

**Submission to the Commission on Nitrates in Groundwater
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Introduction

Why the IIS is making this submission

The mandate of the Institute of Island Studies at the University of Prince Edward Island is to improve the quality of life of Islanders through practical application of the scholarly discipline of Island Studies and in particular, to:

- Encourage and facilitate the greater understanding of Prince Edward Island : its history, culture, governance, ecology and economy
- Promote the development of progressive public policy
- Facilitate and support global comparative island studies through which PEI can learn from the experience of other small islands
- Act as a bridge between UPEI and the wider Island Community

In meeting this mandate, the Institute often works with the volunteer members of its Advisory Council which includes an array of community representatives as well as UPEI faculty and students. Where there seems to be a gap in either publicly available information or opportunities to discuss public policy issues, the Institute may develop public meetings, a forum with invited resource persons or a conference. Where the government has taken the lead, the Institute works with community and university partners to develop evidence-based input to government forums and commissions. Given its limited resources, there are times when the IIS cannot provide input; however, fundamental issues of social security, natural resource management, heritage and governance receive high priority. Water quality is an issue that cuts across all of the above.

Water Issues on PEI in the Context of North America and the World

The water that is in circulation on the surface and in the shallow soils of the planet was deposited when the earth first formed, billions of years ago, and it is all the water we will ever have. There are no new sources of water; it does not rain down from outer space, nor can it spring anew from any natural process on earth, although it cycles continually between living and non-living parts of the biosphere.

Precious little of the planet's water is fresh and therefore potable. Of all the water on earth, more than 97% is salty. Just over 2% is bound up in the (now shrinking) polar ice caps, and 0.6% lies in the earth --- half of which we can reach and extract with wells. A mere 0.009% is fresh water that lies on the surface of the earth in ponds, lakes and rivers (Tweedie, 1966).

“Increasing scarcity, competition and arguments over water in the first quarter of the 21st century will dramatically change the way we value and use water and the way we mobilize and manage water resources.” - Dutch Crown Prince Willem-Alexander, World Water Forum 1999

“Even where supplies are sufficient or plentiful, they are increasingly at risk from pollution and rising demand.” – UN Secretary General Kofi Annan, 2002

Internationally it has been recognized that conflicts within and between nations, as well as urgent refugee situations, are most likely to arise as a result of competition over water because, on a global scale, access to clean fresh water essential for life is diminishing both in terms of quantity and quality (Shiva, 2002; Barlow, 2007). North America is experiencing both extinctions of native freshwater wildlife (Ricciardi & Rasmussen 1999) and invasions of exotic species. These trends are exacerbated by climate change but have their roots in longer term patterns of unsustainable industrial development, wastefulness and pollution of the environment.

We tend to associate water shortages, gross environmental pollution and resource conflicts with developing countries. We also tend to be complacent in the belief that Canada has relatively massive fresh water resources (mostly in the Great Lakes and northern ice fields) and that North America generally is sufficiently wealthy that any potential problems can be fixed through development and application of technologies, no matter how expensive these may be. It is increasingly clear that such thinking has no basis in scientific reality. There is no economically viable technological fix foreseeable for wide-scale polluted groundwater, and climate change is already threatening the water levels of Canada's ponds, lakes and rivers. For example, there is real evidence of declining water levels in our Great Lakes (Lenters, 2004; Steen et al, 2006).

Human demand for fresh water has tripled in the past 50 years, but the quantity of clean, fresh water available for human use is diminishing across North America (Postel & Vickers, 2004). About 70% of all water used by humans is dedicated to agriculture, 22% to industry and the rest to municipal water supplies. Nitrate pollution in ground and surface waters, often linked to industrial agriculture, is a cause of concern across the globe (Camargo & Alonso, 2006). In North America, elevated nitrates in groundwater are commonly accompanied by pesticides and other contaminants (Gosselin et al, 1997; Squillace et al, 2002).

Water Issues on Small Islands

Water resources on small islands are acknowledged to be particularly limited and vulnerable in this era of climate change and environmental degradation. Agricultural and industrial practices and waste management are always critical issues on small islands because they lack space where pollutants can be safely broken down or stored. Almost all of the predicted changes in climate will affect the fresh water resources of islands, whether it be through salt water intrusion or changing patterns of storms, rainfall and evaporation. PEI's friable bedrock, sandy soils and small size means that we will be hard hit by climate change impacts.

Water Quality on Prince Edward Island

Background concentrations of nitrate on PEI

It is generally accepted in North America that nitrate concentrations in excess of 3 ppm indicate some form of water pollution, whether from chemical fertilizers, landfill leachate, industrial effluent, human wastes or animal manures (Squillace et al, 2002). On PEI, clean wells – often found in forested areas – register levels of less than 1 ppm nitrate (Breadalbane Community water tests, 2008 from I Novaczek pers comm) and in many cases can be dramatically less (< 0.1 mg/L; M. van den Heuvel, unpublished data). While more than a century of agricultural disturbance on the Island precludes an absolute determination of 'natural' background levels of nitrate on PEI, those levels were almost certainly less than 1 mg/L. Elevated nitrate concentrations are especially common in western Queens and eastern Prince counties and the correlation with use of agricultural fertilizers is unambiguous (Benson et al, 2006).

The Problem with Nitrate in Groundwater

Connectivity of surface, ground, riverine and marine systems

Nitrate seeps into the underlying groundwater and from there into rivers and streams, while manures and fertilised soil are swept into ponds and streams by rain, especially where soil tilth is poor and where plant cover has been removed. The resulting cascade of ecological troubles runs with the river all the way to the sea where algae, stimulated by excess fertilizers, rapidly grow and reproduce. Soon the algae die, drop to the bottom and rot, a process that removes oxygen from the water, triggering the death of bottom dwelling fishes and shellfish. In the sea, natural nutrient balances are disrupted, which can trigger blooms of toxic

plankton --- such as the *Nitzschia* outbreaks that poisoned some shellfish consumers and shut down mussel aquaculture in the late 1980s.

Interaction of Nitrate with Pesticides and other Pollutants

When nitrate enters ground and surface waters it may reach concentrations that are in themselves harmful. On PEI, nitrate is increasingly found at levels above thresholds deemed acceptable for human health. What water quality guidelines fail to account for is that wherever agricultural nitrate is found --- even at currently acceptable levels --- traces of other farm chemicals may also be present. This has already been recorded in PEI, in wells close to potato and blueberry fields (Somers et al 1999). Even higher concentrations of combined pesticides and nitrate are found in the Island's rivers (ibid.). Similarly, where nitrate levels are high because of manure, landfill, factory or sewage inputs, other deleterious substances and pathogens are likely to also be present. Human health and ecological impacts of certain pesticides and other pollutants are magnified if nitrate is also present (see below).

Implications of Nitrate Pollution for PEI

Human Health

Nitrates in drinking water can be a health hazard when present at relatively high concentrations (over 10 ppm). At much lower concentrations, nitrate interacts with other pollutants such as trace mixtures of pesticides to produce health impacts. A mixture of nitrate and ppb concentrations of pesticides have been found in rural wells and surface waters of PEI (Somers et al, 1999). Such mixtures have been implicated in a range of immune system, endocrine and nervous system conditions (Guillette et al, 2005; Porter et al, 1999) including various cancers (Pearce & McLean, 2005; Thorpe & Shirmohammadi, 2005), childhood diabetes (Kostraba et al, 1992; van Maanen et al, 2000; Parslow et al, 2000 among others), thyroid dysfunction (Eskiocak et al, 2005) and attention deficit disorders (Porter et al, 1999), as well as reproductive problems and birth defects (Manassaram et al, 2006). These impacts are most serious for small children, the frail elderly and persons with pre-existing diseases affecting the immune, endocrine or nervous systems.

Much of the evidence of human health impacts of nitrate is very recent and some results differ from those of earlier studies conducted in the 1990s (Steindorf et al, 1994; Fewtrell, 2004). Scientists are calling for further studies to clarify the impacts of low concentration, complex chemical mixtures in water (Cantor, 1997; van Grinsven et al, 2006; Guillette et al, 2006; Ward et al, 2006), but the weight of evidence is already mounting. The levels of combined nitrate and pesticides in drinking water that can be considered safe need to be re-evaluated. The fact that pesticides are also encountered in the air that all species breathe during the growing season on PEI, and the potential for these exposures to be additive, should also be taken into account (White et al, 2006). Clearly there are implications (as yet unquantified) in terms of the health care costs that could result from widespread, long term consumption of what authorities now consider to be only mildly contaminated water and air.

Wildlife Health

Humans can drill deeper wells or purchase bottled water from clean sources to meet their needs, but wildlife depend entirely on surface waters that are increasingly contaminated. Whereas the nitrate concentration deleterious for human health is set at 10 ppm, the CCME limit proposed for protection of aquatic life is only 2.9 ppm. Most species, having a smaller body mass than the average human, will be more affected than humans are by the chemicals in their water supply and environment. Recent studies point to impacts of nitrate on the health of amphibians and crabs (Orton et al, 2006; Romano & Zeng, 2007a, 2007b; Griffis-Kye & Ritchie, 2007).

Fisheries, Shellfisheries and Aquaculture

Because nitrate pollution in rivers, estuaries and nearshore marine environments can have serious direct and indirect impacts on fish and shellfish, this problem also affects fisheries and aquaculture. Nutrient loading, soil erosion and other forms of water pollution have been noted as a concern among fishers affected by the collapse of the Northumberland Strait lobster, scallop and spring herring fisheries (GTA, 2006).

Sources of Nitrate in Water

Agricultural Inputs

Nitrate in ground water is most strongly correlated with agricultural land in potato rotation (Benson et al. 2006). Nitrate rich fertilizers move through soil into groundwater during summer when applications exceed the absorptive capacity of the crop. In winter, nitrate may be mobilized from organic matter in soils. Recent research indicates that the common practice of fall ploughing greatly exacerbates the liberation of nitrate from soil organic matter (Somers, pers comm May 2008; Lynch et al, in press). This practice therefore robs the soil of nutrients that would otherwise be available for growing crops the following season, pollutes groundwater and increases demand for chemical fertilizers.

Industrial agriculture releases massive quantities of nitrogen rich fertilisers into the Island's environment. Assuming a conservative application rate of 135 kg N per hectare per yr (Lynch et al, in press) for land in potato production, the annual planting of more than 100,000 acres (40,500 hectares) of potatoes on PEI adds at least 5.5 million kg N to the land. The practice of applying fertilizer at planting means that in a wet year up to 80% of nitrogen can be leached into the soil before the potato plant even starts to grow (R. Coffin, Cavendish Farms, personal communication). During the remainder of the season, rain also moves fertilizer that is not quickly absorbed by growing plants into the ground and surface waters. Recent measurements of the subsequent loading of nitrates into PEI streams range up to 1000 kg N *per day* in some watersheds (Dr M. van den Heuvel, pers comm, April 2008).

Human and animal waste

Sewage outfalls from primary treatment plants on PEI dump minimally treated human sewage directly into rivers and the sea. Such sewage contains not only nitrates but pharmaceutical drugs, cleansers and other toxic substances as well as pathogenic organisms (Jorgensen & Halling-Sorensen, 2000; Sanderson et al, 2003). Where secondary treatment of sewage occurs on the Island, there is evidence of significant phosphate release (added to the treatment process in order for bacteria to thrive; M. van den Heuvel unpublished data). Combined with agriculturally-derived nitrate, this can dramatically exacerbate the already deteriorating status of Island estuaries. In unincorporated areas characterized by ribbon development, and in the many small villages and towns lacking sewage treatment infrastructure, faulty household septic systems can add significant loads of nitrate and other pollutants to aquifers and streams. Individual household septic tanks are periodically pumped out and the sludge is either sent to sewage treatment plants and thus into surface waters, or spread directly on agricultural land (without composting).

Owing to intensive dairy, beef and pork operations, PEI has, in recent years, been among the top areas in Canada in terms of manure production per acre of land base. Manures are spread on the limited land base, and this is largely controlled not by regulation but by voluntary guidelines. There has so far been no movement toward the systematic use of the manure resource for biogas production.

Landfills

PEI has made significant progress in landfill and waste management, diverting organic material to a composting facility, dramatically reducing the number of landfills and applying modern standards of landfill construction and management. However, enriched leachate from the Richmond landfill is still being pumped out and disposed through municipal sewage treatment plants that dump their effluents into inshore marine waters.

Fish and food processing

There are a number of fish and food processing plants on PEI that generate nutrient rich effluents. Some efforts have been made to recover wastes for use in downstream processing (for example the capture and use of whey by ADL). The Cavendish Farms potato processing factory has an engineered wetland to help polish its effluents. However, these and other factories operate under federal regulations which, while providing for a useful minimum standard across the country, often fail to adequately protect particular receiving waters from deleterious impacts.

Solutions for Future Sustainability

PEI's Track Record of Commissions, Reports and Public Consultations

Over the past 40 years the public purse has paid for a series of commissions and deliberative processes to consider land use practices and more recently, forest policy and watershed management. Many excellent recommendations have been made, but only a few have been fully enacted. . The most recent of these, released only a year ago, (Environmental Advisory Council, 2007) has 43 recommendations in response to public consultation, many of which would be directly related to the issue of nitrate contamination on PEI. This trend of using public commissions and consultations to forestall action has led to considerable cynicism and apathy on the part of stakeholders. Most insidious is the frustration felt amongst those members of watershed and other community group that volunteer significant amounts of their time to environmental improvement – without these individuals we are truly lost. Clearly, there is much to be done that has already been clearly outlined in previous studies. The answers have been obvious for decades, but the political will to act has faltered. It is for this reason that the Commission for Nitrate in Groundwater has seen so few submissions from academics.

Consultation with stakeholders such as the farm community, municipal sewage managers and factory effluent managers is important so that to the extent possible, stakeholders are well informed and encouraged to make voluntary efforts to reduce water pollution. This should be balanced by consultation with fishers, defenders of wildlife, tourism operators, health care providers, teachers and others who are adversely affected by the impacts of “business as usual” water pollution. As stated above, it is important to consider that while valuable when used judiciously, consultation processes can also result in procrastination or paralysis if they are overdone.

Learning from Other Jurisdictions – and Our Own History

Because many other jurisdictions face the same problems as we do with respect to contamination of water, there is ample published literature and new studies coming out every day that include recommendations on how to prevent water contamination (e.g. Muscutt et al, 1993; Stoddard et al, 2005; Oquist et al, 2007; Reichenberger et al, 2007). We can look to jurisdictions in Europe which, in many instances, have already banned particularly dangerous and unnecessary chemicals and practices, set in place new governance structures and invented technologies that can help Canada come to grips with our water and climate change challenges (e.g. Haycock & Muscutt, 1995; Withers et al, 2002). Whereas research on PEI has great value, it need not be a prerequisite to action. We need to search out and adopt evidence-based best practices from other jurisdictions. Historically, many jurisdictions --- including the Great Lakes and the Rhine River watershed --- have significantly reversed and remediated nutrient-related issues. All that was required was the will to do it.

We can also look to our local, pre-industrial farm practices, to the cultural values of the Island's Aboriginal people and to current organic agricultural practices for inspiration. For example new research by Lynch et al (in press) conducted in PEI and NB clearly lays out the benefits of spring clover plough-down compared to use of chemical fertilizers, in terms of the risk of nitrate contamination.

Educating our young people is a critical part of public education and could be advanced effectively through development of a provincial museum of natural history that dedicated significant resources to supporting citizen science, informing watershed management and offering educational programs to schools.

End of Pipe Mitigation vs Prevention

There is no technological fix for a polluted aquifer that can serve the needs of both humans and other species. The most cost effective solutions for the long term all involve the prevention of water pollution rather than mitigation or treatment. A Precautionary Approach to development and resource management has been entrenched in various national and international laws and conventions, including Canada's Oceans Act. However, precaution has yet to be adequately integrated into day to day decision-making at any level of government (Kerans and Kearney, 2006).

Regulation vs Voluntary Guidelines

Public education and peer pressure leading to voluntary compliance with best practices for eliminating water pollution are necessary but not necessarily sufficient. Well crafted regulatory measures followed up by enforcement and suitable penalties are also required. For example, consideration must be given to replacing current manure management guidelines with appropriate regulations.

Regulatory gaps

The regulatory and governance systems of PEI are poorly equipped for the challenge of stemming water pollution. As has been detailed by previous commissions, changes are needed in land use zoning, planning and management structures.

Recently there has been a surge in on-the-ground action by Island citizens under the umbrella of various watershed groups. This is a tremendous asset. Consideration should be given, when developing better land management models and tools, to regulatory arrangements that cover geographic areas consistent with watershed boundaries.

Federal regulatory frameworks and laws related to allowable effluent discharges from fish and food processing facilities fail to take into account the carrying capacity of the receiving waters. These regulations should be backed up by provincial restrictions appropriate to the particular receiving waters. Sewage treatment standards are similarly lax and inadequate to protect receiving waters. The province could research and promote cost-effective tertiary treatment systems using biological processes, such as engineered wetlands. European jurisdictions appear to be far advanced in pollution prevention as well as treatment technologies, and will provide a valuable source of new ideas.

Improving Agricultural methods

Existing regulations aimed at preventing soil erosion need to be strengthened and enforced. The legislation of science-based limits on the annual amounts of nitrogen that can be spread on any given field, directly linked to the crops that will be grown, is another possibility. There are decades of scientific development of slow-release fertilizers, so the eventual outright banning of nitrate-based fertilizers may be inevitable. Since the leaching of nitrate from agricultural soil over winter is stimulated by fall ploughing, this practice needs to be banned. Eliminating the practice of spreading manure in the fall or over the winter, when there are no growing plants to take up the nitrogen, would also be sensible. Limiting fertilization until after the plant emerges would definitely have significant benefits. To stem nitrate pollution associated with soil erosion, broader riparian zones could be established and left unploughed and mandatory crop rotations could be lengthened.

The government could further support and reward implementation of organic farming methods that improve soil tilth and reduce the need for chemical fertilizers. With the growing recognition of the value of medicinal herbs and flowers needed to support emerging biosciences, promoting such new crops and new forms of agriculture --- especially ones that require fewer inputs and can be done with minimal ploughing -- are promising opportunities. The withdrawal of subsidies and supports from less sustainable forms of agriculture is also necessary.

Investing in Climate Change Preparedness

Climate change will unfold largely through changes in the cycling of water. There will be changes in patterns of rainfall, bringing increased summer droughts. Rain, when it does fall, will fall with greater intensity, increasing soil erosion and the movement of silt and fertilisers into fresh water bodies. Winter snowfall will diminish as climate change kicks in, leaving ploughed fields more vulnerable to winter wind erosion. As climate change intensifies, moving to sustainable farming practices and replacing wasteful mass irrigation with micro-irrigation will be urgent priorities.

Focused use of Federal Infrastructure Funds

New funds directed to improving sewage treatment, upgrading water supply infrastructure, protecting wellfields and watersheds etc that are coming from the federal level need to be deployed strategically through coordinated, holistic planning that crosses government departments.

Strengthening local governments, watershed groups and citizen science

The province has already begun to improve supports for municipalities and watershed groups. Such efforts require coordination and long range planning so that they support future water security for the Island. Recommendations from UPEI biology professors for advancing watershed management were included in a previous submission to the Environmental Advisory Board (Teather et al, 2007).

Establishing a Coherent Vision for the Next Century

Protection and rehabilitation of water resources is a complex, long term process requiring a holistic, publicly supported vision of the future of our economy and society on Prince Edward Island. More than any other resource, water cuts across and has impacts on every facet of our lives and livelihoods.

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