Jessica E. Liggett
Lisa A. Atkinson
Kelsey E. MacCormack
Gregory Hartman
Nevenka Nakevska

Alberta Energy Regulator-
Alberta Geological Survey
402, Twin Atria Building
4999-98 Avenue
Edmonton, AB
www.aer.ca
www.ags.gov.ab.ca

Integration of Regional Geological and Hydrogeological Mapping for Land-use Planning in Southern Alberta

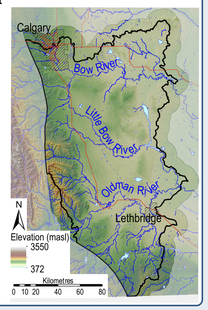
Introduction

Surface water sources in southern Alberta are fully allocated and it is projected that groundwater resources will face increased pressure as a result. In order to facilitate the development of a regional land use plan and groundwater management framework, the Alberta Geological Survey is conducting a regional hydrogeological assessment in the Calgary-Lethbridge Corridor (CLC). The CLC study takes an integrated approach to deliver a comprehensive assessment of the regional hydrogeology, grounded in an updated geological framework.

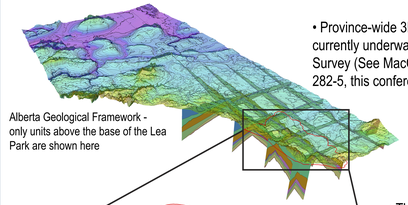
New geological modelling is underway to produce a 3D geological model of bedrock units in the region. Mapping the Neogene-Quaternary sediments overlying bedrock focuses on delineating the spatial distribution and hydrostratigraphy of coarse-grained units (potential aquifers) and fine-grained units (potential confining layers). Once these geological models are complete, we can use them in conjunction with hydrogeological information (e.g. hydraulic heads, water chemistry, water use) from sources such as the Alberta Water Well Information Database to deliver a regional hydrogeological assessment of the CLC. Regional recharge, which is important for considering the sustainability of groundwater resources and scoping an enhanced groundwater monitoring strategy, will be estimated via a 1D modelling approach.

Calgary-Lethbridge Corridor (CLC)

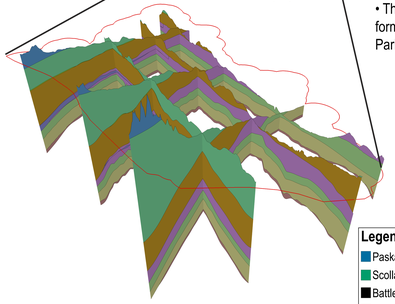
- Surface water sources are fully allocated: water-use sectors are turning to groundwater
- Semi-arid area: ~300 mm/y of precipitation, high evapotranspiration
- Relatively large population, intensive agriculture, and hydrocarbon development
- Need for updated understanding of regional groundwater flow and potential groundwater-surface water interaction



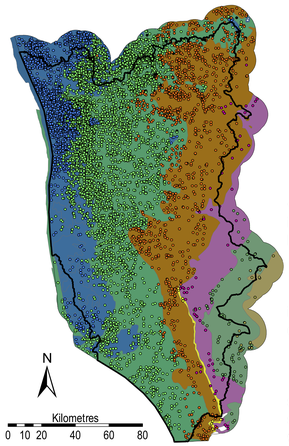
Bedrock Geology/Hydrogeology



- Province-wide 3D geological modelling is currently underway at the Alberta Geological Survey (See MacCormack K.E. - paper no. 282-5, this conference)



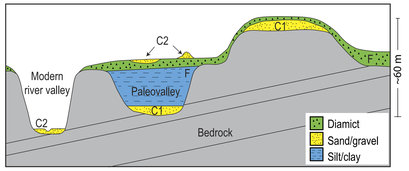
- The CLC focuses on the formations above the Lea Park/Pakowki



Legend (bedrock units)
- Paskapoo/Porcupine Hills
- Scollard/Willow Creek
- Battle
- Horseshoe Canyon/St. Mary River
- Blood Reserve
- Strathmore
- Bearpaw
- Oldman
- Foremost
- Lea Park/Pakowki (model base for CLC study)
- Water Well (corresponding unit colour)

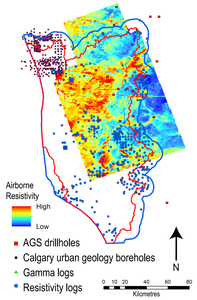
- Using the geological modelling we can identify water wells completed in each of the bedrock units
- The 3D geological surfaces allow for better identification of water well completions, especially in areas near subcrop boundaries
- Next steps include mapping potentiometric surfaces, determining vertical gradients, and slice mapping to identify permeable bodies within each bedrock unit

Quaternary-Neogene Geology/Hydrogeology



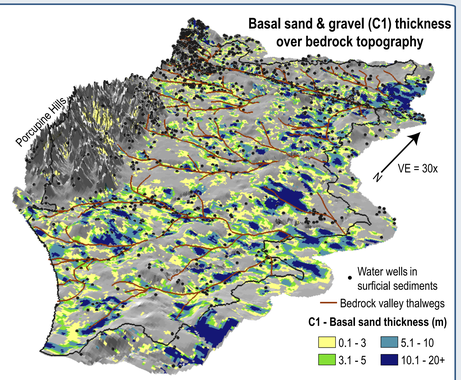
- Three Neogene-Quaternary hydrostratigraphic units are mapped to identify potential shallow aquifers:

C2: Surficial sand, sand & gravel, or silty sand (potential aquifer)
F: Intervening fine-grained silt, clay, diamicton (aquitard)
C1: Basal sand & gravel, silty sand (potential aquifer)



Data Sources: Airborne resistivity, historical mapping, historical drilling, borehole logs (AGS holdings, water well drillers, resistivity logs, gamma logs)

Basal sand & gravel (C1) thickness over bedrock topography



- With well and hydraulic data from the Alberta Water Well Information Database, the state of, use, and development of these surficial aquifers will be determined

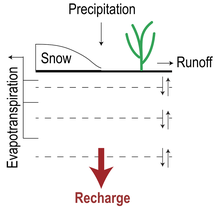
Conclusions

- Detailed regional geological modelling and integration of the province-wide geological framework provides a solid foundation for the hydrogeological analysis
- Preliminary results show a strong dependence on groundwater use from bedrock and buried sands in paleovalleys
- Recharge of shallow groundwater system is low on average, but is highly variable year to year
- This assessment will help prioritize areas which require further study or special considerations in developing a comprehensive approach for groundwater management and monitoring in southern Alberta for land-use planning
- Land-use planning process will develop policy related to the connectivity of groundwater to nearby surface water sources

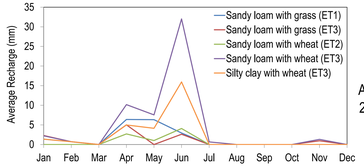
Groundwater Recharge

- Precipitation in the CLC recharges the shallow groundwater system
- 1D water balance model to quantify recharge in the CLC (VSMB)
- 12 different simulations accounting for different conditions: 2 soils (sandy loam/silty clay), 2 vegetation (grass/wheat), 3 ET routines (= 12 models)
- 8 years of weather data from southern CLC (2005-2013)

Virtual Soil Moisture Budget (VSMB) model



Of models with recharge (5/12)...

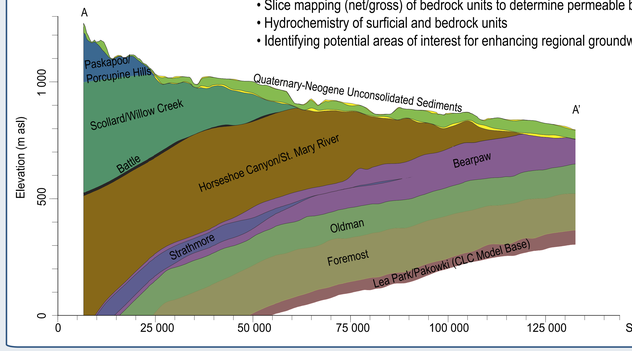


Average annual recharge: 24 mm (0-122 mm range)

- Very little recharge in the CLC (concurs with previous studies on Canadian Prairies)
- Highly variable year to year, and occurs mainly between April and June as snow melts and ET is lower
- Occurs on higher permeability soils and sediments (e.g. C2 Quaternary-Neogene units)

Ongoing Work

- Grounded in the geological framework for the CLC we are focusing on the hydrogeological flow systems in surficial and bedrock units, including:
  - Mapping potentiometric surfaces and vertical gradients for bedrock units
  - Slice mapping (net/gross) of bedrock units to determine permeable bodies (potential aquifers)
  - Hydrochemistry of surficial and bedrock units
  - Identifying potential areas of interest for enhancing regional groundwater monitoring program



Acknowledgments

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