

An Overview of Hydrogeology Program Activities in 2014

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Introduction

The 2014 research activities of the Nova Scotia Department of Natural Resources (DNR) Hydrogeology Program included the analysis of methane distribution patterns in groundwater, the initiation of a project to update the arsenic-in-groundwater risk mapping, the development of a project to establish provincial background concentrations of selected substances in soils, reporting and compilation of data to update our understanding of groundwater resources of Sable Island, and the continued participation in a baseline assessment of hydrologic impacts to a disturbed peatland on Brier Island. The Hydrogeology Program also helped to co-ordinate two water forums held in March and October to discuss initiatives, challenges and opportunities for collaboration between government employees involved with water management. Technical advice was provided to various government and private-sector clients throughout 2014, and the Hydrogeology Program participated in a national workshop to develop a long-term framework for collaboration with national partners on groundwater science.

Program Highlights

Groundwater Data Management and Access

Work continued on the organization and maintenance of provincial groundwater information in a centralized spatial database, including routine updating of groundwater databases, such as the Nova Scotia Well Logs Database (Nova Scotia Environment 2014), the Nova Scotia Pumping Test Database (Nova Scotia Department of Natural Resources 2014a), the Nova Scotia Groundwater Chemistry Database (Nova Scotia Department of Natural Resources 2014b) and the Nova Scotia Test

Holes Database (Nova Scotia Department of Natural Resources 2014c). The location of water wells drilled in 2013 is shown in Figure 1.

Progress continued in 2014 on improvements to the georeferencing of groundwater data, including the Nova Scotia Well Logs Database (Nova Scotia Environment 2014). Compared to 2008, the percentage of well logs georeferenced to at least the property level (total of methods D1, D2, G and M in Table 1) has increased from 9.3 % (9,923 wells) to 31.4% (37,171 wells).

The water well and pumping test layers of the online interactive groundwater map service and portal for government groundwater information were updated in November of 2014 (version 6) (<http://gis4.natr.gov.ns.ca/website/nsgroundwater>).

Groundwater Research and Mapping

Assessing Patterns of Dissolved Methane in Shallow Aquifers Located in Nova Scotia's Sedimentary Basins

Using data collected from surveys of methane in well water in Nova Scotia's sedimentary basins, patterns of groundwater methane in shallow aquifers were examined to improve our understanding of the factors influencing the observed distribution. Statistical analyses of the methane data did not detect a significant difference between groupings of methane concentrations for aquifer type, bedrock group and distance to wetlands. A significant difference, however, was observed between groupings of methane concentrations for sedimentary basins and bedrock formations, which was largely attributed to localized higher methane concentrations found in the Stellarton Formation/basin compared to other on-shore sedimentary basins of the province.

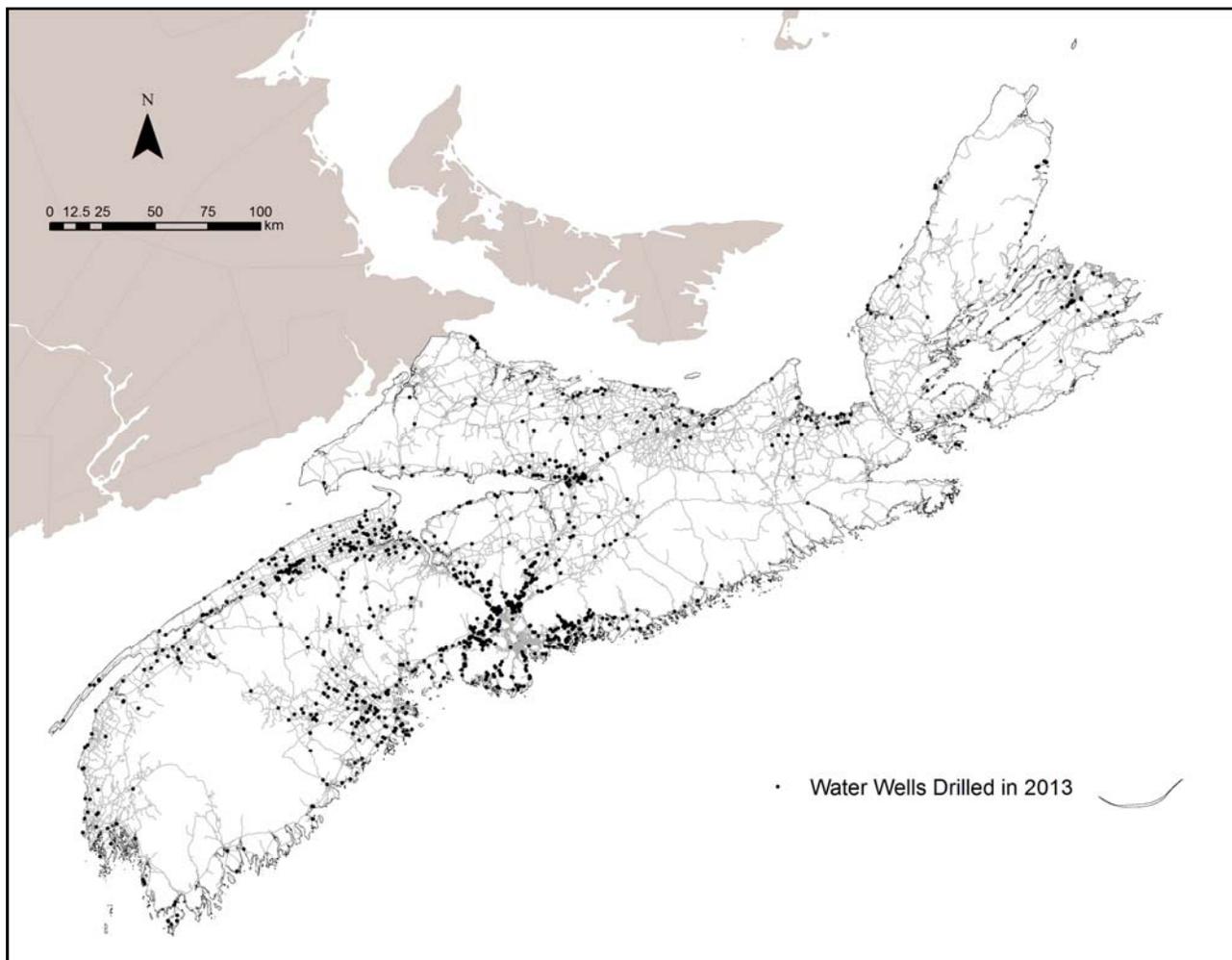


Figure 1. Distribution of water wells drilled in 2013.

Geochemical classification indicated that elevated dissolved methane in well water is associated with sodium-dominated groundwater. Details on the study are included in a manuscript submitted to *Atlantic Geology* for publication in a special issue on environmental geoscience.

Background Soils Chemistry

In the past number of year, various agencies have initiated or completed projects to obtain data related to background soil chemistry. These agencies, which worked in collaboration with various partners, include Environment Canada, Health Canada and the Nova Scotia Department of Natural Resources. The development of quantitative information on background concentrations of various substances in soils is

important to enhance science- and evidence-based decision making in relation to contaminated sites. A project was initiated in 2014 to develop background concentrations for selected substances using existing data, which will be supplemented by additional soil sampling proposed in the Halifax Regional Municipality for 2015.

Update to Arsenic in Well Water Risk Mapping

In 2014, preliminary work on the development of a spatial database for arsenic risk mapping was conducted. Datasets assembled include arsenic concentrations measured in stream sediment, lake sediment, biological media, till, bedrock and groundwater.

Table 1. Summary of Well Log Georeferencing.

Georeference Method	Description	Estimated Georeference Accuracy	Count 2008	Count 2013	Count 2014
A1	Nova Scotia Mapbook (grid reference centroid)	±707 m	74,439 (69.4%)	59,747 (50.9%)	58,782 (49.6%)
A2	Nova Scotia Atlas (grid reference centroid)	±641 m	869 (0.8%)	901 (0.8%)	964 (0.8%)
B1	NTS – Claim (grid reference centroid)	±1130 m	1,862 (1.7%)	1,878 (1.6%)	1,871 (1.6%)
B2	NTS – Tract (grid reference centroid)	±282 m	16,064 (15.0%)	14,701 (12.5%)	14,588 (12.3%)
C	Community gazeteer location from Nova Scotia Mapbook	±7,829 m	3,619 (3.4%)	3,024 (2.6%)	3,006 (2.5%)
D1	Property centroid from NSPRD	~10 to 2,000 m	1,149 (1.1%)	13,785 (11.8%)	14,966 (12.6%)
D2	Property location using NSPRD/ NSCAF/other	~10 to 2,000 m	595 (0.6%)	1,584 (1.4%)	1,584 (1.3%)
E	Grid reference centroid plotting in ocean moved to nearest coast	707 to 1130 m	0 (0%)	1713 (1.5%)	1,711 (1.4%)
G	GPS	±15 m	7,812 (7.3%)	15,691 (13.4%)	16,722 (14.1%)
M	Estimated from site map	50 to 150 m	367 (0.3%)	3,878 (3.3%)	3,899 (3.3%)
U	Could not locate UTM	-	429 (0.4%)	378 (0.3%)	382 (0.3%)
TOTAL			107,205	117,280	118,475

NSPRD: Nova Scotia Property Registration Database
NSCAF: Nova Scotia Civic Addressing File

Groundwater Resources of Sable Island

A compilation report summarizing available hydrogeological information was produced in order to update our baseline understanding of the groundwater resources of Sable Island, which was recently designated a National Park Reserve in 2013. The report and accompanying mapping was released as Open File Report ME 2014-001 and is available at <http://novascotia.ca/natr/meb/pdf/14ofr01.asp>.

Hydrologic Baseline Characterization of the Big Meadow Bog

The DNR Hydrogeology Program's involvement with a collaborative, multi-disciplinary wetland

research effort at the Big Meadow Bog on Brier Island continued in 2014. The wetland complex, which has been impacted by historical drainage activities, hosts *Geum peckii* (Eastern mountain avens), a globally rare plant. Hydrologic baseline information is being collected to better understand the impacts and to inform potential restoration activities. In 2014, research activities focused on groundwater-level trends in the peatland. An open file report, *2014 Baseline Hydrological Monitoring at Big Meadow Bog, Brier Island*, will provide detailed reporting of 2014 project activities.

Groundwater Management

DNR worked with Nova Scotia Environment (NSE) and Dalhousie University to advance

research and policy on the management of naturally occurring uranium in groundwater. This work builds on existing DNR research that identified the potential for uranium to be mobilized in groundwater by certain land-use activities (http://novascotia.ca/natr/meb/data/pubs/cs/cs_me_2013-001.pdf). The intent of the research is to develop new methods for proactively identifying situations where uranium can be mobilized so that mitigation measures can be implemented. The work is expected to be ongoing in 2015.

Outreach and Support Activities

Assistance to the DNR Parks Branch

Where requested, the DNR Hydrogeology Program provided assistance to the DNR Parks Branch with respect to various well water supply issues encountered at provincial parks, including Caribou Provincial Park.

Technical Support to Various Clients

DNR assisted various clients with data requests and requests for technical advice in 2014, especially groundwater consultants requesting background information on groundwater quality and quantity in areas of proposed project undertakings. DNR also provided support to the DNR Wildlife Branch with respect to establishing a wetland groundwater monitoring network in Nova Scotia.

Aquifer Sustainability in Subdivision Developments

In recent years, several subdivision developments in the Halifax Regional Municipality that rely on private wells have experienced water shortages due to declining aquifer levels. To help address this problem, DNR had previously worked with NSE to develop a groundwater assessment guide and toolkit as planning tools to ensure aquifer sustainability in subdivision developments. DNR is building on this work by supporting research at Dalhousie University to model the effects of low-impact-design stormwater management methods on aquifer sustainability.

Atlantic PATH Well Water Project

The DNR Hydrogeology Program participated in activities related to the arsenic-in-well-water

sub-study of the Atlantic PATH project. The Atlantic PATH project is part of a national study that is following the health of 300,000 Canadians for 30 years to investigate how genetics, the environment, lifestyle and behaviour contribute to the development of cancer. The research is especially important for Atlantic Canada, which has the highest cancer rates in the country. Arsenic is a known carcinogen and is the most common natural groundwater contaminant in Nova Scotia, with approximately 9% of wells across the province exceeding the drinking water guideline. Activities in 2014 included attending a workshop on the arsenic-in-well-water sub-study and participating in a private-wells working group. For more information about the project, visit <http://atlanticpath.ca/arsenic/summary.html>.

Radon Awareness

Staff from DNR's Hydrogeology Program provided support to radon awareness and risk-reduction initiatives by partnering with universities, NGOs and government agencies. Specific activities included participation in the Atlantic Radon Network with the Lung Association of Nova Scotia and Health Canada, and participation in a public outreach event led by Health Canada during Radon Action Month in November. DNR maintains an on-line interactive radon risk map that can be viewed at <https://fletcher.novascotia.ca/DNRViewer/?viewer=Radon>.

Historical Gold Mine Tailings

Staff from DNR's Hydrogeology Program provided support to projects related to the management of historical gold-mine tailings. Specific activities included a review and summary of existing environmental studies on gold-mine tailings in Nova Scotia, consultations on proposed research regarding tailings re-vegetation methods, and advice to DNR Regional Services Branch on specific gold-mine tailings sites.

Nitrate in Bedrock Aquifers

Elevated nitrate levels in well water occur in many regions of Canada and overseas, and are often associated with fertilizer use in agricultural areas. Nova Scotia's nitrate monitoring program has been

operating in Kings County since the 1980s, and the results show that approximately 20% of water wells continue to exceed the drinking water guideline for nitrate. To address this issue, water managers need scientific and economic information to select appropriate management options. The Canadian Water Network initiated a project in 2012 to address nitrate in bedrock aquifers in some of the agricultural regions of the Maritime Provinces. The research is taking a collaborative approach that involves scientists, universities, government departments and agricultural stakeholders. DNR is providing local hydrogeological expertise to the project team. The 2014 project activities included attending project meetings in PEI, attending drilling and field installation of a multi-level groundwater monitoring well in Bible Hill, and delivering a presentation on nitrate in groundwater at the Third Atlantic Canada WATER Symposium and Forum in Truro in March. For more information about the project, visit http://www.ucalgary.ca/ryan/bedrock_nitrate.

Meetings, Input to Policy Documents and Working Group Activities

The Hydrogeology Program provided technical input to various government policy and strategy documents in 2014 and participated in working groups such as the Flood Action Working Group and the Atlantic Radon Network. Staff also assisted with organizing the Third Atlantic Canada WATER Symposium and Forum in Truro, and two government Water Forums, which were held in March and October.

Other Presentations

The DNR Hydrogeology Program delivered the following presentations during 2014:

- A hydrogeology lecture for the Dalhousie University School of Planning;
- A hydrogeology lecture for a St. Mary's University hydrogeology class;
- A presentation on the Big Meadow Bog project and on uranium mobility in groundwater at the Atlantic Geoscience Society Colloquium in Wolfville;
- A presentation at the Government Water Forum on the Hydrogeology Program;
- A presentation on nitrates in well water and the Big Meadow Bog project at the Third Atlantic Canada WATER Symposium and Forum in Truro;
- A presentation at a National Groundwater Workshop on provincial perspectives on managing and disseminating groundwater data; and
- A presentation on mapping arsenic in well water at the workshop in Halifax titled *Tackling Arsenic in Private Wells: From Knowledge to Action*.

Publications

The following is a list of publications by the DNR Hydrogeology Program released in 2014.

Report ME 2013-001: Activities of the Hydrogeology Program, 2012, by G. W. Kennedy and J. Drage, 2014. Mineral Resources Branch, Report of Activities 2012; Nova Scotia Department of Natural Resources, p. 9-16. Available online at http://novascotia.ca/natr/meb/data/pubs/13re01/13re01_Kennedy_Drage.pdf.

Report ME 2014-001: An Overview of Hydrogeology Program Activities in 2013, by G. W. Kennedy and J. Drage, 2014. Mineral Resources Branch, Report of Activities 2013, Nova Scotia Department of Natural Resources, p. 25-32. Available online at http://novascotia.ca/natr/meb/data/pubs/14re01/14re01_Kennedy_Drage.pdf.

Report ME 2014-001: Methane in Well Water in Nova Scotia, by J. Drage and by G. W. Kennedy, 2014. Mineral Resources Branch, Report of Activities 2013, Nova Scotia Department of Natural Resources, p. 3-20. Available online at http://novascotia.ca/natr/meb/data/pubs/14re01/14re01_Drage_Kennedy.pdf.

Open File Map ME 2014-009: Methane in Well Water in Nova Scotia, Scale 1:475 000, by J. Drage and G. W. Kennedy, 2014. Available online at

http://novascotia.ca/natr/meb/download/mg/ofm/htm/ofm_2014-009.asp.

Open File Report ME 2014-001: Groundwater resources of Sable Island, by G. W. Kennedy, J. Drage and T. W. Hennigar, 2014. Available online at <http://novascotia.ca/natr/meb/pdf/14ofr01.asp>.

Report ME 2014-001: Identification and Preliminary Mapping of Surficial Aquifers in Nova Scotia, by G. W. Kennedy, 2014. Mineral Resources Branch, Report of Activities 2013, Nova Scotia Department of Natural Resources, p. 33-43. Available online at http://novascotia.ca/natr/meb/data/pubs/14re01/14re01_Kennedy.pdf.

DP ME 490, Version 1, 2014: Potential Surficial Aquifers of Nova Scotia, by G. W. Kennedy. Available online at <http://novascotia.ca/natr/meb/download/dp490.asp>.

Open File Map ME 2014-004: Potential Surficial Aquifers for the Western Region of Nova Scotia, Scale 1:200 000, by G. W. Kennedy, 2014. Available online at http://novascotia.ca/natr/meb/download/mg/ofm/htm/ofm_2014-004.asp.

Open File Map ME 2014-005: Potential Surficial Aquifers for the Central Region of Nova Scotia, Scale 1:185 000, by G. W. Kennedy, 2014. Available online at http://novascotia.ca/natr/meb/download/mg/ofm/htm/ofm_2014-005.asp.

Open File Map ME 2014-006: Potential Surficial Aquifers for the Northern Region of Nova Scotia (Sheet 1), Scale 1:150 000, by G. W. Kennedy, 2014. Available online at http://novascotia.ca/natr/meb/download/mg/ofm/htm/ofm_2014-006.asp.

Open File Map ME 2014-007: Potential Surficial Aquifers for the Northern Region of Nova Scotia (Sheet 2), Scale 1:150 000, by G. W. Kennedy, 2014. Available online at http://novascotia.ca/natr/meb/download/mg/ofm/htm/ofm_2014-007.asp.

Open File Map ME 2014-008: Potential Surficial Aquifers for the Eastern Region of Nova Scotia, Scale 1:225 000, by G. W. Kennedy, 2014. Available online at http://novascotia.ca/natr/meb/download/mg/ofm/htm/ofm_2014-008.asp.

The following is a list of publications associated with the DNR Hydrogeology Program released in 2014.

Chappells, H., Parker, L., Fernandez, C. V., Conrad, C., Drage, J., O'Toole, G., Campbell, N. and Dummer, T. J. B. 2014. Arsenic in private drinking water wells: an assessment of jurisdictional regulations and guidelines for risk remediation in North America. *Journal of Water and Health*. 12(3): 272-392. doi: [10.2166/wh.2014.054](https://doi.org/10.2166/wh.2014.054).

Chappells, H., Campbell, N., Drage, J., Fernandez, C. V., Parker, L. and Dummer, T. J. B. 2014. Understanding the translation of scientific knowledge about arsenic risk exposure among private well water users in Nova Scotia. *Science of the Total Environment*, 505: 1259-1273. doi: [10.1016/j.scitotenv.2013.12.108](https://doi.org/10.1016/j.scitotenv.2013.12.108).

Rivera, A. 2014. Canada's Groundwater Resources. Compiled and edited by A. Rivera. (Contributing author J. Drage). Fitzhenry and Whiteside, Ontario, Canada, 803 p.

Sterling, S. M., Garroway, K., Guan, Y., Ambrose, S. M., Horne, P. and Kennedy, G. W. 2014. A new watershed assessment framework for Nova Scotia: A high-level, integrated approach for regions without a dense network of monitoring stations. *Journal of Hydrology*, 519: 2596-2612. doi: [10.1016/j.jhydrol.2014.07.063](https://doi.org/10.1016/j.jhydrol.2014.07.063).

Research Directions

The Hydrogeology Program will continue its efforts to organize and compile current and historical sources of groundwater information, and publish this information as map services for public use. Work on the development of the next generation viewer application will be initiated in 2015. Many of the projects described under the 2014 program highlights are ongoing. Areas of continued research include groundwater quality issues relating to arsenic, uranium and nitrate; aquifer sustainability in subdivisions serviced by individual wells; and the hydrologic characterization of Big Meadow Bog.

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References

Nova Scotia Department of Natural Resources 2014a: Nova Scotia Groundwater Chemistry Database; available online as part of <http://gis4.natr.gov.ns.ca/website/nsgroundwater/viewer.htm>.

Nova Scotia Department of Natural Resources 2014b: Pumping Test Database; available online as part of <http://gis4.natr.gov.ns.ca/website/nsgroundwater/viewer.htm>.

Nova Scotia Department of Natural Resources 2014c: Test Holes Database; available online as part of <http://gis4.natr.gov.ns.ca/website/nsgroundwater/viewer.htm>.

Nova Scotia Environment 2014: Well Logs Database; available online at <http://www.gov.ns.ca/nse/water/welldatabase.asp> or as part of <http://gis4.natr.gov.ns.ca/website/nsgroundwater/viewer.htm>.