Geoscience Data Compilation for Groundwater Mapping across the Alberta and Northwest Territories Transboundary Region

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Introduction

- Knowledge of groundwater resources in the Alberta-Northwest Territories (AB-NWT) transboundary region is limited (Figure 1).
- The Government of Northwest Territories and the Government of Alberta have established a transboundary agreement to manage shared water resources (AB-NWT, 2015).
- Transboundary hydrogeological mapping is difficult due to data fragmentation and differing methodologies.
- Geoscience data compilation and analysis is required to build unified geological models to inventory transboundary groundwater.

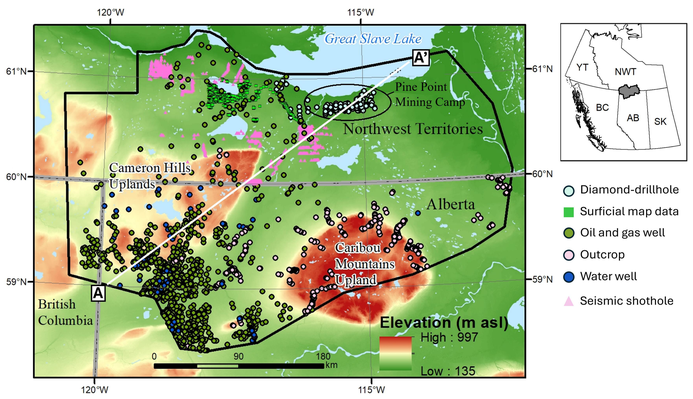

Figure 1. AB-NWT transboundary region study area with data sources compiled for geological mapping and physiographic features (Pettapiece, 1986; Utting et al., 2023). Figure 4 cross-section location shown in white.

Geological Model Data Compilation

- Data was compiled from boreholes, groundwater wells, geophysical logs, drill cuttings, hydrocarbon wells, and field observations for unified geological model development (Figure 1).
- Bedrock top information was interpreted from geophysical logs and confirmed with drill cuttings (Figure 2a). Top of bedrock and depth to water table mapping was aided by these data sources.
- Outcrop locations and lithological descriptions were incorporated in geological modelling of sediment thickness (Figure 2b).

Figure 2. (a) Drill cuttings from oil and gas well 10-04-123-02W6 at depth 800-810 ft (243.8-246.9 m) interpreted to be of fluvial or glaciofluvial origin (Utting et al., 2023). Well location indicated on Figure 3a. (b) Outcrop viewed in study area used in geological modelling.

Unified Geological Model

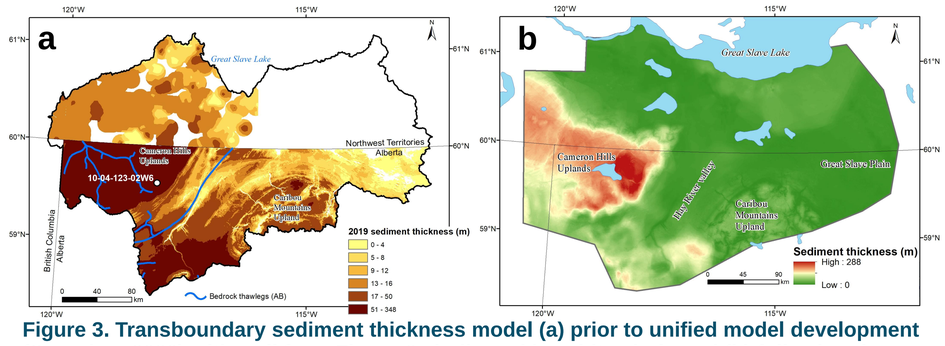

Figure 3. Transboundary sediment thickness model (a) prior to unified model development (Smerdon, 2020) with well from Figure 2a indicated by white circle and (b) following data compilation and geological modelling (Utting et al., 2023).

- Sediment above bedrock modelling resolves discrepancies in transboundary sediment thickness (Figure 3). Geological modelling indicates sediment thickness >250 m in the Cameron Hills Upland. Updated bedrock topography modelling was completed (Utting et al., 2023).
- Regional cross-sections (Figure 4) were constructed using the updated modelling (Utting et al., 2023), the Geological Framework of Alberta (AGS, 2021), and formation tops for petroleum exploration in NWT (Hogue and Gal, 2008).
- The extent and geometry of bedrock formations and surficial sediments is visualized through the unified geological model development.

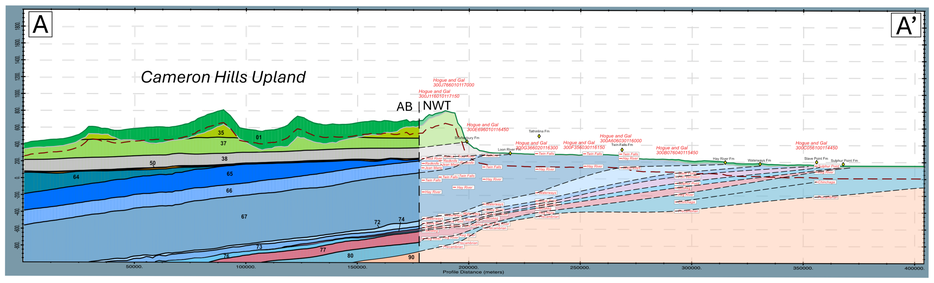

Figure 4. Regional transboundary cross-section visualizing sediment above bedrock, bedrock formation thickness, and geometry with formation tops (Hogue and Gal, 2008).

Aquifer Mapping

- Resolved bedrock geometry mapping supported allocation of hydrogeological data to transboundary aquifers for groundwater flow and quality mapping.
- Baseline hydraulic head and groundwater salinity was mapped for bedrock and surficial aquifers using data from drill-stem tests and water wells (Government of Alberta, 2023; S&P Global Inc., 2023) (Figure 5).

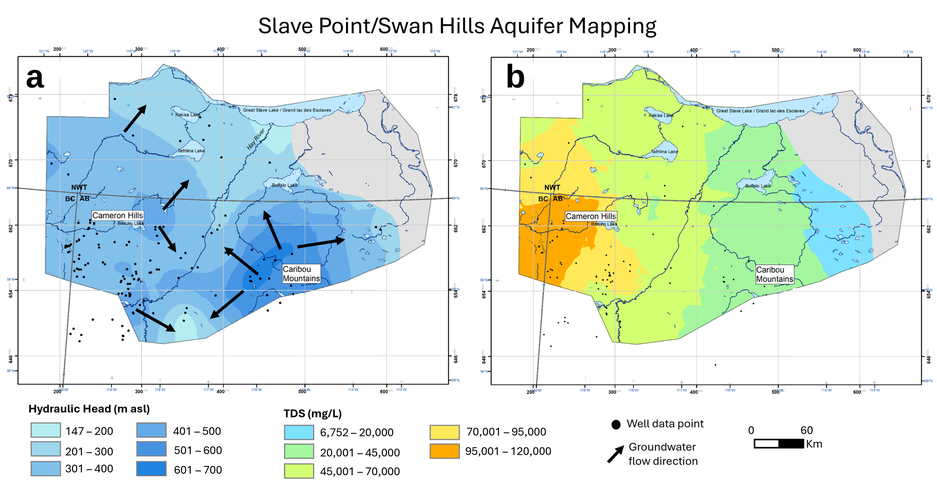

Figure 5. Hydrogeological mapping of (a) hydraulic head with inferred groundwater flow direction and (b) groundwater salinity in total dissolved solids (TDS).

Groundwater-Surface Water Interaction

- Sampling of the Hay River and Groundwater Observation Well Network (GOWN) wells was completed in October 2023 and 2024 respectively to assess groundwater-surface water interaction (Figure 6).
- Samples were analyzed for isotopic and geochemical tracers to determine baseflow contributions to the Hay River and to assess groundwater circulation.
- Preliminary results suggest a lack of groundwater connection to the Hay River and low degree of circulation between surface water and groundwater (figures 6 and 7).

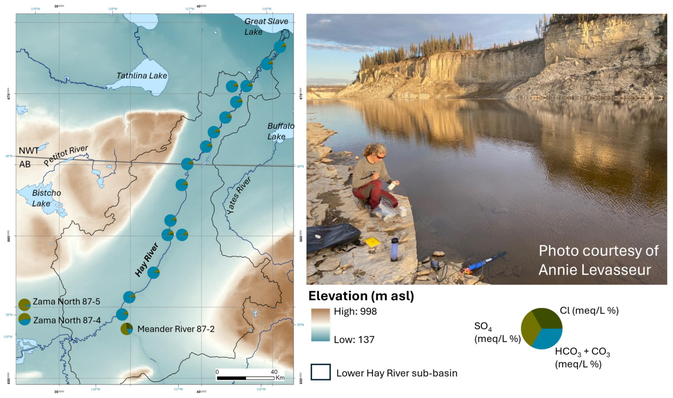

Figure 6. Locations of Hay River and GOWN water samples in the lower Hay River sub-basin with river sampling field photo. Anion results are displayed at sample locations.

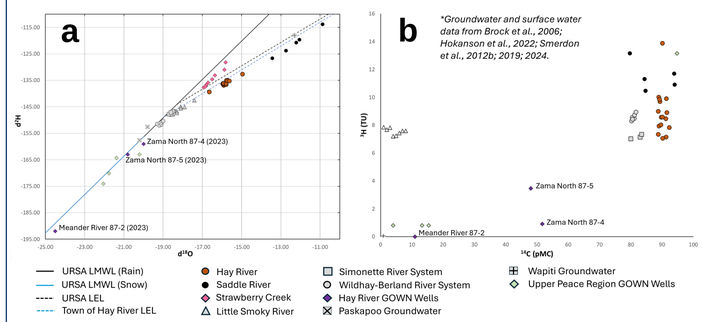

Figure 7. (a) δ^2H vs $\delta^{18}O$ and (b) ^3H vs ^{14}C results for the lower Hay River sub-basin compared to various groundwater and surface water results in Alberta*.

Summary

Data fragmentation and differing methodologies causes inconsistencies in geological mapping and modelling across shared borders. Data compilation and unified mapping is essential in resolving knowledge gaps relating to transboundary groundwater resources. A regional evaluation of the transboundary area provides the framework for sub-regional and local-scale investigations such as water monitoring programs. This work supports the management of water resources across shared borders.

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