The New Brunswick Groundwater Chemistry Atlas: A Geographical Representation of Groundwater Quality in New Brunswick

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Introduction

Under the Potable Water Regulation of the *New Brunswick Clean Water Act*, the Province of New Brunswick maintains a database of groundwater quality data collected from domestic water wells drilled since 1994.

New Brunswick privacy regulations prohibit the distribution of these water quality data by any method which identifies the individual well owner or associated property. These data can only be provided to researchers and other interested parties in aggregate form with all identifying coordinate data removed.

In 2006, as a means of making these data available in a spatial format to various user groups, the New Brunswick Department of Environment (DENV) began development of a series of thematic maps of groundwater quality using information in the domestic water well database. The goal was to develop a series of maps which could be publicly released without compromising privacy regulations. Based in part on the previous work done by Rivard et al. (2005) in the Maritimes Carboniferous Basin, the resulting *New Brunswick Groundwater Chemistry Atlas* (Atlas) was published in December 2008.

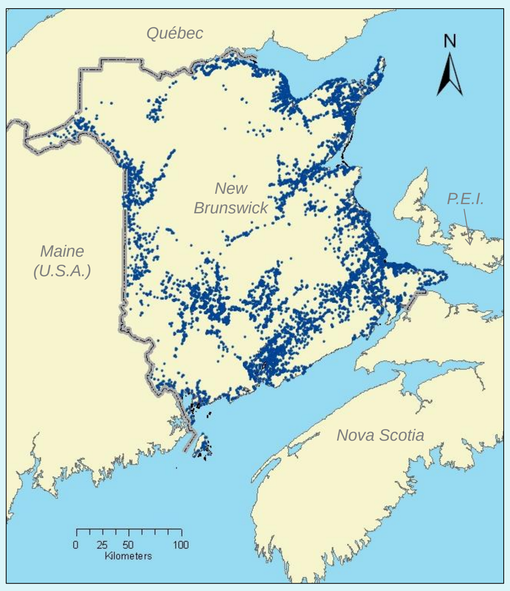

Figure 1. Location map of New Brunswick illustrating the distribution of new or deepened domestic water wells drilled in the province from 1994 to 2007.

Background

When a domestic water well is drilled in the Province of New Brunswick, the well driller completes a Water Well Driller's Report outlining the well location, construction details, estimated water yield and geology encountered. The report is forwarded to the DENV where the information is entered into the domestic well log database.

The well owner is also given a copy of the Water Well Driller's Report and is required by law (under the *Potable Water Regulation – New Brunswick Clean Water Act*) to purchase a Water Quality Analysis Voucher at the time of drilling. The well owner then redeems the voucher by collecting the necessary water samples, using the bottles and a methodology provided by the DENV, and submitting them to the DENV Analytical Services Laboratory for a standard inorganic chemistry analysis.

Results are entered into the DENV water quality database and a report with the results is sent to the well owner by the New Brunswick Department of Health (NB Health). A flow chart of this process is illustrated in Figure 2.

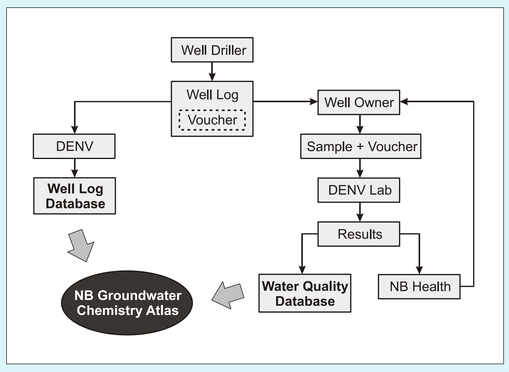

Figure 2. Flow chart of water quality analysis voucher process for newly drilled domestic water wells in New Brunswick.

Methodology

The results of water quality analyses were extracted from the water quality database for the period of January 1, 1994 to December 31, 2006. This resulted in 10,664 usable water chemistry results, although not every parameter was analysed in each case resulting in variations in the sample size. The domestic well log database reported 20,478 usable well logs for the same time period.

The discrepancy between the number of well logs and the number of water chemistry results indicates that roughly 50% of well owners did not submit a water quality sample to the DENV for analysis and redeem their Water Quality Analysis Voucher over the reporting period.

The parameters mapped in the Atlas include:

- Alkalinity
- Aluminum
- Antimony
- Arsenic
- Barium
- Boron
- Bromide
- Cadmium
- Calcium
- Chloride
- Chromium
- Conductivity
- Copper
- Fluoride
- Hardness
- Iron
- Lead
- Magnesium
- Manganese
- Nitrate
- pH
- Potassium
- Selenium
- Sodium
- Sulphate
- Thallium
- Uranium
- Zinc

Sample Atlas Page

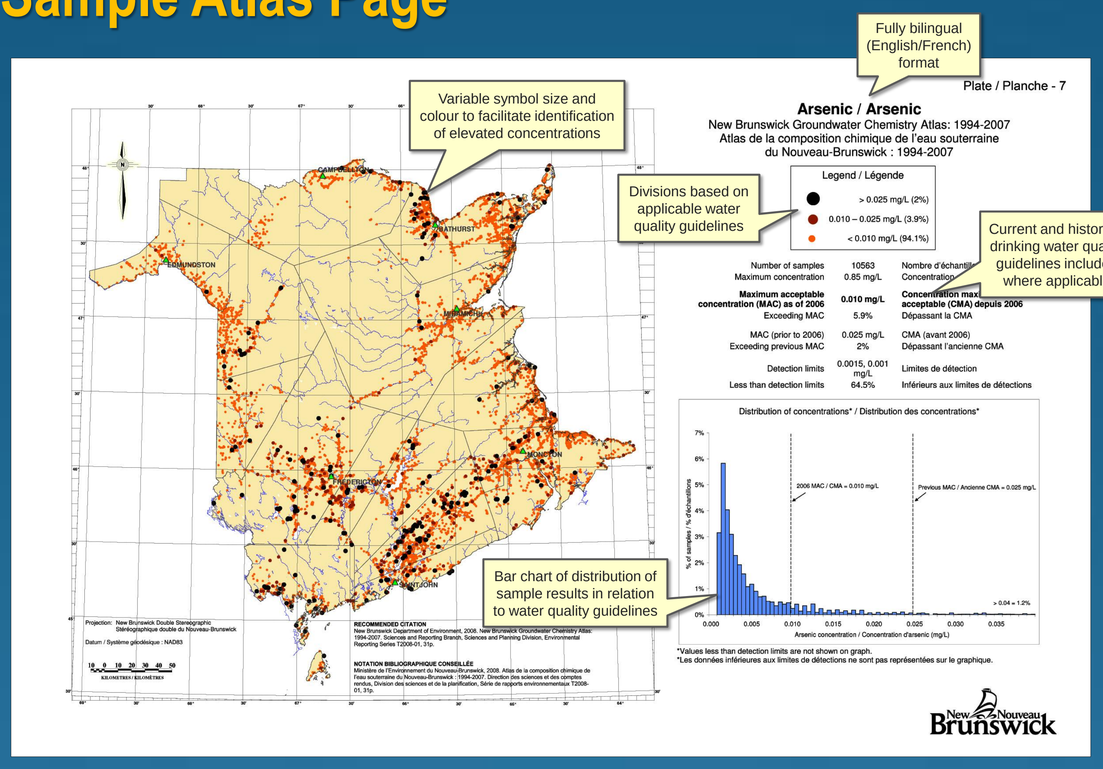

Figure 3. The plate for Arsenic is shown here as a sample page from the *New Brunswick Groundwater Chemistry Atlas* illustrating the general layout of the Atlas. The distribution of water quality results for 28 inorganic chemistry parameters from new or deepened domestic water wells in the province are individually mapped in the Atlas. For each parameter, the range in concentrations and information pertaining to the distribution of the data and their relationship to applicable drinking water quality guidelines is presented.

Results

For each individual parameter, the Atlas plate indicates the range in concentrations of the parameter along with information pertaining to the distribution of the data and their relationship to the Health Canada (2008) Guidelines for Canadian Drinking Water Quality. The following tables provide a detailed breakdown of the compliance of New Brunswick domestic water well samples with health-based and aesthetic guidelines (Tables 1 and 2). These results indicate that in general the water quality of domestic water wells in New Brunswick is very good. The most common water quality issues in New Brunswick are due to excessive iron and manganese in well water, which is attributable to the natural geology of the province.

Table 1. Compliance of samples with health-based guidelines.

Parameter	Samples in compliance
Antimony	99.4%
Arsenic	94.1%
Barium	98.6%
Boron	100%
Cadmium	99.9%
Chromium	99.8%
Fluoride	95.0%
Lead	97.3%
Nitrate	99.4%
Selenium	98.9%
Uranium	97.9%

Table 2. Compliance of samples with aesthetic guidelines.

Parameter	Samples in compliance
Chloride	96.7%
Copper	99.9%
Hardness	89.2%
Iron	71.2%
Manganese	60.2%
pH	86.3%
Sodium	96.6%
Sulphate	99.4%
Zinc	99.9%

In certain instances, the Atlas indicates a relationship between a water chemistry parameter and the bedrock geology, the geological history, or general land use of the area. For example, elevated sodium and chloride can indicate aquifers that are vulnerable to salt water intrusion but can also outline inland areas where relic sea water from the late Quaternary is found at depth (Figure 4). Other examples of these relationships include the presence of higher concentrations of iron and manganese in domestic water wells in the Carboniferous Basin, and higher nitrate concentrations in agricultural areas along the upper Saint John River valley (Figure 5).

Examples…

Relic Seawater

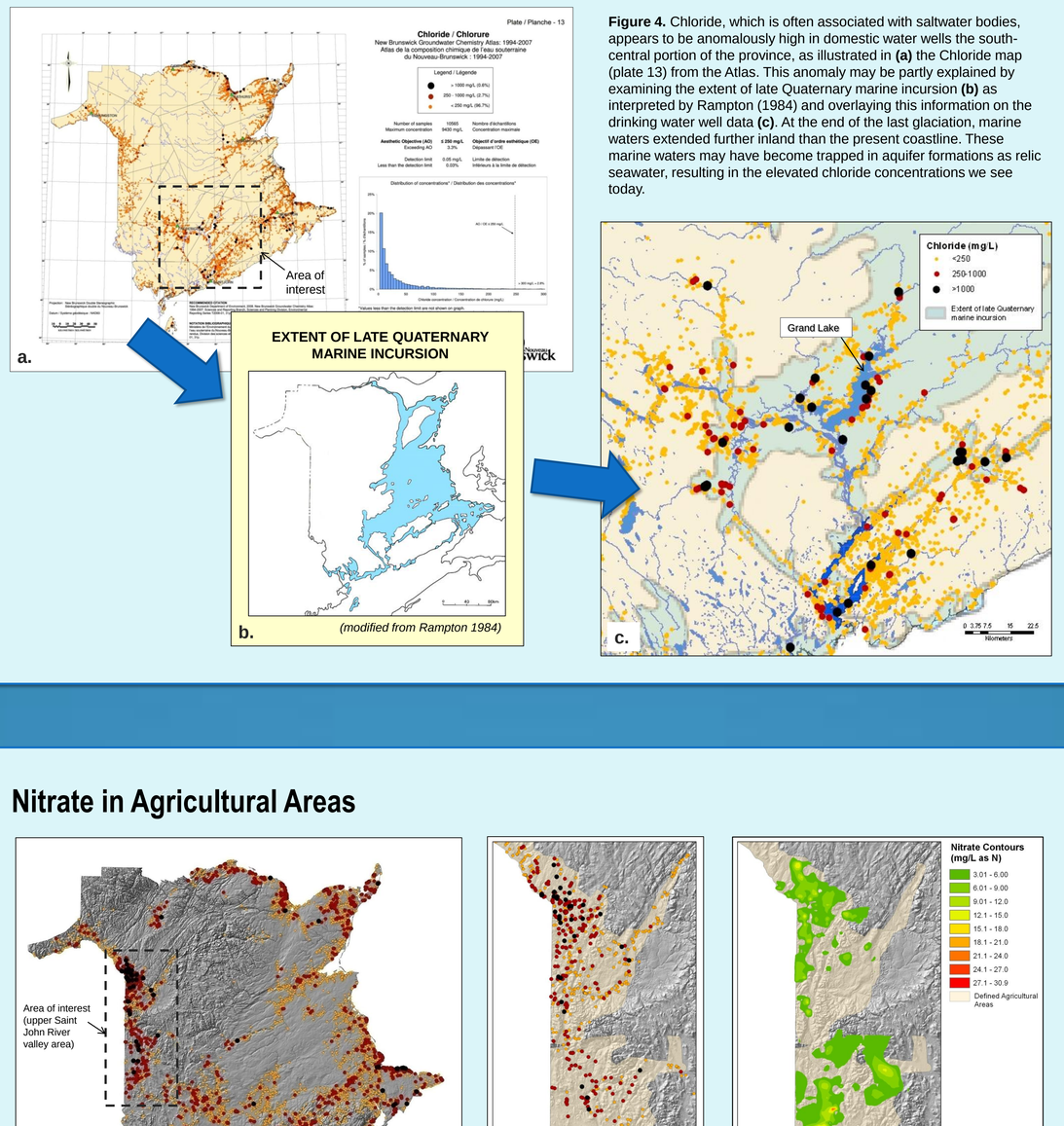

Figure 4. Chloride, which is often associated with saltwater bodies, appears to be anomalously high in domestic water wells the south-central portion of the province, as illustrated in **(a)** the Chloride map (plate 13) from the Atlas. This anomaly may be partly explained by examining the extent of late Quaternary marine incursion **(b)** as interpreted by Rampton (1984) and overlaying this information on the drinking water well data **(c)**. At the end of the last glaciation, marine waters extended further inland than the present coastline. These marine waters may have become trapped in aquifer formations as relic seawater, resulting in the elevated chloride concentrations we see today.

Nitrate in Agricultural Areas

Figure 5. (a) The distribution of nitrate concentrations in groundwater samples from domestic water wells in New Brunswick serves as an example of the interaction between groundwater quality and land use. While the drinking water guideline for nitrate is set at less than 10 mg/L (as nitrogen), concentrations above 1 mg/L often indicate an anthropogenic influence on the water supply. Elevated nitrate concentrations are often seen in agricultural areas due to the application of fertilizers containing high amounts of nitrogen. This relationship is clearly seen in the upper Saint John River valley, a major potato producing area of New Brunswick, when nitrate concentrations **(b)** are plotted over the defined agricultural lands. While the plotted data **(b)** indicate elevated nitrate concentrations in throughout area of interest, contours of the data **(c)** provide more detail on the specific areas with highest concentrations.

Future Work

In the future, additional data analysis will be conducted on the data from the water quality database in order to further examine the relationships between groundwater chemistry and; well depth, surficial and bedrock geology, and structural features such as fault zones (see Figure 6).

Since the Atlas only includes water chemistry data up to December 31, 2006, it is intended to be periodically updated as additional well water quality data become available.

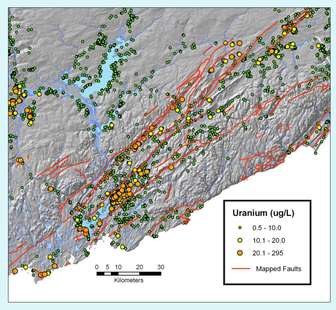

Figure 6. Distribution of uranium concentrations in groundwater samples from domestic water wells in southern New Brunswick with the location of known fault zones overlain. Elevated uranium concentrations appear to be associated with the fault zones, and may also be associated with particular bedrock units. Further investigation into these relationships are a possible area of future work.

Conclusions

Since its release in December 2008, the *New Brunswick Groundwater Chemistry Atlas* has proven to be a useful tool to help educate New Brunswickers about general groundwater quality in the province and identify areas with potential water quality concerns. The Atlas can be used in conjunction with other information by planners and developers to make informed decisions about land use planning and sustainable development. The data are also being used in environmental health research and mineral exploration by groundwater researchers and geologists.

The Atlas provides a basis for further research into factors that affect natural groundwater chemistry. It also serves as a baseline for comparing shifts in water quality overtime due to climatic changes and other factors. It should be used for general information purposes only, and independent confirmation of groundwater quality for specific sites is recommended.

Acknowledgements

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References

Health Canada 2008. Follow: Environmental and Workplace Health, Guidelines for Canadian Drinking Water Quality, 30/05/08, http://www.hc-sc.gc.ca.

Rampton, V.N. 1984. Generalized surficial geology map of New Brunswick. Department of Natural Resources and Energy; Minerals, Policy and Planning Division. NR-8.

Rivard, C., Deblonde, C., Michaud, Y., Boisvert, V., Carrier, C., Castonguay, S. & Lefebvre, R. 2005. Hydrogeological Atlas of the South-Central Areas of the Maritimes Carboniferous Basin. Geological Survey of Canada, Open File **4884**, 54p.

For more information or to obtain an electronic copy of the New Brunswick Groundwater Chemistry Atlas go to…

www.gnb.ca/environment