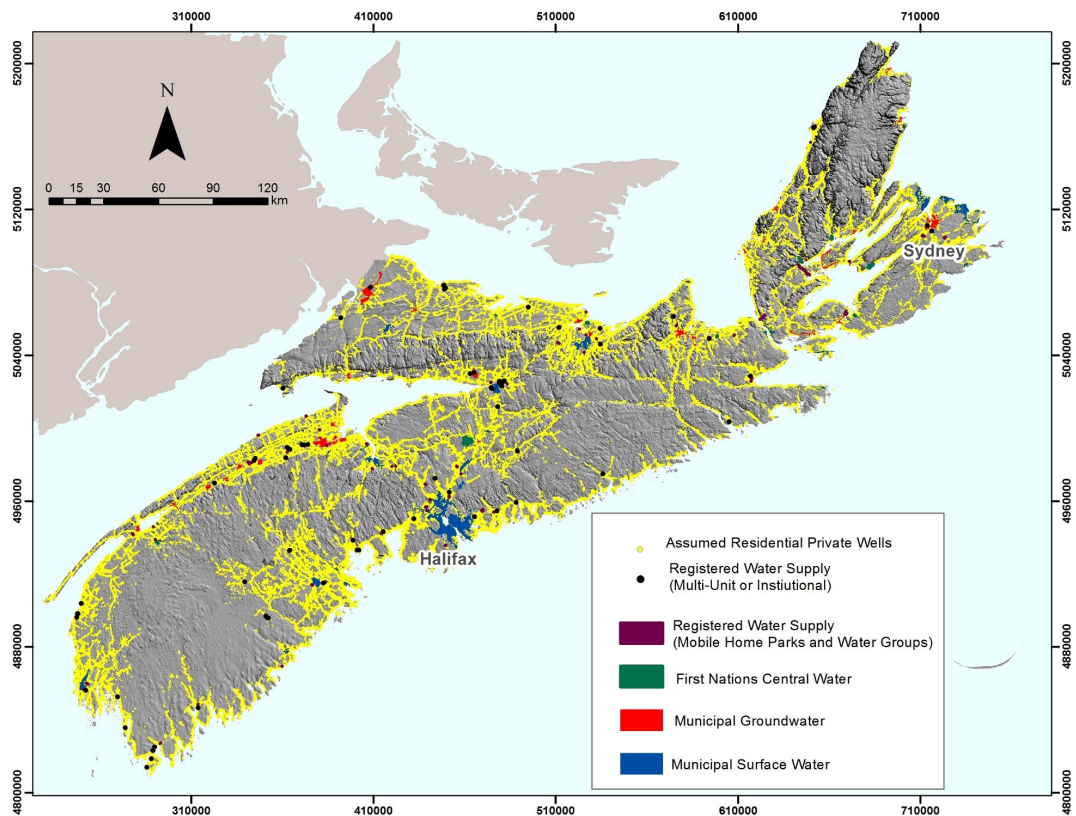


# Where Does Our Tap Water Come From? An Analysis of Domestic Water Source and Supply Demographics in Nova Scotia

*G. W. Kennedy and A. Polegato*

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# Where Does Our Tap Water Come From? An Analysis of Domestic Water Source and Supply Demographics in Nova Scotia

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## Abstract

To better understand and monitor where Nova Scotians obtain their domestic water, a methodology was developed 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. A map was derived that estimates the number of permanent residents per residential civic point, and the water source and supply type was assigned to each of these civic points based on Nova Scotia Environment file information and the location of the civic points compared to the boundaries of public water-supply zones. The population associated with various domestic water sources and supply types was summarized and 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 number of residential service connections estimated using the geoprocessing technique showed relatively close agreement (<5% difference) with the estimated number of residential customers reported by the water utilities. 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.

## Introduction

Nova Scotians obtain domestic water from public or private water supplies, generally from either groundwater or surface-water sources. Public water supplies in Nova Scotia are defined as systems having at least 15 service connections or regularly serving at least 25 people per day for 60 days of the year, or systems serving daycares, restaurants and commercial accommodations for at least 60 days of the year (Nova Scotia Environment, 2017a). Public drinking-water supplies include both approved water supplies, comprising all municipal water systems, and registered water supplies, comprising smaller institutional or commercial systems, such as hospitals, schools, mobile home parks, restaurants and campgrounds. Water systems operated by First Nations fall under Federal jurisdiction and therefore are not registered with Nova Scotia Environment (NSE) as public drinking-water supplies. These systems are considered separately herein.

Private water supplies mainly consist of drilled wells in fractured bedrock aquifers, and a smaller proportion of private water supplies consisting of either shallow drilled-wells that are installed in surficial aquifers or dug wells that are typically constructed in thin, low- to moderate-permeability tills. The use of private surface-water supplies and cisterns are not tracked by the Province, but these supply types represent a minor percentage of all domestic private-water supplies. Private water supplies are not regulated with respect to water quality, and it is therefore the responsibility of water supply owners to ensure that the water is safe to drink and to mitigate any potential health risks.

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<sup>1</sup>Nova Scotia Department of Environment

To communicate water quality and quantity hazards to private-well owners, the Province has developed a series of maps indicating relative hazard levels of various threats to private wells, such as arsenic (Kennedy and Drage, 2017), uranium and related radionuclides (O'Reilly et al., 2009), seawater intrusion (Kennedy, 2012) and drought (Kennedy et al., 2017). Since hazard occurrence and relative severity is controlled by various hydrogeological and physiographic criteria and is spatially variable, the assessment of risk to private-well owners is predicated on an understanding of the distribution of private-well users across the province. The type of aquifer supplying private wells can also inform these risk analyses. For example, shallow dug-wells are more susceptible to the impacts of surface contamination and drought than deeper bedrock-aquifer wells. An understanding of how water source and supply types vary across the province is therefore critical to understanding the risk of various hazards to private wells.

Health Canada periodically reviews and updates the safe limits for various drinking water criteria (Health Canada, 2017) based on the latest epidemiological evidence. Since the levels of various drinking-water contaminants are often closely associated with the domestic water source and/or supply type, it is important to understand the distribution of domestic water supplies across Nova Scotia to provide an assessment of the potential impact of any proposed guideline change during the consultation phase of the guideline reviews.

Water source and supply demographics change regularly as municipal servicing boundaries are extended or new municipal systems are developed. For example, a survey of Nova Scotia municipalities conducted in 2012 by CBCL (2012) indicated that the percentage of the population receiving municipal water servicing increased from 1996 to 2012, with water servicing provided to an additional 1,685 households (~4,000 persons) over this period. Monitoring these water source and supply demographic changes is useful for epidemiological studies of population exposure to drinking water contaminants, and to ensure effective deployment of government resources.

Various estimates of water-supply types in the province have reported that between 55% and 65% of Nova Scotians are serviced by public water supplies (Kennedy et al., 2010, CBCL, 2012, Nova Scotia Environment, 2016), with the remainder of the population relying on private water supplies. For example, Nova Scotia Environment's (2016) annual accountability report, which tracks the percentage of Nova Scotians supplied with domestic water that meets the health-based criteria for microbiological quality, estimates that 65% of Nova Scotians obtain their drinking water from municipal water supplies. The proportion of the population serviced with municipal water, however, has never been quantified using a rigorous approach. The objectives of this work are to develop a consistent, transparent and reproducible methodology for estimating and tracking domestic water source and supply types in Nova Scotia with the aim of answering the following key questions:

- How many Nova Scotians obtain their domestic water from municipal (i.e. approved), registered or private water systems?
- How many Nova Scotians are supplied by surface-water sources compared to groundwater sources (bedrock and surficial aquifers)?

## Methods

Spatial analyses were conducted to derive a map that estimates the number of permanent residents per residential civic point for the province's census dissemination areas (Statistics Canada, 2017), and to assign a water-supply type (e.g. public water system vs. private water supply) to these points based on their location relative to municipal and registered water-supply zones. Halifax Water (pers. comm., June 5, 2017), the province's largest water utility, uses a similar approach to generate estimates of population

serviced in the Halifax Regional Municipality (HRM). The resulting relative proportion of water source and supply types for domestic water users in Nova Scotia was compared to historical data (Nova Scotia Department of the Environment, undated) to assess demographic changes over the last ~45 years.

## Residential Civic Points

The Province publishes a data product called the Nova Scotia Civic Addressing File (NSCAF) (GeoNova, 2017), which includes a spatial layer of all civic address points in Nova Scotia. These civic address points encompass a variety of geographic locations and building types, including parks, and industrial, commercial and seasonal properties. A series of filters was applied to this layer in ArcGIS™10 (Esri, Inc.) geographic information system software so that any non-residential or seasonal/temporary residential civic-address points were excluded from the layer and a map could be produced showing the location of permanent residential occupied dwellings (i.e. domestic water users).

## Distribution Zones

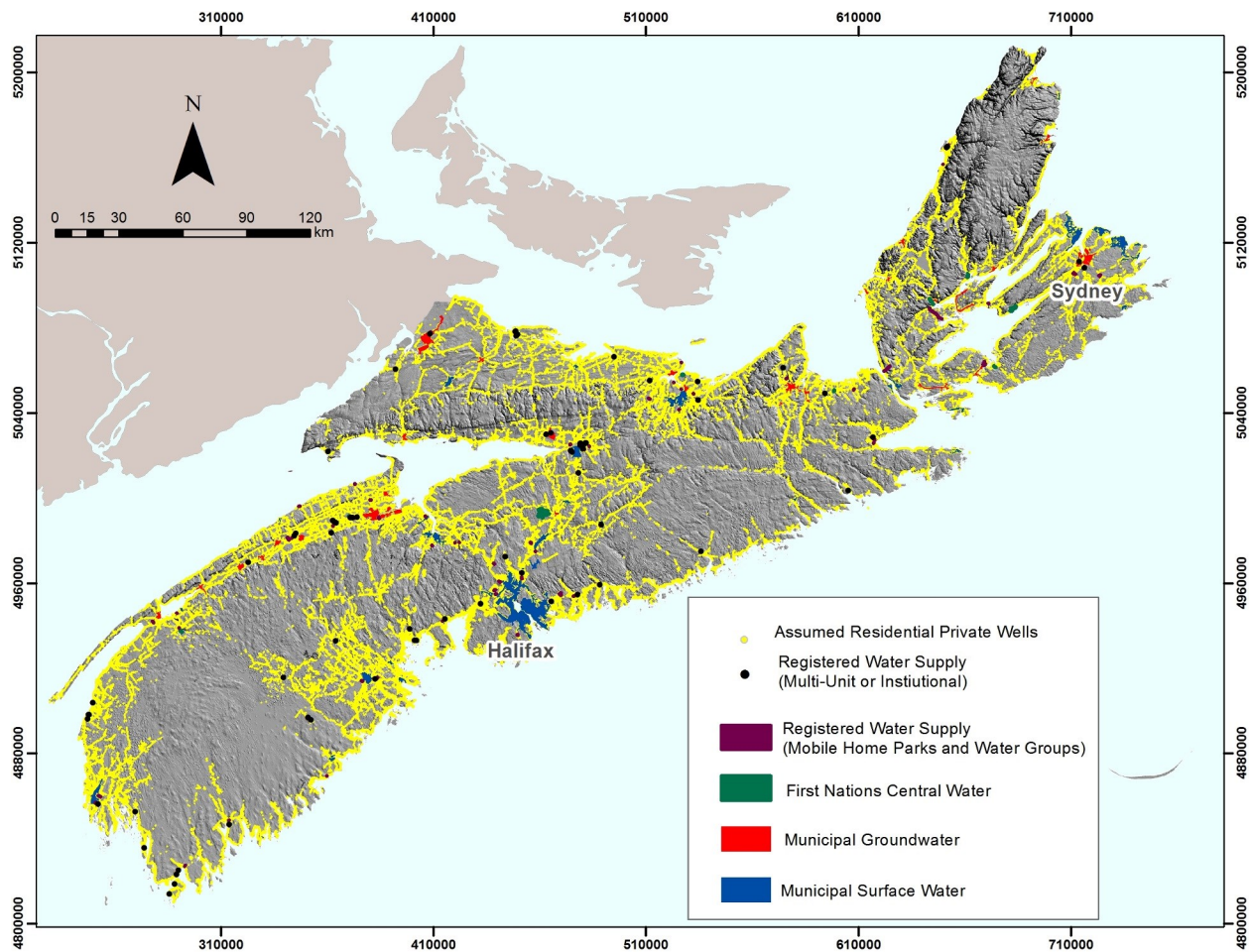
Municipal water-distribution zones previously mapped by Kennedy et al. (2010) were reviewed and updated using the most recent municipal water system assessment reports submitted to Nova Scotia Environment (i.e. 2013), excepting Halifax Water, which shared their current (i.e. 2017) distribution zones in a spatial format. The estimated water distribution-zone boundaries of First Nation and public water supplies were digitized based on property boundaries and available reporting and file information, such as water withdrawal approval reports submitted to Nova Scotia Environment and 2002 system assessment reports of First Nation water supplies submitted to Indigenous and Northern Affairs Canada. For each municipal and registered water supply, the water source (surface water, bedrock aquifer, surficial aquifer) was assigned to the distribution zone polygon. Figure 1 shows the location of municipal, registered and First Nation distribution zones compared to unserved residential civic points (i.e. assumed private wells) across Nova Scotia.

For multi-unit (e.g. apartments) or institutional (e.g. long-term care facilities) registered water supplies that may host a large number of residents but have a common address, an estimate of the population serviced was assigned to the registered water-supply distribution-zone polygon based on Nova Scotia Environment file data (Nova Scotia Environment, unpub. data, 2017).

## Average Civic-Point Household Density

Statistics Canada 2016 census data were used in the analysis to constrain the population estimates to the latest census information (Statistics Canada, 2017). It should be noted that Nova Scotia has a significant population (~2%) of non-permanent residents (e.g. students); however, these residents were not considered in the census population estimates. Population counts for Nova Scotia's 152 census dissemination areas (CDA) (Fig. 2) were imported into ArcGIS and a statistic called the average civic-point household density was derived as follows:

1. A spatial join was implemented between residential civic-address points and the CDA polygons to count the number of residential civic points intersecting the polygons.
2. A spatial join was implemented between the institutional or multi-unit registered water supplies and the polygon generated in the previous step, and a sum of the total population serviced by these types of water supplies was generated for each CDA. This figure was subtracted from the census population in each CDA, yielding an adjusted population figure.
3. The adjusted population for each CDA polygon was divided by the number of intersecting residential civic points to derive the average civic-point household density for each CDA.



**Figure 1.** Water-supply types across Nova Scotia

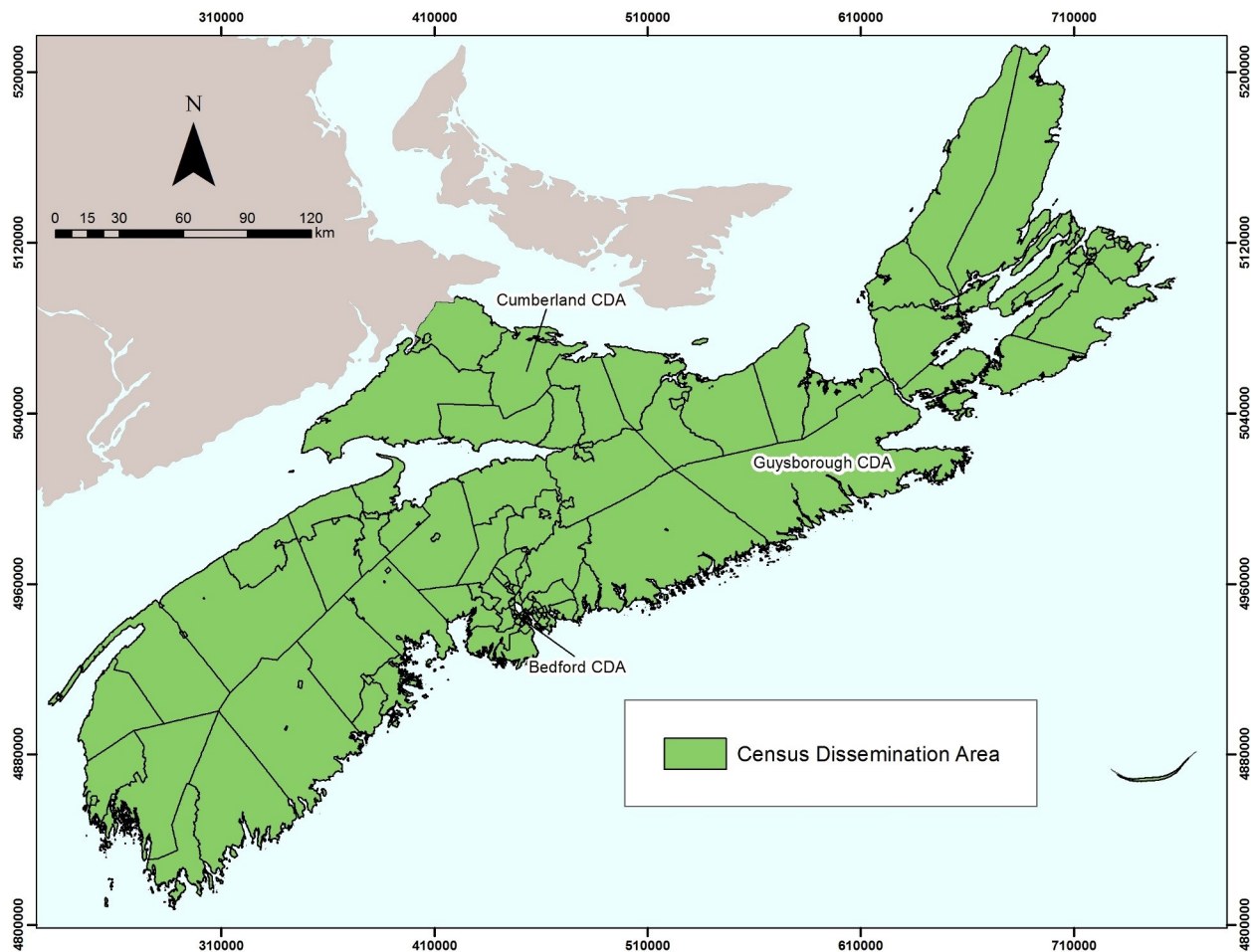
4. A spatial join was then implemented so that each residential civic point within a given CDA was assigned the associated average civic-point household density.

## Population Served by Municipal Water

A spatial join between the residential civic-address points and municipal water-supply distribution-zone polygons was generated to produce a sum of the average civic-point household densities within the zones. This sum was used as an estimate of the population serviced for each of the province's municipal water systems. An e-mail survey of the province's water utilities was conducted during 2016-2017 to collect information on the approximate number of residential customers served by the utility. Where participating utilities could provide an estimate of the total number of residential customers associated with the municipal water system, the count of residential customers was compared to the count of residential civic points within each municipal servicing boundary derived through GIS analysis to evaluate the magnitude of error associated with the approach (Table 1).

## Population Served by Registered Water Supplies and First Nation Supplies

As noted previously, the population supplied by institutional or multi-unit registered water supplies is based on file data and manually assigned to registered water-supply polygons. Where population



**Figure 2.** Census dissemination areas in Nova Scotia.

information was not available, or was suspect, the population serviced by the supply was assumed to be 25 persons. To estimate the population serviced by First Nation water supplies and the remaining registered water supplies, which includes mostly mobile home parks and subdivision water groups (i.e. shared water supply amongst a group of homes and businesses), a spatial join between the residential civic points and the water-supply distribution-zone polygons produced a sum of the average civic-point household densities within the zones.

## Water Source and Supply Type

To permit the summary of the water source and supply-type data for various jurisdictional boundaries (e.g. county, municipality, CDA), a spatial join was conducted between the residential civic points and the distribution zone polygons so that each civic point within the zones was assigned the corresponding code shown in Table 2. Two of Nova Scotia's municipal water systems (New Minas and Kentville) use a combination of bedrock and surficial aquifers. For these two systems, residential civic points were assigned the MGBA and MGSA codes in proportion to the relative contribution of the two aquifer types to the total wellfield production (i.e. pumping volumes).

All other residential civic points were assumed to be supplied by a private well and assigned the 'PG' code. Residential civic-address points outside of municipal, registered or First Nation distribution zones were all assumed to be supplied by private wells since other private domestic water-supply types, such

**Table 1.** Comparison of the estimate of residential civic points derived by GIS analysis and water utilities' estimate of the number of residential customers within distribution zones.

Municipal Water System	Residential Civic Points: GIS Estimate	Residential Customers: Utility Estimate	Difference	Per Cent Difference
Aerotech Park (Goffs)	0	0	0	0.0%
Amherst	3788	3246	542	15.4%
Antigonish	2596	2488	108	4.2%
Arichat	527	504	23	4.5%
Baddeck	471	528	-57	11.4%
Bomont S/D (Elmsdale)	20	17	3	16.2%
Bridgetown	529	558	-29	5.3%
Canning	362	413	-51	13.2%
Canso	476	435	41	9.0%
Centerville	14	14	0	0.0%
Chéticamp	124	77	47	46.8%
Collins Park S/D (Fall River)	96	85	11	12.2%
Debert	112	129	-17	14.1%
Digby	919	903	16	1.8%
Dingwall	96	91	5	5.3%
East Hants (Enfield, Elmsdale, Lantz)	2239	2138	101	4.6%
Falmouth	750	785	-35	4.6%
Five Island Lake S/D (Hubley)	14	12	2	15.4%
Floral Heights S/D (Howie Centre)	42	35	7	18.2%
Gaspereaux Lake	41	40	1	2.5%
Glace Bay <sup>1</sup>	8102	8088	14	0.2%
Hantsport	570	600	-30	5.1%
Ingonish Beach	210	157	53	28.9%
Kentville	3109	3000	109	3.6%
Lawrencetown	282	320	-38	12.6%
Little Narrows	143	100	43	35.4%
Lockeport	3	3	0	0.0%
Louisdale - Evanston	576	555	21	3.7%
Lower South River–St. Andrews	524	268	256	64.6%
Mahone Bay	375	414	-39	9.9%
Margaretsville	130	145	-15	10.9%

(Table 1 concludes next page.)

**Table 1** (concluded).

Municipal Water System	Residential Civic Points: GIS Estimate	Residential Customers: Utility Estimate	Difference	Per Cent Difference
Middle Musquodoboit	120	102	18	16.2%
Middleton	726	650	76	11.0%
Miller Lake S/D (Fall River)	60	51	9	16.2%
Mulgrave	348	307	41	12.5%
Neils Harbour	168	150	18	11.3%
New Glasgow–Westville	5230	4846	384	7.6%
New Minas	1779	1600	179	10.6%
New Waterford <sup>1</sup>	3493	3466	27	0.8%
North Sydney–Sydney Mines <sup>1</sup>	6604	6461	143	2.2%
Oxford	497	486	11	2.2%
Pictou	1285	1219	66	5.3%
Port Williams	398	389	9	2.3%
Sandy Court S/D (Aylesford)	16	15	1	6.5%
Shelburne	270	195	75	32.3%
Sherbrooke	109	103	6	5.7%
Shubenacadie	270	285	-15	5.4%
Silver Sands S/D (Cow Bay)	46	40	6	14.0%
Liverpool–Brooklyn	1079	944	135	13.3%
Springhill	1537	1542	-5	0.3%
St. Peters–Sampsonville	421	428	-7	1.6%
Stellarton	1532	2147	-615	33.4%
Stewiacke	541	572	-31	5.6%
Sydney <sup>1</sup>	9504	9024	480	5.2%
Tatamagouche	239	250	-11	4.5%
Trenton	1086	1004	82	7.8%
Truro–Bible Hill	4866	4150	716	15.9%
Windsor–Three Mile Plains	1978	1963	15	0.8%
Yarmouth	2743	2595	148	5.5%
<b>TOTAL</b>	<b>74185</b>	<b>71200</b>	<b>2985</b>	<b>4.2%</b>

1. CBRM connections assumed to be 96% residential (Cape Breton Regional Municipality, 2015).  
S/D: subdivision.



**Table 2.** Water supply codes assigned to residential civic points.

Code	Water Supply
MGBA	Municipal Groundwater - Bedrock Aquifer
MGSA	Municipal Groundwater - Surficial Aquifer
MS	Municipal Surface Water
RGBA	Registered Groundwater - Bedrock Aquifer
RGSA	Registered Surficial Aquifer
RS	Registered Surface Water
FGBA	First Nation Groundwater - Bedrock Aquifer
FGSA	First Nation Groundwater - Surficial Aquifer
FS	First Nation Surface Water
PG	Private (Groundwater) Well

as surface water and rainwater collection systems, are uncommon in Nova Scotia. Small systems that do not qualify as registered drinking-water systems (less than 15 connections or 25 people) were also regarded as private well-water supplies. Due to the inherent limitations of the Nova Scotia Well Logs Database (Nova Scotia Environment, 2017b), the well logs data cannot be used to reliably assign aquifer types to individual private wells across the province. The percentage of domestic wells installed in surficial aquifers (e.g. dug wells and drilled wells completed above bedrock) within a given area (e.g. county, municipality), however, can be used to indicate the regional prevalence of bedrock or surficial aquifer reliance.

The distribution of domestic water sources and supply types across Nova Scotia was calculated as the sum of the average civic-point densities for each of the categories in Table 2, excluding private-well supplies. The average civic-point densities for private well supplies (i.e. PG category) were summed and divided into bedrock (PGBA) and surficial aquifer (PGSA) categories based on the percentage of surficial aquifer wells compared to all wells in the Nova Scotia Well Logs Database (Nova Scotia Environment, 2017b).

A similar approach was used to generate summaries of domestic water source and supply types at the county and municipality level by implementing spatial joins between the residential civic-address points and the jurisdictional boundary polygons, and dividing private-well users into surficial and bedrock aquifer supplies based on the percentage of well types within each boundary.

## Results and Discussion

### Provincial Water Source and Supply Demographics

The present study yielded an estimate of 378,928 residential civic points in the province. By comparison, the 2016 census estimates that the population of Nova Scotia is 923,598 with 401,990 private dwellings occupied by usual residents (Statistics Canada, 2017). The census definition of a private dwelling includes individual apartment/condominium units belonging to a shared civic address. Average civic-point densities within the CDAs ranged from 1.3 to 14.5, and the overall civic-point density for the province was 2.4. The higher density CDAs (e.g. Fig. 2, Bedford) reflect a large number

of multi-unit buildings within a relatively small CDA boundary, and the low density CDAs (e.g. Fig. 2, Cumberland and Guysborough county CDAs) possibly reflect a large number of vacant or seasonal dwellings that were not accurately coded in the NSCAF.

There was generally good correspondence between the number of residential customers reported by the utilities and the GIS-derived estimate of residential civic points associated with the municipal distribution zones (Table 1). The per cent difference between the estimate reported by the utilities and the GIS analysis was generally less than 15% for the individual municipal water supplies. Variances between the two estimates are mainly attributed to the presence of private well-water supplies within the servicing boundaries and the exclusion of individual residential buildings serviced by private distribution systems (e.g. mobile home parks) from the estimate of residential customers generated by water utilities. For example, when the approximate number of residential civic-address points associated with mobile home parks are added to the utilities' estimate for Lower South River–St. Andrews and Truro–Bible Hill, the per cent difference between the two estimates is lowered from 64.6% to 2.1%, and 15.9% to 1.8%, respectively. Other contributing factors include inaccurate servicing boundaries and inaccurate coding of residential civic address attributes in the NSCAF (e.g. seasonal or vacant houses coded as residential dwellings). Overall, the total per cent difference between the reported and derived figures is less than 5%, which provides a reasonable indication of the magnitude of error that may be associated with the technique, although it should be noted that the list provided in Table 1 is not comprehensive. Survey responses estimating the number of residential customers were received for 59 of the province's 76 municipal water systems.

The province-wide estimate of well type for private water supplies found that of the 112,883 domestic wells recorded in the Nova Scotia Well Logs Database, 91% of well water supplies were drilled wells in fractured bedrock aquifers, 4% were drilled wells in surficial aquifers, and 5% were dug wells (Nova Scotia Environment, 2017b). Dug wells are under-reported in the Well Logs Database compared to drilled wells (Kennedy et al., 2017), and therefore the distribution of well types is biased towards a higher percentage of private-well users relying on drilled wells.

Surface-water and groundwater sources each account for approximately half of domestic water sources in Nova Scotia (Table 3, Fig. 3), with slightly more (5%) Nova Scotians relying on groundwater. Bedrock aquifers were found to be more widely used than surficial aquifers, representing 85% of groundwater sources. The analysis of population serviced by various types of supplies found that approximately 56% of Nova Scotians obtain their domestic water from municipal water supplies, 1.2% from registered water supplies, 0.5% from First Nations central water supplies, and 42% from private wells (Table 3, Fig. 4). There was an estimated 197,395 residential civic points using a private well.

Of the province's municipal water users, most Nova Scotians (84%) are supplied by surface-water sources since the largest population centre in the province, HRM, is supplied with water from Pockwock Lake and Lake Major (Fig. 1). The population-served estimate by Halifax Water using 2011 census data (305,165; Halifax Water, unpub. data, 2017) compares favourably with the number generated in the present analysis (313,931) with a per cent difference of less than 3% between the two estimates. The largest population centre serviced by municipal groundwater in Nova Scotia is in the Sydney area of Cape Breton (Fig. 1).

Registered water supplies are heavily reliant on groundwater sources (>90% of population serviced) for domestic water supply, especially bedrock aquifers, which supply approximately 84% of registered drinking-water users (Table 3). First Nation water supplies also rely heavily on groundwater sources (>97% of population serviced); however, most domestic water users in these communities are supplied by surficial aquifers (81%) (Table 3).

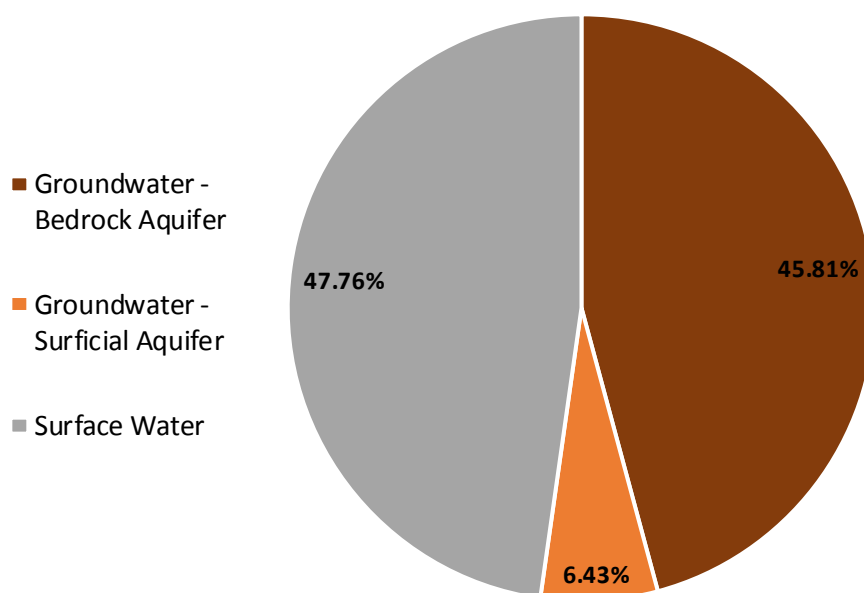
**Table 3.** Province-wide estimates of water source and supply types.

	Municipal		Registered		First Nation		Private		TOTAL
	Population	%	Population	%	Population	%	Population	%	
G-BA	60584	6.56	9083	0.98	779	0.08	352660	38.18	45.81%
G-SA	20701	2.24	1012	0.11	3956	0.43	27049	3.65	6.43%
S	440246	47.67	672	0.07	156	0.02	0	0.00	47.76%
TOTAL	519518	56.47	10961	1.17	4891	0.53	386408	41.84	100.00%

G-BA: Groundwater from a bedrock aquifer source.

G-SA: Groundwater from a surficial aquifer source.

S: Surface water.

**Figure 3.** Sources of domestic water in Nova Scotia.

## Water Source and Supply Type by County and Municipality

Shelburne and Digby counties have the highest percentage of residents using private well-water supplies, whereas Halifax County (i.e. HRM) has the lowest percentage of residents using private well-water supplies (Fig. 5). Although Halifax County has the highest percentage of serviced population, it also hosts the largest population of private-well users since over 40% of Nova Scotians reside in this county (Statistics Canada, 2017). Yarmouth, Shelburne and Inverness counties show the highest reliance on surficial aquifers, with more than 34% of their private-well users relying on dug wells or shallow drilled-wells installed in surficial aquifers, compared to less than 4% in Cumberland, Pictou and Queens counties (Appendix, Table A1). Towns in Nova Scotia are generally serviced with municipal water, whereas municipal units that encompass rural communities show a high reliance on private well-water supplies (Fig. 6; Appendix, Table A2).

## Long-Term Trends

A comparison of the current estimates of domestic water-sources and supply types with an analysis based on 1971 census data (Nova Scotia Department of the Environment, undated) indicates that there

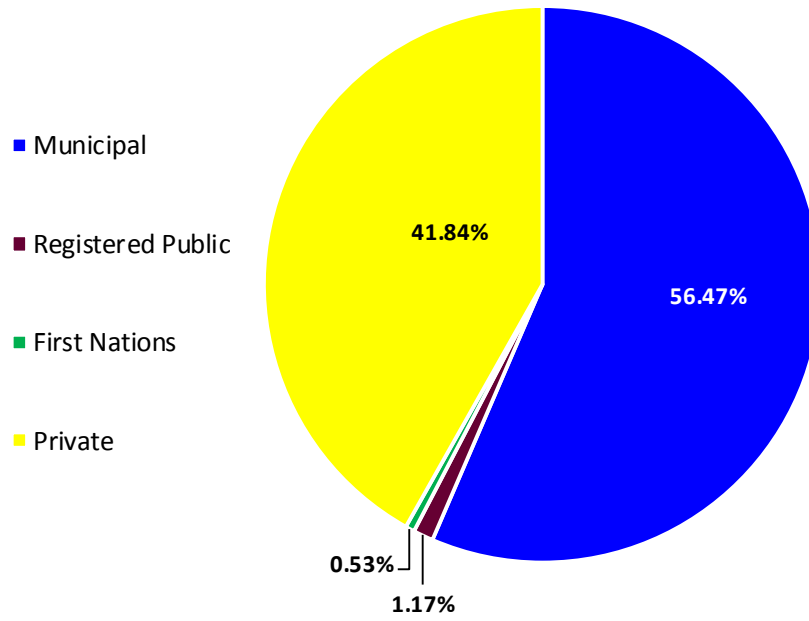


Figure 4. Water-supply types in Nova Scotia.

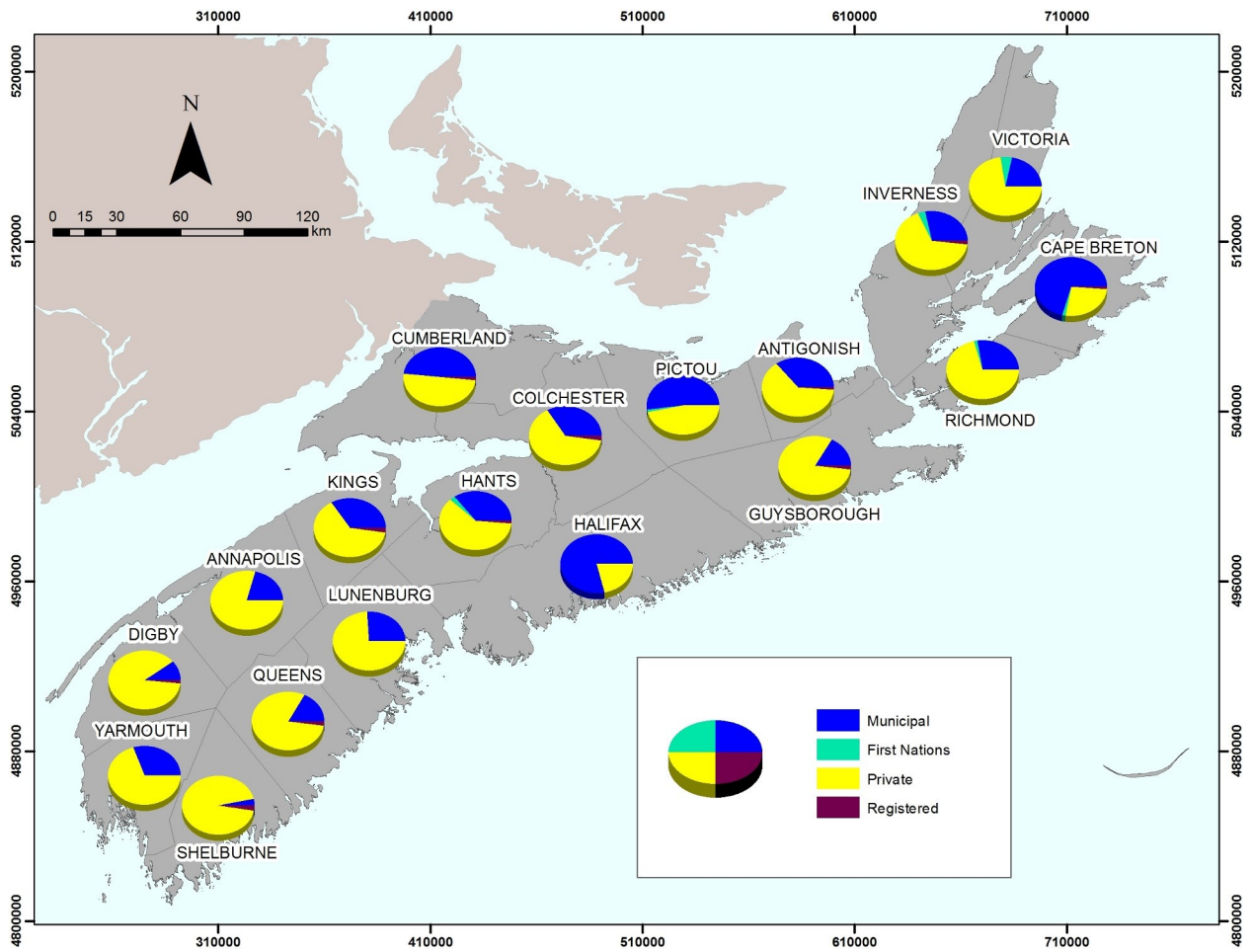
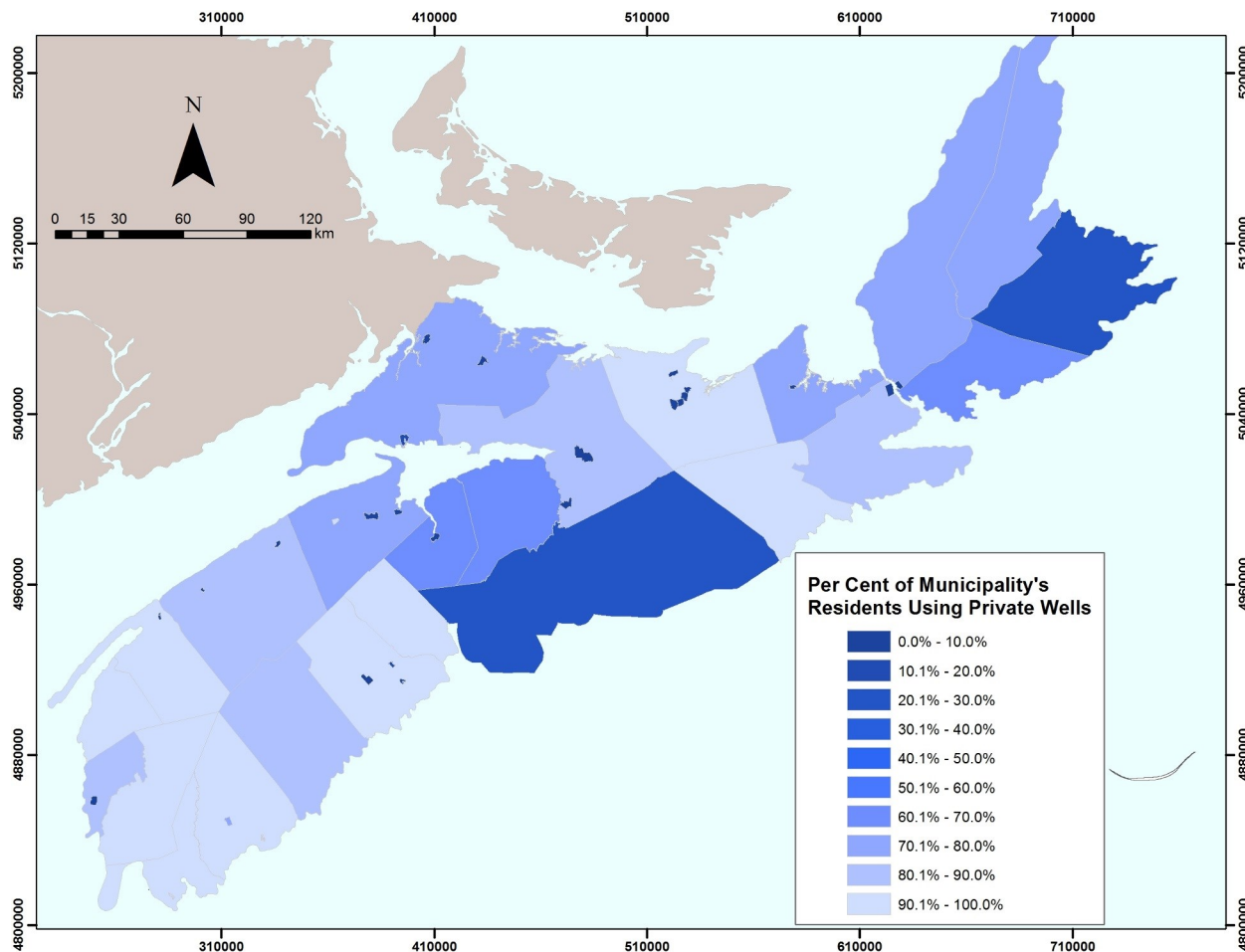


Figure 5. Distribution of water-supply type by county.



**Figure 6.** Per cent of residents within each of the province's 52 municipalities relying on private wells.

has been little change in water sources and water-supply types at the provincial scale, although there are few details on how the earlier analysis was conducted (Table 4). The current estimate, using 2016 census data, shows that a slightly larger percentage of Nova Scotians are serviced with municipal water today as compared to the estimate using 1971 census data—a trend that can be largely attributed to the extension of municipal distribution zones. Although the percentage of Nova Scotians serviced by municipal water supply has increased, it should be noted that the total number of private-well users has also increased, driven by suburban growth in HRM. It should also be noted that a municipal groundwater supply was recently developed for the Village of Pugwash; however, this system had not been commissioned at the time this study was prepared and is therefore not part of the present analysis.

In addition, Table 4 shows a slight increase in groundwater use from 1971 to 2016, which may reflect a general trend over the last fifteen years for municipal systems to switch from surface water to groundwater sources, especially on Cape Breton Island and in Kings and Annapolis counties (e.g. Village of Shubenacadie, Community of Bridgetown, Village of Port Hood, Village of Mabou, City of Sydney). This trend, however, is likely moderated by population growth in HRM, which is supplied by surface water.

## Conclusions and Recommendations

A methodology for estimating and tracking domestic water source and supply types in Nova Scotia was developed and used to determine how many Nova Scotians are supplied by surface water compared to

**Table 4.** Trends in domestic water source and supply demographics.

	Population		Per Cent Municipally Serviced		Per Cent Groundwater Supplied		Per Cent Surface Water Supplied	
	1971	2016	1971	2016	1971	2016	1971	2016
	788960	923598	54.00	56.25	50.00	52.47	50.00	47.53
Change	+134,638		+2.25		+2.47		-2.47	

groundwater (bedrock and surficial aquifers) sources, and how many Nova Scotians are supplied by municipal, registered and private water systems. Slightly more Nova Scotians (5%) rely on groundwater sources than surface water for their domestic water supply, and approximately 57% of Nova Scotians obtain their domestic water from public water systems (municipal and registered). There was good agreement (<5% difference) between the estimated number of residential customers reported by the water utilities and the number of residential service connections estimated by the geoprocessing technique, although the geoprocessing technique appears to slightly overestimate the population serviced.

The geoprocessing technique developed for this project is useful because the estimates of water source and supply type can be updated regularly as the provincial civic-address file (NSCAF) is updated, although the technique relies on maintaining current boundaries of all public and First Nation water supplies. The spatial data can be queried by water scientists and managers to better understand the local population at risk for various water quality and quantity hazards. The water source and supply demographic information generated during this study will be used by government scientists, water managers and decision-makers to support accountability reporting; the development of targeted, effective policy measures; and the communication and mitigation of risk.

Improvements are recommended to the attribute information contained in the NSCAF so that dwelling types are more consistently coded and can be easily filtered to identify residential civic points. To improve the accessibility of the data and the efficiency of domestic water demographic analyses, assistance could be provided to municipalities with the publication of municipal water-distribution zone boundaries on municipal web-based mapping platforms. Improving compliance with respect to the required submission of dug well records would provide a more accurate assessment of the importance of various aquifer types and therefore the vulnerability of private-well users to various hazards.

The analysis herein shows that the second largest population of domestic water users in the province, after municipal water users, are private-well users. Although private-well users are not regulated, it is recommended that outreach and education initiatives that promote practices contributing to safe drinking water are strengthened, which will engender improved public health outcomes.

## Acknowledgments

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## Appendix

**Table A1.** Estimated population supplied by each water source and supply type by county.

County	Municipal				Registered				First Nations				Private			Total
	MGBA	MGSA	MS	MS	RGBA	RGSA	RS	RS	FGBA	FGSA	FS	FS	PGBA	PGSA	PGSA	
Annapolis	3660	0	569	0	154	0	0	0	11	0	0	0	15428	759	20581	
Antigonish	1199	5797	0	0	50	181	0	0	183	0	0	0	10576	1305	19292	
Cape Breton	25222	0	44170	0	1056	9	0	0	0	1726	0	0	25279	1256	98718	
Colchester	266	0	17251	0	1105	36	0	0	0	0	0	0	29700	2262	50621	
Cumberland	10709	1187	2699	0	451	0	0	0	0	0	0	0	14484	469	29998	
Digby	1663	0	0	0	146	111	0	0	100	0	0	0	13199	2097	17316	
Guysborough	0	0	1233	0	133	0	0	0	0	0	0	0	5251	1013	7630	
Halifax	313	0	316087	0	2728	138	514	0	0	0	0	0	78999	4587	403366	
Hants	0	749	14644	0	397	118	0	0	0	1064	0	0	22049	3572	42594	
Inverness	1091	1103	2703	0	215	6	85	0	0	625	0	0	9664	1739	17230	
Kings	9314	11431	197	0	1381	0	0	0	0	124	0	0	34763	3404	60615	
Lunenburg	0	0	12183	0	298	156	0	0	0	0	0	0	31596	2873	47106	
Pictou	4664	0	17818	0	434	0	0	0	485	0	0	0	19898	448	43748	
Queens	0	0	1708	0	212	0	0	0	0	0	0	0	8128	291	10339	
Richmond	1613	0	859	0	0	0	73	0	0	0	156	0	5834	431	8966	
Shelburne	0	0	436	0	128	216	0	0	0	0	0	0	8192	4995	13968	
Victoria	869	433	236	0	0	0	0	0	0	417	0	0	4456	684	7096	
Yarmouth	0	0	7455	0	194	41	0	0	0	0	0	0	10905	5820	24415	
<b>Total</b>	<b>60584</b>	<b>20701</b>	<b>440246</b>	<b>0</b>	<b>9083</b>	<b>1012</b>	<b>672</b>	<b>779</b>	<b>3956</b>	<b>156</b>	<b>38005</b>	<b>348402</b>	<b>923598</b>	<b>38005</b>	<b>923598</b>	

PGBA: Private well utilizing bedrock aquifer

PGSA: Private well utilizing surficial aquifer

Refer to Table 2 for all other water supply codes



**Table A2.** Estimated population supplied by each water source and supply type by municipality.

Municipality	County	Municipal				Registered				First Nations				Private		Total
		MGBA	MGSA	MS	MS	RGBA	RGSA	RS	RS	FGBA	FGSA	FS	FS	PGBA	PGSA	
Cape Breton Regional Municipality	Cape Breton	25222	0	44170	44170	1056	9	0	0	0	1726	0	25279	1256	98718	
Halifax Regional Municipality	Halifax	313	0	316087	316087	2753	138	514	0	0	0	0	78999	4587	403391	
Municipality of the District of Argyle	Yarmouth	0	0	0	0	36	41	0	0	0	0	0	5100	2722	7899	
Municipality of District the Saint Mary's	Guysborough	0	0	144	144	0	0	0	0	0	0	0	1823	352	2319	
Municipality of the County of Annapolis	Annapolis	2086	0	569	569	154	0	0	11	0	0	0	15418	758	18997	
Municipality of the County of Antigonish	Antigonish	1199	2104	0	50	181	0	183	0	0	0	0	10572	1305	15594	
Municipality of the County of Colchester	Colchester	266	0	3231	3231	1105	36	0	0	0	0	0	29488	2246	36373	
Municipality of the County of Cumberland	Cumberland	647	12	2699	2699	451	0	0	0	0	0	0	14323	464	18597	
Municipality of the County of Inverness	Inverness	1091	1103	455	215	6	85	0	625	0	625	0	9664	1739	14982	
Municipality of the County of Kings	Kings	6220	4918	197	1162	0	0	0	124	0	124	0	32858	3217	48697	
Municipality of the County of Pictou	Pictou	134	0	1120	434	0	0	0	485	0	0	0	19507	439	22119	
Municipality of the County of Richmond	Richmond	1613	0	859	0	0	73	0	0	0	0	156	5834	431	8966	
Municipality of the County of Victoria	Victoria	869	433	236	0	0	0	0	0	417	0	4456	684	7096		
Municipality of the District of Barrington	Shelburne	0	0	0	62	149	0	0	0	0	0	4011	2446	6668		
Municipality of the District of Chester	Lunenburg	0	0	0	127	156	0	0	0	0	0	9253	841	10377		
Municipality of the District of Clare	Digby	0	0	0	50	111	0	0	0	0	0	7010	855	8026		
Municipality of the District of Digby	Digby	353	0	0	96	0	0	100	0	0	0	6614	807	7969		
Municipality of the District of East Hants	Hants	0	749	6214	368	61	0	0	1064	0	12995	2106	23558			
Municipality of the District of Guysborough	Guysborough	0	0	629	133	0	0	0	0	0	0	3425	661	4848		
Municipality of the District of Lunenburg	Lunenburg	0	0	455	147	0	0	0	0	0	0	22217	2020	24839		
Municipality of the District of Shelburne	Shelburne	0	0	99	66	0	0	0	0	0	0	2871	1750	4786		
Municipality of the District of West Hants	Hants	0	0	4870	29	57	0	0	0	0	0	8999	1458	15412		
Municipality of the District of Yarmouth	Yarmouth	0	0	1094	64	0	0	0	0	0	0	5768	3079	10005		

(Table A2 continues next page.)

**Table A2 (continued).**

Municipality	County	Municipal			Registered			First Nations			Private			Total
		MGBA	MGSA	MS	RGBA	RGSA	RS	FGBA	FGSA	FS	PGBA	PGSA	PGSA	
Region of Queens Municipality	Queens	0	0	1708	212	0	0	0	0	0	0	8128	291	10339
Town of Amherst	Cumberland	9416	0	0	0	0	0	0	0	0	0	0	0	9416
Town of Annapolis Royal	Annapolis	369	0	0	0	0	0	0	0	0	0	8	0	378
Town of Antigonish	Antigonish	0	3694	0	0	0	0	0	0	0	0	4	0	3698
Town of Berwick	Kings	0	0	0	219	0	0	0	0	0	0	1892	185	2296
Town of Bridgewater	Lunenburg	0	0	8527	0	0	0	0	0	0	0	4	0	8532
Town of Clark's Harbour	Shelburne	0	0	0	0	50	0	0	0	0	0	428	261	740
Town of Digby	Digby	1310	0	0	0	0	0	0	0	0	10	1	1	1321
Town of Kentville	Kings	3094	3148	0	0	0	0	0	0	0	13	1	1	6257
Town of Lockeport	Shelburne	0	0	5	0	0	0	0	0	0	0	307	187	499
Town of Lunenburg	Lunenburg	0	0	2238	0	0	0	0	0	0	16	1	1	2255
Town of Mahone Bay	Lunenburg	0	0	962	0	0	0	0	0	0	106	10	10	1077
Town of Middleton	Annapolis	1205	0	0	0	0	0	0	0	0	2	0	0	1206
Town of Mulgrave	Guysborough	0	0	460	0	0	0	0	0	0	3	1	1	464
Town of New Glasgow	Pictou	0	0	9092	0	0	0	0	0	0	57	1	1	9150
Town of Oxford	Cumberland	645	0	0	0	0	0	0	0	0	26	1	1	671
Town of Parrsboro	Cumberland	0	1175	0	0	0	0	0	0	0	134	4	4	1313
Town of Pictou	Pictou	2240	0	0	0	0	0	0	0	0	46	1	1	2287
Town of Port Hawkesbury	Inverness	0	0	2248	0	0	0	0	0	0	0	0	0	2248
Town of Shelburne	Shelburne	0	0	332	0	18	0	0	0	0	575	351	351	1276
Town of Stellarton	Pictou	0	0	3943	0	0	0	0	0	0	3	0	0	3946
Town of Stewiacke	Colchester	0	0	1259	0	0	0	0	0	0	80	6	6	1345

(Table A2 concludes next page.)

**Table A2 (concluded).**

Municipality	County	Municipal			Registered			First Nations			Private		Total
		MGBA	MGSA	MS	RGBA	RGSA	RS	FGBA	FGSA	FS	PGBA	PGSA	
Town of Trenton	Pictou	2290	0	18	0	0	0	0	0	0	32	1	2341
Town of Truro	Colchester	0	0	12761	0	0	0	0	0	0	132	10	12903
Town of Westville	Pictou	0	0	3646	0	0	0	0	0	0	254	6	3906
Town of Windsor	Hants	0	0	3560	0	0	0	0	0	0	55	9	3624
Town of Wolfville	Kings	0	3366	0	0	0	0	0	0	0	0	0	3366
Town of Yarmouth	Yarmouth	0	0	6361	94	0	0	0	0	0	36	19	6510
<b>Total</b>		<b>60584</b>	<b>20701</b>	<b>440246</b>	<b>9083</b>	<b>1012</b>	<b>672</b>	<b>779</b>	<b>3956</b>	<b>156</b>	<b>355297</b>	<b>348837</b>	<b>923598</b>

PGBA: Private well utilizing bedrock aquifer

PGSA: Private well utilizing surficial aquifer

Refer to Table 2 for all other water supply codes