



**Geological Survey of Canada
Scientific Presentation 119**

**Public presentations of October 14, 2020:
Groundwater Geoscience Program, current status of research for the 2019-2024
program cycle**

N. Jacob, H.A.J. Russell, B. Brodaric, C. Rivard, D. Paradis, and N. Benoît

2021

Public presentations of October 14, 2020: Groundwater Geoscience Program, current status of research projects for the 2019-2024 program cycle

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<https://doi.org/10.4095/327583>

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Groundwater Geoscience Program (GGP)

Public presentation of project plans for 2019-2024

On October 14, 2020 all project leaders under the GGP intended to present virtually the status of their research to all NRCan employees wanting to attend. Due to technical difficulties the event was cancelled.

All five of the PowerPoint presentations prepared for this event are included in this synthesis and the pre-recorded presentations can be seen on YouTube via this link:

<https://www.youtube.com/channel/UCH1c7ff3vEdII708VhgsLsg>

Key words: groundwater classification, methods development, groundwater portal, characterization, shallow aquifers, Fox Creek, water resource, modelling, Ring of Fire and assessment.

Groundwater Geoscience Program (GGP)

Public presentations for the 2019-2024 program cycle

- p. 5 - 24 Hazen Russell, Geological Survey of Canada/ **Archetypal Aquifer Project – Consolidating 25 years of GSC Groundwater work**
- p. 25- 41 Boyan Brodaric, Geological Survey of Canada / **Groundwater Information Network (GIN)**
- p. 42 - 55 Christine Rivard, Geological Survey of Canada / **Characterization of Shallow Aquifers and Assessment of Potential Impacts of Oil and Gas Development Activities on these Aquifers in the Fox Creek Area (AB)**
- p. 56 - 61 Daniel Paradis, Geological Survey of Canada / **Water Resources Characterisation and Modelling (WRCM) Project**
- p. 62 - 75 Nicolas Benoît, Geological Survey of Canada / **Ring of Fire: Reconstructing Long-Term Environmental Records to Support Regional Assessment**
- p. 76 Program contacts





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Archetypal Aquifer Project

Consolidating 25 years of GSC groundwater work

Groundwater Geoscience Program 2019-2024

Hazen A.J. Russell

Geological Survey of Canada hazen.russell@canada.ca



GGP: 2020-10-14

Canada

Abstract



Glacial sedimentary aquifers are the most commonly exploited groundwater resource in Canada. To better understand regional groundwater supply issues the Geological Survey of Canada (GSC) has been completing groundwater studies in glaciated terrains for over 25 years. It has predominantly focused work on 30 key Canadian aquifers. There is a need to consolidate and synthesis knowledge from numerous case studies and the broader literature within a framework.. This project will address a **classification for groundwater in glacial settings, consolidate data and knowledge** for those settings, and **collect new data** as necessary. **Analysis and modelling** will enhance existing information in the published literature. To ensure the relevance and ability to support the broader Canadian groundwater community **methods developments** continues in a number of areas. **Communication** of results is critical and the project is embracing traditional avenues and also through participation in the Groundwater Project and contribution to international and provincial Webinars.



Acknowledgements



LMS Project Participants

S. Alpay

R. Knight

N. Benoit

S. Larmagnat

B. Brodaric

C. Logan

M. Bunn

G. Oldenborger

H. Crow

D. Paradis

J. Crowley

M. Parent

B. Dietiker

A. Pugin

M. Hinton

D. Sharpe

Private Sector

S. Frey
(Aquanty)

Collaborators

Universities of Ottawa, Guelph (G360),
Western, Waterloo

Ontario Oil Gas and Salt Resources Library

CanMet Energy

Toronto Regional, South Nation, and Rideau
Valley conservation authorities

York University

Collaborative Funding

Agriculture and Agrifoods Canada

City of Ottawa

Ontario Independent Energy System

Operators (IESO) (proposal in review)



Outline



1. Science Objectives
2. Project activities
3. Alignment with Strategic Directions
4. Activities
5. Summary



Project Science Objectives



- (OB-1) **Classification:** scheme for surficial aquifers that integrates three essential components, reservoir, confinement, and hydraulics (quality, quantity, and flow).
- (OB-2) **Knowledge Consolidation:** collation and analysis of knowledge and identifications of gaps in groundwater geoscience to support OB-1.
- (OB-3) **Data Collection:** data for identified gaps (OB-2) in the knowledge of groundwater settings in glacial sediment
- (OB-4) **Methods Development:** to ensure the necessary geoscience support is available for continued improvement of groundwater geoscience studies and to address data gaps identified in OB-2.
- (OB-5) **Communication:** S&T communication via GSC publications, journal publications, meetings (conferences, workshops) and social media.
 - Contribute to an international synthesis of groundwater knowledge the Groundwater Book Project (lead: John Cherry, University of Guelph)





Project Activities

- 1. Aquifer Classification and Archetypes (OB-1)**
- 2. Archetypal Aquifer Characterization (OB-2 and 3)**
 1. Legacy Data Consolidation
 2. Champlain Sea Mud Aquitard,
 3. ATEs study CANMET Energy
 4. Groundwater–Surface-water modelling
- 3. Methods Development (OB-4)**
 1. Field Laboratories
- 4. S&T Communications (OB-5)**
 1. Groundwater E book Contribution
 2. Webinars



Alignment – Strategic Directions

NRCan strategic priorities	LMS strategic directions	Ongoing LMS program areas	Current LMS programs (funded through Treasury Board)*	Planned LMS strategic initiatives	Regulatory responsibilities
Improving market access and competitiveness in the natural resource sectors	Enhance economic development and competitiveness	Provision of federal leadership in the minerals and metals sector	Emergency Management Strategy (\$38M, 2023–24)	Canadian Minerals and Metals action plans**	International Boundary Commission Act
Protecting Canadians from the impacts of natural and human-induced hazards	Assert Canada's global leadership***	Geoscience to keep Canada safe	Adapting to Climate Change (\$31M, 2020–21; \$3M ongoing)	Critical minerals strategy	Explosives Act and Regulations
Accelerating the development of clean technology and supporting the transition to a low-carbon future	Develop community and regional capacity***	Climate change adaptation	Building Regional Adaption Capacity and Expertise (\$17M, 2021–22)	Battery initiative	Canada Lands Surveys Act
Ensuring our decisions and actions are grounded in transparent and robust science	Drive Canada's science, technology and innovation ecosystem	Explosives safety and security	Enhancing Explosive Safety – regulatory measures (\$7M, 2021–22; \$2M ongoing)	Next generation geoscience***	Resources and Technical Surveys Act
Strengthening relationships and advancing reconciliation with Indigenous peoples	Improve environmental performance	Green mining innovation	Geo-mapping for Energy and Minerals Program (\$185M, 2019–20)	TerraCanada****	Extractive Sector Transparency Measures Act
Internal services	Increase the participation of Indigenous peoples	Geological knowledge on Canada's onshore and offshore land	The United Nations Convention on the Law of the Sea (\$68M, 2023–24)	The strategic initiatives complement the ongoing LMS program areas	Export and Import of Rough Diamonds Act
<ul style="list-style-type: none"> - management and oversight - policy development - planning and reporting - communications - financial management - intellectual property 	<ul style="list-style-type: none"> - human resources - legal services - information management - information technology - real property management - materiel management 	Geoscience for sustainable development of natural resources	Targeted Geoscience Initiative (\$20M, 2019–20)	<ul style="list-style-type: none"> * Dates represent the end of program funding ** Applies to all strategic directions *** These items apply to both the first and second NRCan strategic priorities **** Applies mainly to the fourth strategic direction, but supports all of them 	Donkin Coal Block Development Opportunity Act
		Canada-US international boundary treaty	Cumulative Effects (\$14M, 2022–23)		
		Polar Continental Shelf Program	Marine Conservation Targets (\$9M, 2019–20)		
		Canadian geodetic survey	Impact Assessment (\$5M, 2022–23)		
		Canada Lands Survey	International Boundary Commission (\$4M, 2018–19; \$2M ongoing)		
			Polar Continental Shelf Program (\$9M, 2020–21)		
			Building on the successes of First Nations land management impact assessment (\$13M, 2022–23)		
			Comprehensive Land Claims (\$3M, 2021–22; \$500K ongoing)		

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1. Aquifer Classification and Archetypes



Applied Ontology 0 (0) 1
IOS Press

Water Features and Their Parts

Boyan Brodarcic ^{a,*}, Torsten Hahmann ^b and Michael Gruninger ^c

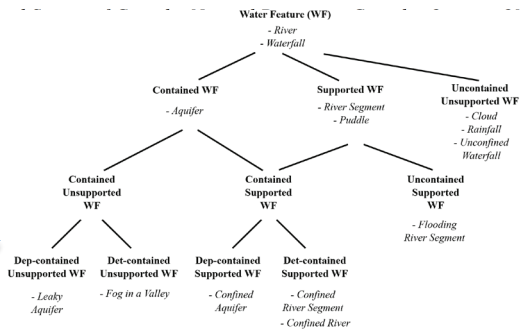


Fig. 4. Water feature taxonomy using containment, support and dependence as differentiae.

- Plethora of local examples
- Need to consolidate information and distill characteristics
- Create a model or archetype
- To provide
 - A Norm
 - Framework for future work
 - Prediction
 - Guide in areas of sparse data

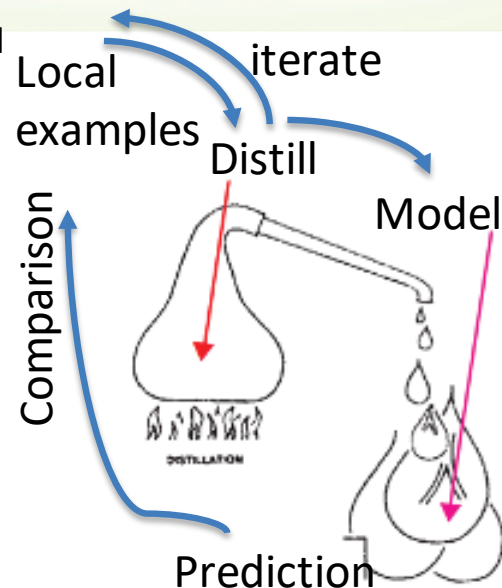


Table 2. Terminology and concepts for petroleum and groundwater plays in unconsolidated sediment

Petroleum play	Groundwater play	Comments
Source (charge)	Hydrology	"Hydrology" integrates precipitation, evaporation/transpiration, infiltration, recharge and discharge.
Reservoir	Aquifer	defined by formative process, most commonly the depositional setting
Seal	Confining units	Aquitard units.
Trap		Hydrostratigraphic architecture.

Sediment-aquifer play types in a list of 30 key Canadian aquifers

Russell, H.A.J.¹, Sharpe, D.R.¹, and Cummings, D.C.²
¹ Geological Survey of Canada, 601 Booth St. Ottawa, ON., K1A 0E8
² DC Geosciences, 12 Decarie Street, Aylmer, QC. J9H 2M3





2. Archetypal Aquifer Characterization

Highlight 4 Activities

1. Legacy Data Consolidation
2. Champlain Sea Mud Aquitard,
3. Aquifer Thermal Energy Storage (ATES)
4. Groundwater–Surface-water modelling



2.1 Legacy Data Compilation

Key Canadian Aquifers



730



ARTICLE

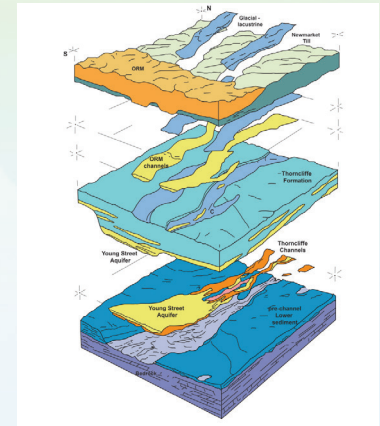
Conceptual hydrogeological model of the Yonge Street Aquifer, south-central Ontario: a glaciofluvial channel-fan setting¹

Richard E. Gerber, David R. Sharpe, Hazen A.J. Russell, Steve Holysh, and Esmaeil Khazaei

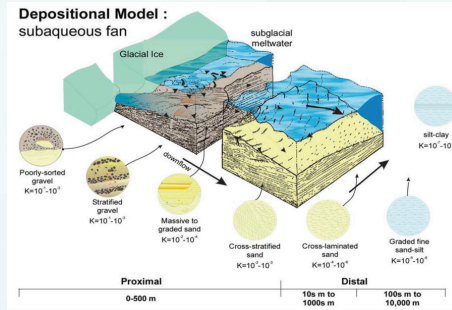
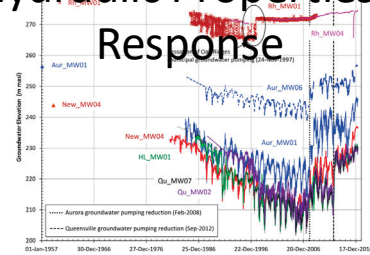
Cordillera	Western Canada Sedimentary Basin	Southern Ontario	St Lawrence Platform	Appalachians
1. Gulf Islands (br)	6. Paskapoo (br)	12. Intertill (s)	18. Oak Ridges	23. Annapolis – Cornwallis (br-s)
2. Nanaimo Lowland (br-s)	7. Buried Valleys (s)	13. Manitoba Carbonate Rock (br)	19. Grand River Basin (br-s)	
3. Fraser Lowland (s)	8. Upper Cretaceous Sand (br)	14. Manitoba Basal Clastic unit (br)	20. Credit River (br-s)	
4. Okanagan Valley (s)	9. Milk River (br)	15. Odanah Shale (br)	21. Waterloo Moraine (s)	
5. Shushwap Highlands (br)	10. Judith River (br)	16. Sandilands (s)	22. Upper Thames River (br-s)	
	11. Eastend – Ravenscrag (br)	17. Assiniboine Delta (s)	25. Mirabel (br-s)	
			26. Châteauguay (br-s)	
			27. Richelieu (br-s)	
			28. Chaudière (br-s)	
			29. Maurice (s)	
			30. Portneuf (s)	
				Maritimes Basin
				24. Carboniferous Basin (br)

Architecture / Confining Units

Aquifer Facies / Physical Properties



Hydraulic Properties / Response

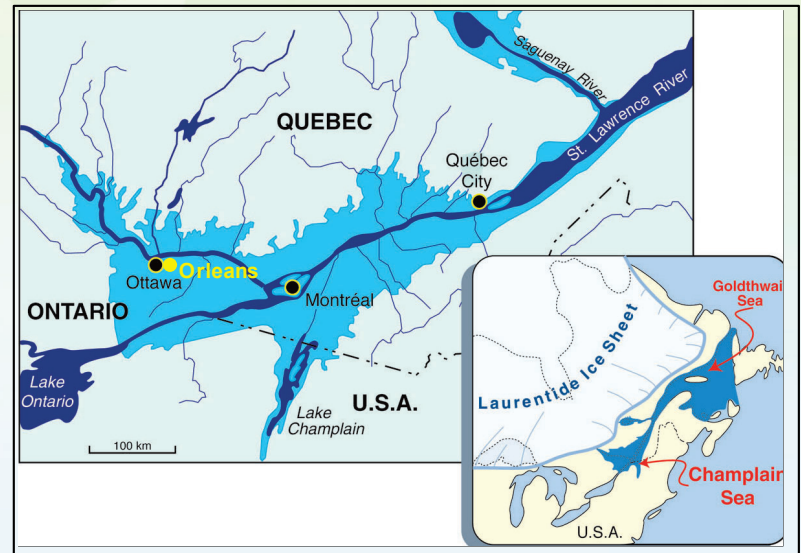


2.2 Champlain Sea Aquitard



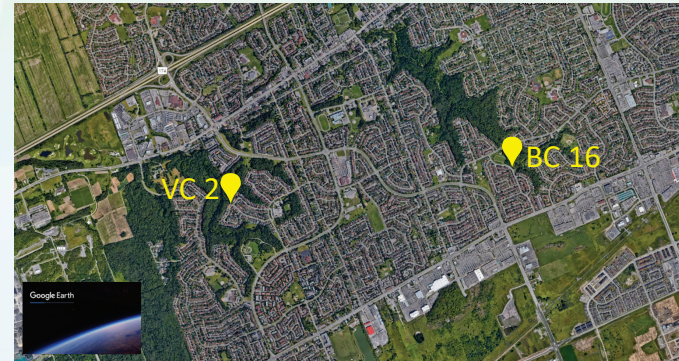
Lead: Hinton and Alpay

- Champlain Sea sediments of eastern Canada
- Societal concern regarding
 - Retrogressive landslides and
 - Aquitard integrity in an area of intense agriculture



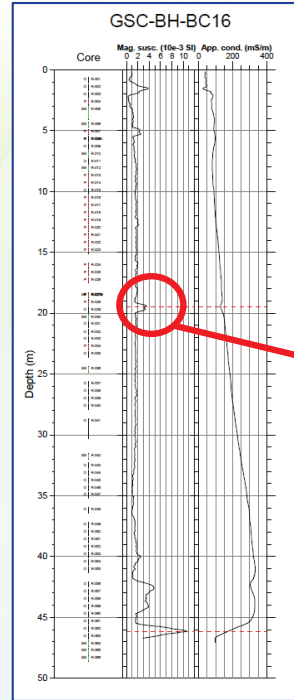
2.2 Champlain Sea Aquitard

- Champlain Sea sediments of eastern Canada
- Societal concern regarding
 - Retrogressive landslides and
 - Aquitard integrity in an area of intense agriculture
- Local example is the Lemieux landslide in the South Nation River watershed
- Study sites in Orleans Bilberry Creek

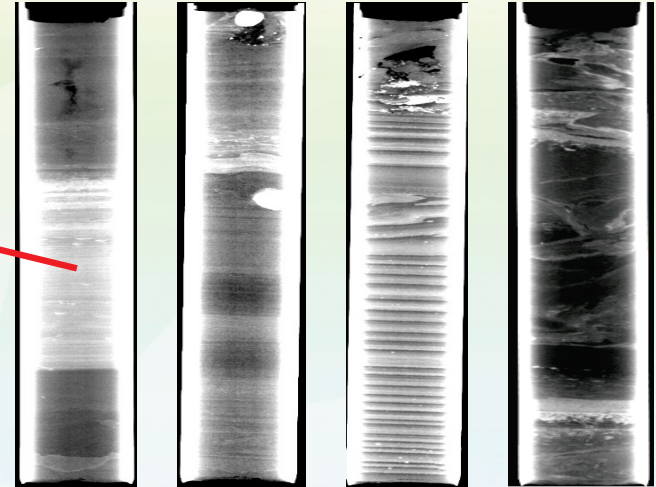


2.2 Champlain Sea Aquitard

- Retrogressive landslides, Aquitards, and groundwater
- Sensitive sediment, salinity, sand horizons
- Pore water character and sedimentology of Champlain Sea Muds



Geophysics



CT scans

2.4 York University ATES Study



Lead: Djebbar (CANMET)

- Basin analysis approach for ATES site evaluation at York University
- Characterize stratigraphy and heterogeneity with 3-component seismic reflection
- Borehole characterization with lithological borehole geophysics, temperature and Borehole Magnetic Resonance tool
- Assessment of regional suitability based on southern Ontario geological framework

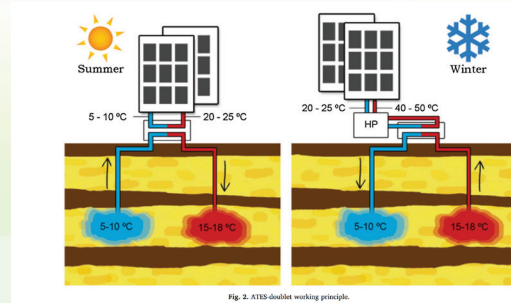


Fig. 2. ATES doublet working principle.

Basic scheme of ATES system. Blomendal et al 2018.

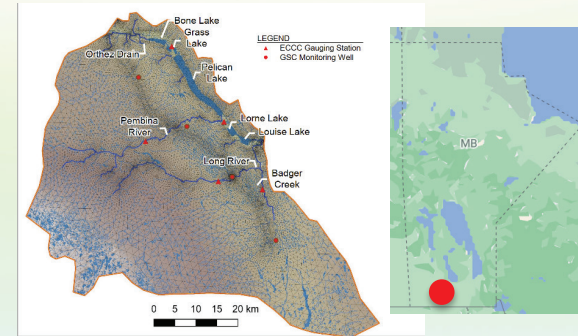


2.3 Groundwater Modelling



Participants: Bunn, Crowley and Frey

- Spiritwood transboundary setting, MB. Bedrock buried valley, low-recharge, low-gradient.
- South Nation
 - Part of AAFC ECO2 project
 - Supporting aquitard characterization, hydrostratigraphy and modelling of impact of agricultural practices
- Great Lakes –S-Ontario GRACE: Water balance and partitioning

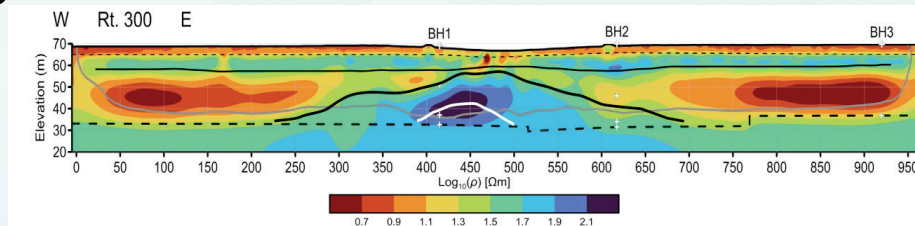


3. Methods Development



Participants: Crow, Dietiker, Knight, Larmagnat, Oldenborger, Paradis, Pugin

1. Field Laboratory sites
2. BMR: borehole magnetic resonance
3. CTscan analysis to support BMR work
4. Seismic data processing
5. Resistivity survey
6. pXRF protocol
7. Passive Seismic techniques



Resistivity

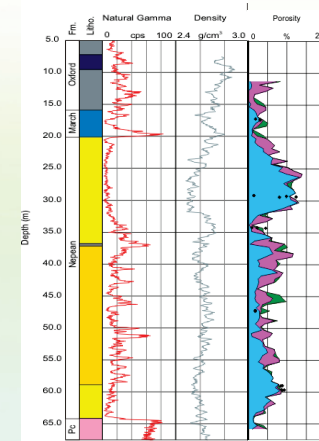


3.1 Field Laboratories



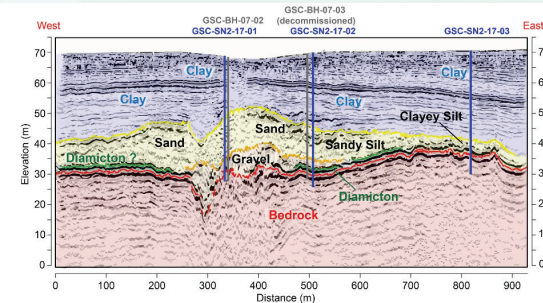
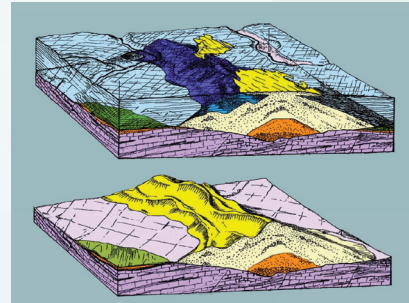
Fractured bedrock: Bells corner facility

- Downhole geophysics in Paleozoic and Precambrian bedrock
- National calibration facility
- G360 collaboration BAFF facility



Embrun Esker site: Vars–Winchester Esker in clay basin,

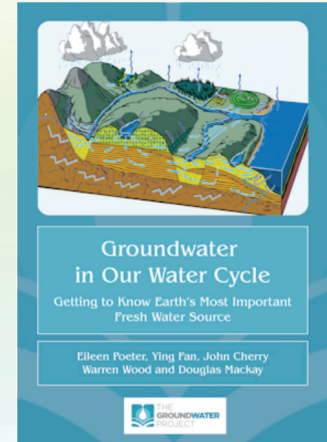
- Hydrogeophysics test site
- Multiple geophysical datasets
- Detailed hydraulic tests



S&T Communication: Groundwater Project



- Chapter reviews –
- Chapter contributions –
 - Groundwater in glacial terrains
 - Glaciomarine aquitards
 - Geophysics for hydrogeology (Borehole)
 - Principal Aquifers – Oak Ridges Moraine
 - Figures: Canada's Groundwater Resources (Rivera)



Graphic from
Hinton 2014

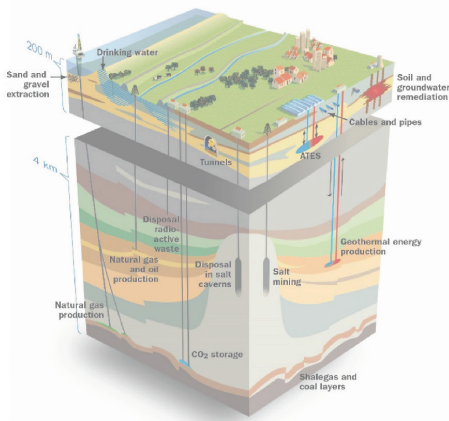
<https://gw-project.org>



S&T Communication



Responding to Societal Needs with 3D Geology: An International Perspective



Part 1: 3D Geoscience

17 November 2020

10:00-11:45 AM EST

Part 2: 21st Century Challenges

19 November 2020

10:00-11:45 AM EST

More information and registration at
[www.americangeosciences.org/webinars/
responding-societal-needs-3d-geology](http://www.americangeosciences.org/webinars/responding-societal-needs-3d-geology)

Adapting to lessons
learned via COVID to
improved online delivery
via Webinars

Sixth southern Ontario (OGS,
CO, GSC) workshop will be
online in February 2021

Sponsored by the World Community of Geological Surveys (WCOGS) and hosted by the American Geosciences Institute.



<https://www.americangeosciences.org/webinars/responding-societal-needs-3d-geology>

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Summary

- Consolidating 25 years of GSC groundwater studies
- Completing data gap infill for selected groundwater settings
- Adapting knowledge to new opportunities (ATES) and more regional challenges (Great Lakes, S-ON)





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Groundwater Information Network

GIN

Réseau d'Information sur les Eaux Souterraines

Boyan Brodaric & GIN Team

October 14, 2020



ABSTRACT

• Groundwater Information Network

Fed-prov-terr-int'l collaboration to share groundwater data online, using international standards; aligned with FGP, GOC Open Data and Open Science, Google Dataset Search.

Third program cycle, since 2010.

<https://gw-info.net>

The screenshot shows the homepage of the Groundwater Information Network (GIN). The header includes the GIN logo and the text "Welcome to GIN". Below this, a paragraph describes the network's purpose: to improve knowledge of groundwater systems and enhance management through increased access to information. It lists various data sources and collaborating provinces and territories, as well as international partners like the USGS.

The main content area is divided into several sections:

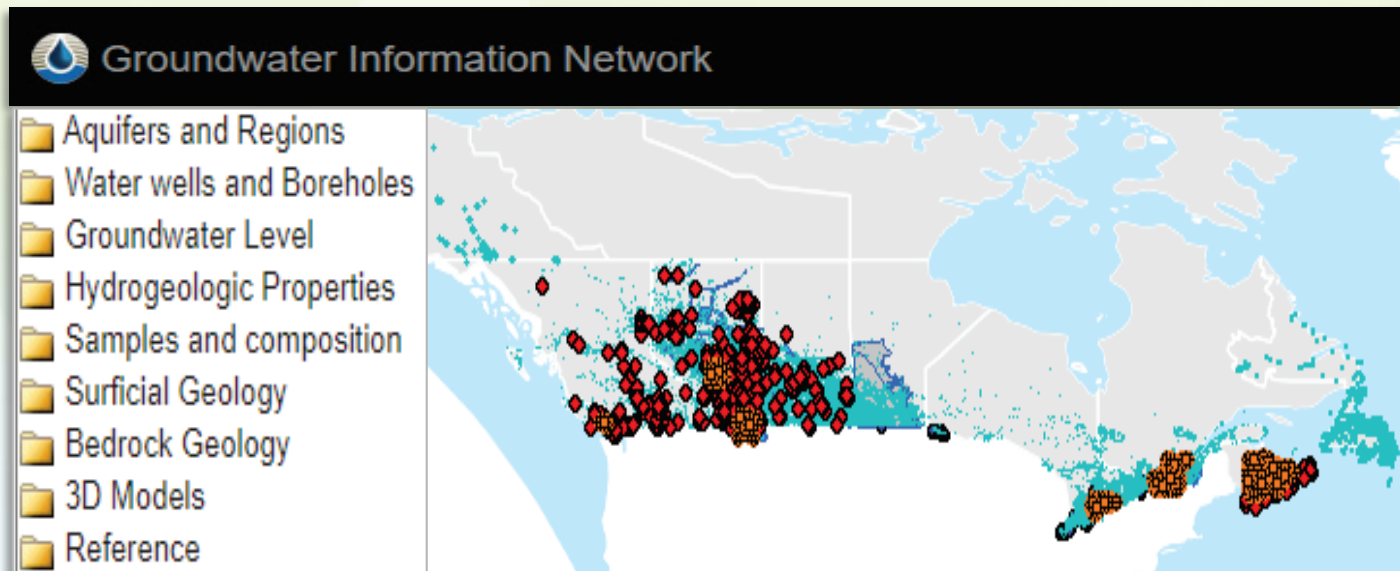
- Explore Maps:** Offers a basic map viewer and an advanced 3D viewer.
- Find Information:** Includes search boxes for water wells, Canadian aquifers, and other groundwater information.
- News:** Features a "Stay informed through our news feeds" section with a "GIN RSS News Feed" link. A recent news item highlights the recognition of the GroundwaterML 2 (GWM2) standard as an Open Data standard.
- Under the Hood:** Lists reusable GIN tools for incorporation into other web sites or applications, such as the GIN Catalog, Well-Log Viewer, Time-Series Viewer, and Data Standards.
- Partners:** Lists the success of the GIN network as a result of collaboration with provincial, territorial, and federal stakeholders, including Yukon, British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, Nova Scotia, Canada, and USGS.
- Contact Us:** Provides a link to an online form for general enquiries or technical issues.

The footer of the page includes the copyright notice "© Groundwater Information Network 2014" and a navigation bar with icons for home, search, and other site functions.

2015-2019 GIN Highlights

DATA SHARING national

- **GIN**
national
data
network



YK BC* AB SK* MB ON QC NS* NL* + FGP + OGP

*new well or monitoring data 2015-2019

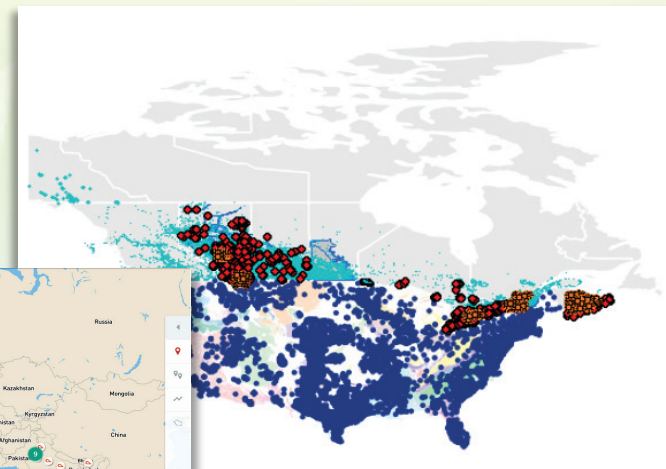
2015-2019 GIN Highlights

DATA SHARING international

- **GIN**
international
data network



IGRAC-UNESCO Global
Groundwater Monitoring Network



US Nat'l GW
Monitoring
Network

2015-2019 GIN Highlights

WEB PORTAL


- **GIN online**

<https://gw-info.net>

1000-1400 users / mth

25000-30000 sessions / yr

2100-2600 data downloads / yr

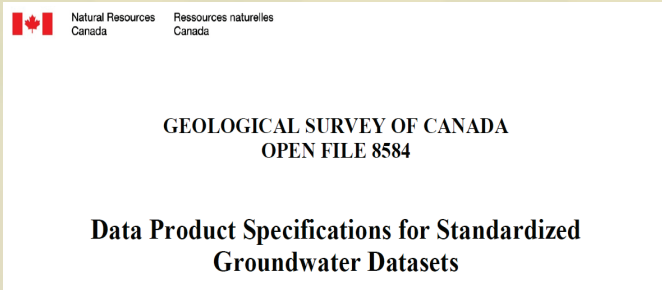
Country	Sessions	% New Sessions
 Canada		
Sep 22, 2019 - Sep 21, 2020	12,445	38.82%
Sep 22, 2018 - Sep 21, 2019	15,013	45.89%
 United States		
Sep 22, 2019 - Sep 21, 2020	4,272	46.70%
Sep 22, 2018 - Sep 21, 2019	5,527	44.33%
 France		
Sep 22, 2019 - Sep 21, 2020	2,360	21.10%
Sep 22, 2018 - Sep 21, 2019	1,799	23.24%

2015-2019 GIN Highlights

STANDARDS

- GIN data standards development

1. GGP Data Standards

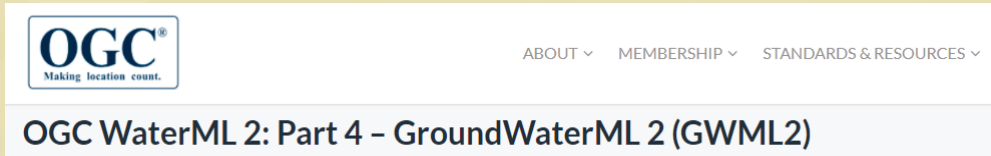


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**GEOLOGICAL SURVEY OF CANADA
OPEN FILE 8584**

**Data Product Specifications for Standardized
Groundwater Datasets**

2. OGC GWML2 revision

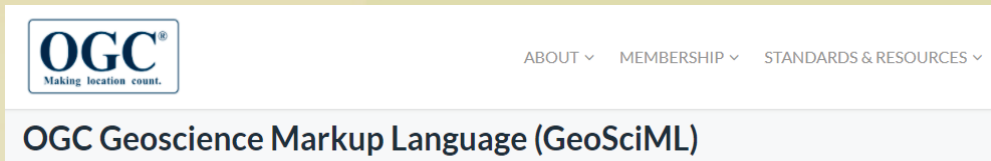


OGC
Making location count.

ABOUT ▾ MEMBERSHIP ▾ STANDARDS & RESOURCES ▾

OGC WaterML 2: Part 4 - GroundWaterML 2 (GWML2)

3. OGC GeoSciML adoption



OGC
Making location count.

ABOUT ▾ MEMBERSHIP ▾ STANDARDS & RESOURCES ▾

OGC Geoscience Markup Language (GeoSciML)

4. WMO submission



WORLD METEOROLOGICAL ORGANIZATION

Home About the e-Board HWRP **CHy-15 Pre-Session** Login

Standardized Data Sharing in Hydrology

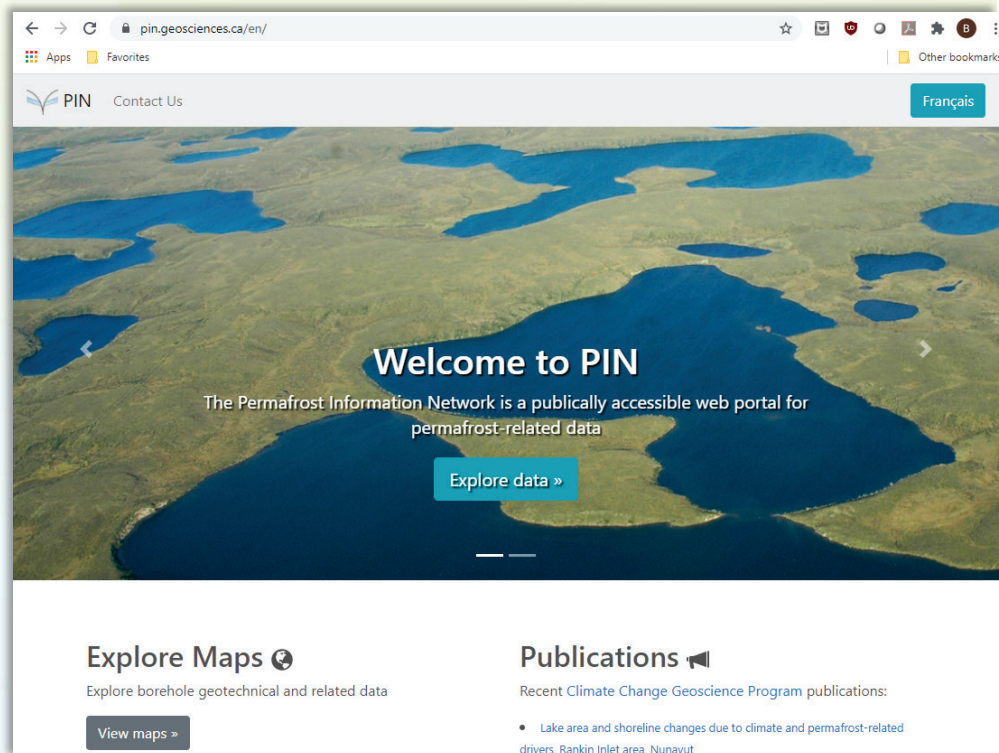
CHy-15 Pre-Session

2015-2019 GIN Highlights

TECH TRANSFER

- **PIN**
Permafrost
Information
Network

<https://pin.geosciences.ca>

A screenshot of a web browser displaying the homepage of the Permafrost Information Network (PIN). The browser's address bar shows the URL "pin.geosciences.ca/en/". The page features a large aerial photograph of a landscape with numerous lakes and ponds. Overlaid on the image is the text "Welcome to PIN" and "The Permafrost Information Network is a publicly accessible web portal for permafrost-related data". A blue button labeled "Explore data »" is positioned below the text. At the top right of the page, there is a "Français" button. Below the main image, the page is divided into two sections: "Explore Maps" with a globe icon and a "View maps »" button, and "Publications" with a speaker icon and a list of recent publications, including "Lake area and shoreline changes due to climate and permafrost-related drivers, Rankin Inlet area, Nunavut".

pin.geosciences.ca/en/

Apps Favorites

PIN Contact Us

Français

Welcome to PIN

The Permafrost Information Network is a publicly accessible web portal for permafrost-related data

Explore data »

Explore Maps 🌐

Explore borehole geotechnical and related data

View maps »

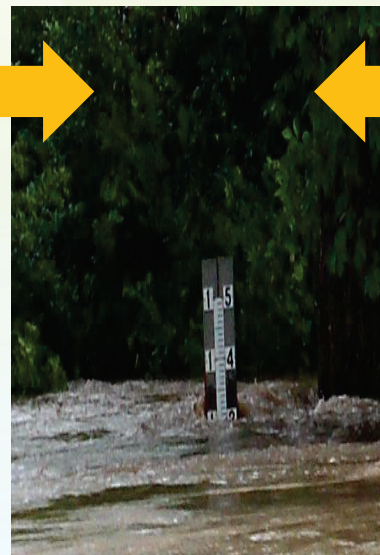
Publications 🔊

Recent Climate Change Geoscience Program publications:

- Lake area and shoreline changes due to climate and permafrost-related drivers, Rankin Inlet area, Nunavut

2015-2019 GIN Highlights

LINKED DATA linking water data across the water cycle



atmospheric water

gauges,...

Climate data

(<http://climate.weather.gc.ca>)

surface water

ivers, lakes, watersheds,...

Nat'l Hydro Network

(www.geobase.ca)

surface water

gauges,...

Nat'l Hydrometric Network

(www.wateroffice.ec.gc.ca)

groundwater

aquifers, wells, gauges...

GW Info Network

(www.gw-info.net)

2015-2019 GIN Highlights

LINKED DATA

- Cross-border pilot project (USGS-NRCan)
Linking groundwater and surface water data
- Federal Climate Change Science Plan
GOC Linked Open Data Pilot
- OGC EFLIE 1 and ELFIE 2
OGC Environmental Feature Linked Interop Experiments

2015-2019 GIN Highlights

LINKED DATA

- Discoverability with Google Dataset Search

The screenshot shows a Google Dataset Search interface. The search bar contains 'aquifers in canada'. Below the search bar are filters for 'Last updated', 'Download format', 'Usage rights', 'Topic', and 'Free'. The search results are displayed in a list format. The first result is 'Hydrogeological Units of the Paskapoo Formation' from gin.gw-info.net, updated on Dec 31, 2009. It offers download formats of dxf, gml, csv, json +2 and was updated on Jun 10, 2016. The second result is 'Hydrogeological Regions' from open.canada.ca, updated on Jan 26, 2017, with a zip, jp2 format. The third result is 'Annapolis Valley Hydrogeological Units' from gin.gw-info.net, updated on Jun 9, 2016, with a dxf, gml, csv, json +2 format. On the right side, a detailed view of the 'Hydrogeological Units of the Paskapoo Formation' dataset is shown, including a button to 'Explore at gin.gw-info.net', download format options, and metadata such as 'Dataset updated Jun 10, 2016', 'Dataset provided by Groundwater Information Network', 'Time period covered Dec 31, 2007 - Dec 30, 2008', and 'Area covered'. A description of the Paskapoo aquifer system is also provided.

Google Dataset Search results for 'aquifers in canada'.

Filters: Last updated, Download format, Usage rights, Topic, Free, Saved datasets

updated Dec 31, 2009

Hydrogeological Units of the Paskapoo Formation
gin.gw-info.net
dx, gml, csv, json +2
Updated Jun 10, 2016

Hydrogeological Regions
open.canada.ca
zip, jp2
Updated Jan 26, 2017

Annapolis Valley Hydrogeological Units
gin.gw-info.net
dx, gml, csv, json +2
Updated Jun 9, 2016

Hydrogeological Units of the Paskapoo Formation
Explore at gin.gw-info.net
dx, gml, csv, json, html, kml

Dataset updated Jun 10, 2016

Dataset provided by
Groundwater Information Network

Time period covered
Dec 31, 2007 - Dec 30, 2008

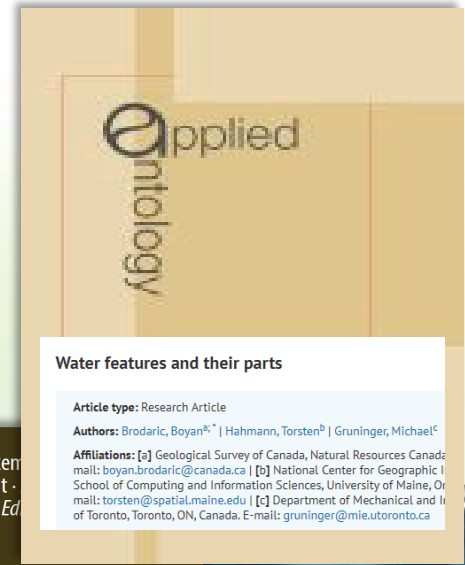
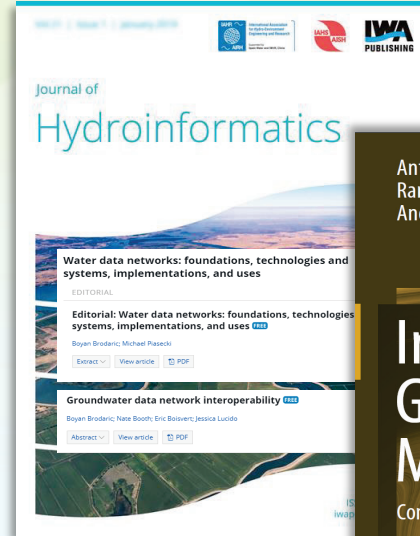
Area covered

Description
Paskapoo aquifer system is located in southern Alberta. It extends from Pincher Creek to a little northern than Whitecourt. The system follows the east side of the Rockies Mountains. The Formation consists of three geological units, creating discontinuous aquifers of isolated fluvial channels and other types of sand bodies with limited spatial continuity. The complex and heterogeneous sedimentary geology of the Paskapoo Formation creates highly variable physical

2015-2019 GIN Highlights

RESEARCH

- AI Knowledge Representation
re-conceptualizing water features
- Groundwater Data Interoperability
from SDI to Linked Data



Anthony J. Jaken
Randall J. Hunt
Andrew Ross Ed

Integrated Groundwater Management

Concepts, Approaches and Challenges

Springer Open



2019-2024 GIN Objectives

- **new** Web Portal
- **renewed** Data Network
- **toward** Internet of Water
- **advance** Standards
- **continue** Research

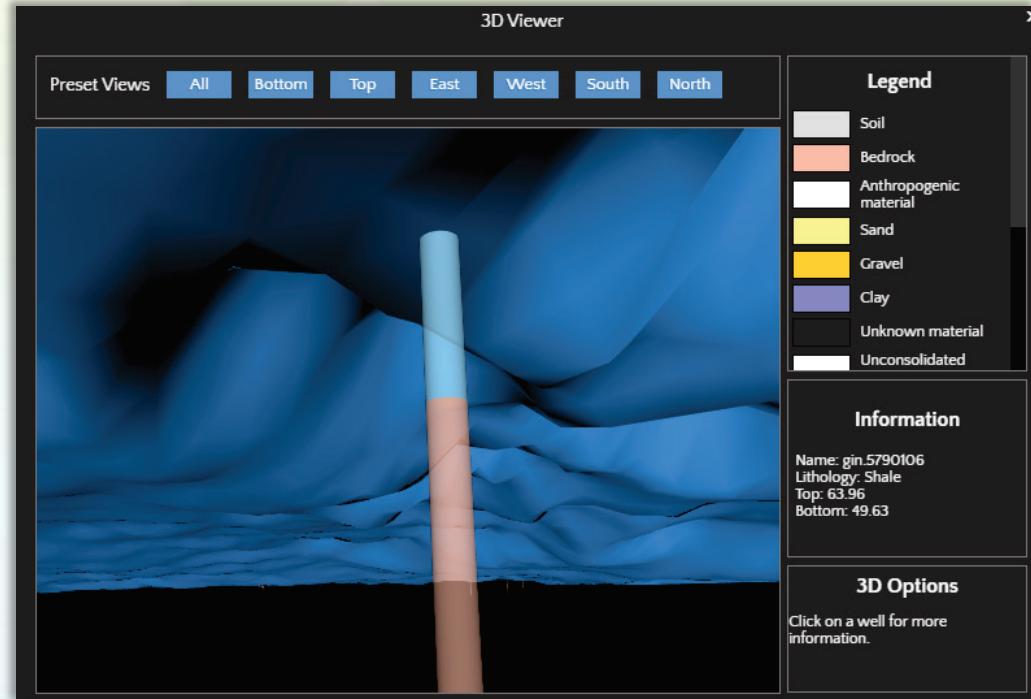


2019-2024 GIN Objectives

WEB PORTAL

- new user interface
 - advanced mapping application
- new tools
 - 3D / multi-param well viewer
 - aquifer dashboard
 - water level calculator

■ done ■ in progress ■ planned



2019-2024 GIN Objectives

DATA NETWORK

- renew partnerships
 - provinces, territories
- more data
 - updated, missing, real-time, GGP... data
- advance PIN
 - new user interface
 - support partnership expansion, e.g. PNet

■ done
 ■ in progress
 ■ planned

© Permafrost Information Network 2018
 — The Permafrost Information Network is a joint federal-territorial collaboration that seeks to increase ease of access to datasets from multiple collections and repositories

2019-2024 GIN Objectives

INTERNET OF WATER

- infrastructure

- web-centric

- partnerships

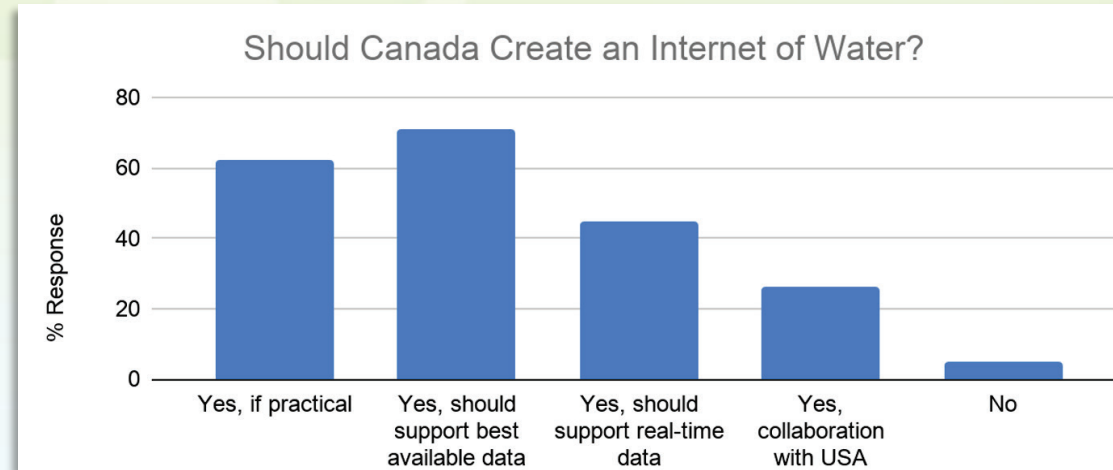
- US, CDN national collaborators

- semantic web AI

- linked data engine

■ done
 ■ in progress
 ■ planned

NHN Workshop 4 – July 2020



PROJECT MEMBERS



Groundwater Information Network
Réseau d'Information sur les Eaux Souterraines

- Boyan Brodaric
- Éric Boisvert
- Héryk Julien
- François Létourneau
- Étienne Girard
- Joost Van Ulden

CONTACT INFORMATION

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- <https://gw-info.net>

Thank you / Merci!



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Caractérisation des aquifères superficiels et évaluation des impacts potentiels liés aux activités pétrolières et gazières sur ces aquifères dans la région de Fox Creek (AB)

Characterization of shallow aquifers and assessment of potential impacts of oil and gas development activities on these aquifers in the Fox Creek area (AB)

Christine Rivard

October 14, 2020



ABSTRACT

A multidisciplinary and multi-institutional project was initiated in the **Fox Creek** area (west-central Alberta) in April 2019 to study environmental impacts of hydrocarbon development activities. **The initial objective** was to specifically **study potential impacts on shallow groundwater**. However, different Sectors within NRCan later identified the Fox Creek area as a region of interest for developing regional **cumulative effects evaluation methods** in support of new impact assessment legislation. Therefore, the project **scope is now much larger** and includes studies on vegetation, forest, snow cover, wetlands, landscape evolution and woodland caribou habitat. The project involves many collaborators from the federal and provincial governments, and academia. This project is supported by both the GGP and EGP programs and is also funded by the Cumulative Effects initiative.



Project members

(including EGP, GGP and Cumulative Effects)

C. Rivard¹, O. Haeri Ardakani¹, C. Paniconi², H. Crow¹, E. Konstantinovskaya³, B. Smerdon⁴, D. Lavoie⁵, J. Lovitt⁶, G. Bordeleau², A. Bahramiyarahmadi³, L.I. Guarin-Martinez^{1,2}, R. Chalaturnyk³, D. Alessi³, S. Safari³, K. von Gunten³, B. Xu.⁷, H. Kao¹, R. Lavoie⁸, P. Leblanc-Rochette^{1,8}, S. Heckbert⁴, D. Jiang¹, B. Giroux², A.C. Dip², I. Aubin⁹, D. Degenhardt⁹, J. Harvey⁹, S. Leblanc⁶, H.P. White⁶, S. Grasby¹

¹ *Geological Survey of Canada, Natural Resources Canada (NRCan);*

² *Institut national de la recherche scientifique – Eau Terre Environnement (INRS-ETE)*

³ *University of Alberta*

⁴ *Alberta Energy Regulator*

⁵ *Consultant*

⁶ *CCMEO, Natural Resources Canada*

⁷ *Northern Alberta Institute of Technology (NAIT)*

⁸ *Université Laval, École supérieure d'aménagement du territoire et de développement régional*

⁹ *Canadian Forest Service, Natural Resources Canada*

≈30 people

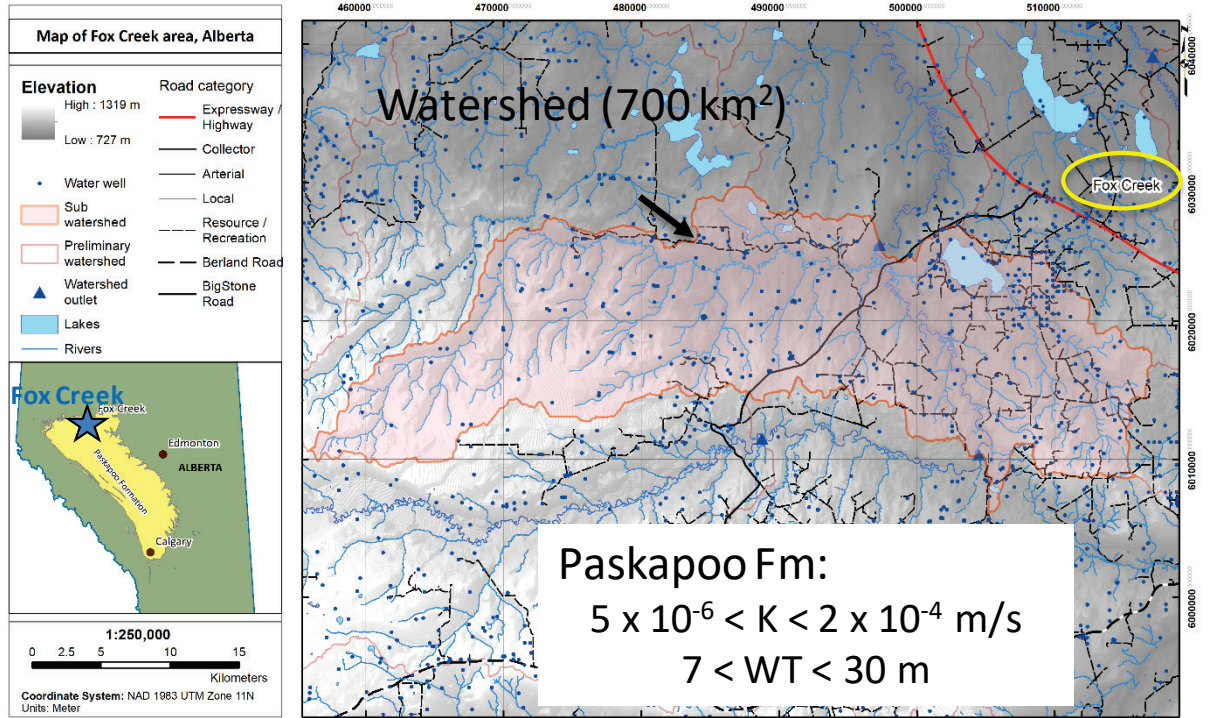
2 MSc students

2 PhD students



Description of the study area

Fox Creek, west-central Alberta: one of the most active regions for O&G production in Canada



The study area is mainly **forested** and unpopulated

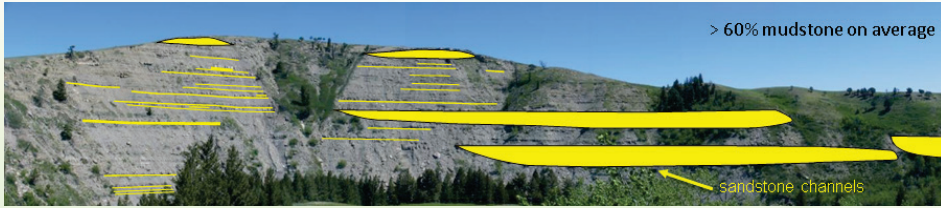
Elevations range from 785 to 1180 m

The regional aquifer is located in the **Paskapoo Fm.:** a complex succession of interbedded mudstone with sandstone channels



Project objectives

- 1) Characterize shallow aquifers (GGP)
- 2) Study the intermediate zone integrity (EGP)

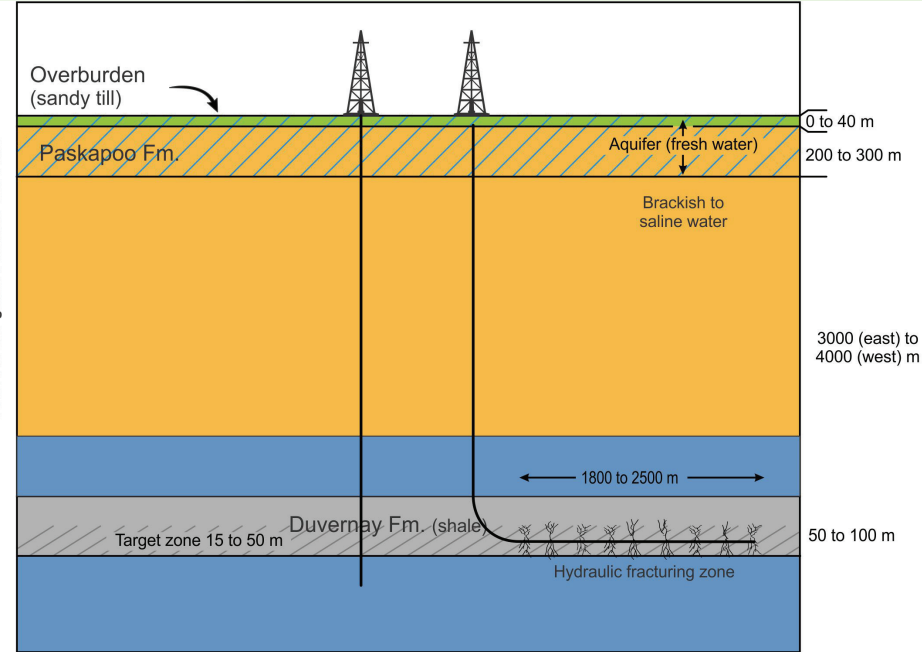
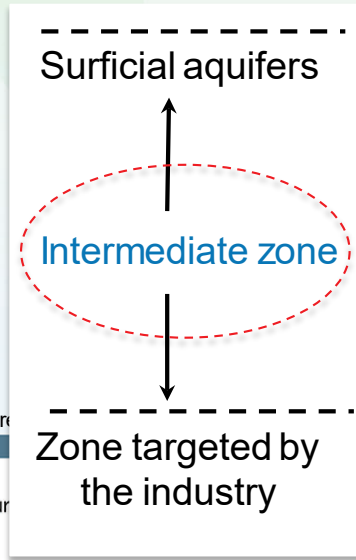


Paskapoo: the most important GW supply in the province

Mean water-well depth in the Paskapoo Fm: ≈50 m



Mean O&G well depth: ≈3500 m



Fieldwork in 2020

Drilling of 9 monitoring wells : depths from 35 to 90 m

- Rock (cuttings) sampling (with specific interests on rock heterogeneity and on eventual coal horizons for hydrocarbon source)
- Borehole geophysical logging
- Installation of pressure transducers
- Groundwater sampling for targeted compounds

Installation of a gauging station

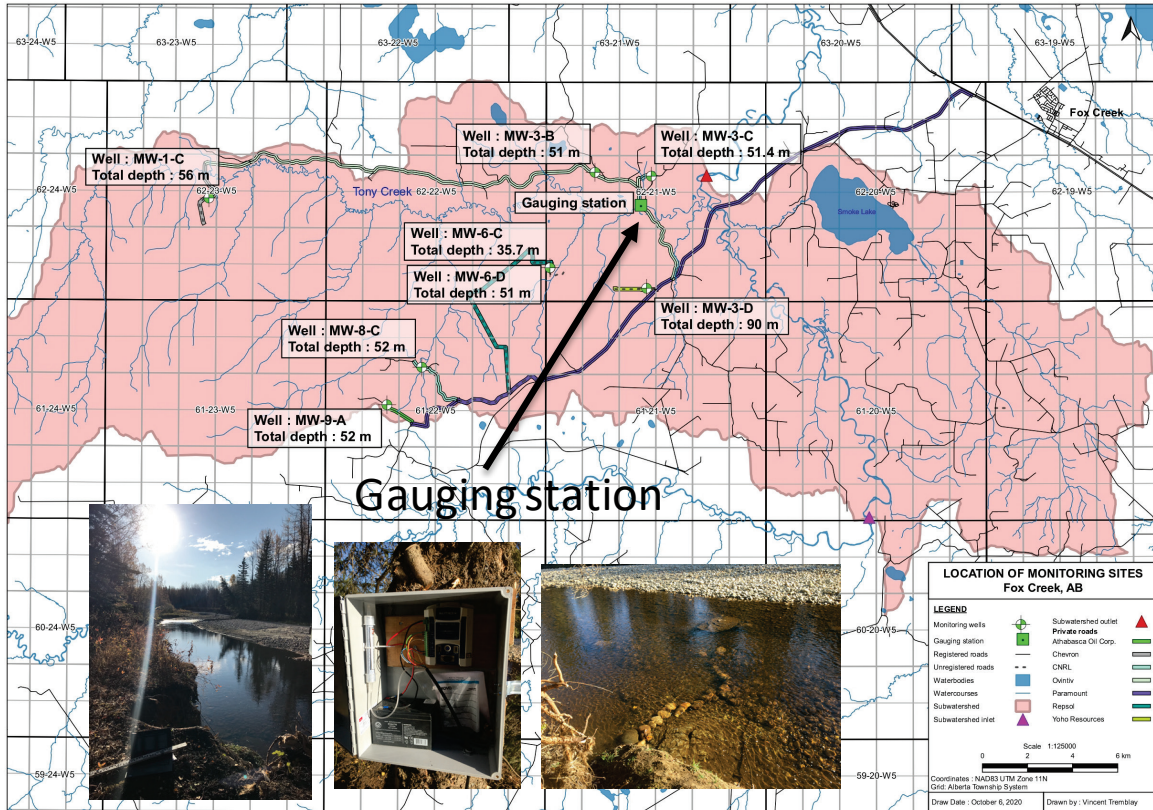
In 2021: Permeability tests (slug tests)

GW sampling for the complete series (cations, anions, trace metals, tritium, ^{14}C , $\delta^{13}\text{DIC}$ and various other isotopes)

GW monitoring (C_1 , C_2 and C_3 concentration and isotopic composition, and $\delta^{13}\text{DIC}$)



Fieldwork in 2020



8 wells drilled on Crown Land,
including a cluster well (MW-6)

+

1 well drilled on an active O&G
well pad

Each well very different!

- Depth to bedrock
- Water level
- % mudstone vs sandstone
- Number of fractured zones
- Number of flowing fractures
- Yield





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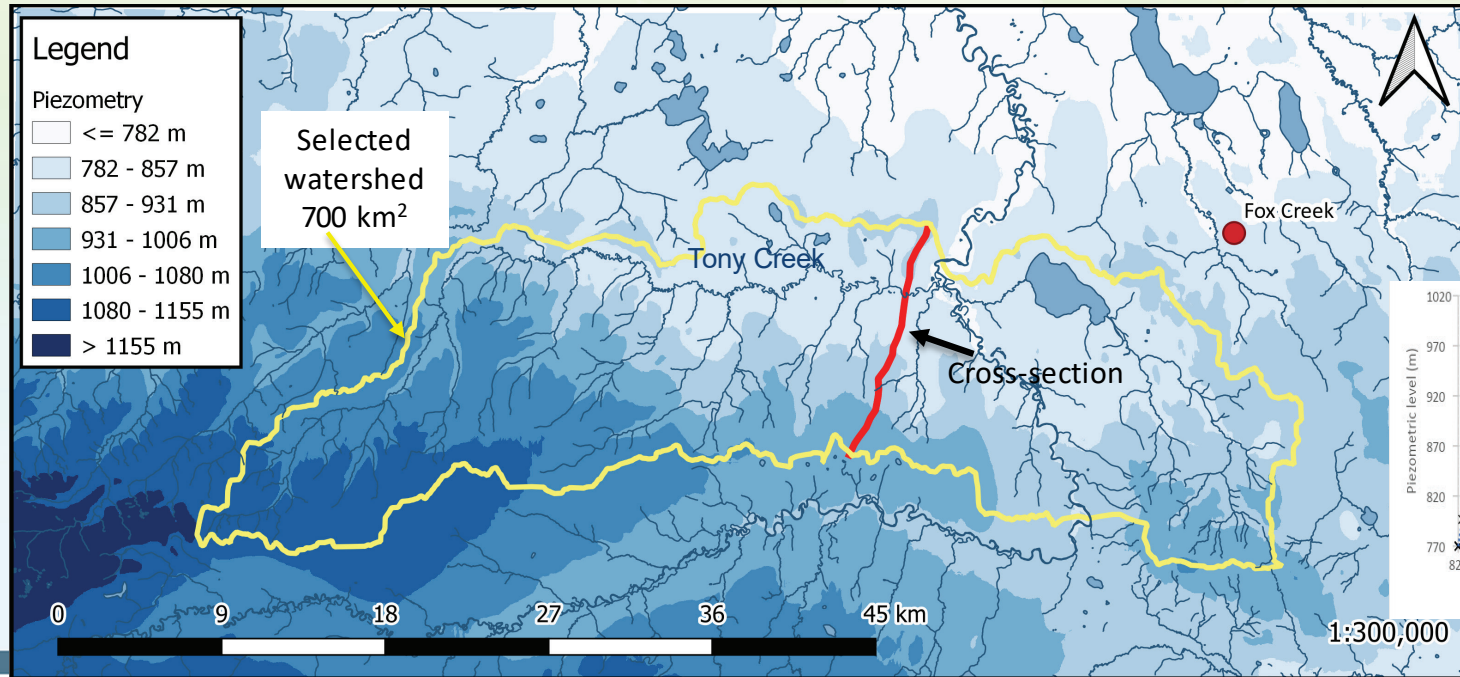
Preliminary results



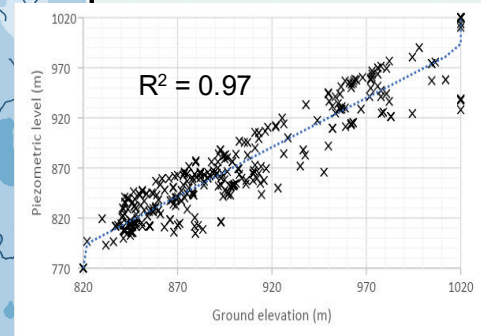
Canada 

Hydrogeological map

The **piezometric map** was obtained based on available water levels and topography (using kriging with an external drift).

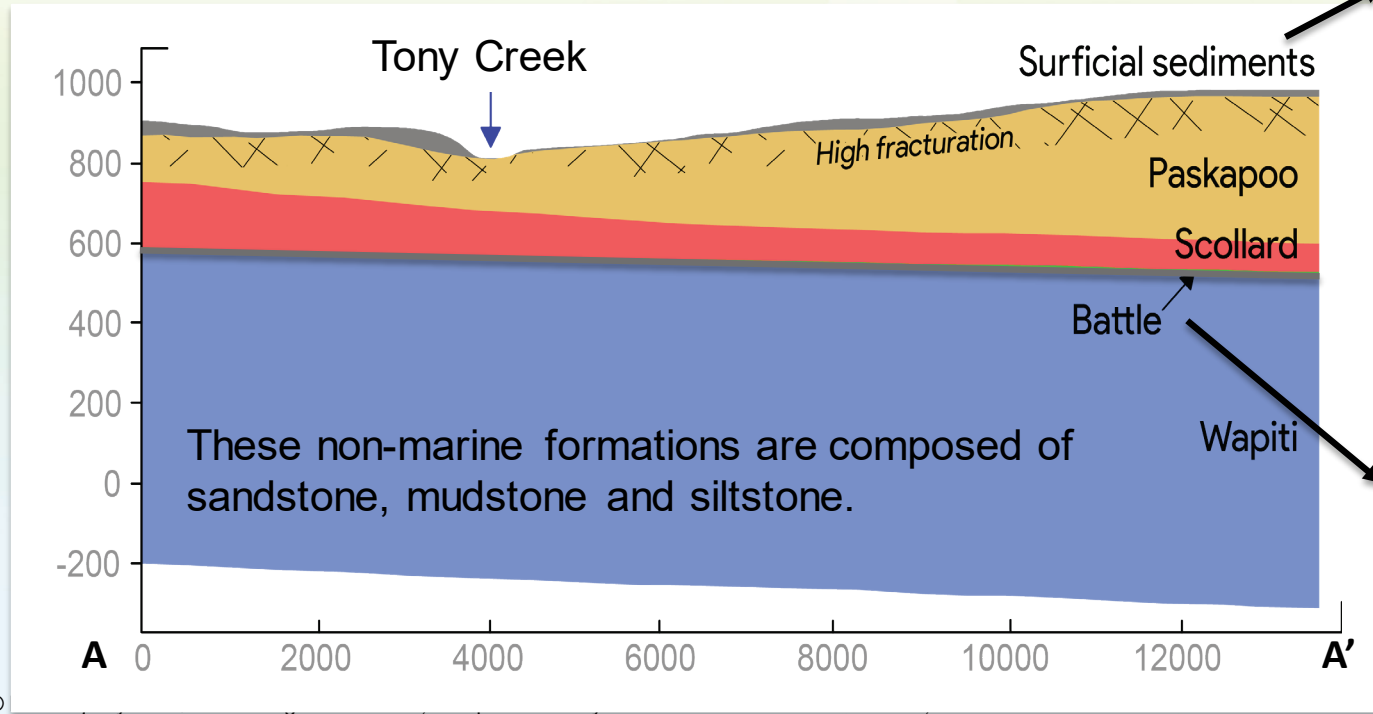


The **cross-section** for the 2D model is aligned with a groundwater flowpath.



2D hydrogeological model

Zoom on the upper 1st km



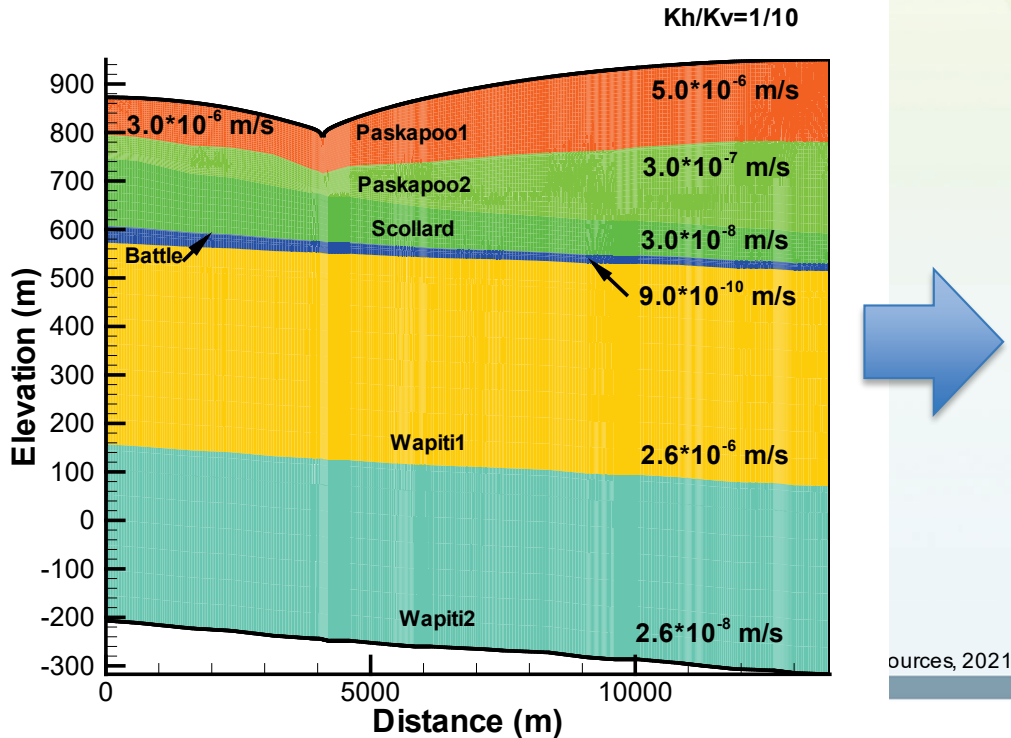
The surficial sediment cover is quite thin (typically < 10 m) and composed of coarse-grained sediments.

Battle Fm.: mudstone-dominated (nearly impermeable), very thin and discontinuous

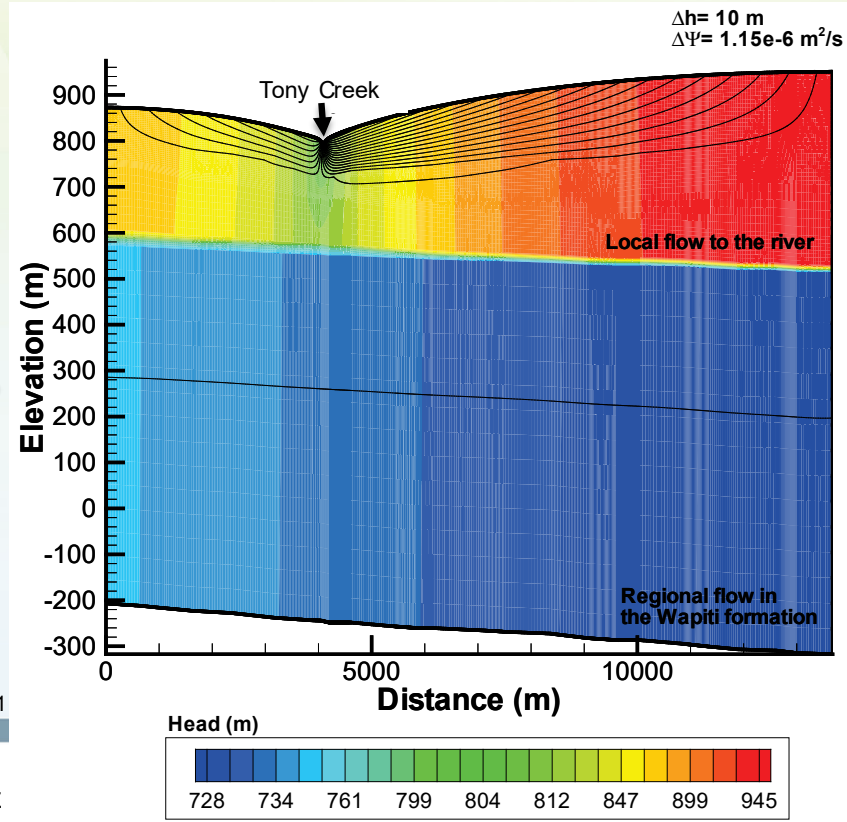


2D hydrogeological model

Values of hydraulic conductivity and porosity were found for each units, based on existing data



Hydraulic heads and flow lines

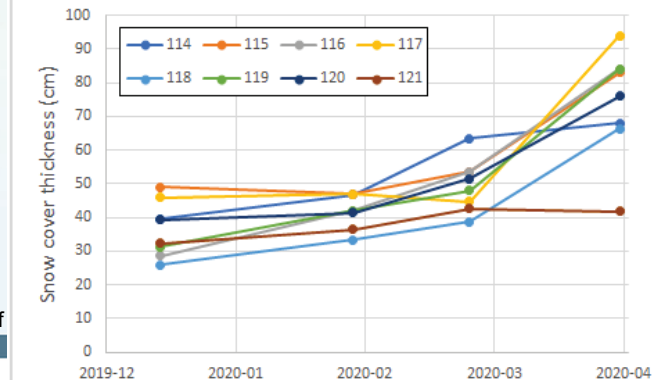
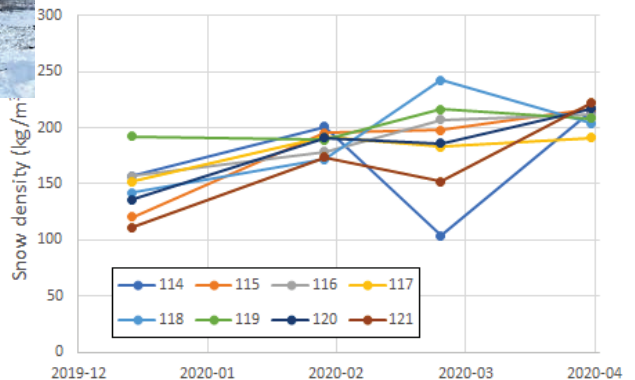


Snow study

7 sites + 2 reference (control) sites

Goal: to measure thickness of the snowpack, its density and to sample for snow chemistry

- Many elements correlate positively: all high concentrations appear together, with some exceptions for Zn and Pb
- The distance between a sampling site and the closest active gas well show high correlation with the element concentrations.



Activities for 2020-2021

- interpretation of borehole geophysical logging data ;
- definition of the **local stratigraphy** based on the lithostratigraphic logging of cores from new shallow monitoring wells drilled in the study area ;
- analysis of **hydrocarbon composition in rocks** from new monitoring wells ;
- **preliminary identification of source** (thermogenic or microbial) **and provenance** (geological unit) of **hydrocarbons present in groundwater**, if any.

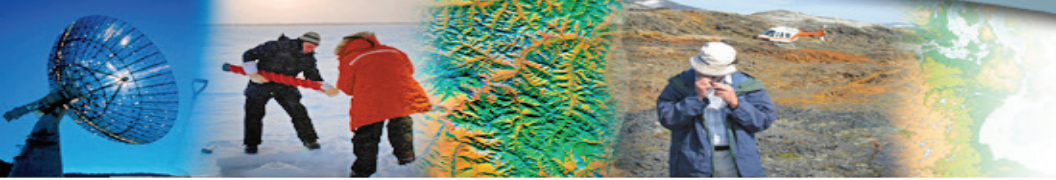


CONTACT INFORMATION

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THANK YOU!





NATURAL RESOURCES CANADA - INVENTIVE BY NATURE

Water Resources Characterisation and Modelling (WRCM) Project

Summary of the 2020-21 Mid-Year Activities

Daniel Paradis
October 14, 2020



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Abstract

The Water Resources Characterisation and Modelling (WRCM) Project is intended to **support hydrogeological studies** by the development of innovative approaches tailored to emerging issues threatening water resources across Canada. The Project has **scientific collaborations with public and private sectors** (e.g., governments, firms, and universities), to address specific issues related to **sustainable water resources management**, and to provide a **strong scientific base** to stakeholders involved in water management.

Recent advances include:

- Development of innovative methods for aquifer characterisation
- Advances in validation of satellite-base gravity data for water resources monitoring
- Hydrogeological modelling studies to better support water resources allocation and management

Scientific Collaborators

- Governments :
 - D. Paradis, H. Crow, E. Girard, V. Tremblay, J.-P. Drolet, H. Russell, G. Oldenborger, A. Pugin (GSC)
 - J. Crowley, H. Jianliang (CGS)
 - M. Ouellet, M. Chaussé, N. Roy, L. Ricard , S. Moore (MELCC); J.-F. Cyr, C. Malenfant (DEHQ)
 - C. Couegnas. M. Krimissa (EDF, France)
- Universities :
 - R. Lefebvre, E. Gloaguen, R. Martel, A. St-Hilaire, M. Claprood, J.-M. Ballard (INRS)
 - R. Therrien, C. Dupuis, H. Delottier (U. Laval); O. Bour, N. Lavenant (U. Rennes I, France)
- Private :
 - G. Plassart, P. Semaoune, A. Heude (Envisol, France); E. Grunewald (Vista-Clara); A. Germain (TechnoRem)
- Graduate Students :
 - L. Arzola, A. Nefzi, S. Gernez, M. Liang (PhD); R. Mathis (MSc)

Collaboration Highlights

- MELCC (Quebec) and EDF (France) **adopted the aquifer characterisation framework and methods** that were previously developed by the GSC for the remediation of their respective contaminated sites (VOC, DNAPL, radionuclide);
- Held a first provincial/GSC/University workshop on the comparison of SW and GW interaction modelling approaches to **improve the existing provincial modelling platform** of water resources forecasting;
- Joint research at GSC-INRS' Experimental Site (St-Lambert, QC):
 - Maintain **collaborations with research universities** to develop innovative characterisation approaches in hydraulics, geophysics and geothermal;
- In-kind funding:
 - 100k\$ for graduate student grants (INRS)
 - 600k\$ for specialized wells and professional services (MELCC)

Key Scientific Achievements/Progress

Innovative methods for characterisation and monitoring

- Numerical and field analysis to improve Kv testing in complex hydrogeological contexts (Paradis et al. in prep., *JHydrol*)
- Developed numerical and field data acquisition approaches to estimate aquifer K-anisotropy from electrical resistivity measurements (Gernez et al. 2020, *Comput Geosci*; Gernez et al. in prep, *Groundwater*)
- Sediments permeability from NMR data corrected for magnetic susceptibility (Crow et al., in prep, *Groundwater*)
- Make advances in the validation of satellite-based gravity data for water resources monitoring (internal report)

Hydrogeological modelling

- Implications of low-resolution regional modelling on river baseflow and groundwater residence time estimations (Abhervé et al., in prep., *Groundwater*)
- Development of a conceptual approach to calibrate sw/gw models using long-term groundwater level and river flow monitoring (Paradis et al. in prep. *JHydrol*)

Contact Information

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Ring of Fire: Reconstructing long-term environmental records to support regional assessment

Nicolas Benoit nicolas.benoit@canada.ca

Josué Jautzy josue.jautzy@canada.ca

October 14, 2020



Abstract

Ring of Fire (RoF) = large mineral deposits of Ni/Cu/Zn/Cr and PGM

- Located in one of the world's largest peatland system;
- Sensitive to climate change (Hadley et al., 2019) and anthropogenic stresses (Leclair et al., 2015)

Environmental conditions

- Additional knowledge required to understand how baseline conditions respond to climate change and new anthropogenic stresses (e.g., roads, mining camps,...).
- Natural presence and behavior of metal(loid)s in this system needs to be carefully assessed prior to any development.
- Changes to groundwater flow dynamic, changes in lake sediment conditions and forest fires can potentially enhance the remobilization of metal(loid)s over time.
- Explore and develop environmental indicators adapted to the RoF environment.

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PROJECT TEAM

N. Benoit¹, J. Jautzy¹, J. Marion¹, M. Parsons¹, A. Desbarats¹,
M. Bunn¹, J. Galloway¹, M. Nastev¹, J. Ahad¹, C. Bégin¹, É.
Girard¹, F. Letourneau¹, A. Dixit¹, E. Berryman², J. Girard³,
M. Garneau³, N. Balliston⁴, S. Finkelstein⁵

¹*Geological Survey of Canada, Natural Resources Canada (NRCan)*

²*CanmetMINING, Natural Resources Canada (NRCan)*

³*Environment Canada*

³*Université du Québec à Montréal*

⁴*University of Waterloo*

⁵*University of Toronto*



Main objective

Improve knowledge on the evolution of the wetlands baseline conditions in response to climate and anthropogenic stresses and their effects on metal(loid)s mobility.



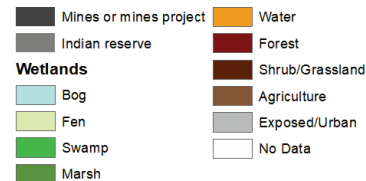
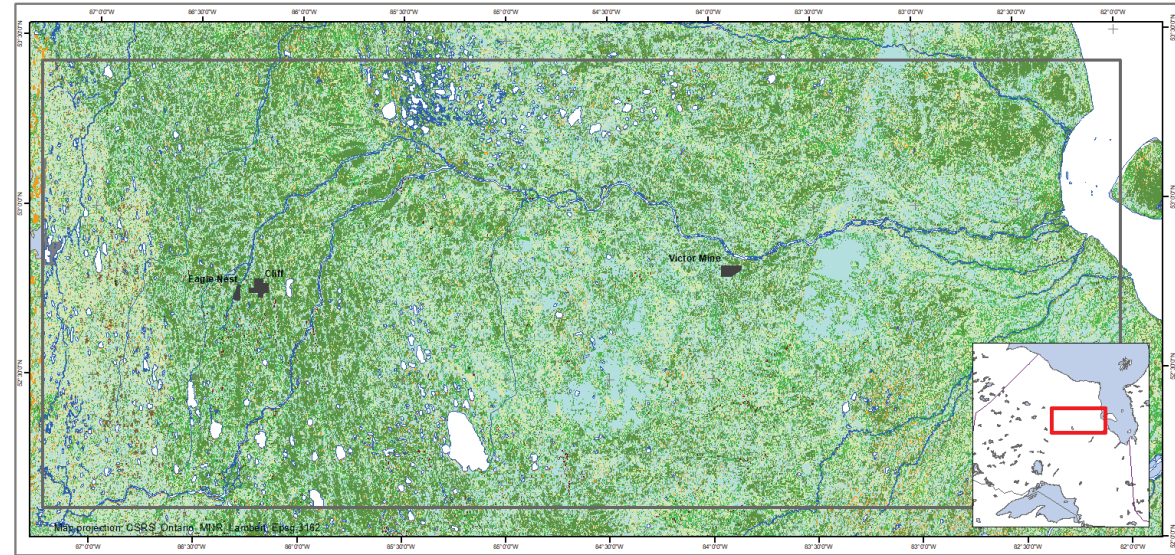
Activities

- Determine geoscience baseline conditions – current knowledge;
- Characterize regional hydrogeology and conduct paleo-environmental reconstruction to assess cumulative effects with time;
- Study alternative analog site(s): hydrogeochemical field study of a stratiform chromite deposit.



Study area

- Located approx. 540 km northeast of Thunder Bay;
- Among the world's largest Wetlands (99.2% of the territory: bogs, fens, swamp, marsh and surface waters);
- First Nation communities: Webequie and Attawapiskat (South);
- Near by communities (<50 km): Fort Albany, Marten Falls, Attawapiskat (North)



0 150 300 600 900 1,200
Kilometers

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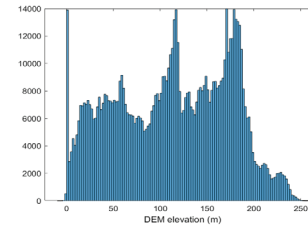
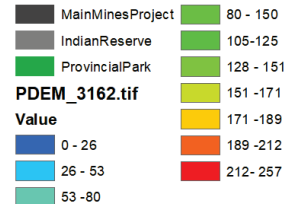
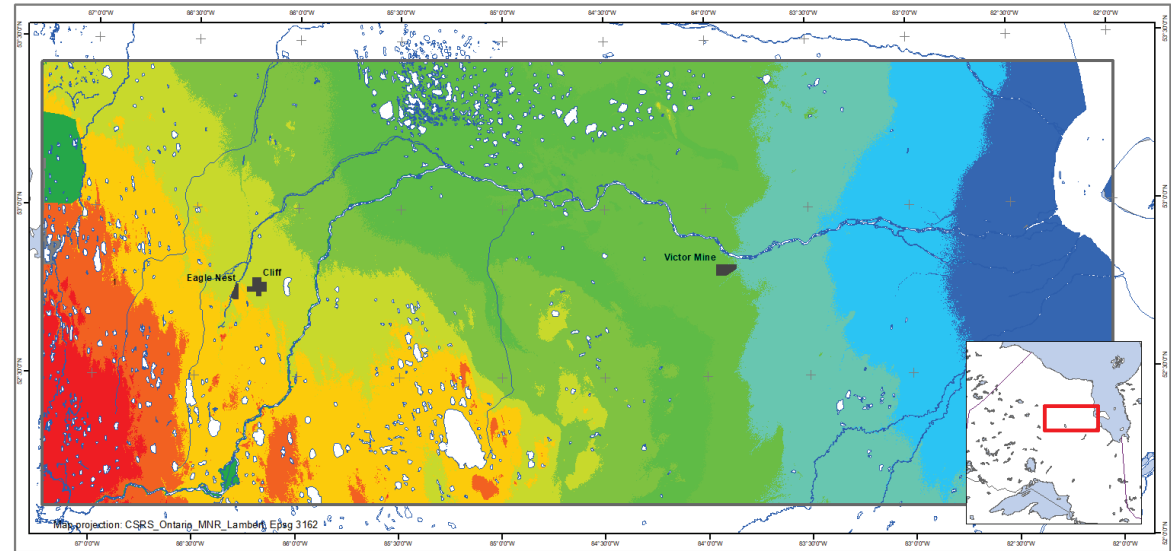
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Topography

- Topography relatively flat;
- Low regional gradient;
- Range from sea level up to 257 m;
- Elevation decreases along the Attawapiskat River to its outlet in James Bay;
- Local topographic highs associated to glacial deposits such as till and esker.



Map 3
Ring of Fire Study Area
Digital elevation model

0 150 300 600 900 1,200
Kilometers

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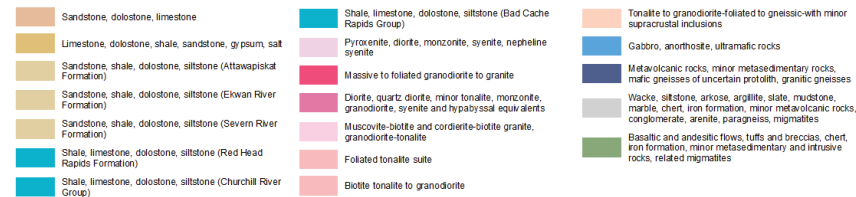
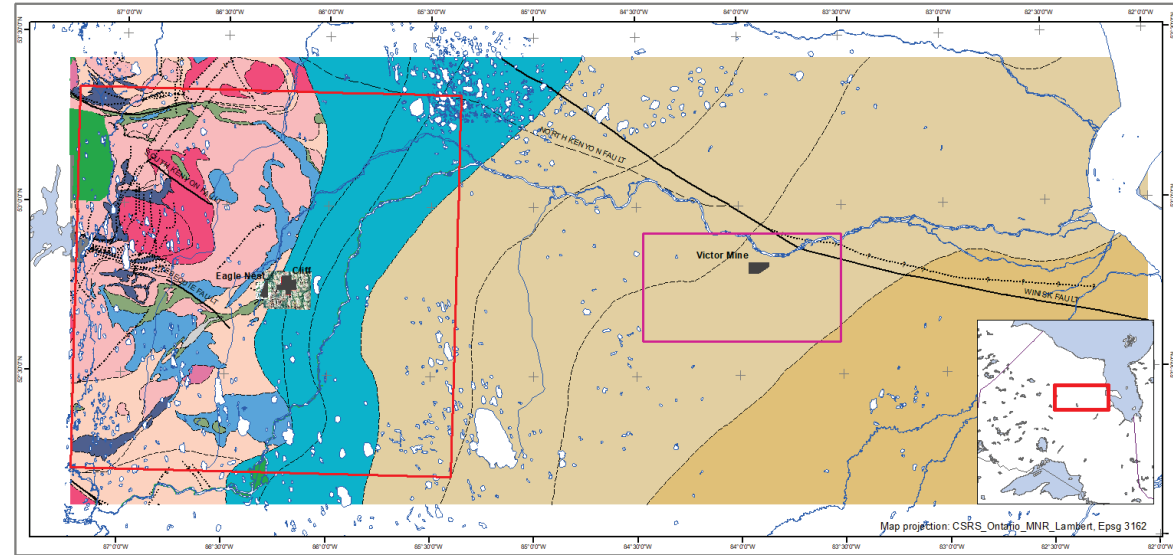
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Bedrock geology

- Distinct settings in these two bedrock domains
- Paleozoic rocks (East)
- Shield rocks (West)
- Zoom-in: Noront exploration area and Victor mines area



Map 1

Bedrock Geology

0 150 300 600 900 1,200
Kilometers

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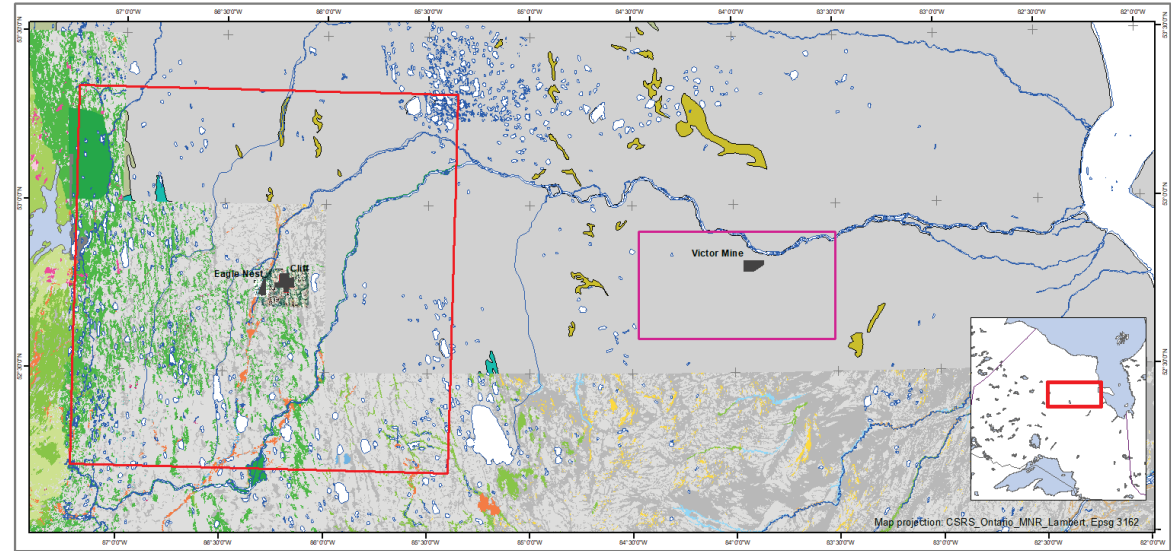
Surficial geology

1:1M map (North):

- 87.1% organic deposits
- 12.5% glacial (till)
- 0.4% others

1:100K maps (South)

- 71.2% organic deposits
- 21.6% glacial (till)
- 4.6% marine
- 2.1% fluvial and glaciofluvial
- 0.4% others



Map 1



Surficial Geology

Average thickness of the deposits ~11 m (max 127 m)

0 150 300 600 900 1,200 Kilometers

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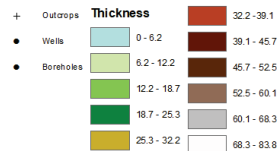
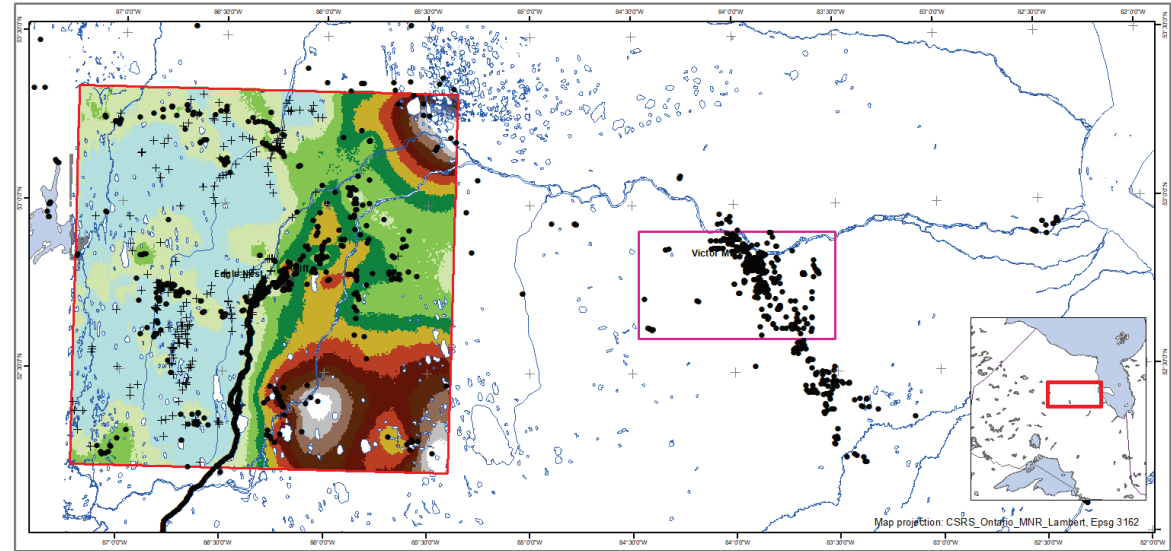
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Boreholes and wells

- 1,823 Boreholes (green)
- 241 Wells (red) and 249 rock outcrops;
- Data sparse and clustered
- Sediments thickness estimation;
- Cross-sections and precise the GW-SW interaction.



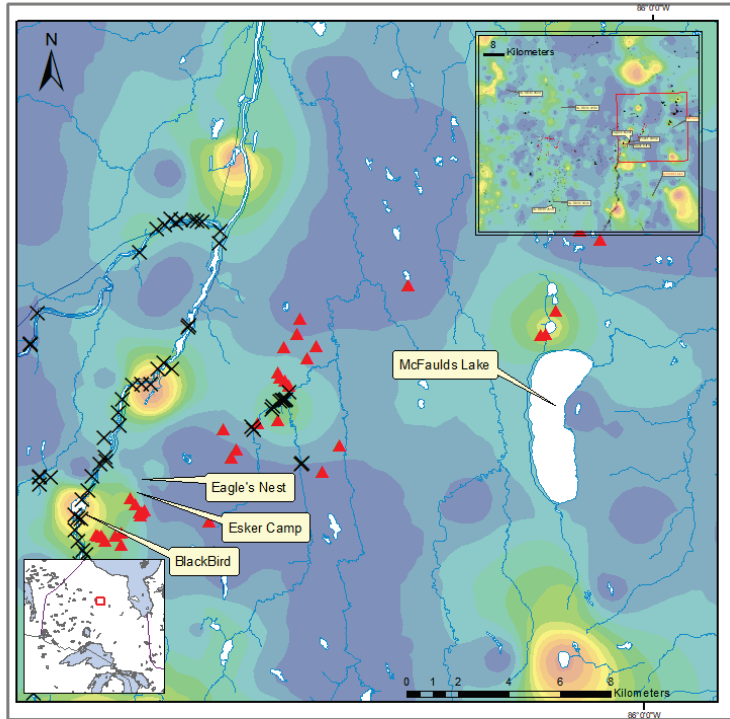
Hydrogeology

- Existing data not validated, additional data required;
- No wells from Provincial Groundwater Monitoring Network;
- Drawdown in Paleozoic bedrock likely affects water level in wetlands;
- Lack of knowledge GW-SW (wetlands) interaction;
- Hydraulic role (permeability, porosity) of regional faults is unknown (e.g., North Kenyon and Stull–Wunnummin faults);
- Shield bedrock weathering;
- Development of a conceptual model of GW-SW interaction in Shield and Paleozoic settings.

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Surface Water and sediment Geochemistry



Lakes water geochemistry anomalies

- Possible indicator for GW-SW interaction (lake conductivity)
- Evaluation of differences between concentrations in water and sediment to provide preliminary insights into distribution of speciation sensitive metal(loid)s such as Cr

Lake sediment (case of Pb)

- Anthropogenic deposition recorded since the onset of industrialization



Conclusion

- GIS and associated databases of existing and collected data;
- Regional hydrogeological conceptual model(s);
- Improved understanding of Cr and other metalloids of concern;
- Insights on the long term evolution of metals in the environment;
- Synthesis of current knowledge, identify gaps and targets;
- Field works is planned next summer.



CONTACT INFORMATION

- Project co-leaders Nicolas Benoit and Josué Jautzy
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- josue.jautzy@canada.ca

Thank you / Merci!



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Program manager: eric.boisvert2@canada.ca

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