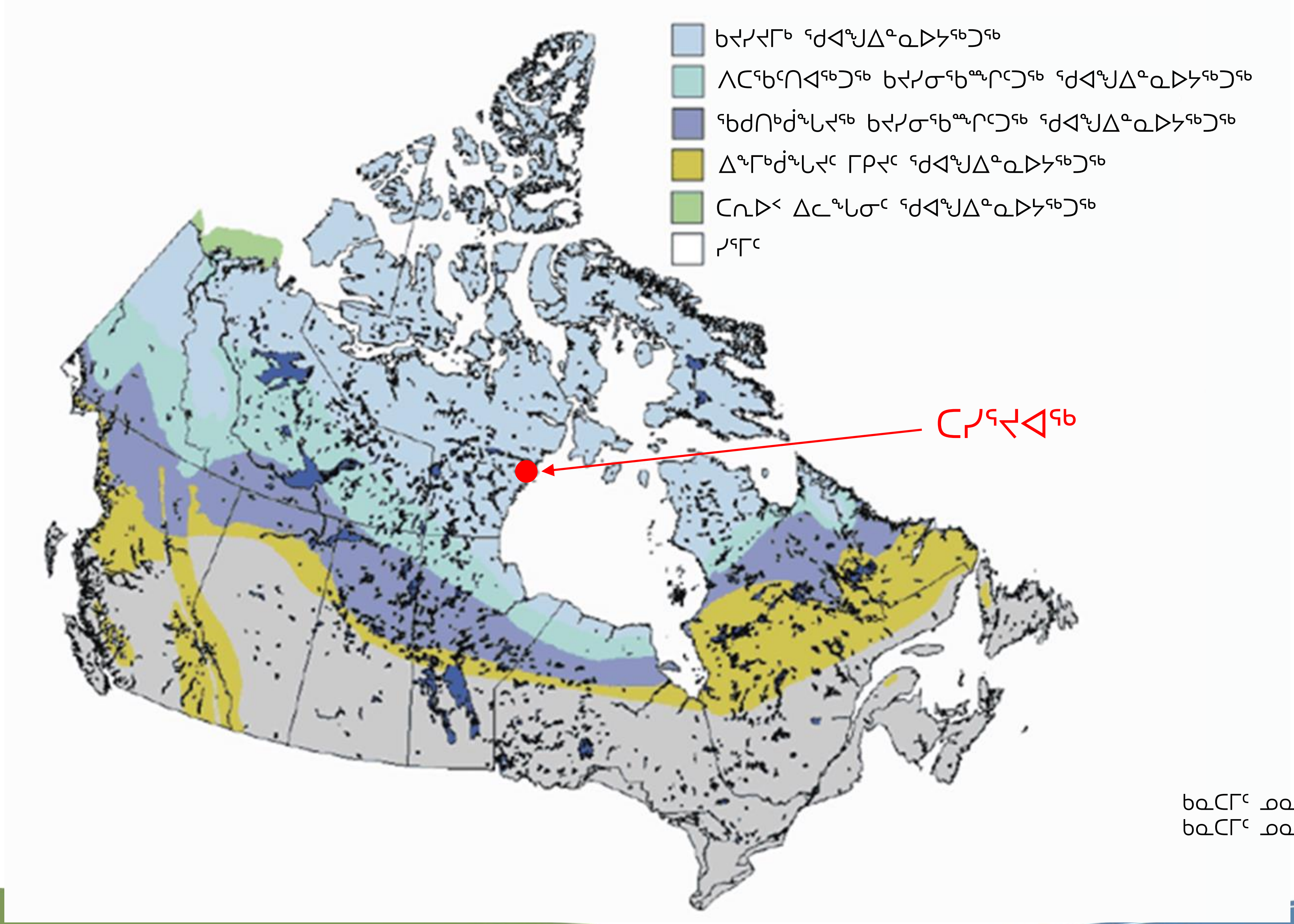
- ᖃᐅᔨᒪᓂᖃᓇᐊᖃᕐᓇᖅᑐᖅ ᖁᐊᖑᐃᓐᓇᐅᔭᖅᑐᒥᒃ ᒥᑭᓛᒃᑰᖅᑎᓐᓂᐊᕐᓗᑎᑦ ᐊᒃᑐᖅᓯᓂᐅᔪᑦ ᐱᓕᕆᐊᕐᒥᑦ ᐱᔪᑦ ᐊᕙᑎᒧᑦ, ᐊᒻᒪᓗ ᐊᒃᑐᖅᓯᓂᐅᔪᑦ ᐊᕙᑎᒥᑦ ᐱᔪᑦ ᐱᓕᕆᐊᕐᒧᑦ.
- ᖃᐅᔨᒪᓂᓇᔭᐅᔪᖅ ᓇᒦᓐᓂᖏᓐᓄᑦ ᖁᐊᖑᐃᓐᓇᐅᔭᖅᑐᑦ ᐊᒻᒪᓗ ᖁᐊᖅᓯᒪᙱᑦᑐᑦ ᒪᓂᕋᖅ (ᐅᑭᐅᓗᒃᑖᖅ ᐃᒪᐅᖏᓐᓇᖅᑐᖅ) ᐱᒻᒪᓇᐅᔪᖅ ᖃᐅᔨᓂᐊᕐᓗᓂ ᒪᓂᕋᕐᒥᑦ ᐃᒪᐅᑉ ᑯᕕᓂᖏᓐᓄᑦ ᐊᑉᖁᑎᖏᑦ.

ᐱᔾᔪᑕᐅᔪᑦ ᐃᓱᒪᒃᓴᖅᓯᐅᕈᑎᒋᔭᐅᔪᑦ:

- ᐆᓇᖅᑎᑦᑎᓂᕐᒧᑦ ᐋᖅᑭᐅᒪᔪᖅ – ᐃᑲᔪᕐᓂᐊᕐᓗᓂ ᐋᖅᑭᒃᑕᐅᓂᖏᑦ ᐅᔭᖅᑕᓇᐅᕐᒥᑦ ᐊᒃᑰᖅᑕᐅᔪᓄᑦ ᑐᖅᖁᖅᓯᓯᒪᕝᕖᑦ
- ᒪᓂᕋᕐᒥᑦ ᐆᓇᖅᑎᑦᑎᓂᕐᒧᑦ ᖃᓄᐃᓕᐅᕐᓂᐅᔪᑦ ᐱᓕᕆᐊᖃᕐᕕᐅᔪᒥᑦ
- ᐊᒡᓃᒃᑯᑦ ᑭᐅᔪᑦ ᐱᓂᐊᕐᓂᓇᔭᐅᔪᖅ 19-ᒧᑦ (ᐆᓇᖅᑎᑦᑎᓂᕐᒧᑦ ᐋᖅᑭᐅᒪᔪᖅ ᐃᒪᕐᒥᒃ ᑐᖅᖁᖅᓯᓯᒪᕝᕕᐅᓚᐅᐱᓪᓚᒃᑐᒧᑦ ᓄᓇᒥᑦ ᐃᓗᑦᑐᖅᓯᒪᔪᓂᑦ)
- ᐊᒡᓃᒃᑯᑦ ᑭᐅᔪᑦ ᐱᓂᐊᕐᓂᓇᔭᐅᔪᖅ 42-ᒧᑦ (ᓄᓇᒥᑦ ᐃᓗᑦᑐᖅᓯᒪᔪᒥᑦ ᐃᓕᔭᐅᓂᖏᑦ ᐊᓯᐊᒍᖕᓛᖅ ᐊᒻᒪᓗ ᐃᓕᔭᐅᔪᓂᒃ ᖃᐅᔨᓴᐃᓂᖅ)

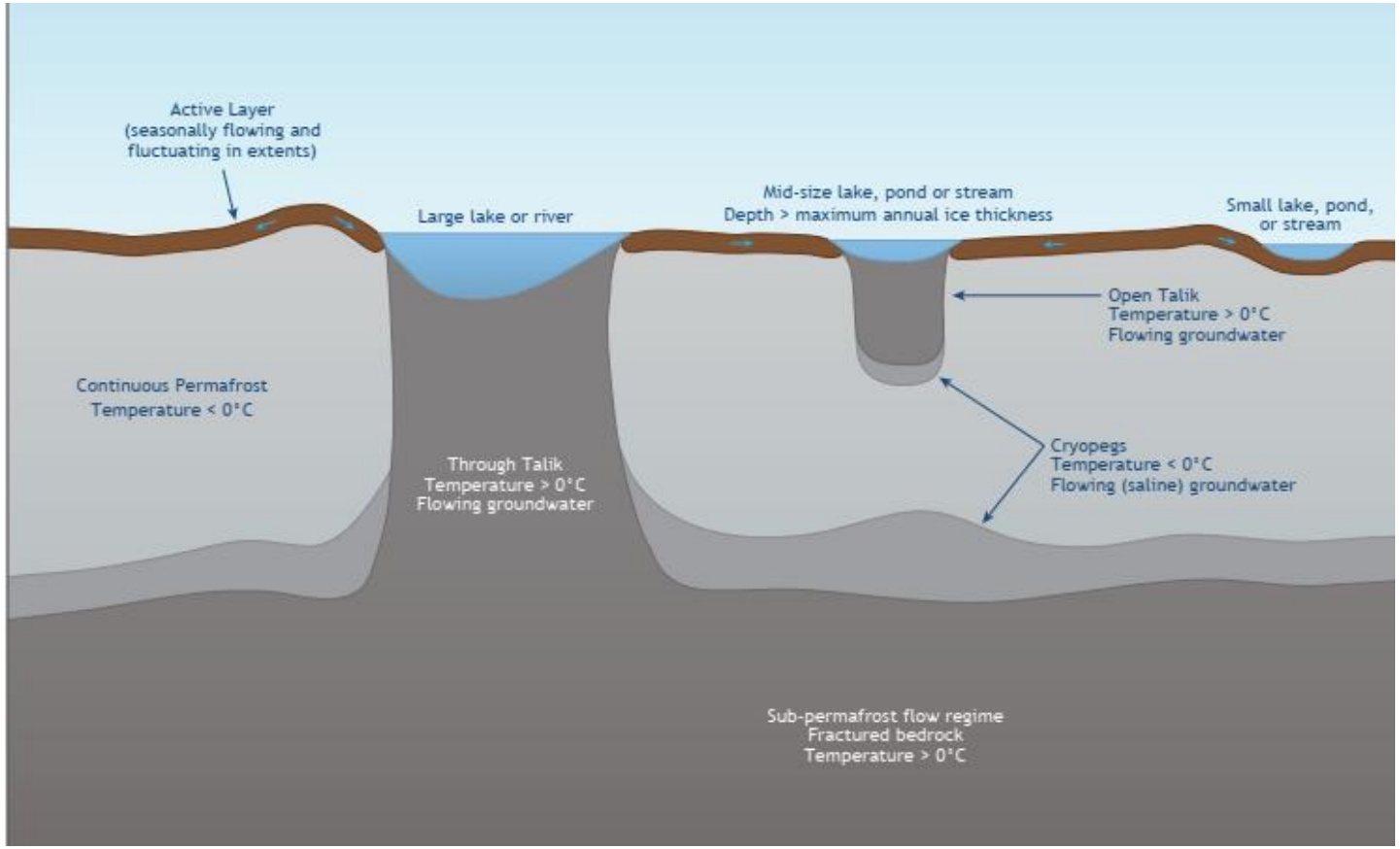


Geologic Survey of Canada,
Natural Resources Canada



ᑲᓇᑕᒥᑦ ᓘᓇᒥᒃ ᖃᐅᔨᓴᐃᔨᒃᑯᑦ,
ᑲᓇᑕᒥᑦ ᓘᓇᒥᑦ ᐱᕚᐅᖃᑦᑕᖅᑐᓕᕆᔨᒃᑯᑦ

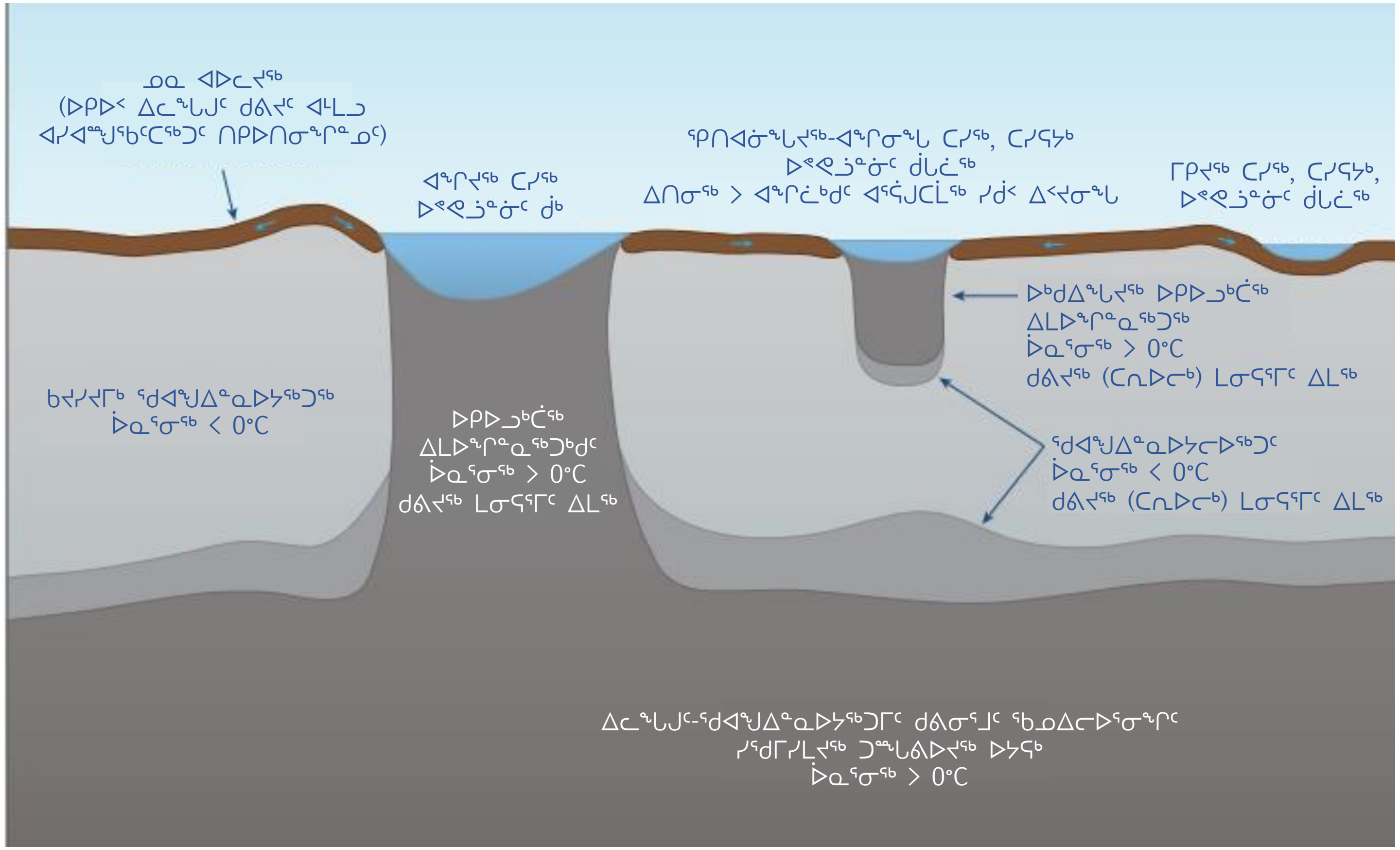
Permafrost



Source – Rescan, Sabina Gold FEIS submission to NIRB, 2017

- Although permafrost is continuous at Meliadine, unfrozen ground (talik) can exist beneath lakes.
- Through taliks beneath large deep lakes or pits provide unfrozen groundwater flow pathways between these lakes and pits, and also with mine workings below the continuous permafrost.

ᖁᐊᖑᐃᓐᓇᐅᓯᖅᑐᖅ



ᐱᕙᐅᔪᖅ – ᓇᖃᓐ, ᓴᐱᓇ ᒎᓗᒃᑯᑦ ᑭᖑᓪᓚᖅᐹᖅᑕ ᐊᕙᑎᒥᒃ ᐊᒃᑐᖅᓯᓂᕐᒧᑦ ᑎᑎᖅᑲᖅ ᑐᓂᓴᐅᔪᖅ ᐊᕙᑎᓕᕆᔨᒃᑯᓐᓄᑦ, 2017

- ᖁᐊᖑᐃᓐᓇᐅᓯᖅᑐᖅ ᑕᐃᒪᐅᖅᑎᓐᓇᐅᓯᕋᓗᐊᖅᑎᓪᓗᒍ ᑕᓯᕐᔪᐊᕐᒥᑦ, ᖁᐊᖅᓯᒪᓖᑦᑐᑦ ᒪᓂᕋᖅ (ᐅᑭᐅᓗᒃᑖᖅ ᐃᒪᐅᖅᑎᓐᓇᖅᑐᖅ) ᑕᐃᒪᐅᔪᓐᓇᖅᑐᑦ ᑕᓰᑦ ᐊᑖᓂᑦ.
- ᐅᑭᐅᓗᒃᑖᖅ ᐃᒪᐅᖅᑎᓐᓇᖅᑐᒃᑯᑦ ᐊᑖᓂᑦ ᐃᑎᔪᕐᔪᐊᓂᑦ ᑕᓯᕐᓂᑦ ᐅᕝᕙᓘᓐᓃᑦ ᓄᓇᒥᑦ ᐃᓗᑦᑐᖅᓯᒪᔪᓂᑦ ᖁᐊᖅᓯᒪᓖᑦᑐᓂᒃ ᒪᓂᕋᕐᒥᑦ ᐃᒪᕐᒥᑦ ᑯᐱᔪᓄᑦ ᐊᑉᖁᑎᖅᑲᖅᑐᑦ ᐊᑯᓐᓂᕐᒋᓐᓂᑦ ᐃᑎᔪᑦ ᑕᓰᑦ ᐊᒻᒪᓗ ᐃᓗᑦᑐᖅᓯᒪᔪᓂᑦ, ᐊᒻᒪᓗ ᐅᔭᕋᒃᑕᓇᐊᕐᒥᑦ ᐱᓕᕆᓂᕐᒧᑦ ᐱᔪᓂᒃ ᐊᑖᓂᑦ ᖁᐊᖑᐃᓐᓇᐅᓯᖅᑐᓂᑦ.

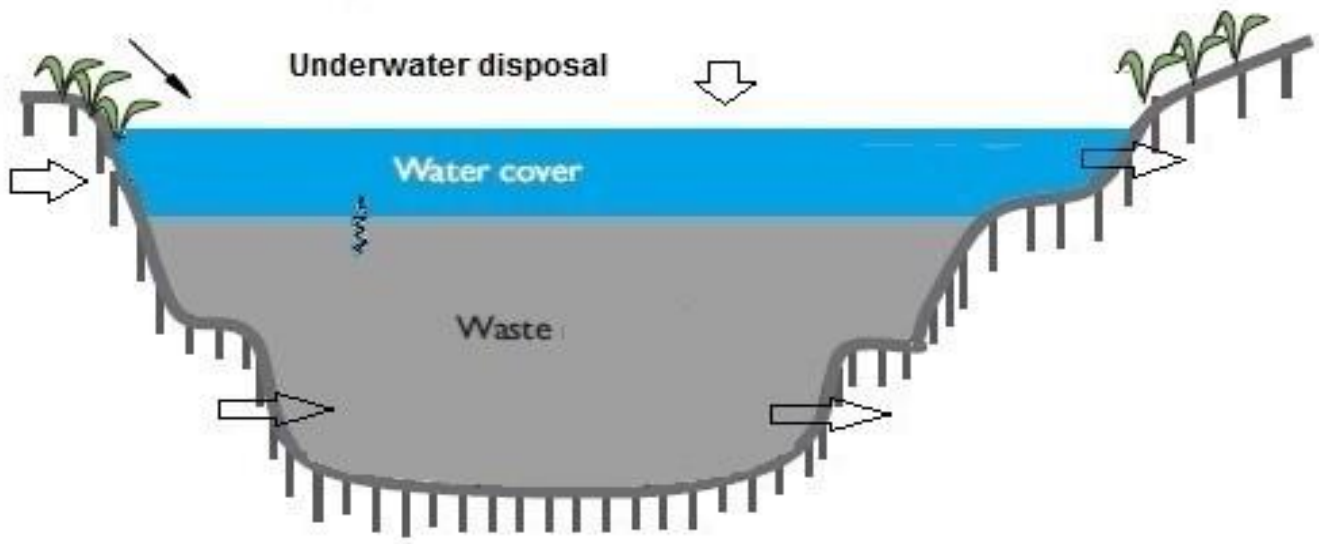
Technical Review: Mine Waste Management

- Representative characterization of mine waste is essential to identify adequate management methods to limit the impacts to the receiving environment.
- Some mine waste presents acid rock drainage and arsenic leaching potential. Therefore, Natural Resources Canada recommends on-going laboratory and field characterization of mine waste.
- This characterization should be used to validate site water quality predictions and the proponent should adapt its mine waste management strategy accordingly.

ᐱᓕᕆᐊᕐᒥᑦ ᕿᒥᕐᕈᓂᖅ: ᐅᔭᕋᒃᑕᕆᐊᕐᒥᑦ ᐊᒃᑕᑯᓂᒃ ᐊᐅᓚᑦᑎᓂᖅ

- ᐱᔪᓂᒃ ᖃᓄᐃᓕᐅᕐᓂᐅᔪᓄᑦ ᐅᔭᕋᒃᑕᕆᐊᕐᒥᑦ ᐊᒃᑕᑰᖅᑕᐅᔪᓂᒃ ᐱᔪᓂᒃ ᐱᒻᒪᕆᐅᔪᖅ ᖃᐅᔨᓂᐊᕐᓗᓂ ᓈᒻᒪᒃᑐᓂᒃ ᐊᐅᓚᑦᑎᓂᕐᒧᑦ ᐊᑐᖅᑕᐅᔪᓂᒃ ᑭᒡᓕᖅᑲᖅᑎᓐᓂᐊᕐᓗᒋᑦ ᐊᒃᑐᖅᓯᓂᐅᔪᑦ ᐊᕙᑎᒧᑦ.
- ᐃᓚᖏᑦ ᐅᔭᕋᒃᑕᕆᐊᕐᒥᑦ ᐊᒃᑕᑯᐃᑦ ᐋᓯᑦᓕᖕᓂᒃ ᐅᔭᕋᓂᑦ ᑯᕕᓂᖅᑲᖅᑐᑦ ᐊᒻᒪᓗ ᐋᓯᓂᒃᒥᑦ ᑯᕕᔪᖅᑲᕈᓐᓇᖅᑐᓂᒃ. ᑕᐃᒪᓐᓇᓗᑦ, ᑲᓇᑕᒥᑦ ᓄᓇᒥᑦ ᐱᕝᕕᐅᖅᑲᑦᑕᖅᑐᓕᕆᓯᒃᑯᑦ ᖃᐃᓯᓴᐃᕝᕕᑎᒍᑦ ᖃᐅᓯᓴᖅᑕᐅᖏᓐᓇᖅᑯᓯᔪᑦ ᐊᒻᒪᓗ ᐱᓕᕆᕝᕕᐅᔪᓂᑦ ᖃᓄᐃᓕᐅᕐᓂᖏᓐᓂᒃ ᐅᔭᕋᒃᑕᕆᐊᕐᒥᑦ ᐊᒃᑕᑯᓂᒃ.
- ᖃᓄᐃᓕᐅᕐᓂᖏᑦ ᐊᑐᖅᑕᐅᔭᕆᐊᓖᑦ ᓇᓗᓇᐃᕐᓂᐊᕐᓗᒋᑦ ᐃᓂᐅᔪᒥᑦ ᐃᒪᐅᑉ ᖃᓄᐃᓐᓂᖓᓄᑦ ᓇᓚᐅᑦᑖᖅᑕᐅᔪᑦ ᐊᒻᒪᓗ ᐱᓕᕆᐊᓕᒃ ᐊᑐᖅᑕᐅᑎᓪᓗᒍ ᐅᔭᕋᒃᑕᕆᐊᕐᒥᑦ ᐊᒃᑕᑯᓂᒃ ᐊᐅᓚᑦᑎᓂᕐᒧᑦ ᖃᓄᖅᑰᕈᑎᖓᑦ.

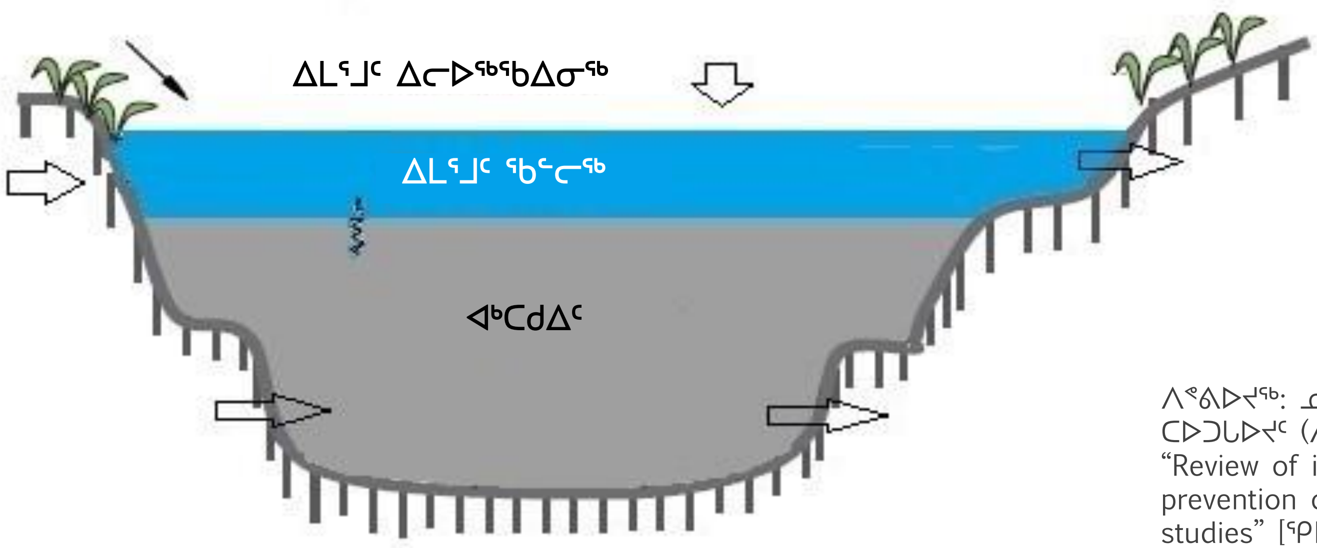
Mine Waste Management: In-pit Disposal



- In-pit disposal under the water table reduces/eliminates:
  - acid rock drainage and metal leaching;
  - groundwater contamination if appropriately designed; and
  - maintenance of above ground dam structures.
- Natural Resources Canada recommends that acid rock drainage and arsenic leaching mine waste be placed in exhausted open pits to the extent practicable as recommended by Mine Environment Neutral Drainage 2.36.1 and 2.36.1b

Source: Pit disposal concept (adapted from Mine Environment Neutral Drainage report 2.36.1 “Review of in-pit disposal practices for the prevention of acid mine drainage – Case studies”,) from Subaqueous in-pit disposal – Mine Closure (gtk.fi)

ᐅᔾᕿᒃᑕᓇᐊᕿᒥᑦ ᐊᒃᑕᑯᓂᒃ ᐊᐅᓚᑦᑎᓂᖅ: ᓄᓇᐅᑉ ᐃᓗᐊᓄᑦ ᐃᓕᐅᖅᑲᐃᓂᖅ



ᐱᕝᕕᐅᔪᖅ: ᓄᓇᒥᑦ ᐃᓗᑦᑐᖅᓯᒪᔪᒥᑦ ᐃᓕᐅᖅᑲᐃᓂᖁᑦ ᑕᐅᑐᒐᐅᔪᑦ (ᐱᔭᐅᔪᖅ MEND ᐅᓂᑉᑳᖅ 2.36.1-ᒥᑦ "Review of in-pit disposal practices for the prevention of acid mine drainage – Case studies" [ᖃᒥᕿᕈᔭᐅᓂᖓ ᓄᓇᒥᑦ ᐃᓗᑦᑐᖅᓯᒪᔪᓗᐊᖅᓯᖃᑦᑕᕿᓂᖁᓄᑦ ᐋᓯᑦ ᐅᔾᕿᒃᑕᓇᐊᕿᒥᑦ ᑯᕕᑎᑦᑕᐃᓕᓂᖁᑦ – ᐱᓯᒪᔪᒥᒃ ᖃᐅᔨᓴᐃᓃᖁ]) ᐅᕙᖕᒐᑦ Subaqueous in-pit disposal – Mine Closure [ᓴᙱᓂᖃᙱᑦᑐᖅ ᓄᓇᒥᑦ ᐃᓗᑦᑐᖅᓯᒪᔪᒧᐊᖅᑐᑦ – ᐅᔾᕿᒃᑕᓇᐊᖅ ᐅᒃᑯᐊᖅᑎᓪᓗᒍ] (gtk.fi)

- ᓄᓇᐅᑉ ᐃᓗᐊᓄᑦ ᐃᓕᐅᖅᑲᐃᓂᖅ ᐃᒪᐅᑉ ᐃᓗᐊᓄᑦ ᒥᒃᓵᕆᐊᖅᓯᖅᑲᑦᑕᖅᑐᖅ/ᐱᑕᖅᑲᕈᓐᓃᖅᑎᑦᑎᖅᑲᑦᑕᖅᑐᖅ:
  - ᐋᓯᑦᑖᓪ ᐅᔾᕿᓂᑦ ᑯᕕᑎᑦᑎᓂᖅ ᐊᒻᒪᓗ ᓴᕕᖕᒥᑦ ᑯᕕᔪᖅ;
  - ᒪᓂᕿᕿᒥᑦ ᐃᒪᖅ ᐱᐅᖏᑦᑐᓕᒃ ᓈᒻᒪᒃᑐᒃᑯᑦ ᐋᖅᑭᒃᓯᖅᑕᐅᓯᒪᒃᐸᑦ; ᐊᒻᒪᓗ
  - ᐱᓕᕆᐊᕐᔪᖅᑲᑦᑕᕐᓂᖏᑦ ᖁᓖᓅᑦᑐᑦ ᒪᓂᕿᕿᒥᑦ ᐊᕙᓗᓄᑦ ᐋᖅᑭᒃᓯᒪᔪᑦ.
- ᑲᓇᑕᒥᑦ ᓄᓇᒥᑦ ᐱᕝᕕᐅᖃᑦᑕᖅᑐᓕᓇᐅᒃᑯᑦ ᐋᓯᑦᑖᓪ ᐅᔾᕿᓂᑦ ᑯᕕᑎᑦᑎᓂᖅ ᐊᒻᒪᓗ ᐋᓯᓂᒃᒥᑦ ᑯᕕᓂᖅ ᐅᔾᕿᒃᑕᓇᐊᕿᒥᑦ ᐊᒃᑕᑯᓂᑦ ᐃᓕᔭᐅᖁᐹᔪᑦ ᓄᓇᒥᑦ ᓇᖑᑎᖅᓯᒪᔪᑦ ᐅᒃᑯᐃᖓᔪᓄᑦ ᐊᔪᙱᓐᓂᓕᒫᒃᑯᑦ ᐱᖁᔭᐅᓯᒪᓂᖓᑐᑦ MEND 2.36.1-ᒥᑦ ᐊᒻᒪᓗ 2.36.1b-ᒥᑦ

Questions?

ᐊᐱᖅᑯᑎᖅᑲᖅᐱᐅᓪ?