One Island, One Source: A Review of the Literature Concerning Prince Edward Island's Groundwater Resources

Ryan O'Connor, PhD

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Introduction[1]

Prince Edward Island's groundwater resources are of utmost importance to Prince Edward Islanders. As the only province with total reliance on groundwater, the water supply is experiencing unprecedented pressures. These pressures include a growing population, expanding industrial applications, increasingly intensive agricultural operations, and the ever-present dangers associated with climate change, which exacerbate the aforementioned factors.

This report provides a general overview of the research completed thus far on the Island's groundwater supply. The literature examined within this review meet two specific guidelines. First, the studies are specific to groundwater and Prince Edward Island. Second, the studies examine the science behind the issue. These sources took the form of journal articles, book chapters, government reports, theses and dissertations, and conference papers.

As this review of the literature reveals, there have been two major areas of study concerning Prince Edward Island's groundwater resources. The first is saltwater intrusion, which in recent times has been primarily studied with respect to potential effects caused by climate change. The second is nitrate contamination, which has been studied for its connection with the agricultural industry and, in more recent years, for the anticipated consequences of climate change.

For the purpose of this analysis of the existing research, groundwater should be defined as water located beneath the water table, within the zone of saturation. An aquifer is a permeable layer of rock from which groundwater can be obtained, utilizing a well, in usable amounts. A

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watershed is the catchment area of a drainage basin. The water table is water that is stored underground in the pores of rock and in soil.

Groundwater on Prince Edward Island

Brandon, L.V. "Groundwater Hydrology and Water Supply of Prince Edward Island." Geological Survey of Canada (1966). Department of Mines and Technical Surveys.

This report surveys information about the province's groundwater potential, with planned use for "new industries and growing municipalities requiring greater supplies of water." (1) It notes that groundwater is available in abundance throughout the province, explaining that "At no point on the island is it possible to drill a dry hole." Most groundwater is of excellent quality for drinking and industrial purposes, with the exception of areas experiencing saltwater intrusion and where nitrate levels are high. It notes that wells drilled within close proximity of the seashore are prone to saltwater intrusion, which necessitates shallow wells whenever possible in such locations. (35)

Francis, Rory M. "Hydrogeological Properties of a Fractured Porous Aquifer, Winter River Basin, Prince Edward Island." MSc (Earth Sciences) University of Waterloo, 1981.

This study examines the effect of fractures and matrix on volumetric flux and fluid velocity within the province's aquifer. As the author explains, "The results of this study emphasize the need for protection and management of the bedrock aquifer of Prince Edward Island. The high vertical and horizontal frequencies and high fracture permeability in the upper portion of the aquifer, coupled with the generally high permeability of the overlying till allow potential contaminants on the ground surface to quickly move into the bedrock and degrade water quality in the upper aquifer zone." (70) This results in the problem that the greatest quantity of Prince Edward Island's water supply is the most easily contaminated. The area of study, the Winter River Basin, is the main source of Charlottetown's water supply.

Blundell, Gary and Jackie Harman. "A Survey of the Quality of Municipal Supplies of Drinking Water from Groundwater Sources in Prince Edward Island." Sierra Club of Canada Eastern Canadian Chapter and University of Waterloo. (2000).

Samples of municipal groundwater were analyzed from 18 wells located in 12 Prince Edward Island communities. These samples were compared against the standards established in the Guidelines for Canadian Drinking Water Quality (GCDWQ). It was determined that "drinking water supplied by municipal groundwater wells across PEI is generally of good quality." (50) No pesticides were detected, while levels of nitrates, tetrachloroethene, and trihalomethanes did not exceed the levels permitted according to the GCDWQ. The only inorganic concentration found to exceed permitted levels was lead, which was detected in 2 communities. This report also contained a legislative review, which noted that while existing legislation did exist to protect provincial groundwater resources, "it is not specific to groundwater and does not form a unified or integrated system of groundwater protection." (49) The report recommends that the PEI Department of Technology and Environment should ensure that water supplies be regularly tested by municipalities to ensure they remain in accord with the GCDWQ, and that the government should enact groundwater-specific legislation. It was also recommended that an Island-wide groundwater monitoring program be established which measures ambient groundwater quality, as this "would be a more effective way of monitoring change in groundwater quality than sampling domestic or municipal wells." (52-53)

Groundwater Pressures/Issues: Saltwater Intrusion

Carr, P.A. "Salt-water intrusion in Prince Edward Island," *Canadian Journal of Earth Sciences* 6.63 (1969): 63-74.

This study examines the Eliot River (West River) estuary. It notes that saltwater is carried inland from saline estuaries during high tide, eventually penetrating the bedrock aquifer. Saltwater has created a large zone of diffusion along the banks of the Eliot River estuary, which the author highlights is not attributable to local groundwater consumption. The saltwater extends 1,200 feet inland, and to a depth of 185 feet. Sandwiched between this and a second level of saltwater 600 feet underground is fresh groundwater. It is noted that the saltwater and the fresh groundwater are separated, not by a "confining stratum," but by the higher head of the fresh water, which "maintains a dynamic equilibrium with the heavier salty water." (63) It is concluded that the significance of density in separating the two is less important than previously thought.

Prince Edward Island Department of Environment, Labour and Justice. *"Saltwater Intrusion and Climate Change: A primer for local and provincial decision-makers*." Atlantic Climate Adaptation Solutions Association (2011).

This study notes that saltwater intrusion is a problem in coastal regions, such as Atlantic Canada, and that this problem is expected to be aggravated with the onset of climate change. As such, the Atlantic Regional Adaptation Collaborative of Natural Resources Canada has initiated case studies in each of the Atlantic provinces, with the purpose of better understanding the effect climate change will have on saltwater intrusion throughout the region.

Hansen, Brian Alden. "Simulating the Effects of Climate Change on a Coastal Aquifer, Summerside, Prince Edward Island." MSc (Earth Sciences) Saint Francis Xavier University, 2012.

This study utilizes a variable-density groundwater flow and transport model, applying extensive geological, geophysical, geochemical, and hydrological data "to estimate submarine groundwater discharge and predict the influence of climate change on the coastal aquifer" in Summerside. (iii) The author concludes that climate change will have limited impact on the water resources for the Summerside area. While sea-level rise simulations indicate saltwater intrusions (30-60 m) will occur, the effects will be mitigated by increased precipitation rates and the subsequent groundwater recharge. In fact, the simulations demonstrated "that heavy groundwater pumping was the dominant factor in future water security for the study site and not climate change." (iii) The author therefore recommends that pumping and modelling tests be conducted before heavy groundwater extractions are permitted in the area. It is also noted that the thesis does not examine the full effects of saltwater intrusion resulting from the inland migration of saltwater that may accompany climate change-induced coastal erosion.

Somers, George and Peter Nishimura, eds., *Managing Groundwater Resources: Assessing the impact of climate change on salt-water intrusion of coastal aquifers in Atlantic Canada*. Atlantic Climate Adaptation Solutions Association. (2012).

This publication includes two case studies specific to Prince Edward Island. In "Simulating Saltwater Intrusion in a Changing Climate," authors Brian Hansen and Grant Ferguson note that geochemical analysis shows that the saltwater-fresh water transition zone is located 20-40 m below the surface, and that it extends beyond 80 m. The transition zone fluctuates daily and seasonally due to tidal influences, recharge, and the position of the water table. This study repeats the conclusion of Hansen (2012), noting that the effects of climate change on saltwater intrusion and submarine groundwater discharge are minimal in comparison to the effects of even moderate levels of groundwater pumping.

In "Investigation of the Risk of Salt Water Intrusion to Water Supply Infrastructure, Lennox Island, PEI," Hansen and Ferguson echo the findings Hansen (2012), "where it was found that groundwater use is a more important consideration in the management of saltwater intrusion issues" than climate change. (43)

Groundwater Pressures/Issues: Nitrates

Priddle, M.W., R.E. Jackson and J.P. Mutch. "Contamination of the Sandstone Aquifer of Prince Edward Island, Canada by Aldicarb and Nitrogen Residues." *Groundwater Monitoring & Remediation* 9:4 (1989): 134-140.

The quality of groundwater was measured beneath two potato farms in eastern Prince County between 1985 and 1988. Aldicarb (Temik) was applied once or twice to each field between 1985 and 1988. In May 1988, 12 percent of the 48 monitoring well samples exceeded the water guideline limit for total aldicarb, while 32 percent of samples exceeded the nitrate limit. It is recommended that aldicarb be applied when temperatures are warmer and recharge is higher to limit its persistence.

Bukowski, John, George Somers and Janet Bryanton. "Agricultural Contamination of Groundwater as a Possible Risk Factor for Growth Restriction or Prematurity." *Journal of Occupational and Environmental Medicine* 43:4 (2001): 377-383.

This study examines groundwater nitrate exposure on Prince Edward Island and its possible impact on prematurity and intrauterine growth restrictions. Utilizing a database of births in the province, the cases of 210 intrauterine growth restriction cases, 336 premature births, and 4,098 controls were examined. After adjusting for several covariates, a positive association was established between exposure to higher levels of nitrates and cases of intrauterine growth restriction and prematurity. The authors do note that a study "using nitrate levels for individual study subjects is needed to confirm this association." (377)

Liao, S.L., M.M. Savard, G.H. Somers, D. Paradis and Y. Jiang. "Preliminary results from water-isotope characterization of groundwater, surface water, and precipitation in the Wilmot River watershed, Prince Edward Island." Geological Survey of Canada (2005). Natural Resources Canada.

In this study of the Wilmot River watershed, 107 groundwater and 17 surface water samples were taken from 4 season field operations, along with 13 precipitation samples. The authors used the stable isotopes of oxygen and hydrogen with the goal of analyzing the source of nitrate concentrations in ground and surface water, with strong implication that agricultural activity is the potential leading source. It was discovered that there is no relationship between well depth and nitrate concentrations in the groundwater. While more research is needed on this topic, the early research implies that the groundwater in the Wilmot River watershed comes entirely from precipitation, and that surface water comes almost entirely from groundwater.

Benson, Victoria S., John A. VanLeeuwen, Javier Sanchez, Ian R. Dohoo and George H. Somers. "Spatial Analysis of Land Use Impact on Ground Water Nitrate Concentrations." ***Journal of Environmental Quality*** **35 (2006): 421-432.**

Utilizing spatial aggregation, this study examines the correlation between land use practices and concentrations of nitrate within Prince Edward Island's groundwater. Samples were taken from 4,855 private wells. The results determined that land utilized for potato, hay, and grain were significantly associated with groundwater nitrate concentrations, while blueberry, clear-cut woodland, and other agriculture were only marginally significant.

Paradis, Daniel, Jean-Marc Ballard, Martine M. Savard, René Lefebvre, Yefang Jiang, George Somers, Shawna Liao, and Christine Rivard. "Impact of Agricultural Activities on Nitrates in Ground and Surface Water in the Wilmot Watershed, PEI, Canada" Sea to Sky Geotechnique 2006: 59th Canadian Geotechnical Conference and 7th Joint CGS/IAH-CNC Groundwater Specialty Conference, Vancouver, BC, October 1-4 (2006). (Conference Proceedings).

A 3-D groundwater flow and mass transport model of the Wilmot River watershed was developed in order to assist aquifer management decisions, with a special interest in agricultural activities. This model shows that the aquifer intervals most susceptible to nitrate contamination are those exploited by domestic wells. It was predicted that the mean nitrate concentration could increase from 6.5 mg/L in 2000 to 10.5 mg/L in 2055 if the current nitrate load is maintained.

Savard, Martine M., Dainel Paradis, George Somers, Shawna Liao and Eric van Bochove. "Winter nitrification contributes to excess NO_3 in groundwater of an agricultural region: A dual-isotope study." ***Water Resources Research*** **43:6 (2007): 1-10.**

This study utilizes the Wilmot River watershed-aquifer system to contest the popular assumption that nitrification from fertilized soils used for agriculture reduces during the winter. Tests were carried out between 2003 and 2005, reproducing "the observed water and nitrate oxygen-isotope trends." (1) The study concludes that nitrification occurs year-round, and that winter-produced nitrate, the product of snow cover, is a significant contributor to the total nitrate load within the Wilmot River watershed.

Savard, Martine M., George Somers, Daniel Paradis, Eric van Bochove, Harold Vigneault, René Lefebvre, Georges Thériault, Reinder De Jong, Yefang Jiang, Budong Qiang, Jean-Marc Ballard, Rim Cherif, Noura Ziadi, John MacLeod, Odile Pantako, Jingyi Y. Yang. "Consequences of climatic changes on contamination of drinking water by nitrate on Prince Edward Island." Earth Science Sector Geological Survey of Canada (2007). Agriculture and Agri-Food Canada and Prince Edward Island Environment, Energy and Forestry.

This study conducts research on nitrogen levels and sources in individual watersheds and uses modelling to apply their findings, province-wide. The study was able to confirm previous beliefs that nitrogen inputs from agricultural practices were a major contributor to the heightened nitrogen levels in the aquifer. The study also identified important seasonal fluxes in nitrogen inputs. During the summer/active growing season, direct leaching is the main cause of nitrogen contribution. Nitrogen contribution is most significant from the nitrification of residual plant life during the winter/off season. Upon completion of modelling, a trend was identified that indicated that the nitrate level will continue to rise under today's agricultural practices. In order to counteract this trend this study suggests that a substantial reduction in the input of nitrogen during both seasons through proper application and management of residual plant life is the only way to reverse the pattern. Finally, continuing monitoring activities and intensifying efforts on strategic plans and partnerships will determine the future sustainability of PEI's groundwater.

Jiang, Yefang, George Somers, and Daniel Paradis. "Estimation of Groundwater Residence Times in the Wilmot River Watershed on Prince Edward Island – Implications for Nutrient Reduction."(2007). (Conference Paper).

This report examines residence times, ages, and lag times of groundwater from the time nitrate sources are managed and reduced, and improvement of nitrate conditions in surface and groundwater of the Wilmot River watershed. These reductions in nitrate are realized through the implementation of best management practices on farms. Shallow groundwater could be improved within 4-15 years if best management practices are followed; the same reductions in deep groundwater would take 11-50 years.

Vignault, Harold, Jean-Marc Ballard, René Lefebvre, Daniel Paradis, Martine M. Savard, and George Somers. "Evolution of Groundwater Nitrate Concentrations Under Various Climate Change Scenarios for Prince Edward Island, Canada." (2007). (Conference Paper).

The researchers developed 2-D infiltration model and a 3-D numerical model of groundwater flow and nitrate mass transport in order to examine how climate change could affect nitrate levels in Prince Edward Island's groundwater. It was determined that if current recharge and nitrate loading levels continued, nitrate levels would increase by 11 percent. When climate change's effects on recharge were factored, nitrate levels increased by 11-17 percent. The increase of nitrates was 25-32 percent in the scenario where agricultural producers adapted to climate change by increasing nitrogen loads due to predicted intensification of agriculture.

Benson, Victoria S., John A. VanLeeuwen, Henrik Stryhn and George Somers. "Temporal analysis of groundwater nitrate concentrations from wells in Prince Edward Island, Canada: application of a linear mixed effects model." *Hydrology Journal* 15:5 (2007): 1009-1019.

Nitrate levels in groundwater were determined to be highest in wells tested in agricultural areas, with urban areas testing lower, and areas of low human-impact showing the lowest levels. It was also determined that groundwater nitrate concentrations were influenced more by short-term temporal changes than yearly effects, with areas of row crops having the highest nitrate levels in summer, and manure storage areas being higher in the spring and autumn. This highlights the significance of land use as an influence on nitrate concentrations, and which in turn is influenced by the season.

Somers, George and Martine M. Savard. "Economic implications of increasing nitrate in groundwater due to climate change, Prince Edward Island, Canada." (2008). (Conference Paper).

It is noted that the groundwater found in 5 percent of domestic wells across Prince Edward Island, and over 10 percent of wells in the province's more intensively cultivated watersheds, experience nitrate contamination. It is predicted that this number will increase by 10 percent by 2050 if current land practices remain in place. If the agricultural industry reacts to climate change as expected, anticipated contamination rates could triple. These changes could result in a doubling of the number of wells with nitrate contents exceeding guidelines.

Jiang, Yefang and George Somers. "Modeling effects of nitrate from non-point sources on groundwater quality in an agricultural watershed in Prince Edward Island, Canada." *Hydrogeology Journal* 17 (2009): 707-724.

This study utilizes numerical models to simulate nitrate-N transport in groundwater, as well as to improve the understanding of how farming affects water quality in the Wilmot River watershed. Increased concentrations of nitrate-N in the base flow were linked to the intensity of potato crops; likewise, it was noted that in order to lower nitrate levels of surface water to meet Canadian Water Quality Guidelines standards, reductions in nitrate-N loading are necessary. As the simulations demonstrated, it will take several years to reduce the levels of nitrate-N in the shallow areas of the aquifer, while the deeper areas will take several decades, if not longer, to recover.

Somers, George and Savard, Martine, M. "Stable Isotopes of Nitrate Reveal the Important Role of Soil Organic Matter in Mediating Nitrogen Transfer to Groundwater with Implications for Consequences of Climate Change." (2009). (Conference Paper).

The transfer of nitrogen from soils to groundwater is examined in two Prince Edward Island agricultural areas. Strong seasonal differences are noted under crop cultivation, but absent from areas of livestock production, suggesting differences in chemical behaviour of inorganic fertilizers and manures. Nitrate inputs are particularly strong during the winter as there is little plant life to absorb nitrate in the soil. This study predicts that climate change will result in higher minimum soil temperatures, which could accelerate the rate of winter nitrate inputs. The authors call for effective management of crop residues in an effort to reduce nitrate contamination of groundwater.

Somers, George and Martine M. Savard. "Report to Canada-PEI National Water Program: Investigation of Nitrogen Cycling in Agricultural Settings of PEI Using Stable Isotopes of Nitrate." Prince Edward Island Environment, Energy and Forestry, Canada Geological Survey, and Natural Resources Canada. 2010.

These findings echo the authors' 2009 report. In addition, it is noted that the impact of high nitrate concentrations in groundwater can lead to high nitrate concentrations in surface water, leading to premature eutrophication.

Savard, Martine M., George Somers, Anna Smirnoff, Daniel Paradis, Eric van Bochove and Shawna Liao. "Nitrate isotopes unveil distinct seasonal N-sources and the critical role of crop residues in groundwater contamination." ***Journal of Hydrology*** **381 (2010): 134-141.**

This study, based out of Prince Edward Island's Wilmot River watershed, demonstrates that freshwater serves as a transport vector, moving nitrate from agricultural soil to groundwater and surface water. The authors conclude that "strategies to attenuate contamination by nitrate in waters of temperate climate row-cropping regions must consider nitrogen cycling by soil organic matter, including the crucial role of crop residues throughout both the growing and non-growing seasons." (134)

Love, Jonathan. "Determination of the Effect of Nutrient Management Plans on Nitrate Concentrations in the Soil and Water Below the Root Zone in Commercial Potato

Production," MSc (Plant and Animal Sciences) Dalhousie University in co-operation with Nova Scotia Agricultural College, 2010.

This study measures nitrate leaching in potato farms in different growing conditions (inorganic fertilizer use and no fertilizer use). The largest nitrate concentration is found to occur during the agricultural off-season due to improper dissipation of inorganic fertilizers. Subsequently, the author calls for an emphasis on best management practices after harvest.

Somers, George H. and Martine M. Savard. "Considerations for the mitigation of nitrate contamination: stable isotopes and insights into the importance of soil processes." Water Science & Technology 64:6 (2011): 1254-1260.

This study examines nitrate contamination of experimental potato plots. It reveals the effect of non-growing season nitrogen flux accounts for less than 10 percent of direct leaching, even with heavy application of fertilizer. Other factors include residual fertilizer in the soil organic matter pool being released via mineralization and nitrification. It brings to light the potential of using residual nitrogen from past growing seasons to minimize the amount of nitrogen applied in subsequent seasons.

Danielescu, Serban and Kerry T.B. MacQuarrie. "Nitrogen loadings to two small estuaries, Prince Edward Island, Canada: a 2-year investigation of precipitation, surface water and groundwater contributions." ***Hydrological Processes*** **25 (2011): 945-957.**

This study examines dissolved inorganic nitrogen (DIN) loadings, derived from direct precipitation, stream flow, and groundwater discharge. The two sites examined, the McIntyre Creek and Trout River estuaries, exhibit symptoms of excessive nitrogen, which is believed to come from adjacent estuaries. As was demonstrated, the dominant source of dissolved inorganic nitrogen loads in both estuaries was streams, with groundwater discharge contributing approximately 15-18 percent. This highlights the fact "that direct groundwater discharge to estuaries in PEI should not be ignored and that seasonal variations in loading may be important for managing DIN delivery to such estuaries." (945)

Jiang, Yefang, Bernie Zebarth and Jonathan Love. "Long-term simulations of nitrate leaching from potato production systems in Prince Edward Island, Canada." ***Nutrient Cycling in Agroecosystems*** **91 (2011): 307-325.**

A LEACHN model was used to simulate nitrate leaching from a Prince Edward Island potato farm. Simulations revealed that it was during the non-growing season that the majority of nitrate leaching occurred, as "crop uptake diminishes, and nitrate from mineralization and residual fertilizer coexists with excessive moisture from rainfall and snowmelt infiltration." (307) Due to this, the authors argue that in order to reduce nitrate accumulation in the soil, future research must investigate practices to reduce nitrate accumulation both during and outside of the growing season both in potato phase and the rotation crop phases.

Jiang, Yefang, Bernie J. Zebarth, George H. Somers, John A. MacLeod and Martine M. Savard. “Nitrate Leaching from Potato Production in Eastern Canada,” in Zhongqi He, Robert Larkin, and Wayne Honeycutt, eds., *Sustainable Potato Production: Global Case Studies*. New York: Springer, 2012. (233-250).

This chapter, which focuses on Prince Edward Island, examines nitrate leaching that results from potato production systems. It notes that the source of nitrate leaching differs seasonally. Nitrate leaching during the growing season is largely attributable to mineral fertilizers and mineralization of soil organic nitrogen, while out-of-season nitrate leaching is largely the result of mineralized nitrogen, which includes microbially-modified fertilizer nitrogen. It is noted that implementing practices to reduce nitrates in the root zone, particularly during potato harvest, can reduce nitrate leaching. It is recommended that the frequency of growing potatoes within the crop rotation be lessened, along with the adoption of practices to reduce residual nitrate.

Grizard, Pierre, “Modeling Nitrate Loading From Watersheds to Coastal Waters of the Northumberland Strait,” MSc (Engineering) University of New Brunswick, 2013.

The author developed a spatially lumped model to estimate annual nitrate loads and concentrations derived from Prince Edward Island’s watersheds. The model demonstrated that 91 percent were the result of agriculture, with 57 percent specifically linked to potato production. By contrast, only 4 percent is believed to come from home septic systems. The author notes that 70 percent of the nitrate loadings “come from delayed flow, taking longer than one year to be transported, while the remainder comes from rapid flow.” (109)

Danielescu, Serban and Kerry T.B. MacQuarrie. “Nitrogen and oxygen isotopes in nitrate in the groundwater and surface water discharge from two rural catchments: implications for nitrogen loading to coastal waters.” *Biogeochemistry* 115 (2013): 111-127.

The deposit of nitrogen concentrations to estuaries was compared at two catchments with different land uses. The effect of the natural filtration process in each catchment was examined, with attention to the filtration of nitrogen. It was discovered that the natural filtration process does not effectively filter out nitrogen deposits.

Bugden, G., Y. Jiang, M.R. van den Heuvel, H. Vandermeulen, K.T.B. MacQuarrie, C.J. Crane and B.G. Raymond, “Nitrogen Loading Criteria For Estuaries In Prince Edward Island.” Canadian Technical Report of Fisheries and Aquatic Sciences (2014). Fisheries and Oceans Canada.

This study examines the development of a model to measure nitrate criteria on Prince Edward Island. The model measures theoretical nitrate concentrations that could potentially exist in any estuary without physically measuring the amounts.

Conclusion

While considerable attention has been devoted to nitrates and saltwater intrusion, it is clear that there is room for more research on Prince Edward Island's groundwater resources. Much has been written about agriculture's impact on groundwater, but this review of the literature did not uncover any research pertaining to the growing aquaculture sector. The connection between Prince Edward Island's industrial sector and groundwater resources is understudied. Perhaps most importantly, given recent media attention devoted to the issues, the author of this review notes that there has been little to no published research concerning high-capacity wells or hydraulic fracturing ("fracking") and their potential impact on the province's groundwater supply.

The implications for contaminated groundwater are twofold. First, contaminated groundwater leads to contaminated drinking water, which is a health problem. Second, groundwater is the source of nearly all surface water on Prince Edward Island. Contaminated groundwater can lead to environmental issues, such as premature eutrophication, of surface water bodies. This is an issue that affects all residents of Prince Edward Island, since each Islander derives their drinking water from the groundwater. Subsequently, this is an issue that requires attention and cooperation from stakeholders, including policymakers, industrial interests, and academics.

This literature review demonstrates that scientific research has tended to follow public concern regarding Prince Edward Island's groundwater supply. This is most notable in the wealth of research concerning agriculture's link to nitrate contamination, and more recently with respect to the impact of climate change on nitrification and salt water intrusion. While groundwater is renewable, it is dependent on a complex series of environmental processes. As such, it would be reckless to proceed with any developments involving provincial groundwater without first gaining a fuller understanding of all potential implications.