Surface-groundwater interactions in permafrost regions: a case study of the Rankin Inlet area

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Ressources naturelles Canada

Canada

About GEM-GeoNorth

Continuation of NRCan's Geo-Mapping for Energy and Minerals (GEM) program, but with a broader scope to reflect today's realities and priorities in northern Canada.

GEM-GeoNorth is collecting, and will provide new, public geoscientific data, knowledge and maps of northern Canada.

Renewed until 2027

Geoscience for sustainable and economic development in the context of a changing climate

Focus on areas of the North **where development is likely to occur and benefit Northern communities**

What is this research project about?

- We aim to use a **multidisciplinary approach** to determine where **lakes in the Rankin Inlet area** are **connected to deep (below permafrost) groundwaters** via unfrozen ground portions (i.e., taliks). Those methods could then be applied to other northern regions.

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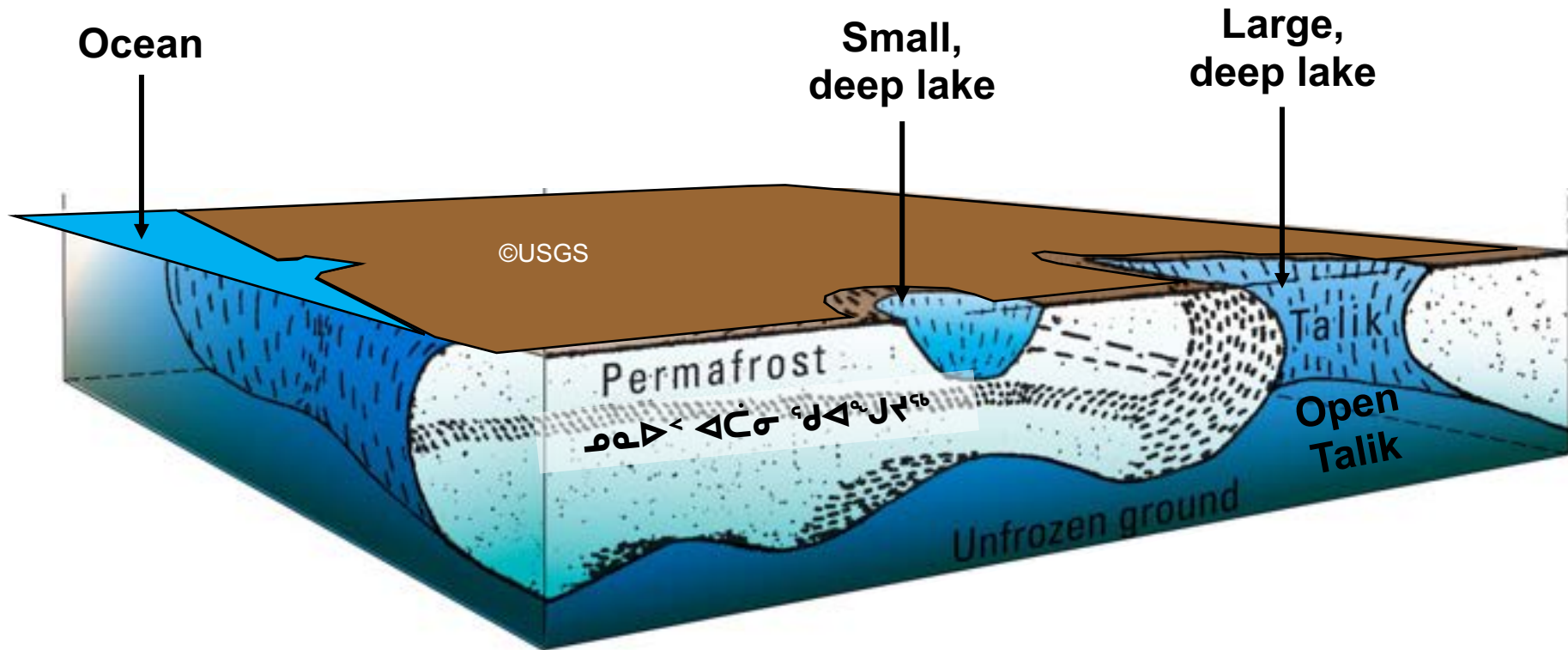
Why should we care about this?

- The occurrence of **taliks beneath large lakes** has implications for managing **hypersaline water inflow**, potentially affecting mine operations and operating life. Hence, their **identification is detrimental to durable mining operations in the north**.
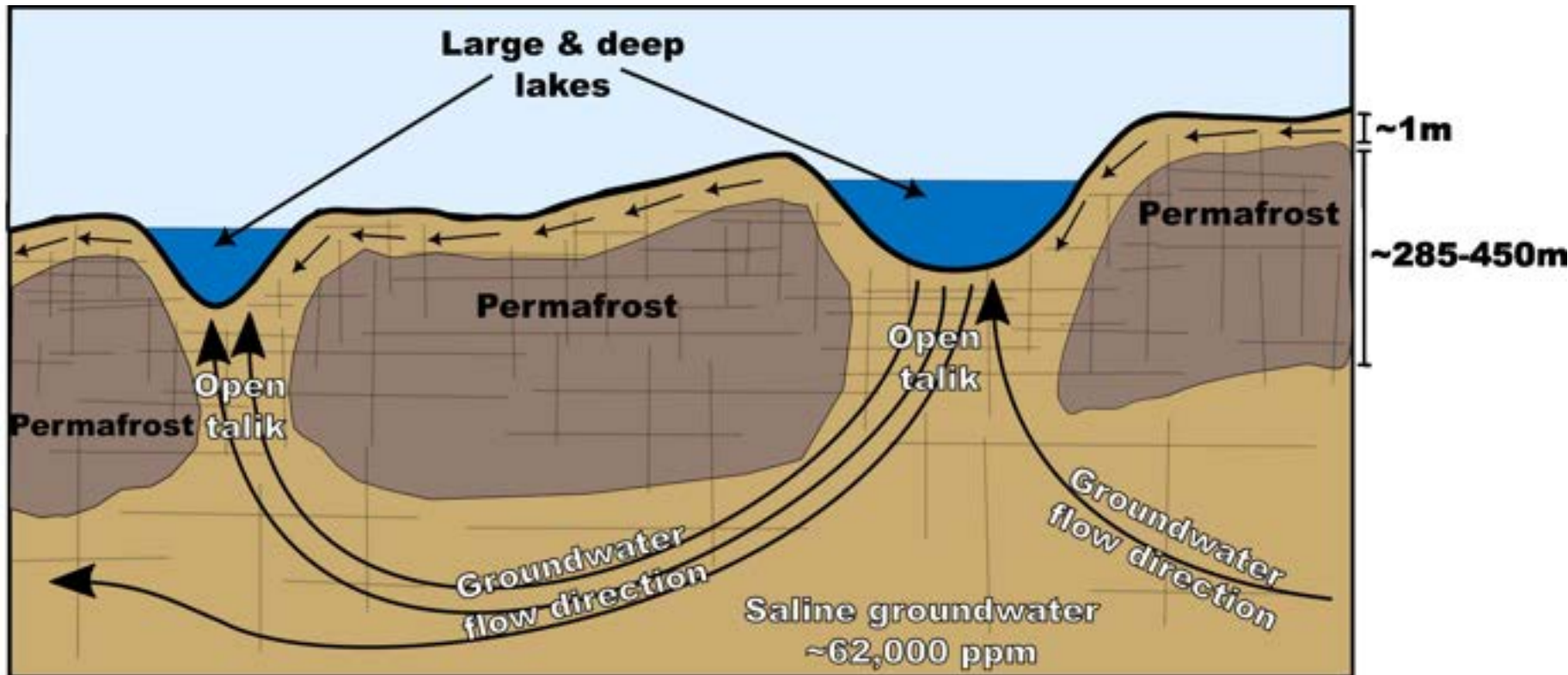
A multidisciplinary approach to locating open taliks
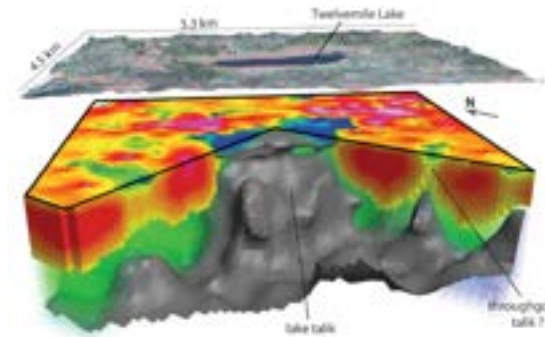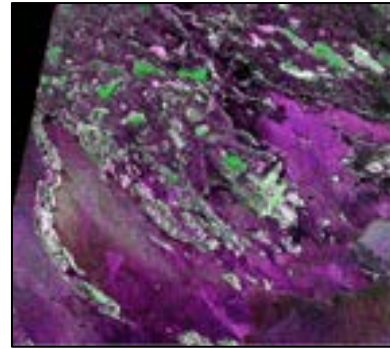

Talik identification
- Geomatics
- Lake water chemistry
- Permafrost characteristics
- Geophysics
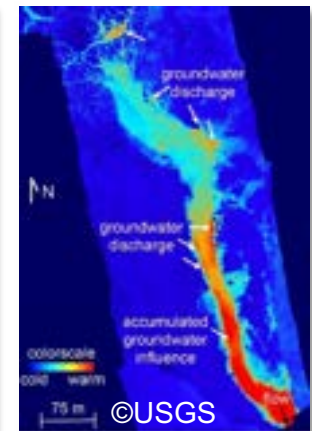- Drone (UAVs) mapping and water sampling
- Hydrogeological modelling

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Who is involved in the research endeavour?

Anne-Marie LeBlanc
Permafrost

Greg A. Oldenborger
Geophysics

Benoit Faucher
Permafrost (hydro)geochemistry

Nicolas Benoit
Hydrogeology

Oleksandra Pedchenko
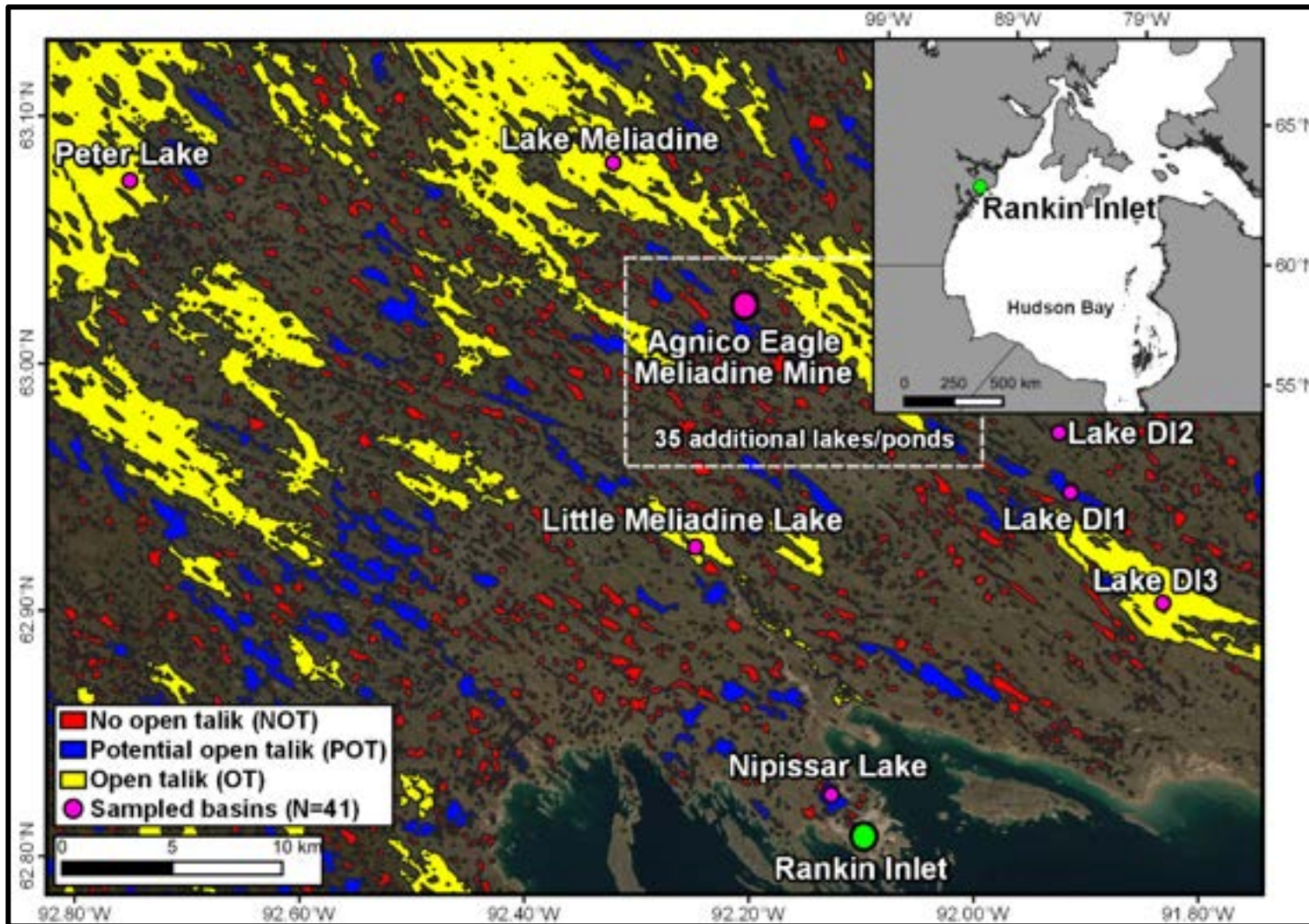Hydrogeology

Kevin Brewer
Geophysics

Etienne Girard
Drone mapping and water sampling

Geomatics

- Using topography, satellite imagery, machine learning, and steady-sate thermal disturbance equations to identify lakes with open taliks.

LeBlanc, A.-M., Chartrand, J., & Smith, S.L. (2022). Regional assessment of the presence of taliks below lakes. Geological Survey of Canada Scientific Presentation.

Geomatics

- Using radar satellite data to locate ground-fast lake ice.
  - Lakes frozen to their bottom should not have an open talik.
 - Presence of liquid water below ice cover required to have open talik.

Geomatics

- Using radar satellite data to locate ground-fast lake ice.
  - Lakes frozen to their bottom should not have an open talik.
    - white/pink = ground-fast lake ice; green = unfrozen water below ice cover
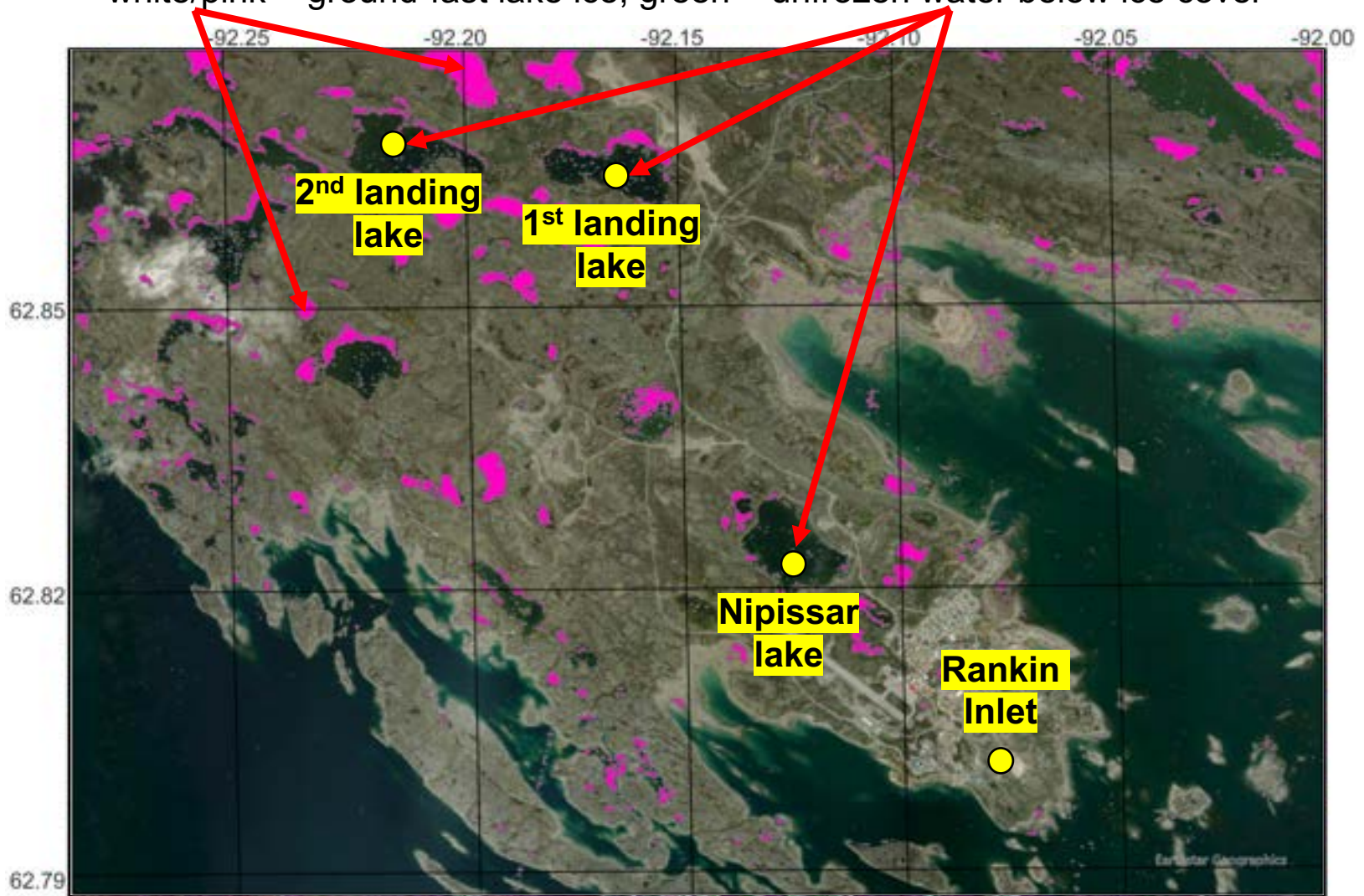
Lake water chemistry

- Initiated in 2021 with exploratory data analysis (41 lakes in the Rankin Inlet area) of archived datasets (CIRNAC-KIA-Meliadine Mine).
  - Lakes suspected of having sublacustrine open taliks cannot be identified by assessing their "basic" physicochemical parameters.
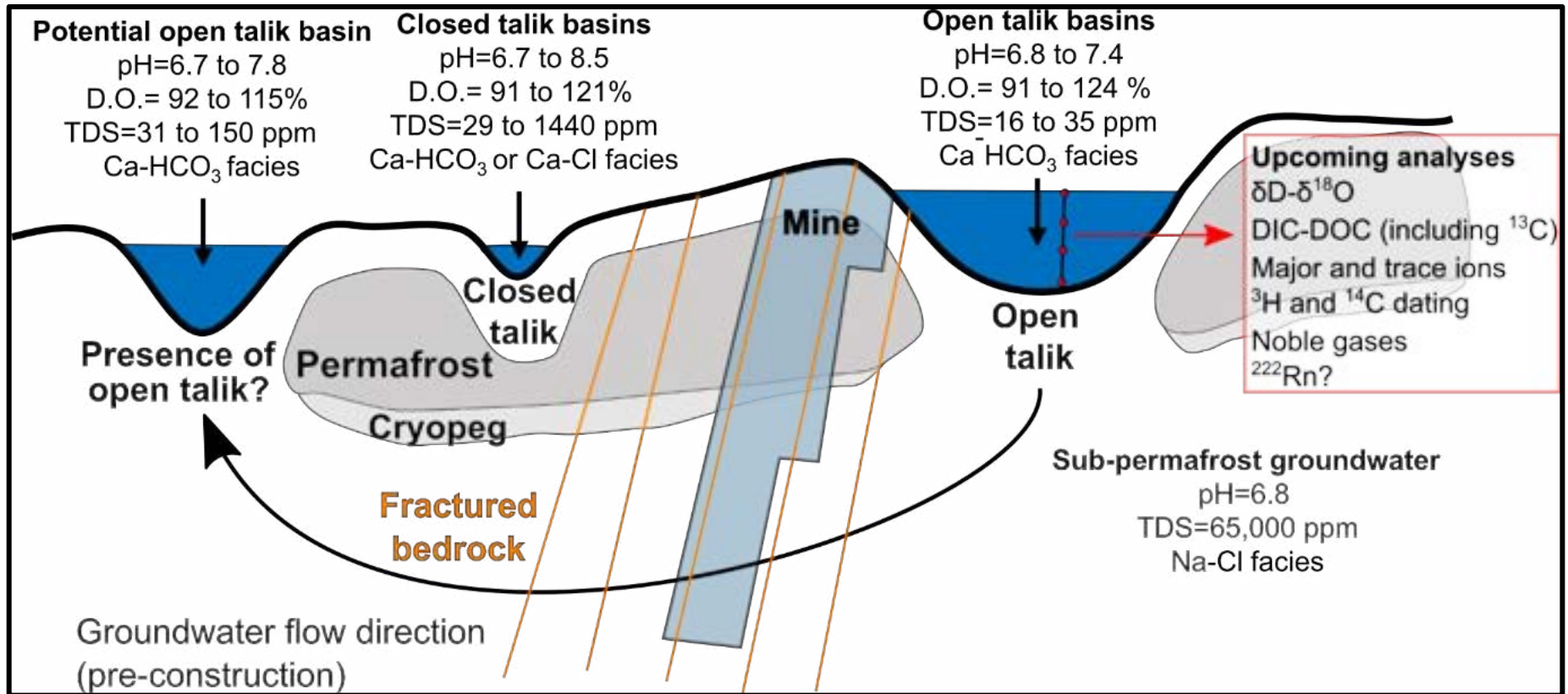
Faucher, B., LeBlanc, A.-M., Utting, N., & Blade, M. (2022). Assessment of physicochemical and hydrochemical properties in lentic surface water bodies of the Rankin Inlet area (Nunavut) for sublacustrine open talik detection. Geological Survey of Canada, Open File.

Lake water chemistry

- In-depth hydrochemical analyses to be conducted on lake water samples collected in future months.
 - Aim is to use derived data to identify groundwater infiltrations in lakes via open taliks.

Permafrost characteristics

- Characterising local permafrost conditions is detrimental to assessing how its degradation may impact the water quality of nearby water bodies.
  - CT Scan vs. laboratory measurements of ground ice content
  - Several geochemical analyses to come (influence on lake water chemistry?)

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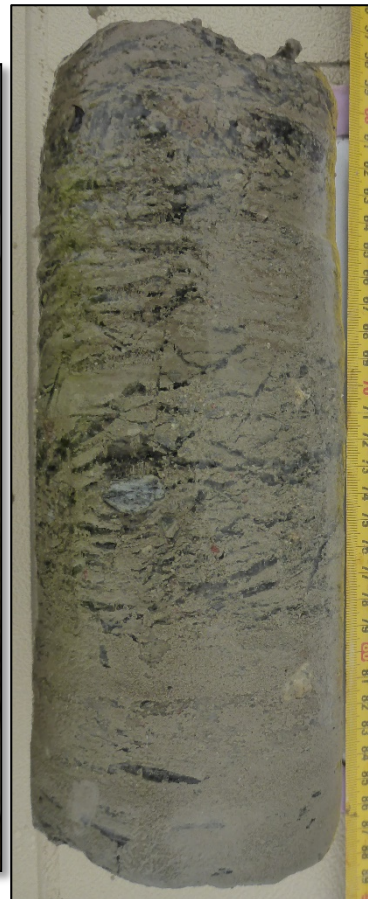
Geophysics

- Use of time-domain electromagnetic surveys on lake ice to create an image of the subsurface (i.e., locate if/where taliks are situated below lakes).
    - Fieldwork currently (i.e., this week…) underway.
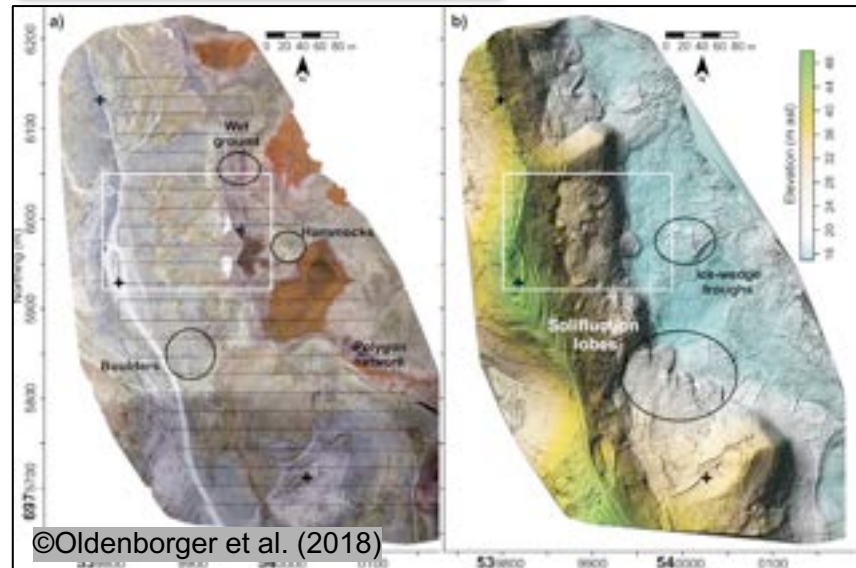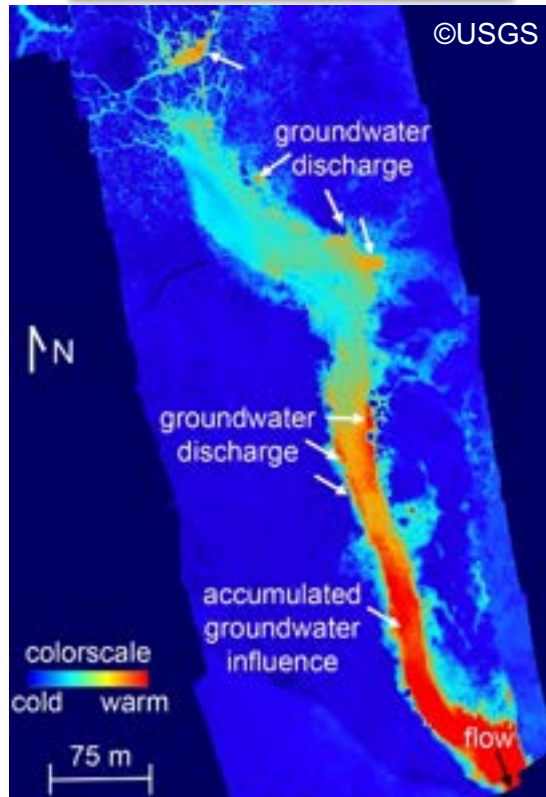
throughgoing talik ?
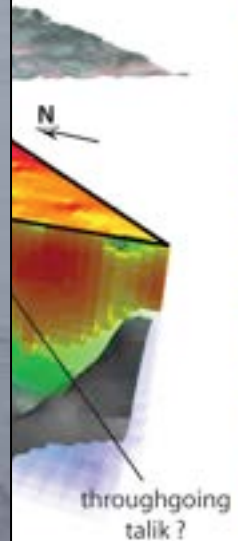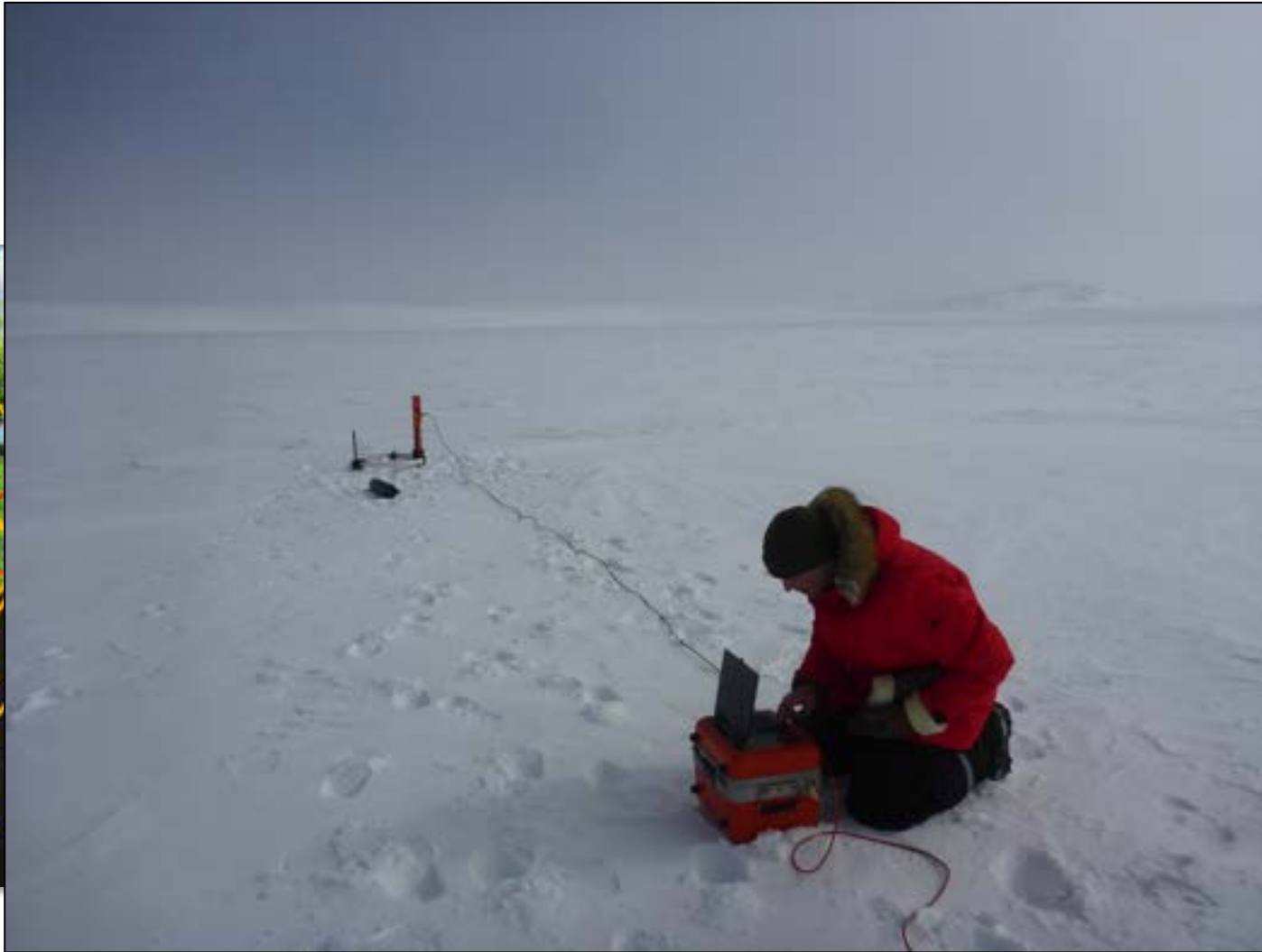
Drone (UAVs) surveys and water sampling

- Use of drones to map lake temperatures contrasts in lake surface waters (i.e., potential groundwater inputs) and collect water samples.


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groundwater discharge

groundwater discharge

accumulated groundwater influence

flow

colorscale
cold   warm

75 m

©DJI

©Oldenborger et al. (2018)

Past study using a drone in Iqalugaarjuup Nunanga Territorial Park

©Oldenborger et al. (2018)

Hydro(cryo)geological modelling

- Creation of 2D/3D subsurface conceptual models based on empirical data to better understand groundwater flow, brine transport and heat transfer in continuous permafrost environments.

  - Example below predicts where and how fast water should be flowing in the presence/absence of permafrost.
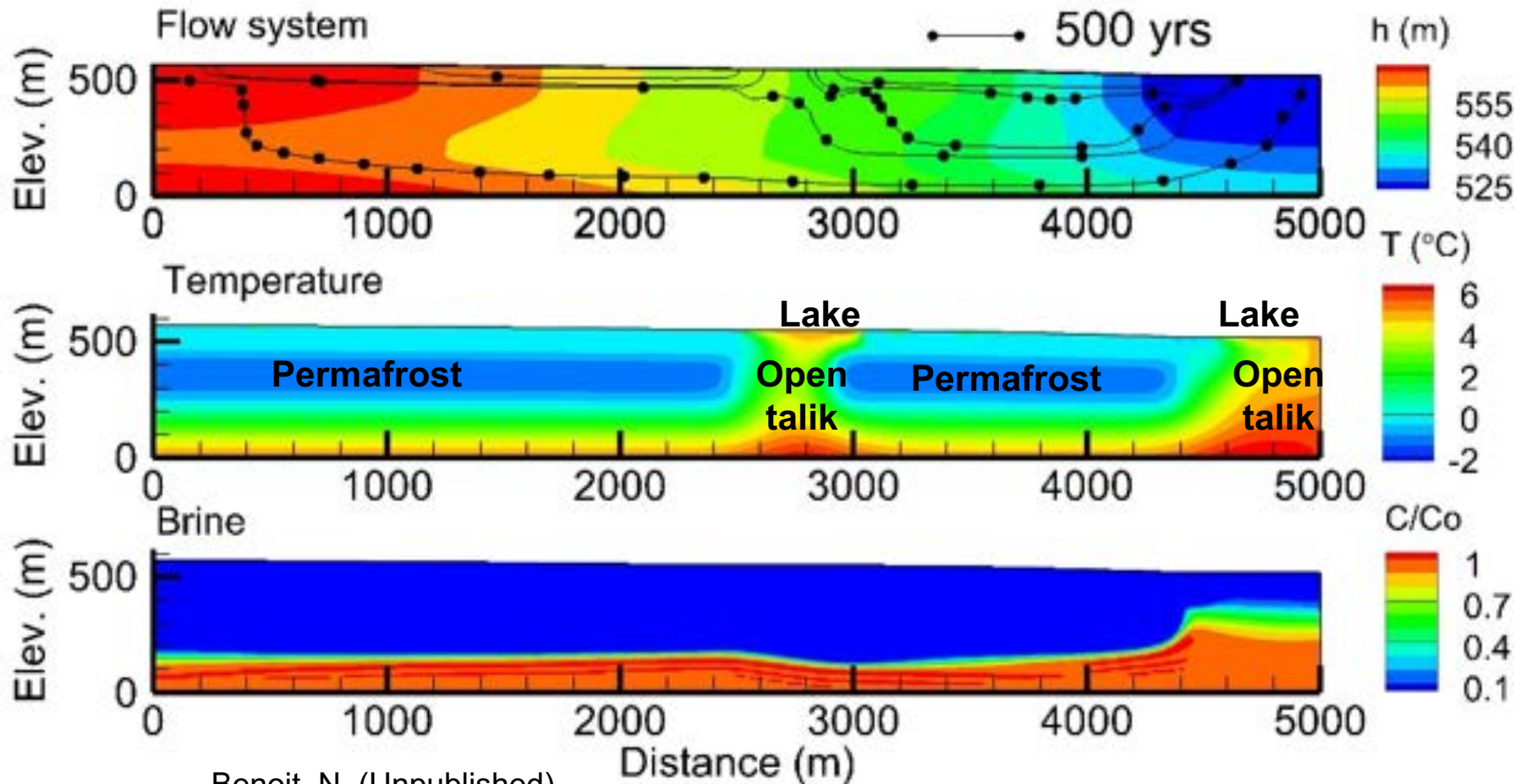
Benoit, N. (Unpublished)

How can our findings be used?

Support decisions and planning for sustainable mining operations

Complement existing baseline datasets on lake water chemistry

Provide information to the community about the lake water's origin

Support local Environmental Assessments

Assess the effect of climate change on the water quality of several lakes

Thank you!

For more information:

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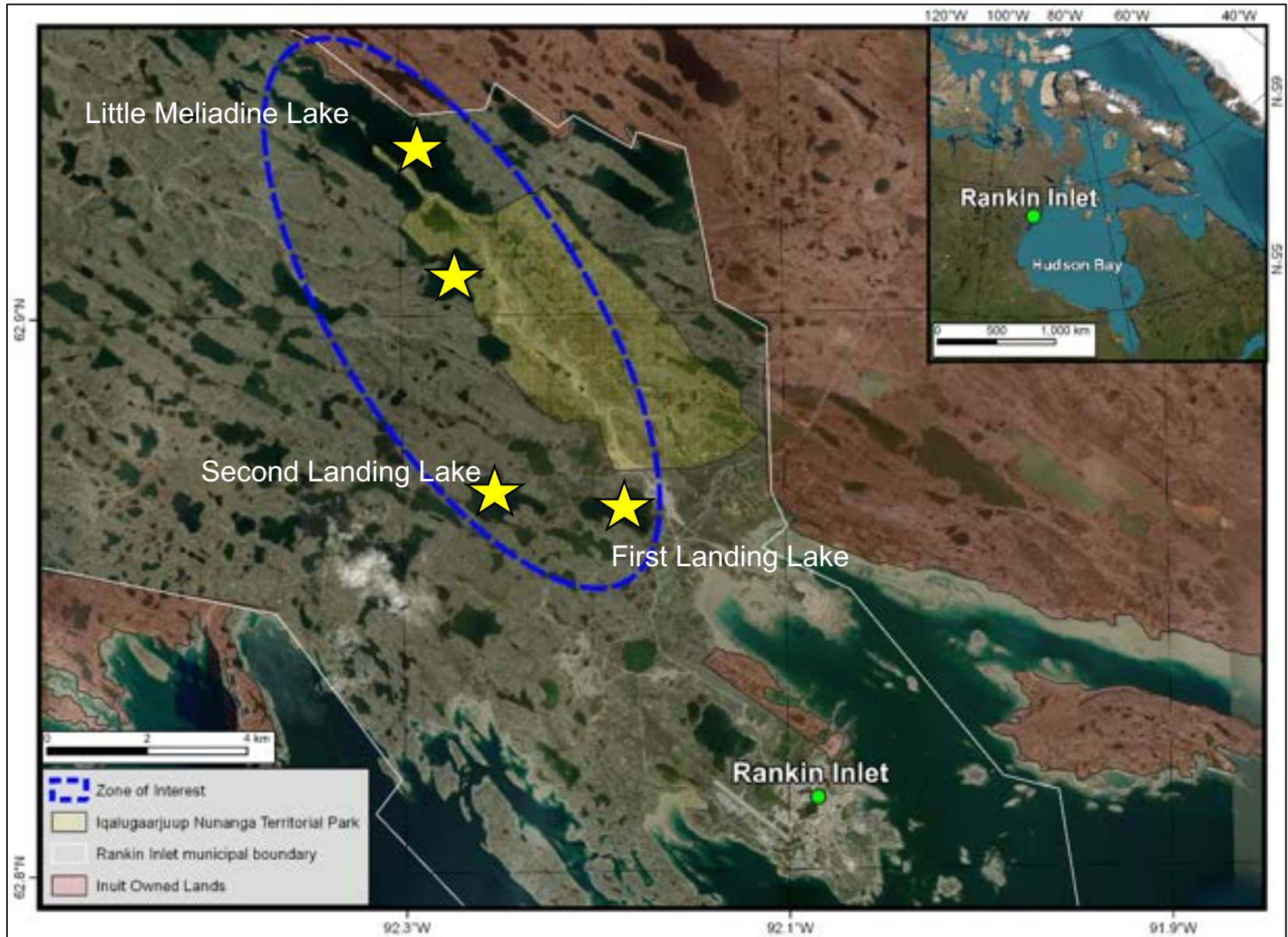**E-mail:** gem-geonorth-gem-geonord@nrcan-rncan.gc.ca
NRCan twitter: @NRCan / @RNCan
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Potential lakes of interest near Rankin Inlet

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