An Overview of Hydrogeology Program Activities for April 2017 to March 2018

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Introduction

During 2017–18 (April 1, 2017 to March 30, 2018), the Nova Scotia Department of Natural Resources (DNR) Hydrogeology Program focused on developing our understanding of the distribution of various naturally occurring contaminants in private well water, such as arsenic, uranium, and manganese. Over the past year, in collaboration with Nova Scotia Environment (NSE), Hydrogeology Program staff also improved our understanding of the demographics of domestic water source and supply types across Nova Scotia. Another key activity was the development and field testing of a low-cost technique for monitoring water levels in shallow wells. Collaborative work with external organizations included data and technical support to various B.Sc. and M.Sc. student projects. Nova Scotia Department of Natural Resources activities related to geohazard research are reported in the Geohazard Program report (Drage and Kennedy, this volume, p. 15-18).

Program Highlights

Groundwater Data Management and Access

Updates to Groundwater Databases

Activities related to the management of provincial groundwater information in 2017–18 mainly involved routine updating of groundwater databases, including the Nova Scotia Well Logs Database (Nova Scotia Department of Natural Resources, 2017a) and the Nova Scotia Groundwater Chemistry Database (Nova Scotia Department of Natural Resources, 2017b).

The georeferencing of groundwater data is continuously being improved. The percentage of well logs georeferenced to at least the property level of spatial accuracy (total of methods D1, D2, G, GC, and M in Table 1) has increased from 9.3% (9,923 wells) in 2008 to 35.2% (43,223 wells) in 2017. The locations of water wells constructed in 2016 are shown in Figure 1.

Web Services and Client Applications

A new client application for arsenic in well water risk in bedrock wells was launched in 2018 and can be accessed at https://fletcher.novascotia.ca/DNRViewer/?viewer=As_Risk_Wells#. Owners of private wells in bedrock aquifers can enter their civic address and find out if their well is in a low-, medium-, or high-risk zone for arsenic in well water. Well water testing is the only way to find out whether arsenic is a present, however, so it is recommended that private well owners regularly test their water no matter where they live. The development of the risk zones is discussed in the next section.

The Nova Scotia Groundwater Atlas, which can be accessed at https://fletcher.novascotia.ca/DNRViewer/?viewer=Groundwater, was updated in March of 2018.

The Potential Impact of Drought to Private Wells application was updated monthly during the summer of 2017. It can be accessed at https://fletcher.novascotia.ca/DNRViewer/?viewer=DroughtIndex.

Groundwater Research and Mapping

Arsenic in Well Water

A project was initiated in 2015 to expand our knowledge of the occurrence and mobility of arsenic in groundwater and to produce an updated

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Table 1. Summary of well log georeferencing.

Georeference Method	Description	Estimated Georeference Accuracy	Count 2008	Count 2016	Count 2017
A1	Nova Scotia Mapbook (grid reference centroid)	±707 m	74,439 (69.4%)	57,479 (47.4%)	57,300 (46.7%)
A2	Nova Scotia Atlas (grid reference centroid)	±641 m	869 (0.8%)	973 (0.8%)	962 (0.8%)
B1	NTS – Claim (grid reference centroid)	±1130 m	1,862 (1.7%)	1,844 (1.5%)	1,833 (1.5%)
B2	NTS – Tract (grid reference centroid)	±282 m	16,064 (15.0%)	14,369 (11.8%)	14,333 (11.7%)
C	Community gazeteer location from Nova Scotia Mapbook	±7,829 m	3,619 (3.4%)	2,967 (2.4%)	2,972 (2.4%)
D1	Property centroid from NSPRD	~10 to 2,000 m	1,149 (1.1%)	15,881 (13.1%)	16,199 (13.2%)
D2	Property location using NSPRD/ NSCAF/other	~10 to 2,000 m	595 (0.6%)	1,884 (1.6%)	1,896 (1.5%)
E	Grid reference centroid plots location in ocean so point moved to nearest coast	707 to 1130 m	0 (0%)	1,693 (1.4%)	1,688 (1.4%)
G	GPS	±15 m	7,812 (7.3%)	19,003 (15.7%)	20,192 (16.5%)
GC	Geocode Address	~10 to 2,000 m	0	595 (0.5%)	649 (0.5%)
M	Estimated from site map	50 to 150 m	367	4,254	4,287
U	Could not locate UTM	-	429 (0.4%)	348 (0.3%)	343 (0.3%)
		TOTAL	107,205	121,290	122,654

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

arsenic risk map for well owners. Arsenic is a Class I human carcinogen and is considered the most prevalent naturally occurring groundwater contaminant in the province.

A review of historical research related to arsenic in Nova Scotia well water was published in 2016 by the Geoscience and Mines Branch as an Open File Report titled *A Review of Activities Related to the Occurrence of Arsenic in Nova Scotia Well Water* (Kennedy and Drage, 2016). The review found that bedrock geology was the dominant control on arsenic levels in water wells. A second Open File Report titled *An Arsenic in Well Water Risk Map for Nova Scotia Based on Observed Patterns of Well Water Concentrations of Arsenic in Bedrock Aquifers* (Kennedy and Drage, 2017a) was released in 2017. About 40% of Nova Scotians obtain their drinking water from private wells (Kennedy and Polegato, 2017), and the report estimated that as many as 20% of private well owners in Nova Scotia may have arsenic exceeding permissible

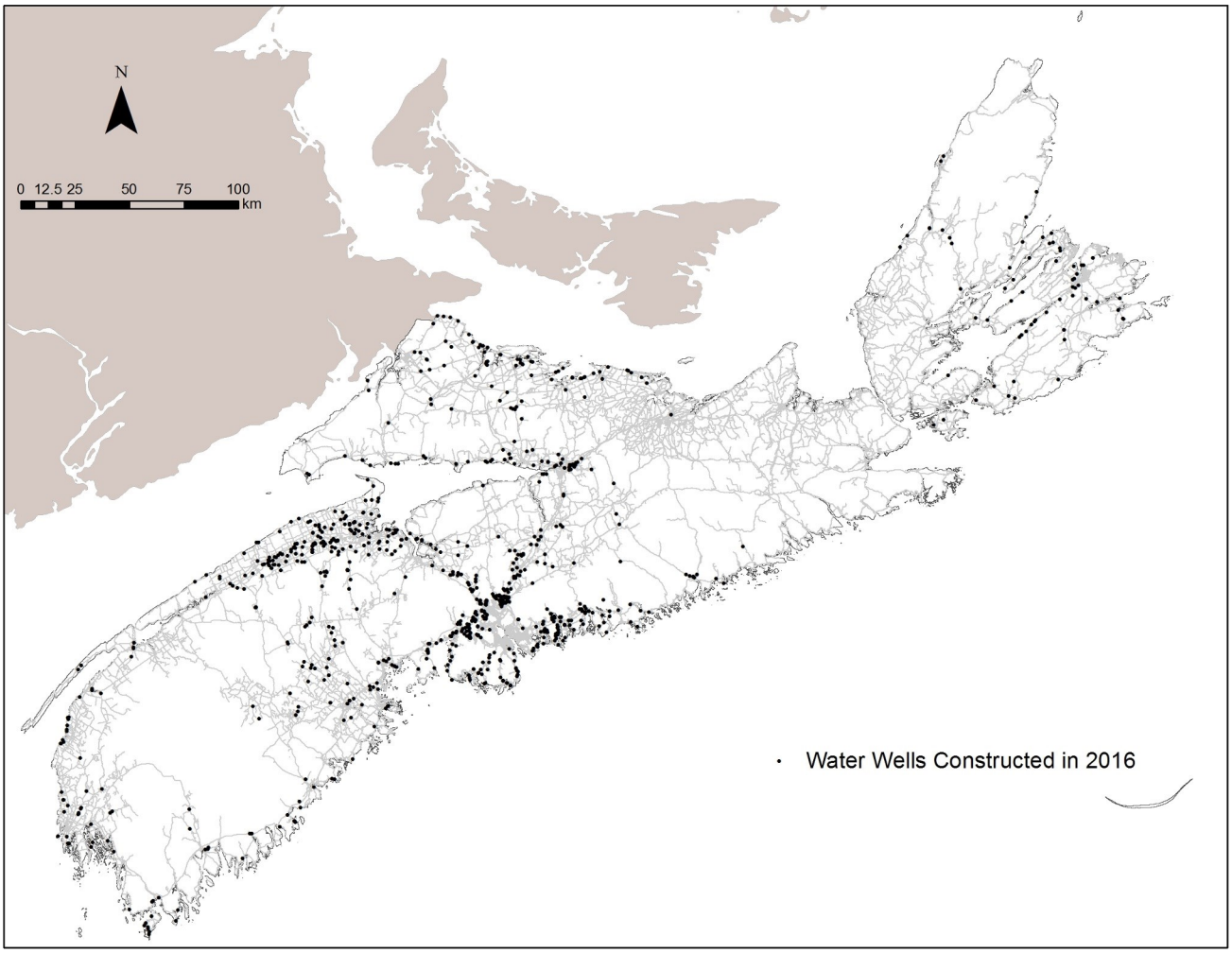

Figure 1. Distribution of water wells constructed in 2016 (as submitted by well drillers and well diggers). Note that additional logs still may be submitted by well drillers and well diggers for the year 2016.

drinking water limits in their untreated well water, with most of these users concentrated in Halifax, Hants, and Lunenburg counties. A province-wide arsenic in well water risk map based on bedrock geology was produced as part of the 2017 Open File Report and was published as a map application (see above; https://fletcher.novascotia.ca/DNRViewer/?viewer=As_Risk_Wells#).

The objectives of the arsenic in well water risk map, including the map application, are

- To build public awareness of the risk of arsenic in well water;
- To provide a simple tool for planners and private well owners to learn about risk levels and ways to mitigate arsenic in well water;
- To encourage regular testing and treatment of well water; and
- To improve public health.

Uranium in Well Water

Uranium is the second most common naturally occurring chemical contaminant in Nova Scotia well water and is associated with kidney damage at levels above the Health Canada (2017a) maximum acceptable concentration (MAC) of 20 µg/L. About 40% of Nova Scotians obtain their drinking water from private wells (Kennedy and Polegato, 2017), and preliminary analyses estimate that as many as 15% of private well owners in Nova Scotia may have uranium exceeding safe drinking-water limits in their untreated well water. A project was

initiated in 2017–18 to develop our understanding of the hydrogeological controls of uranium in well water, which will be used to develop a risk communication tool and to target education and intervention activities. The overall objective of the project is to protect the health of Nova Scotians from exposure to uranium in well water by promoting the importance of water testing and appropriate treatment.

Activities of Hydrogeology Program staff in 2017–18 included a review of available research related to uranium occurrence in water well in Nova Scotia and the digitization of various historical uranium in well water datasets. Future work will include the spatial correlation between uranium in well water and hydrogeological criteria, the preparation of two open file reports, and the development of a risk map and web mapping application.

Manganese in Well Water

Manganese is a naturally occurring chemical found in Nova Scotia well water. The existing Health Canada guideline for manganese in drinking water is an aesthetic objective of 50 µg/L. In response to epidemiological studies suggesting adverse neurological effects of manganese exposure to children, the guideline is currently under review by Health Canada (2016), and a health based maximum acceptable concentration of 120 µg/L has been proposed. The new guideline is expected to be adopted by Health Canada in 2018.

Approximately 40% of Nova Scotians rely on private wells for drinking water (Kennedy and Polegato, 2017), and it is estimated that approximately 30% of the untreated water in these wells will exceed the proposed manganese drinking water guideline. A project was initiated in 2017–18 under the Hydrogeology Program to develop our understanding of the hydrogeological controls of manganese in well water, which will be used to develop a risk-communication tool and to target education and intervention activities, with the aim of protecting the health of Nova Scotians from exposure to manganese in well water by promoting water testing and appropriate treatment.

Activities in 2017–18 included the compilation of manganese in well water datasets into the Nova Scotia Groundwater Chemistry Database and updating the manganese in well water distribution map. Future work will focus on the spatial correlation between manganese in well water and hydrogeologic criteria, and the development of a risk map and web mapping-application.

Potential Corrosivity of Groundwater

Ingestion of lead in drinking water can have adverse effects on the central nervous system and has also been associated with adverse neurological impacts. Exposure to lead in drinking water is generally attributed to the dissolution of lead contained in water pipes and other water system components. The amount of lead that may be dissolved depends on factors such as the pH, hardness, and standing time in the water piping or storage system. The current maximum acceptable concentration of lead in drinking water is 10 µg/L, although the MAC is presently under review by Health Canada (2017b) and a lower MAC of 5 µg/L has been proposed (Health Canada, 2017c).

Although many municipalities have programs to mitigate the potential for lead in municipal drinking water (e.g. pH adjustment) and lead is tested annually (flushed samples) in municipal distribution systems, private well-water owners are required to conduct their own lead monitoring and mitigation. A project was initiated in 2017–18 to investigate the relationship between groundwater corrosivity and hydrogeological criteria, and to characterize spatial trends in relative corrosivity across the province. This analysis will help identify areas that are most susceptible to elevated metals, such as lead, in household drinking-water. This knowledge could be used to raise awareness amongst private well owners in Nova Scotia concerning the risk of lead in drinking water.

Activities in 2017–18 of the Hydrogeology Program included preliminary spatial correlation between corrosivity indices, lead, and the province's major groundwater regions. Future work includes the preparation of an open file report.

Water Source and Supply Demographics in Nova Scotia

Since hazard occurrence and relative severity is controlled by various hydrogeological and

physiographic criteria and is spatially variable, an understanding of how water source and supply types vary across the province is critical to understanding the risk of various hazards to private wells. Various estimates of water sources and supply types have been published for Nova Scotia over the years; however, there is no clear, documented process for estimating these figures. A project was completed in 2017, in collaboration with NSE, that involved the development of a methodology for estimating domestic water source (e.g. groundwater or surface water) and supply types (e.g. public water system or private water supply) using existing data and simple geoprocessing techniques. The results were published in *Where Does Our Tap Water Come From? An Analysis of Domestic Water Source and Supply Demographics in Nova Scotia* (Kennedy and Polegato, 2017).

It was found that slightly more Nova Scotians (5%) obtain their domestic water from groundwater compared to surface-water sources, and approximately 57% of Nova Scotians obtain their domestic water from public (municipal and registered) water systems. Bedrock aquifers represent a much larger source of domestic groundwater supply (over 85% of all domestic groundwater users) in Nova Scotia compared to surficial aquifers. The spatial data and information generated during this study will be used by government scientists, water managers, and decision-makers to support accountability reporting; policy development; and risk assessment, communication and mitigation.

Shallow Aquifer Water-Level Monitoring

The need for a real-time monitoring network for shallow aquifers was highlighted during a drought in Nova Scotia in 2016. The drought was particularly severe in southwestern Nova Scotia where it was the driest summer recorded in 137 years. This area of the province relies heavily on shallow dug wells for private water supplies and over 1,000 wells went dry. During the drought, there was a need to track aquifer levels so that emergency management staff could plan appropriate management responses and the public and media could be kept informed about the drought impacts. Although Nova Scotia has a provincial groundwater observation well network, it monitors drilled wells and is not equipped for real-time reporting. Therefore, a low-cost real-time water level meter for dug wells was developed and pilot tested in 2017. The meters are permanently installed in each well and use an ultrasonic sensor to measure water levels. The monitoring data are transmitted daily via WiFi. The meters have performed well compared to pressure transducers and manual measurements. The pilot network will be expanded in 2018 and the results will be made available online.

Groundwater Management

Recently, Health Canada has proposed lowering aesthetic and/or health-based limits for several chemical parameters for drinking water quality, such as aluminum, copper, lead, manganese, strontium, and uranium. To assist NSE with the evaluation of the potential impact of the proposed changes for aluminum, manganese, and strontium on private and public water supplies in Nova Scotia, Hydrogeology Program staff performed analyses of available well water chemistry data (Nova Scotia Department of Natural Resources, 2017b) and water-use demographics to estimate the scope of the affected supplies. These analyses formed part of impact statements submitted to Health Canada during the consultation phase of the drinking water quality guideline reviews. In addition, Hydrogeology Program staff provided on-going technical support, delivered a presentation to members of the Atlantic Canada Water Works Association, and participated on an intergovernmental working group to prepare for changes to the manganese guideline, which is estimated to impact up to 30% of private well users in the province.

Outreach and Support Activities

Support Activities

Hydrogeology Program staff assisted various clients with requests for data and technical advice in 2017–18. Clients included other DNR branches and government departments, universities, homeowners, municipalities, and groundwater consultants. For example, program staff provided

technical advice in 2017–18 on sealing an abandoned borehole on Crown land at Point Aconi and on water supplies in provincial parks, and assisted Parks Canada with planning future water resource assessment activities on Sable Island. Support to universities included the provision of data to an interuniversity gas-seepage project (GaSP), which aimed to identify and mitigate fugitive emissions of methane from legacy resource extraction sites in the Maritimes. Staff also provided technical and data support to B.Sc and M.Sc. projects on the hydrological dynamics of Big Meadow Bog, and an M.Sc. self-directed project on water-level trend analysis of provincial observation wells.

The Hydrogeology Program provided technical input to government policy documents as needed, and participated in working groups, such as the manganese working group and the Nova Scotia Flood Working Group.

Presentations

The DNR Hydrogeology Program delivered the following presentations during 2017–18:

- A lecture on the hydrogeology of Nova Scotia to a first-year hydrogeology class in the Faculty of Engineering at Dalhousie University;
- A presentation to the Nova Scotia Groundwater Association on the 2016 drought;
- A conference presentation at GeoOttawa on the development of indices to assess the potential impact of drought to private wells in Nova Scotia;
- A presentation to Atlantic Canada Water Works Association on the planned changes to the Canadian Drinking Water Quality Guideline for manganese and its estimated impacts on Nova Scotia drinking water;
- A presentation on Arsenic in Nova Scotia Well Water at the Association of Professional Geoscientists of Nova Scotia Annual General Meeting; and
- A presentation on the 2016 drought at the Association of Professional Geoscientists of Nova Scotia Annual General Meeting.

Publications

The following publications by the DNR Hydrogeology Program were released in 2017–18:

- Open File Report: An Overview of Hydrogeology Program Activities in 2016 (Kennedy and Drage, 2017b), available online at https://novascotia.ca/natr/meb/data/pubs/17re01/17re01KennedyDrage.pdf
- Open File Report: An Arsenic in Well Water Risk Map for Nova Scotia based on Observed Patterns of Well Water Concentrations of Arsenic in Bedrock Aquifers (Kennedy and Drage, 2017a), available online at https://novascotia.ca/natr/meb/data/pubs/17ofr03/ofr_me_2017-003.pdf
- Open File Report: Where Does Our Tap Water Come From? An Analysis of Domestic Water Source and Supply Demographics in Nova Scotia (Kennedy and Polegato, 2017), available online at https://novascotia.ca/natr/meb/data/pubs/17ofr04/ofr_me_2017-004.pdf
- Open File Map: Arsenic in Groundwater from Bedrock Aquifers in Nova Scotia (Kennedy, 2018), available online at https://novascotia.ca/natr/meb/download/mg/ofm/htm/ofm_2018-003.asp
- Conference Extended Abstract: Development of indices to assess the potential impact of drought to private wells in Nova Scotia (Kennedy et al., 2017), available online at https://novascotia.ca/natr/meb/data/pubs/cs/cs_me_2017-005.pdf

Research Directions

The Hydrogeology Program will continue to develop our understanding of the hydrogeological controls on naturally occurring contaminants in private well water, such as arsenic, uranium, and manganese, and to provide risk communication tools to promote appropriate testing and water treatment. The Hydrogeology Program will also continue to investigate the development of simple monitoring tools to monitor and predict where well water shortages may occur, especially given that

climate change forecasts predict that drought events will occur more frequently in Nova Scotia. The compilation of legacy groundwater data, the improvement of data capture processes, the maintenance of spatial data, and the development of online applications to publish and provide access to these data will remain an area of focus for the Hydrogeology Program.

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