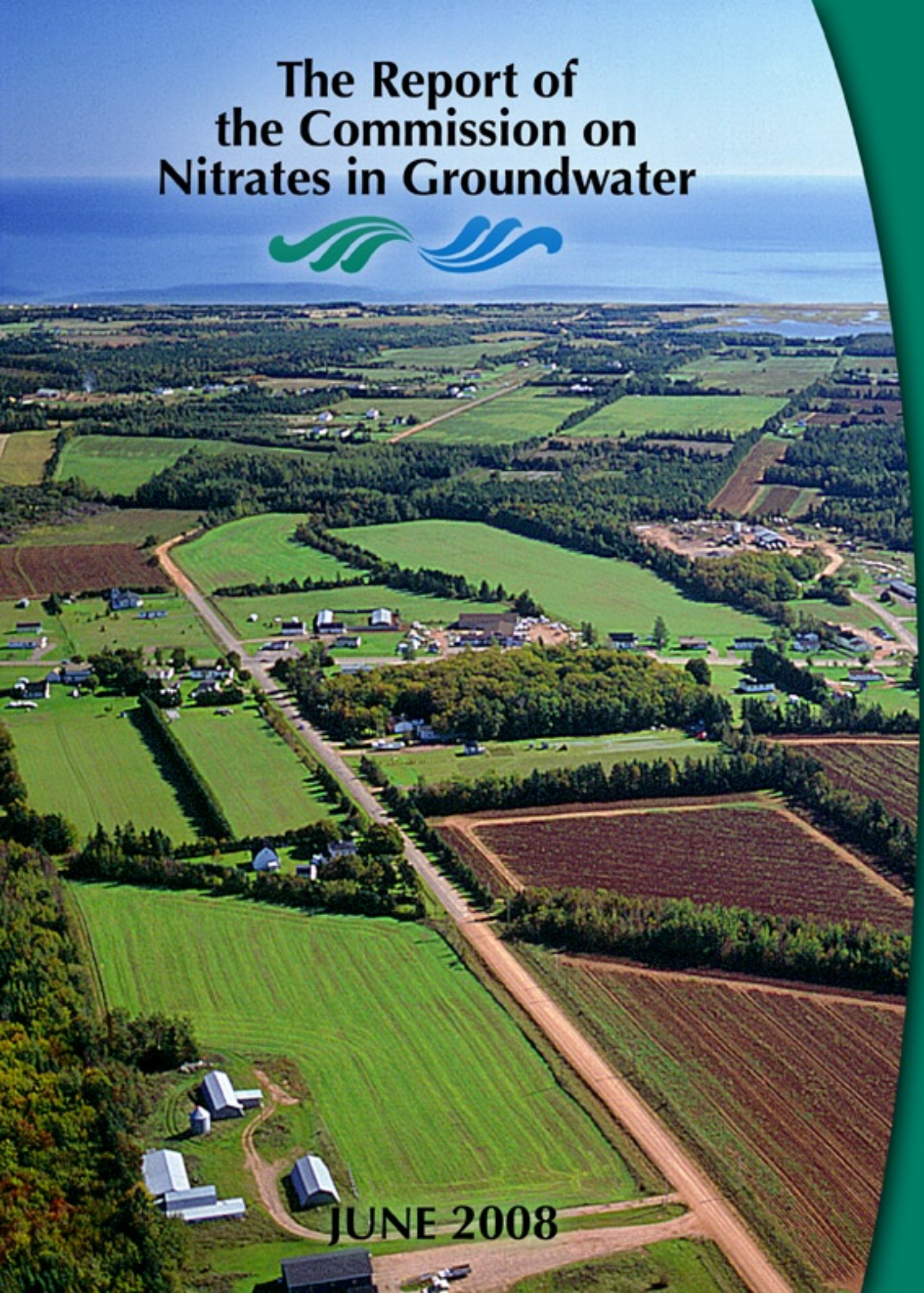
The Report of the Commission on Nitrates in Groundwater



JUNE 2008

"….In the realm of time, the physical time we spend upon this Earth is but a blip. We use the land and the resources at our disposal for a time, and then our time is gone. However, the land, the water, the natural resources, they remain. As time passes, the stewards of our Mother face new challenges and mounting pressures and some may say we are now at a critical point in time. As the pressure mounts, we must stop, reflect and plan the path before us….."

Chief Darlene Bernard

We can know what's going on,
and we can fix what's gone wrong.
That's the point of it all.

Marque de Villiers in Water,
The Fate of Our Most Precious Resource

Photos Credits / Cover: Ron Garnett, AirScapes International Inc.

Table of Contents

Commission on Nitrates in Groundwater

Chair, The Honourable J. Armand DesRoches
c/o Tony Sturz
PO Box 2000
Charlottetown, Prince Edward Island
Canada C1A 7N8

Commission sur les nitrates dans l'eau souterraine

L'honorable J. Armand DesRoches, président
a/s de Tony Sturz
C. P. 2000
Charlottetown (Île-du-Prince-Édouard)
Canada C1A 7N8

July 7, 2008

Premier Robert Ghiz
Government of Prince Edward Island
PO Box 2000
Charlottetown, PE C1A 7N8

Dear Premier Ghiz:

Human health concerns have arisen about the quality of our drinking water, the natural systems which provide that water, and the aquatic ecosystems that are reliant on that water. One key concern is the threat posed by nitrate contamination of our aquifers and watersheds and the steady increase in nitrate concentrations in some Island streams and private wells. Government has made a commitment to finding solutions to this problem.

In fulfilment of this commitment, you appointed a five-member independent commission in July 2007 to conduct research and consultations, and submit a written report of its findings.

This document has been prepared in fulfilment of that responsibility.

Respectfully submitted:

Hon. J. Armand DesRoches, Chair

Mr. Stuart Affleck

Dr. John MacLeod, Ph.D.

Chief Darlene Bernard of Lennox Island First Nation

Dr. Heather Morrison, D.Phil., M.D.

Tel/Tél. : 902 620 3357 *avsturz@gov.pe.ca* Fax/Téléc. : 902 368 6118

Message From the Chair

I begin by expressing my profound and sincere gratitude and appreciation to the members of the commission for the dedication and energy they applied to the difficult task to which we were assigned. Each member brought to our discussions and deliberations his or her own background, knowledge and experience; each contributed in her or his own unique way to an effective and amicable team.

Also, on behalf of the members of the commission, I wish to praise the hard work of our Secretariat, Christine MacKinnon, P. Eng., and Dr. Tony Sturz, Ph.D. Our task would have been immeasurably more difficult without their very able assistance and support. We sincerely thank them.

Prince Edward Island is totally dependent on groundwater for drinking water; and yet, as reported in the first State of the Environment report published in June 2003 by the Government of PEI:

> "The nitrate concentration in private wells has increased steadily since 1984-85. In 2000, 3.5% of wells exceeded the 10 mg/L guideline; 4.9% exceeded the guideline in 2001; and 5.2% of tested wells exceeded the 10 mg/L Canadian guideline in 2002."

As we state in this report, the tests conducted at a series of free nitrate drinking water clinics have revealed that in 2007, six per cent of private wells exceeded the 10 mg/L guideline, and an alarming 11 per cent tested between eight and 10 mg/L. Why was the condition of our drinking water allowed to reach this critical point? It has not been because we only recently learned of the deteriorating situation.

In its report *Cultivating Island Solutions*, published in August 1997, the Round Table on Resource Land Use and Stewardship identified two dimensions to the issue of groundwater quality in PEI; human health and consumption, and aquatic habitat and organisms living in Island watercourses. The Round Table found that drinking water quality was, at that time, one of the most critical environmental issues on Prince Edward Island. It determined that Islanders … "want Government to take stronger measures to protect ground and surface water and to move smartly in that direction."

In 1999, the PEI Water Quality Interpretive Report made the following prediction:

> "Given the well-established link between land use and nitrate concentrations in groundwater, recent expansion of potato acreage in the province could be expected to result in an even greater frequency of elevated nitrate levels in domestic water supplies and … has considerable significance for surface water quality."

The Speech from the Throne in 2002 contained the following undertaking:

> "As people living on an island, we are acutely aware that our resources are finite, fragile and limited. Ensuring the sustainability of our Island and its natural resources for present and future generations must be a priority for all Islanders and their Government."

Some 10 years after *Cultivating Island Solutions* was published, in April 2007, a Report on the Public Consultation on Managing Land and Water on a Watershed Basis, *We are all downstream, We are all upstream, We are all part of a watershed,* prepared by the Environmental Advisory Council, reported that many presenters had identified water quality as the "first issue." The report had this to say about nutrient enrichment:

> "Nutrient enrichment and nitrates in surface and groundwater was a source of considerable concern to many participants. Nitrate levels were seen by many as being dangerously high, '*an all-time high in both surface and groundwater*,' and '*while much has been made of the potential hazards of increased nitrates in our drinking water, almost nothing has been done to reverse the problem*.' Nitrate concentrations in wells were problematic in some areas. Nutrient enrichment poses serious problems in watercourses, contributing to the growth of sea lettuce and algal blooms and to potentially anoxic conditions that are destructive of habitat and produce a foul odour. While '*filtration systems can help a household water supply, you can't filter a river system, let alone a watershed*.' The principal sources of nutrient enrichment appear to be agricultural chemicals and manure. The problem is highly related to the siltation of waterways resulting from runoff from fields and other types of erosion. There is also concern about the role of faulty and outdated septic systems, and disposal of untreated sewage in watercourses."

(The italicized quotes are drawn directly from the presentation and submissions of consultation participants.)

The Role of Government portion of the Report included the following specific reference to nitrates:

> "Nitrates – *'It is inconceivable that the problem has been allowed to reach this state and further delays in implementing sound farming practices may be catastrophic.'* Suggestions included requiring Nutrient Management Plans from all farmers and industries (e.g., golf courses), strictly enforced three- or four-year crop rotations, and regular testing of watercourses across the Island."

Finally, a study completed by the Earth Science Sector, Geological Survey of Canada, concerning contamination of drinking water by nitrate on PEI, presented on March 20, 2007, concluded:

> "Just to maintain GW [groundwater] at its present-day concentrations, it will be necessary to reduce soil nitrate loading under the present-day rates. A substantial further reduction in nitrate loading under present-day values would be required to reduce the number of wells exceeding the 10 mg/L guideline concentration for drinking water. … The main implication of our research results is that alternative agricultural practices to mitigate nitrate GW contamination and sustain drinking water supply in PEI have to be developed."

Now, here we are in 2008. This Commission on Nitrates in Groundwater was established by Premier Robert Ghiz in July 2007. By its Terms of Reference, it was charged with reviewing and assessing current research, associated recommendations and available solutions and developing a strategy to reduce nitrate concentrations in surface and groundwater.

In his letter to me dated July 18, 2007, Premier Ghiz stated in part:

> "Protecting our water resource is a societal priority. Human health concerns arising from the quality and quantity of our drinking water, the natural systems which provide that water, and the aquatic ecosystems that are reliant on that water are a key concern for all Islanders.
>
> It is our desire that this commission will develop a strategy to reduce nitrate concentrations in surface and groundwater so that our residents will be able to rely on high-quality natural drinking water, and our streams, rivers, ponds and estuaries will continue to be able to support a healthy variety of aquatic life."

The recommendations contained in this report reflect the submissions and presentations received by the commission, and are consistent with current research and available solutions. While we have not included in the report a specific recommendation concerning research, we are convinced that improvements of efficiency of nitrogen used in crop production and in handling of nitrogen containing wastes will be required if nitrate levels in surface and groundwater are to be reduced while maintaining or increasing agricultural productivity and population levels. Research in agricultural and waste management technology is required to ensure that technology suitable to local environmental conditions is developed. Reduction in the number of scientists working in this area, especially in the provincial Department of Agriculture and Agri-Food Canada, has been identified as a concern.

It is clear that potato varieties differ in their nitrogen use efficiency. The commission believes that continued research is required to develop new varieties of potatoes that require less nitrogen fertilizer compared to some varieties now being produced on Prince Edward Island. The development of potato products from varieties that require less nitrogen would represent an important step in reducing nitrate levels. Efforts must be made to convince makers and consumers of potato products that the use of more nitrogen-efficient varieties of potatoes would be of significant environmental benefit.

We urge the Government of Prince Edward Island to lobby the Government of Canada to increase research capability and the funding of research and technology development in the areas of efficiency of nitrogen used in agriculture, the leaching of nitrates into groundwater, and waste management technology in relation to nitrate leaching.

Our report is based on two basic principles:

1. The present state of nitrates in the Island's surface and groundwater did not occur overnight; the solution also will be long-term.
2. All Islanders have contributed to the problem; all must participate in the solution.

All members of the commission are confident that when the recommendations in this report are implemented, a major step will have been taken to address the rising level of nitrates in Island water. We very much appreciate the opportunity to develop this strategy, and to present this report. In closing, we echo the final words of the report of the Environmental Advisory Council of April 2007:

> "Ten years have passed since Government received the Round Table on Resource Land Use and Stewardship report. If Government waits another 10 years, no amount of funding will fix the problem; it will be too late."

Armand DesRoches, Chair

Executive Summary

Report of the Commission on Nitrates in Groundwater

Over the past three decades, Prince Edward Island has experienced a steady increase in the level of nitrates – both in the groundwater we rely on for drinking water, and in rivers, streams and estuaries that are home to a wide variety of wildlife and a source of livelihood and enjoyment for many people. Islanders are concerned about this trend and the effects on their health and the environment; and they are frustrated that nitrate concentrations have been allowed to reach current levels without something being done to address the problem.

The Commission on Nitrates in Groundwater was created to find solutions to reduce nitrate contamination in water. Appointed by Premier Robert Ghiz in July 2007, the commission is chaired by the Honourable Armand DesRoches, former Chief Justice of the Supreme Court of Prince Edward Island Trial Division. Other members are Stuart Affleck of Bedeque, a retired potato producer; Chief Darlene Bernard of Lennox Island First Nation; Dr. John MacLeod, a retired research scientist who has done extensive research on soil fertility and nutrient cycling; and Dr. Heather Morrison, the Province's Chief Health Officer.

Work of the Commission

The Commission on Nitrates in Groundwater reviewed research and reports related to nitrate contamination, looked at actions other areas have taken to address nitrate problems and heard from Islanders. The commission received 33 formal written submissions and heard 27 oral presentations. An additional 20 submissions were received on the website. The presentations and submissions came from a wide range of individuals and groups including environmental associations, agriculture and shellfish industry groups, representatives of Government departments and concerned Islanders.

This executive summary outlines the actions the commission recommends to reduce nitrate contamination and the findings on which the recommendations are based.

The Report of the Commission on Nitrates in Groundwater is based on two basic principles:

1. The present state of nitrates in the Island's surface and groundwater did not occur overnight; the solution also will be long-term.
2. All Islanders have contributed to the problem; all must participate in the solution.

Commission Findings

Nitrates occur naturally in our environment and are an essential nutrient for plant growth. But if there are more nitrates than plants can use, the excess nitrates can contaminate groundwater and affect water quality in rivers and streams. Over time, as agricultural practices became more intensive and housing development increased, this is what has happened in Prince Edward Island. Today, nitrates are the most common chemical contaminant in water. The key sources of nitrate pollution are agricultural fertilizers,

manure storage and spreading operations, septic systems and fertilizers applied to lawns, golf courses and other recreational facilities.

The *Guidelines for Canadian Drinking Water Quality* set the maximum acceptable concentration for nitrate at 10 milligrams per litre (mg/L). Water tests done at a series of nitrate clinics – a quick start recommendation of the Commission on Nitrates in Groundwater – showed six per cent of private wells above the 10 mg/L guideline and another 11 per cent at the high end of the guideline, testing between eight and 10 mg/L. A total of 2,511 water samples were tested for nitrates at the province-wide clinics.

Aquatic life in our rivers, streams and estuaries are more sensitive to nitrate pollution. Recent studies suggest that a maximum nitrate level of two mg/L would be appropriate to protect the most sensitive freshwater species.

Health Concerns

The major health concern related to elevated nitrate levels in drinking water is methemoglobinemia or blue-baby syndrome. This is a potentially fatal condition in which the blood's ability to carry oxygen is reduced, causing a blue discolouration of the skin and shortness of breath. It can primarily affect bottle-fed infants under six months of age. There have never been any reported cases of blue-baby syndrome in Prince Edward Island.

Concerns have been raised about possible links between nitrates and other illnesses, particularly some types of cancer and birth defects. Many studies have attempted to link these health effects to nitrates in drinking water. However, results have been inconclusive. There is no consensus about the health risks associated with nitrate intake. More research is needed on the role of nitrates as a risk factor for cancer and other illnesses. But clearly, we should take necessary precautions to protect our water from further nitrate contamination.

How Nitrate Affects the Environment

High nitrate levels in rivers, streams and estuaries can directly harm aquatic life and cause eutrophication. This refers to the abundant growth of plants such as algae which leads to a decline in water quality. When the plant material dies and decays, it uses up the oxygen in the water, suffocating fish, shellfish and other aquatic life. During the process, the water turns milky white or cloudy green, and gives off a rotten egg smell.

These effects of nitrate pollution on the environment have significant social and economic costs. These include loss of aquatic life; financial losses for commercial fishers and shellfish harvesters; reduced opportunities for recreation and tourism; significant clean-up costs; and a decline in real estate values.

Commission Recommendations

The Report of the Commission on Nitrates in Groundwater includes 30 recommendations in nine categories, dealing with all aspects of nitrate management. Among these, the commission has identified six recommendations that are absolutely essential.

The focus of the Commission on Nitrates in Groundwater was to develop a strategy to reduce nitrate concentrations in groundwater and surface water. The commission reviewed and assessed current information, invited input from Islanders, and recommended options to reduce nitrate contamination in water. The solutions that are identified will involve Government, landowners, industry and the public, working together, with a shared commitment to reducing nitrate levels in our water.

Future solutions will include the development of technology that improve the efficiency of nitrogen utilization in crop production and processing in waste management systems. This will require continued research in agricultural and waste management science to ensure that new technologies continue to be suited to local environmental conditions in Prince Edward Island.

Improving Public Education on Protecting Water Quality:

The Government of Prince Edward Island continue to develop a public education campaign to help Islanders understand the importance of making responsible and appropriate personal choices on issues that affect water quality.

Water quality on Prince Edward Island is the responsibility of each and every Islander. But people must have the information and tools to understand how they can protect and manage water resources. Initiatives such as the water testing clinics are important to raise awareness of water quality issues.

Supporting recommendations:

- The department responsible for the environment:
  - create a web-based public data system to provide Islanders with access to information on maximum, minimum and average nitrate levels in wells in each watershed; and
  - establish a province-wide water well testing program similar to the free clinics held this past winter and urge well owners to have their water tested at least once a year.
- A teaching unit, credit courses and environmental curricula specific to Prince Edward Island be available in public schools.
- Watershed groups be encouraged to play an important role in public awareness and education.

Reducing Nutrient Loading from Sewage Treatment Systems:

Regulations concerning sewage disposal be reviewed and amended, if necessary, to ensure they provide effective groundwater protection in all subdivision developments.

Sewage treatment systems can be a significant source of nitrate pollution in areas where there is housing development on small lots, with individual on-site septic systems to treat household wastewater. When a new subdivision is being developed, the impact of the housing and sewage disposal systems on the drinking water in the area must be considered. An application for subdivision should include a complete plan showing the proposed system for sewage disposal for the area to be developed.

Supporting recommendations:

- Results of analyses of the effluent that is discharged from wastewater treatment plants be available to the public.
- Municipal sewage systems be upgraded to meet current standards and incorporate disinfection with primary and secondary treatment; and tertiary treatment be added if testing shows the effluent from the treatment plant has a negative impact on the waterway where it is discharged.

Supporting Watershed-based Water Management Planning:

Government continue to support watershed-based drinking water and surface water quality protection.

Watersheds are nature's boundaries and therefore the most meaningful and logical unit around which Islanders should develop plans to protect and manage water. Watershed management planning brings together people with different backgrounds and perspectives to define the future of their area. They learn about their watershed and the issues it faces and they work together to develop a plan to protect and restore the watershed.

Supporting recommendation:

- The Government of Prince Edward Island continue to provide start-up funding and technical support to enable the development of community-based watershed planning and management systems for all watersheds, including a network for information exchange.

Mandatory Three-year Crop Rotation:

Government impose a Province-wide mandatory three-year crop rotation in fields under regulated crop production, with no exemptions.

Matching Nutrients With Crop Needs to Reduce Nitrogen Leaching:

The departments responsible for agriculture and environment develop a nutrient management/accounting program for crop and livestock producers to ensure that nitrate levels in the soil during leaching periods are maintained at or below acceptable levels.

There is clear evidence of the relationship between groundwater nitrate levels and fertilizer application rates. If too much fertilizer or manure is applied – or if it is applied at a time when it cannot be absorbed by the crop – excess nitrates will leach into groundwater and nearby rivers and streams. In Prince Edward Island, this is a problem mainly in potato production areas.

The key principle of nutrient management planning is to apply only the fertilizer or manure that can be absorbed by the crop and apply it at the right time. An effective nutrient management plan will optimize the crop yield and quality, minimize fertilizer costs and manure use, and protect soil and water.

Other best management practices that may be incorporated in a nutrient management/accounting program include three-year crop rotation; plowing forage land that contains legumes in spring rather than

fall to prevent nitrogen from leaching into groundwater over the winter; using a cover crop to trap excess nitrogen left in the soil after potato harvest; and increasing forest cover.

Supporting recommendations:

- Training be provided to producers and/or their advisors on how to complete nutrient plans.
- Resources be assigned for adequate auditing of the nutrient management/accounting program.
- An appeal system be developed to settle disputes between the producer (or their advisor) and the auditor.
- Realistic financial incentives be developed to encourage producers to adopt the nutrient management/accounting program.
- New programs be used to encourage the removal of agricultural land from potato production in a way that does not harm producer incomes.
- Application of manure, processing waste and other organic matter be prohibited when there is no active plant growth to take up nutrients.
- Government increase financial incentives for manure storage facilities.
- Government continue to support organic farming and new high value crops that require fewer inputs.

Identifying High Nitrate Areas:

The departments responsible for environment and agriculture identify high nitrate areas, where national standards for safe drinking water and healthy aquatic systems have been compromised, and appropriate corrective actions be taken to address the problem. This might include:

- reduction in fertilizer inputs,
- management of soil organic matter,
- increased tree cover,
- reduction in land under potato production,
- strict controls over all subdivision development, and
- the encouragement of wetland restoration.

With 85 per cent of total land area in Prince Edward Island under some form of managed land use, the entire province is vulnerable to nitrate contamination. But some watersheds – particularly those with a high proportion of land in potato production – are showing significant effects of nitrate pollution. Most producers are committed to protecting and enhancing the environment, but collectively, pollution from farms is having a substantial and negative impact on water quality in Prince Edward Island.

Supporting recommendations:

- The nutrient management/accounting program be mandatory in high nitrate areas.
- Wells be tested annually to monitor the effectiveness of the nutrient management/accounting program.
- Alternative septic systems be required.

Other Recommendations

Reducing Nitrate Contamination From Cosmetic Use of Fertilizers:

A policy be developed to reduce the use of fertilizers for cosmetic purposes.

Amending Land-holding Legislation:

The *Lands Protection Act* be amended to allow for the exclusion of environmentally sensitive lands from land-holding limits (conditional upon the implementation of a mandatory three-year crop rotation).

Protecting and Restoring Wetlands Which Trap Nitrates:

Government and non-government organizations develop funding initiatives to restore, protect, acquire and expand key wetland areas in the province; an information and outreach program about natural wetlands be developed for private landowners; and the Government of Prince Edward Island take the leadership role in forming new partnerships to achieve these goals.

Next Steps

The Government of Prince Edward Island is responsible for regulating and overseeing the safety of drinking water in the province. Clearly, therefore, the Provincial Government must take the lead to restore, protect and enhance groundwater – one of our most valuable public resources.

To help fulfil that role and ensure our groundwater resources are managed for the maximum benefit of all Islanders, the commission recommends the Government give special responsibilities to the Environmental Advisory Council – which is appointed under the *Environmental Protection Act* to advise the minister responsible on matters related to the environment – and an Environmental Co-ordinating Committee, to be made up of deputy ministers responsible for environment, health, agriculture, fisheries and aquaculture, and tourism.

The commission recommends these two bodies (Environmental Advisory Council and the Environmental Co-ordinating Committee) review and evaluate policies, legislation, programs and procedures in place to protect and improve groundwater quality; make recommendations for improvements; and report annually to the Premier and the Legislative Assembly on groundwater quality and the Province's enforcement efforts.

For the full Report of the Commission on Nitrates in Groundwater, visit *www.gov.pe.ca*.

Sommaire

Rapport de la Commission sur les nitrates dans l'eau souterraine

Au cours des trois dernières décennies, l'Île-du-Prince-Édouard a affiché un accroissement constant de la teneur en nitrates, à la fois dans l'eau souterraine que nous utilisons comme source d'eau potable et dans les rivières, ruisseaux et estuaires qui donnent refuge à une faune très variée et qui sont une source de subsistance et de plaisir pour de nombreuses personnes. Les Insulaires sont préoccupés par cette tendance et par les effets des nitrates sur leur santé et sur l'environnement. De plus, ils sont mécontents du fait que les concentrations en nitrates ont atteint leurs niveaux actuels sans qu'on ait abordé le problème.

La Commission sur les nitrates dans l'eau souterraine a été créée afin de trouver des solutions pour réduire la contamination en nitrates dans l'eau. Nommée par le premier ministre Robert Ghiz en juillet 2007, la Commission est présidée par l'honorable Armand DesRoches, ancien juge en chef de la Cour suprême de l'Île-du-Prince-Édouard, division de première instance. Les autres membres sont Stuart Affleck, producteur de pommes de terre à la retraite de Bedeque; Chef Darlene Bernard, de la Première nation de Lennox Island; Dr John MacLeod, Ph. D. chercheur à la retraite qui a fait des recherches approfondies sur la fertilité du sol et le cycle des nutriments; et Dre Heather Morrison, M.D. médecin hygiéniste en chef de la province.

Travail de la Commission

La Commission sur les nitrates dans l'eau souterraine a examiné la recherche et les rapports liés à la contamination en nitrates, a observé les actions prises dans d'autres régions pour aborder les problèmes liés aux nitrates, et a écouté les Insulaires. La Commission a reçu 33 soumissions écrites formelles, et a entendu 27 présentations orales. Elle a également reçu 20 soumissions supplémentaires à partir du site Web. Les présentations et les soumissions étaient en provenance d'une grande gamme d'individus et de groupes, notamment des associations environnementales, des groupes des industries de l'agriculture et des mollusques, des représentants des ministères gouvernementaux et des Insulaires concernés.

Le présent sommaire passe brièvement en revue les actions recommandées par la Commission afin de réduire la contamination en nitrates, ainsi que les constatations sur lesquelles elle a fondé ses recommandations.

Le Rapport de la Commission sur les nitrates dans l'eau souterraine est fondé sur deux principes de base :

1. Nous ne sommes pas arrivés à l'état actuel des nitrates dans l'eau de surface et les eaux souterraines de l'Île du jour au lendemain; la solution sera donc aussi à long terme.
2. Les Insulaires ont tous contribué au problème; il doivent donc tous contribuer à la solution.

Constats de la Commission

Les nitrates se produisent naturellement dans notre environnement, et ils sont un élément nutritif essentiel pour la croissance des plantes. Cependant, une quantité de nitrates trop élevée pour les plantes peut contaminer les eaux souterraines, ou peut avoir un effet sur la qualité de l'eau dans les rivières et les ruisseaux. Au fil du temps, à l'Île-du-Prince-Édouard, les pratiques environnementales sont devenues plus intensives et la construction domiciliaire a pris de l'ampleur. Aujourd'hui, le nitrate est le contaminant chimique le plus courant dans l'eau. Les sources principales de la pollution en nitrates sont les engrais agricoles, l'entreposage et l'épandage de fumier, les fosses septiques, et l'engrais utilisé sur les gazons, les terrains de golf et les autres terrains de loisir.

Les *Recommandations pour la qualité de l'eau potable au Canada* ont établi la concentration maximale acceptable de nitrates dans l'eau potable à 10 milligrammes par litre (mg/L). Les analyses d'eau effectuées lors de la série de consultations sur les nitrates – une recommandation hâtive de la Commission sur les nitrates dans l'eau souterraine – ont démontré que 6 pour cent des puits privés étaient au-delà de la recommandation de 10 mg/L et un autre 11 pour cent étaient au seuil élevé des recommandations, dont les résultats étaient entre 8 et 10 mg/L. On a analysé la teneur en nitrates de 2511 échantillons d'eau lors des consultations à l'échelle de la province.

La vie aquatique dans nos rivières, ruisseaux et estuaires est susceptible à la pollution en nitrates. Des études récentes suggèrent qu'une teneur maximale en nitrates de 2 mg/L serait appropriée pour la protection des espèces d'eau douce les plus sensibles.

Préoccupations en matière de santé

La préoccupation principale en matière de santé liée à une teneur élevée en nitrates dans l'eau potable est la méthémoglobinémie infantile, aussi connue sous le nom de syndrome du bébé bleu. Cette condition potentiellement fatale réduit la capacité du sang à transporter l'oxygène, ce qui cause une décoloration bleue de la peau et un essoufflement. Cela touche principalement les nourrissons âgés de moins de 6 mois qui sont nourris au biberon. Il n'y a jamais eu de cas signalé du syndrome du bébé bleu à l'Île-du-Prince-Édouard.

On a soulevé des préoccupations sur des liens possibles entre les nitrates et d'autres maladies, particulièrement certains types de cancer et d'anomalies congénitales. De nombreuses études ont tenté de lier ces effets sur la santé aux nitrates dans l'eau potable. Cependant, les résultats n'ont pas été concluants. Il n'y a pas de consensus sur les risques de santé associés à la consommation de nitrates. Des recherches plus poussées sur le rôle des nitrates en tant que facteur de risque pour le cancer et les autres maladies sont nécessaires. Mais manifestement, nous devons prendre les précautions nécessaires pour protéger notre eau d'une contamination en nitrates plus importante.

Les effets des nitrates sur l'environnement

La teneur élevée en nitrates dans les rivières, ruisseaux et estuaires peut directement nuire à la vie aquatique et causer l'eutrophisation, définie comme étant la croissance accélérée des plantes, telles que les algues, qui mène à une détérioration de la qualité de l'eau. La décomposition de la matière végétale entraîne une réduction de la teneur en oxygène de l'eau, ce qui suffoque le poisson, les mollusques et les

autres formes de vie aquatique. Au cours du processus, l'eau prend une couleur blanc laiteux ou vert trouble et dégage une odeur d'oeuf pourri.

Les effets de la pollution en nitrates sur l'environnement engendrent des coûts sociaux et économiques importants. Les coûts comprennent la perte de vie aquatique; des pertes financières pour les pêcheurs de poissons et de mollusques commerciaux; des occasions réduites pour le loisir et le tourisme; des coûts importants pour le nettoyage; et une baisse de la valeur du marché immobilier.

Recommandations de la commission

Le Rapport de la Commission sur les nitrates dans l'eau souterraine inclut 30 recommandations dans neuf catégories, traitant de tous les aspects de la gestion des nitrates. Parmi celles-ci, la Commission a cerné six recommandations qui sont absolument essentielles.

L'objectif principal de la Commission sur les nitrates dans l'eau souterraine était d'élaborer une stratégie visant à réduire les concentrations en nitrates dans les eaux souterraines et dans l'eau de surface. La Commission a examiné et évalué les renseignements actuels, a invité les Insulaires à soumettre leurs commentaires et a recommandé des choix qui permettront de réduire la contamination en nitrates dans l'eau. Les solutions relevées feront intervenir le gouvernement, les propriétaires fonciers, l'industrie et le grand public qui travailleront ensemble en maintenant un engagement commun de réduire la teneur en nitrates de notre eau.

Les solutions à l'avenir incluront le développement de technologies qui améliorent l'efficacité de l'utilisation de l'azote dans la production de cultures et le traitement des systèmes de gestion des déchets. Cela requerra une recherche continue dans les sciences de l'agriculture et de la gestion des déchets pour veiller à ce que les nouvelles technologies continuent d'être convenables pour conditions environnementales locales à l'Île-du-Prince-Édouard.

Améliorer l'éducation publique en matière de protection de la qualité de l'eau :

Le gouvernement de l'Île-du-Prince-Édouard continue de mener une campagne d'éducation publique qui aide les Insulaires à comprendre l'importance de faire des choix personnels responsables et appropriés sur les questions qui touchent la qualité de l'eau.

La qualité de l'eau à l'Île-du-Prince-Édouard est la responsabilité de chaque Insulaire. Mais les gens doivent posséder les renseignements et les outils pour comprendre de quelle façon ils peuvent protéger et gérer les ressources en eau. Les initiatives telles que les analyses de l'eau sont importantes parce qu'elles permettent de sensibiliser les gens par rapport aux questions portant sur la qualité de l'eau.

Recommandations secondaires :

- Le ministère responsable de l'environnement devrait :
  - créer un système de données publiques en ligne qui donnera aux Insulaires l'accès aux renseignements sur les teneurs maximales, minimales et moyennes des puits dans chaque bassin hydrologique;
  - établir un programme d'analyse de l'eau de puits à l'échelle de la province, semblable aux analyses gratuites qui ont eu lieu l'hiver dernier, et conseiller vivement aux propriétaires de puits de faire analyser l'eau de leur puits au moins une fois par année;
- offrir une unité de formation, des cours à crédit, et un programme d'étude particulier à l'Île-du-Prince-Édouard dans les écoles publiques;
- encourager les groupes de bassins hydrologiques à jouer un rôle important dans la sensibilisation et l'éducation du public.

Réduire la charge en éléments nutritifs des systèmes de traitement des eaux usées :

Les règlements régissant l'évacuation des eaux usées devraient être étudiés et modifiés, au besoin, pour veiller à ce qu'ils offrent une protection efficace de l'eau souterraine dans tous les développements de lotissements.

Les systèmes de traitement des eaux usées peuvent être une source significative de pollution en nitrates dans les régions où il existe beaucoup de construction immobilière sur de petits lots, avec des fosses septiques individuelles sur le site afin de traiter les eaux usées domestiques. Lorsqu'un nouveau lotissement est en cours de développement, on devrait prendre en considération les effets de la construction et de l'évacuation des eaux usées sur l'eau potable. Une demande de construction immobilière devrait inclure un plan complet démontrant le système d'évacuation des eaux usées pour le lieu de construction.

Recommandations secondaires :

- Mettre à la disposition du public les résultats des analyses de l'effluent qui est déversé des usines de traitement des eaux usées.
- Mettre à jour le réseau d'assainissement municipal afin de respecter les normes actuelles et incorporer la désinfection avec le traitement primaire et secondaire; ajouter un traitement tertiaire si les analyses démontrent que l'effluent de l'usine de traitement a un impact négatif sur la voie d'eau où il est déversé.

Appuyer la planification de gestion des eaux fondée sur les bassins hydrologiques :

Le gouvernement continue à favoriser la protection de la qualité de l'eau potable et de l'eau de surface en fonction des bassins hydrologiques.

Les bassins hydrologiques sont les frontières de la nature et par conséquent, les unités les plus significatives et logiques autour desquelles les Insulaires devraient concevoir des plans pour protéger et

gérer l'eau. La planification de gestion des bassins hydrologiques réunit des gens ayant différents antécédents et différentes perspectives afin de définir l'avenir de leur région. Ils apprennent au sujet de leur bassin hydrologique et des enjeux qui s'y rapportent, et ils travaillent ensemble pour développer un plan pour protéger et restaurer le bassin hydrologique.

Recommandation secondaire :

- Le gouvernement de l'Île-du-Prince-Édouard continue à offrir des fonds de démarrage et un appui technique afin de permettre le développement de la planification de bassins hydrologiques et des systèmes de gestion par les citoyens, comprenant un réseau pour l'échange d'information.

Rotation des cultures de 3 ans obligatoire :

Le gouvernement impose une rotation des cultures de trois ans obligatoire dans les champs régis par la production des cultures réglementées sans exceptions.

Faire correspondre les nutriments aux besoins de la culture afin de réduire la lixiviation de l'azote :

Les ministères responsables de l'agriculture et de l'environnement développent un programme de gestion/inventoriage pour les producteurs agricoles et les éleveurs d'animaux de ferme afin de veiller à ce que la teneur en nitrates dans le sol lors des périodes de lixiviation soit gardée à un niveau acceptable ou inférieur.

Il existe des preuves claires qu'une relation existe entre la teneur en nitrates dans l'eau souterraine et le taux d'application d'engrais. Si on applique trop d'engrais ou de fumier – ou si l'application se fait lorsque l'engrais ne peut être absorbé par les plants – les nitrates en excès seront lixiviés dans l'eau souterraine et les rivières et ruisseaux environnants. À l'Île-du-Prince-Édouard, ceci est un problème principalement dans les régions de production de pommes de terre.

Le principe clé de la planification de gestion des nutriments est de faire l'application de l'engrais ou du fumier au bon moment, soit uniquement lorsqu'ils peuvent être absorbés par les plants. Un plan de gestion des nutriments efficace maximisera la qualité et le rendement de la culture, minimisera le coût de l'usage d'engrais et de fumier, et protégera le sol et l'eau.

D'autres pratiques exemplaires de gestion qui pourraient être incorporées dans un programme de gestion/inventoriage comprendraient la rotation des cultures de trois ans; labourer des terres de forage qui renferment des légumineuses au printemps plutôt qu'à l'automne pour éviter la lixiviation de l'azote dans l'eau souterraine au cours de l'hiver; utiliser une culture de couverture pour piéger l'azote en excès dans le sol après la récolte des pommes de terre; et accroître la couverture forestière.

Recommandations secondaires :

- Offrir une formation aux producteurs ou à leurs conseillers sur l'élaboration de plans de nutriments.
- Assigner des ressources pour la vérification adéquate du programme de gestion/inventoriage des nutriments.
- Concevoir un processus d'appel afin de régler les différends entre le producteur (ou son conseiller) et le vérificateur.
- Établir des mesures incitatives financières afin d'encourager les producteurs à adopter le programme de gestion/inventoriage des nutriments.
- Utiliser de nouveaux programmes afin d'encourager le retrait des terres agricoles vouées à la production de pommes de terre d'une façon qui ne nuira pas aux revenus des producteurs.
- Interdire l'application de fumier, de boues d'épuration et d'autres matières organiques en l'absence de croissance active de plants pour absorber les nutriments.
- Accroître les mesures incitatives financières du gouvernement pour les installations d'entreposage du fumier.
- Poursuivre le soutien gouvernemental de l'agriculture organique et des plantes à fort rapport économique qui requièrent moins de facteurs de production.

Répertorier les régions à forte teneur en nitrates :

Les ministères responsables de l'environnement et de l'agriculture répertorient les régions à forte teneur en nitrates, où les normes nationales d'eau potable sécuritaire et de systèmes aquatiques sains ont été compromises, et prennent les actions correctives afin d'aborder le problème.

- Réduire l'utilisation d'engrais.
- Gérer la matière organique du sol.
- Accroître la couverture d'arbres.
- Réduire les terres vouées à la production de pommes de terre.
- Strictement contrôler le développement de lotissements.
- Encourager la restauration des zones humides.

Étant donné que 85 % des terres totales de l'Île-du-Prince-Édouard sont soumis à une certaine forme de gestion, la province entière est vulnérable à la contamination en nitrates. Mais certains bassins hydrologiques – particulièrement ceux qui possèdent un proportion élevée de terres vouées à la production de pommes de terre – démontrent les effets importants de la pollution en nitrates. La plupart des producteurs sont engagés à la protection et l'amélioration de l'environnement, mais collectivement, la pollution en provenance des fermes a un impact important et négatif sur la qualité de l'eau à l'Île-du-Prince-Édouard.

Recommandations secondaires :

- Rendre le programme de gestion/inventoriage des nutriments obligatoire dans les régions à forte teneur en nitrates.
- Analyser les puits annuellement pour surveiller l'efficacité du programme de gestion/inventoriage des nutriments.
- Exiger de différentes fosses septiques.

Autres recommandations

Réduire la contamination en nitrates en provenance de l'utilisation d'engrais à des fins cosmétiques :

Concevoir une politique visant à réduire l'utilisation d'engrais à des fins cosmétiques.

Modifier les lois sur les avoirs immobiliers :

Modifier la loi intitulée *Lands Protection Act* (loi sur la protection des terres de l'Î.-P.-É.) pour permettre l'exclusion des terres écologiquement fragiles des limites des avoirs immobiliers (conditionnel à la mise en vigueur de la rotation des cultures de trois ans obligatoire).

Protéger et restaurer les zones humides qui piègent les nitrates :

Le gouvernement et les organismes non gouvernementaux établissent des initiatives de financement pour restaurer, protéger, acquérir et élargir des zones humides clés dans la province; on établit un programme de sensibilisation du public portant sur les zones humides naturelles qui seront développées pour les propriétaires fonciers; et le gouvernement de l'Île-du-Prince-Édouard joue le rôle de chef de file dans la formation de nouveaux partenariats pour atteindre ces objectifs.

Prochaines étapes

Le gouvernement de l'Île-du-Prince-Édouard est responsable de la réglementation et de la surveillance de la sûreté de l'eau potable dans la province. Par conséquent, le gouvernement provincial doit prendre les devants pour restaurer, protéger et améliorer l'eau souterraine – une de nos ressources publiques les plus précieuses.

Pour aider à remplir ce rôle et veiller à ce que nos ressources d'eaux souterraines soient gérées pour assurer le bienfait maximal des Insulaires, la Commission recommande que le gouvernement donne des responsabilités spéciales au Conseil consultatif sur l'environnement – nommé dans le cadre de la loi intitulée *Environmental Protection Act* (loi sur la protection environnementale) pour conseiller le ministre responsable des affaires liées à l'environnement – et à un Comité de coordination de l'environnement composé des sous-ministres responsables de l'environnement, de la santé, de l'agriculture, des pêches et de l'aquaculture et du tourisme.

La Commission recommande que ces deux groupes (le Conseil consultatif sur l'environnement et le Comité de coordination de l'environnement) examinent et évaluent les politiques, les lois, les programmes, et les procédures en place afin de protéger et améliorer la qualité des eaux souterraines; fassent des recommandations sur les améliorations à apporter; et fassent un rapport annuel au premier ministre et à l'Assemblée législative sur la qualité des eaux souterraines et les efforts de mise à exécution de la province.

Pour obtenir la version complète du rapport de la Commission sur les nitrates dans l'eau souterraine, visitez *www.gov.pe.ca.*

Prologue

Water Is the Lifegiver of All That Lives

Chief Darlene Bernard

As we move forward in building a healthy more prosperous future, it is apparent that all Islanders will be counted upon to play a role. But the role Islanders will be asked to play will require the adoption of new attitudes, a new vision and proactive approaches. This change, like most change, will not come easily. I always say, "change, good or bad, is hard, and we must move through change in a manner that respects the fact that adaptation is a process and progress will only be successful if all involved accept this attitude." Emphasis must be placed on education and helping Islanders embrace positive changes that are required for us to move forward together towards a healthy, protected, sustainable environment.

Through the scope of this commission's important work, we have maintained a focus not to look solely at how we have come to this point in history, but to look at substantive changes which we can implement for the future. This has come from the realization and acceptance that there are issues which require immediate action. Simply put, we must be proactive, because everything we do today with regards to our environment, affects the survival of our children tomorrow.

Sometimes finding the best path forward requires us to look into our past. The First Nations peoples who have inhabited this Earth for thousands and thousands of years have long believed in the close connection between the land and its people. Respecting the land, protecting our resources and treating the land as more than a means to an end was the way of our forefathers. It can and should be the way of our children and grandchildren.

As Chief Seattle once remarked:

> "You must teach your children that the ground beneath their feet is [made up of] the ashes of our grandfathers. So that they will respect the land, tell your children that the earth is rich with the lives of our kin. Teach your children that we have taught our children that the earth is our mother. Whatever befalls the earth befalls the sons of earth."

This great quote, though spoken many years ago, still has powerful meaning. It speaks of using the resources we have in a respectful manner and it speaks of passing along a province to our children better than the one we inherited.

The Mi'kmaq have a word that sums up our perspective of the Earth, our Mother, and how we respect and protect her so that she will continue to nurture and sustain us forever. This word is *L'nu'tukulimk*, it means different things to different people, but the essence of it is "balance." Everything must be in balance in order for the life cycle of all living things to be completed naturally.

We can look at our province today and look at how far we have come. The technological and economic advancements are truly extraordinary. We have not only kept pace with the rest of the country, but in many areas, such as wind energy generation, we are setting the pace. This has resulted in positive economic times for our province, record job growth and the lowest unemployment rate in almost

40 years. But growth comes with a tremendous responsibility, and impacts are not always immediately apparent. We have to find a workable balance that allows us to keep pace, but also allows our land and our resources to be properly and fairly managed so they can thrive for the seven generations, which means for eternity.

The world we live in is fast paced. People have grown accustomed to fast food, fast facts and immediate action. The issues with our groundwater have taken decades to produce and it would be wrong for us to suggest the answers are simple and the results immediate. To be better in the future will require us to change our attitudes and behaviours. It may appear, on the surface, to be a daunting task, but it is a task at which we cannot, we must not fail.

For too long, attitudes toward development and progress have solely been about money and prospering. But as Chief Seattle rightly stated – how does one prosper at the expense of the land? Our growth, while ambitious and impressive in one sense, has not been without its costs. For too long, we have refused to address those costs and we have preferred to ignore them. Ignorance is bliss, but ignorance has brought us to this point. Further ignorance will be catastrophic. Changing our behaviour and acting on those changes is immediately required. Adaptation to these changes means survival.

Simply put, the goals we set will determine the success we can measure. The more ambitious the goals, the greater chance we can see tangible success for today and tomorrow. Finding success can only be found in finding the balance – the balance between growth, prosperity and common sense today, versus sustainability, opportunity and hope for tomorrow.

First Nations people for many years have strived to find, and struggled to keep, balance. Facing a myriad of issues and problems for generations, we have learned for each problem or issue, there are always driving forces and restraining forces. Solving a problem requires marshalling those forces together, finding common ground and balance, and moving forward by setting goals. Through this approach, we have seen success. Through this approach, we believe greater prosperity and well-being can be found.

Integral to that approach for First Nations has been the fact that success and growth does not have to come at the expense of our land, our water and our resources. Success can and must be found by working in harmony with our resources like our forefathers did … and we, our children and grandchildren must.

In the realm of time, the physical time we spend upon this Earth is but a blip. We use the land and the resources at our disposal for a time, and then our time is gone. However, the land, the water, the natural resources, they remain. As time passes, the stewards of our Mother face new challenges and mounting pressures and some may say we are now at a critical point in time. As the pressure mounts, we must stop, reflect and plan the path before us.

The road forward will require change, a change not only in behaviour and attitude, but a change in practice and action. The status quo can no longer be acceptable and embracing the changes required to tackle these issues may very well be the measuring stick by which history will judge us.

Water is one of the sacred elements of life, without it there is no life.

Introduction

It is generally recognized that the quality of both drinking water and water in aquatic ecosystems in Prince Edward Island has deteriorated over the past three decades. The present situation did not occur overnight, but became incrementally worse as agricultural practices became more intensive, and housing development increased. As a consequence, all sectors of society have contributed to the current problem and all must participate in the solution.

It is important to appreciate that while Prince Edward Island is the smallest province in Canada it is also the most densely populated per square kilometre. The total dependence of its inhabitants on groundwater for their source of drinking water has made protecting this water resource a societal priority.

With more than 85 per cent of the total land area under some form of managed land use (40 per cent agriculture, 45 per cent forestry) the entire province is vulnerable to the effects of nitrate pollution.

Generally speaking, nitrate levels in water are expressed as either NO_3 (nitrate) or NO_3-N (nitrate-nitrogen). Nitrate levels above 45 mg/L NO_3 or 10 mg/L NO_3-N may cause significant health problems in humans.[1] A recent survey of nitrate levels in drinking water on PEI has shown that 11 per cent of wells in PEI have well water that falls within the range eight to 10 mg/L NO_3-N and six per cent of wells have water above the 10 mg/L NO_3-N level. (In this report the designation “mg/L” will be used to refer to mg/L NO_3-N).

The socio-economic impacts of water pollution in Prince Edward Island are an important factor in prioritizing solution options and the associated investment required to initiate pollution reduction. While much is known about the sources of nitrate pollution, there is still conflicting information concerning the impacts on human health and on aquatic ecosystems. By reviewing economic activities such as fishing and tourism, as well as the economic dependence on access to reliable water resources, the value of pollution reduction strategies can be more adequately assessed.

To date, sources of nitrate contamination have been found to include municipal sewage, septic fields, agricultural fertilizers, industrial discharges, livestock manure, and recreational and urban nutrient-rich contaminants such as lawn fertilizers. Nitrates also enter waterways and groundwater from a number of natural sources, including soil and plant material. The relative contribution of these sources varies across watersheds and with seasons.

Recent public consultations on PEI have recommended that action needs to be taken to reduce nitrate contamination of our water. To help achieve this objective the Commission on Nitrates in Groundwater was formed.

[1] Health Canada guidelines for Canadian drinking water quality are set at 45 mg/L nitrate (10 mg/L nitrate-nitrogen). *http://www.hc-sc.gc.ca/ewh-semt/alt_formats/hecs-sesc/pdf/pubs/water-eau/sum_guide-res_recom/summary-sommaire_e.pdf*

About the Commission

On July 18, 2007, the Honourable Armand DesRoches was invited to become chair of the Commission on Nitrates in Groundwater. Mr. DesRoches is a former Chief Justice of the Supreme Court of Prince Edward Island Trial Division. Presently, he is counsel with the Charlottetown office of Stewart, McKelvey, Sterling, Scales. In addition, four other Islanders were appointed: Stuart Affleck of Bedeque, a retired potato producer; Chief Darlene Bernard of Lennox Island First Nation; Dr. John MacLeod, Ph.D. a retired research scientist who has done extensive research on soil fertility and nutrient cycling and Dr. Heather Morrison, D.Phil., M.D. the Province's Chief Health Officer. The commission members bring a broad range of experience and expertise to the table.

Government assigned a secretariat to provide research and administrative support to the commission.

Commission Focus

The focus of the Commission on Nitrates in Groundwater was to develop a strategy to reduce nitrate concentrations in groundwater and surface water. The Commission on Nitrates in Groundwater reviewed and assessed current information, invited input from Islanders, and recommended options to reduce nitrate contamination in water. The solutions that are identified involve Government, landowners, industry and the public, working together, with a shared commitment to reducing nitrate levels in our water.

The commission invited written submissions and presentations from individuals and groups with a particular interest or expertise in nitrates. A website, newspaper advertisements and news releases in both official languages were produced to inform the general public of the commission's work and encourage input.

Funding and administrative support was provided by the Department of Environment, Energy and Forestry and Executive Council Office.

The Terms of Reference for the commission are provided (Appendix 1).

The commission met 21 times between August 2007 and June 2008 during which time it received and reviewed 33 written submissions (Appendix 2) and heard 27 oral presentations (Appendix 3). In addition, and as a result of newspaper advertisements, and a dedicated website, a further 20 submissions were received from members of the public.

Quick Start Recommendations

The commission received a large number of submissions over the course of the consultation period. It was felt by the commissioners that some of the suggestions for improving ground and surface water quality should be addressed immediately. To make the work of the commission more effective it initiated a "quick start" series of recommendations which were presented to the Provincial Government prior to

publication of the final report. Listed in the order in which they were submitted, the commission recommended that:

1) the Provincial Government sponsor a series of community-based water testing clinics to raise awareness about the issue of nitrates in drinking water (letter dated August 30, 2007).

2a) the Provincial Government implement a mandatory three-year crop rotation in fields under regulated crop cultivation, with no exemptions (letter dated December 5, 2007).

2b) the *PEI Lands Protection Act* be amended to allow for the exclusion of environmentally sensitive land from land-holding limits. This amendment will be linked to, and conditional upon, a mandatory three-year crop rotation being put in place in fields under regulated crop cultivation (letter dated December 5, 2007).

3) resources be applied to the development of the Nitrate Reduction Concept involving a nutrient management/accounting program to optimize crop yield and quality, minimize fertilizer input costs and protect soil and water quality. Such a concept will include an implementation program and an accountability structure on a watershed or sub-watershed basis and will incorporate the accurate modelling of nutrient flow linked to an appropriate nutrient credit system (letter dated December 18, 2007).

Follow-up
The Department of Environment, Energy and Forestry has held a series of Island-wide community-based "nitrate in drinking water clinics" (Appendix 4). Between November 2007 and May 2008, 2,511 water samples were tested with 17 per cent of samples testing eight to 10 mg/L and above.

Current and Predicted State of the Environment

At present, six per cent of the domestic wells tested in the nitrate in drinking water clinics exceed the 10 mg/L maximum concentration for nitrate recommended for drinking water by the Canadian Water Quality Guidelines. These high nitrate concentrations in well water are strongly associated with agricultural management practices in individual watersheds (Savard and Somers, 2007a).

The result of water testing clinics conducted in 2007-2008 confirmed that the average concentration of nitrate in groundwater is rising in those watersheds under intensive agricultural production as compared to 2000-2005 results (see Figures 1 and 2).

Generally the watersheds with the highest levels of nitrate are in areas where the highest portion of the land is in potato production (Figure 2). Exceptions to this general relationship appear to be related to high nitrate levels in areas with high density of homes/cottages using septic systems for waste disposal.

It is predicted that between 2001 and 2050 the number of watersheds that have nitrate concentrations of between five and 10 mg/L nitrate will increase by approximately 50 per cent (Paradis et al., 2007; Figures

1 and 2). This situation will worsen if climate change models hold true, and groundwater flow and recharge become reduced due to increased evapotranspiration (Savard and Somers, 2007a,b).

Mathematical models of groundwater flow for the Wilmot River watershed show that major changes in agricultural practices will be required in the immediate term and maintained into the long term to ensure that improvements in groundwater drinking water quality are attained (Vigneault et al., 2007).

From the results of mass balance calculations by Savard and Somers (2007b; 2007c) significant benefits are probable by increasing the duration of crop rotations and decreasing fertilizer application rates. The adoption of even a three-year rotation promises an 18 per cent reduction in long term groundwater nitrate levels (7.4 mg/L *vs* 9.1 mg/L estimated for steady state conditions under current land use practices), and a four-year rotation would reduce nitrate contents by as much as 30 per cent (6.2 mg/L *vs.* the same 9.1 mg/L steady state conditions).

It has also been suggested that groundwater nitrate levels are very sensitive to fertilizer application rates. An application rate reduction to 185 kg/ha of fertilizer on potatoes would lead to an average groundwater nitrate concentration in the watershed of 6.8 mg/L, corresponding to a 25 per cent decrease over long term concentrations calculated in the Savard and Somers baseline scenario (Savard and Somers, 2007c). Lower application rates would result in greater decreases.

It is much more difficult to quantify the degree to which nitrogen in soil organic material can be manipulated to reduce nitrate leaching losses to groundwater. However, given its highly significant contribution to nitrate levels in groundwater, and the proportion transferred during the non-growing season with little chance of plant uptake, any practices that would delay the release of nitrate until the growing season begins would have substantial benefits (Savard and Somers, 2007c). Groundwater nitrate levels could be reduced by as much as 30 per cent if farmers changed their management of soil organic material to promote a reduction in over-winter leaching losses from this nitrogen pool (Savard and Somers, 2007c).

Impacts of Inaction

Characterization of nitrogen (N) inputs and geochemical modelling confirm the significant contribution of agricultural inputs, especially chemical fertilizers, to PEI nitrate groundwater contamination (Savard and Somers, 2007). Savard and Somers conclude that:

- Principal sources of nitrate are agrichemical fertilizer inputs, manure and soil organic matter (including crop residues).
- Nitrate is produced in soils all year long and that during winter, snow cover allows nitrification to continue until the ground freezes.
- Nitrate is exported from soils to aquifers whenever recharge is taking place. During winter, thaws and rainfall events allow recharge of aquifers.
- Nitrate contamination from chemical fertilizer sources dominate during the summer months, and from soil organic matter, during the winter months.

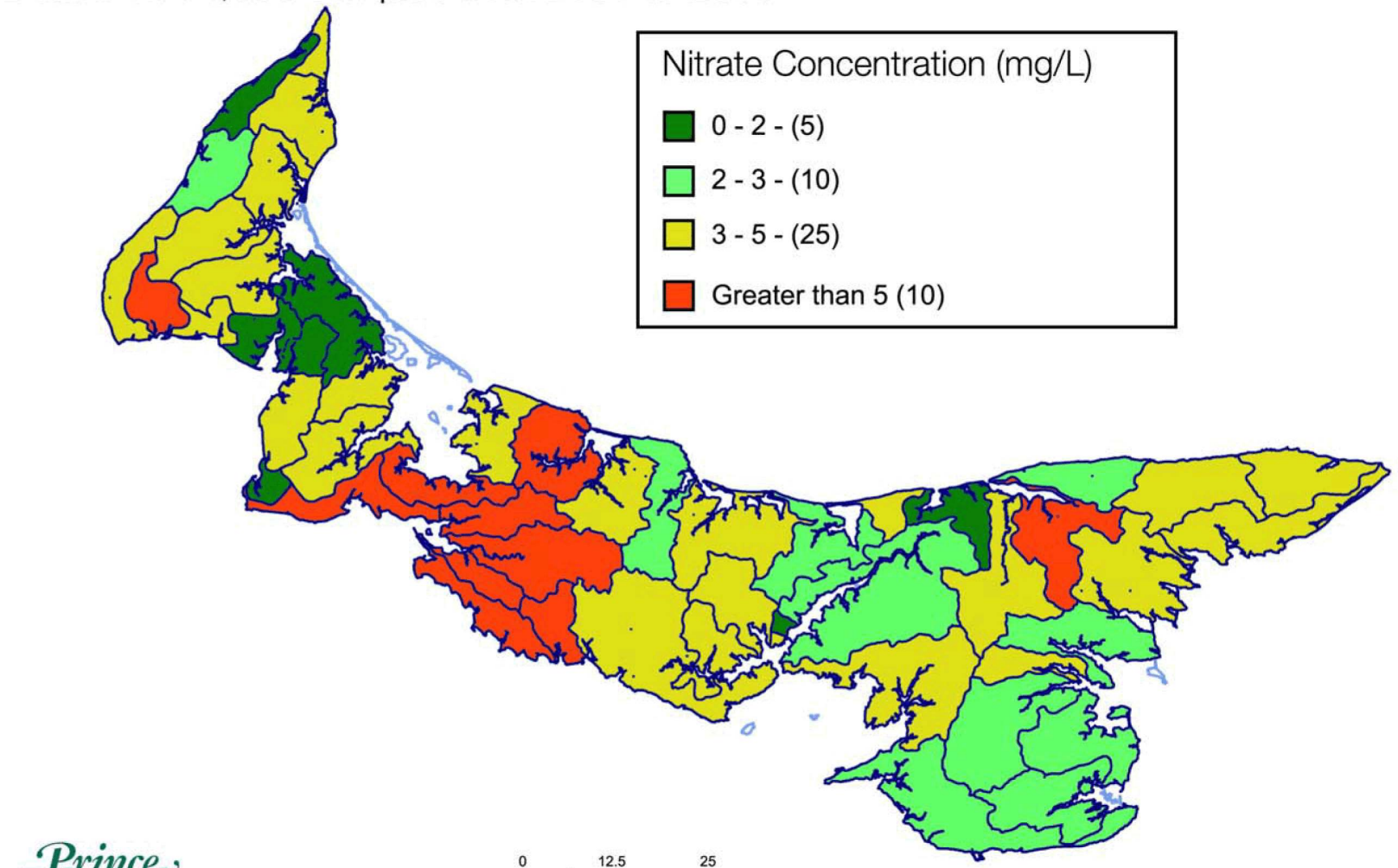
- If agricultural land use practices are maintained as they are now, the average nitrate concentrations in PEI groundwater in 50 years will increase by 11 per cent for the province as a whole, and between five per cent to 30 per cent for individual watersheds.
- If the nitrogen inputs were lowered significantly, it would take about 25 years for nitrate levels to return to non-critical values.
- The impact of climate change and agricultural adaptation to climate change on water quality would mean the average nitrate levels in wells would increase by 32 per cent and the number of watersheds at risk would increase dramatically over the next 25 years.
- The cost of infrastructure replacement will be between $200,000 and $400,000/year for domestic wells, and a doubling of current expenses for municipal water supply.
- Substantial and immediate reductions in nitrogen inputs are needed to decrease nitrate concentration in groundwater.

Savard and Somers (2007c) proposed the following key recommendations:

- Immediate and concrete actions must be taken by decision-makers and agricultural stakeholders to address the nitrate issue.
- A sound baseline by which to evaluate the success of strategies needs to be established. Nitrate concentrations in river water can be used for monitoring and for quantifying improvements in groundwater quality.
- Any strategy for reducing nitrate concentration in groundwater must take into account the seasonally changing sources of nitrate; i.e., chemical fertilizers during summer, and soil organic matter (crop residues) during winter and spring.
- Any strategy designed to reduce nitrate inputs should be based upon an integrated land, water and living resource approach that promotes conservation and sustainability – the “ecosystem approach.”

Average Groundwater Nitrate Concentration

Based on 14,555 samples from 2000 to 2005



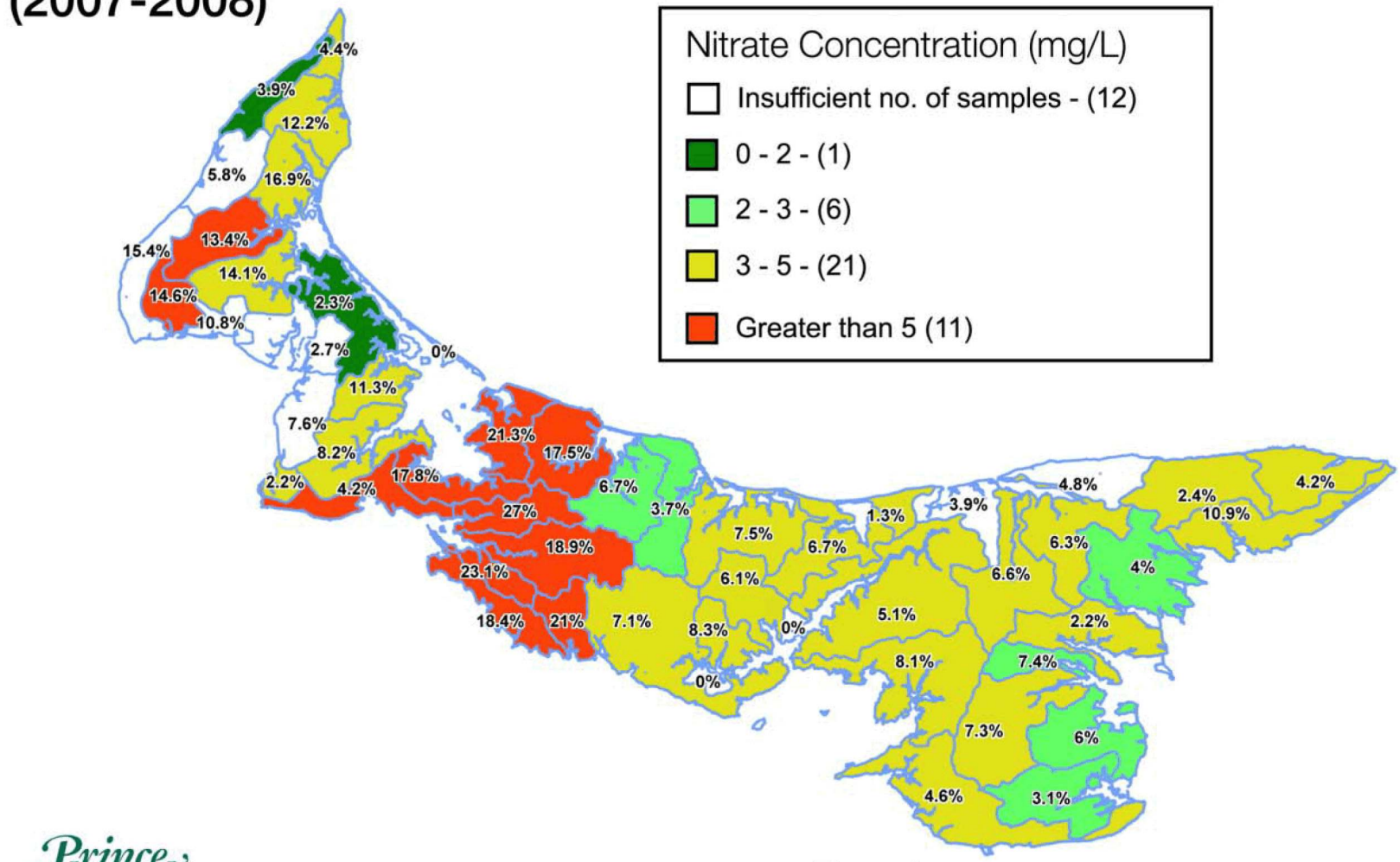
Prince Edward Island CANADA

Environment, Energy and Forestry

April 2008

Figure 1.
Average groundwater nitrate concentration based on samples taken over the period 2000-2005 in each watershed grouping.

Percentage of Land in Potato Production per Watershed Grouping With Average Groundwater Nitrate Concentration From Clinics (2007-2008)



Prince Edward Island CANADA

Environment, Energy and Forestry

0 12.5 25
kilometres

May 2008

Figure 2
Watersheds with the highest levels of nitrate are in areas where the highest proportion of the land is in potato production (based on year 2000). Percentage figures show proportion of land under potato cultivation in each watershed grouping.

Technical Background

The Nitrogen Cycle

The Nitrogen Cycle is one of the most important nutrient cycles found in terrestrial ecosystems (Figure 3). Nitrogen is essential for many biological processes and is crucial for any life here on Earth. Nitrogen (N) occurs in all amino acids, is incorporated into proteins, and is present in the 'bases' that make up nucleic acids, such as DNA and RNA. In plants, much of the nitrogen is used in chlorophyll molecules which are essential for photosynthesis and further growth.

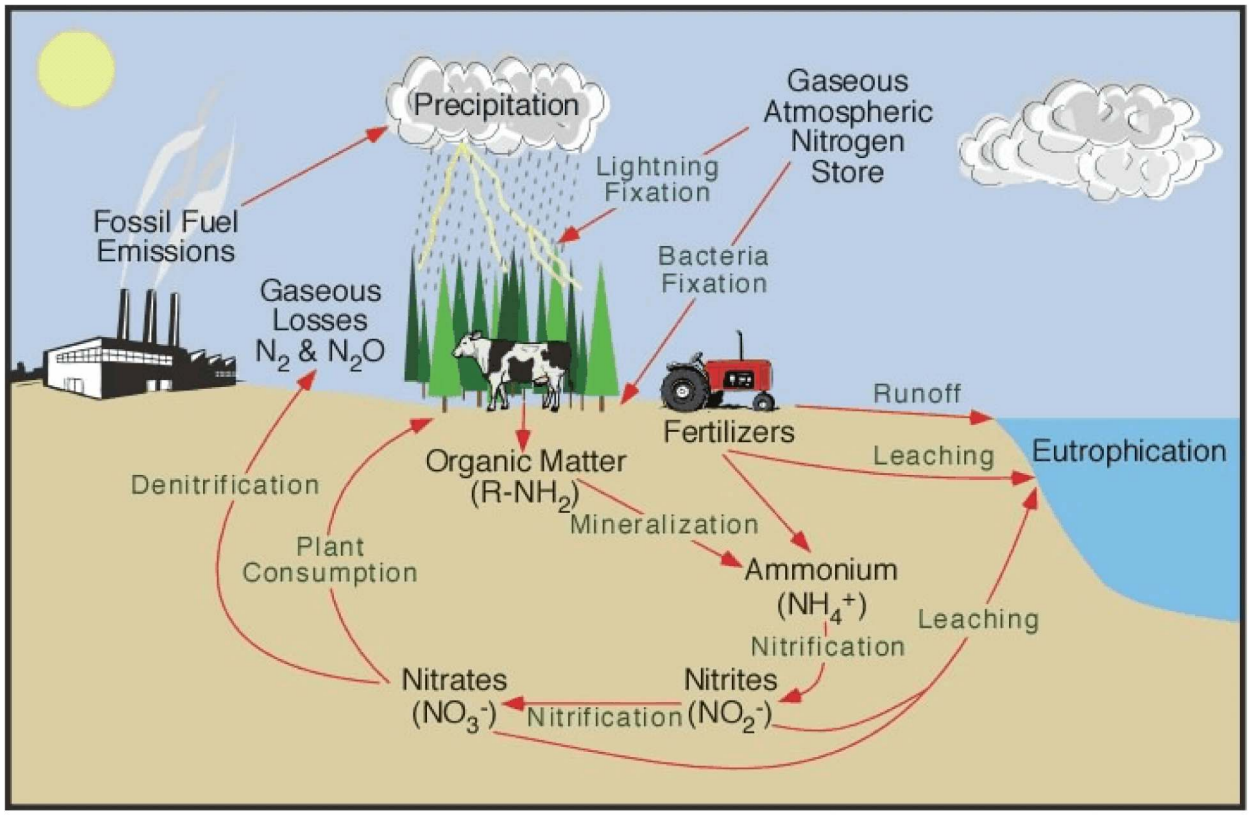


Figure 3. The Nitrogen Cycle [2]

The vast majority of the planet's nitrogen is found in the atmosphere, as the gas N_2, in organic matter in soil and in the oceans. Almost all of the nitrogen found in terrestrial ecosystems originally came from the atmosphere. Significant amounts of atmospheric nitrogen enter the soil in rainfall or through the effects of lightning. The majority, however, is biochemically converted from atmospheric nitrogen by specialized microorganisms which fix nitrogen within the soil, mainly in association with legume crops.

In terrestrial ecosystems nitrogen is primarily stored in living and dead organic matter. This organic nitrogen is converted into inorganic forms when it re-enters the nitrogen cycle following microbial action.

[2] UBC Physical Geography.net

Microbial decomposition occurs in the upper soil layer. Soil microbes chemically modify nitrogen found in organic matter from ammonia (NH_3) to ammonium salts (NH_{4+}). The primary stage of nitrification, the oxidation of ammonia (NH_3), is performed by bacteria which convert ammonia to nitrites (NO_{2-}). Other bacterial species are responsible for the oxidation (nitrification) of nitrites into nitrates (NO_{3-}).

Human activity has significantly altered the balance of the Nitrogen Cycle. Some of the major processes include:

- The application of nitrogen fertilizers to crops under intensive systems of cultivation. This has caused increased rates of denitrification and leaching of nitrate into ground and surface water. Additional nitrogen entering the groundwater system eventually flows into streams, rivers, lakes and estuaries where it can cause eutrophication.
- Increased deposition of nitrogen from atmospheric sources because of fossil fuel combustion and forest burning. Both of these processes release a variety of solid forms of nitrogen through combustion.
- Intensive livestock production leads to the release of large amounts of ammonia into the environment from manure that is applied to the land, and may enter the hydrologic system through leaching, groundwater flow and runoff.
- Human sewage waste and septic tank leaching.
- Nitrogen leaching into ground and surface water from fertilizers applied to golf courses, in parks, lawns and gardens, and various recreational facilities.

Human Health Implications of Nitrate Pollution

Elevated nitrate levels continue to be a human health concern in drinking water (van Grinsven et al. 2006). In the past decade, several case-control and cohort studies have evaluated historical nitrate levels in public water supplies (largely < 10 mg/L) and associated health risks. Unfortunately, the lack of any interdisciplinary agreement among toxicologists, epidemiologists, environmental scientists, agronomists, clinicians and policy-makers, make the accurate assessment of the health risks and cost benefits associated with nitrate exposure problematic (van Grinsven et al. 2006; Ward et al. 2005).

Blue Baby Syndrome (methemoglobinemia)
Currently, the major concern associated with elevated nitrate in drinking water is methemoglobinemia or blue-baby syndrome, a condition caused by the interference of nitrates with blood-oxygen levels in infants that is potentially fatal. Although there have been studies attempting to link nitrate consumption to various illnesses, only methemoglobinemia has been definitively proven to result from ingestion of water containing high nitrate concentrations, above 10 mg/L (Kross 1993). The syndrome occurs in bottle-fed and not breast-fed infants. This condition has never been reported in Prince Edward Island.

Nitrate poisoning resulting in methemoglobinemia continues to be a problem in North America (Greer et al. 2005). Cases of blue-baby syndrome usually occur in rural areas which rely on wells as their primary source of drinking water. These wells have often become contaminated when they are dug or bored too close to cultivated fields, feedlots, manure lagoons or septic tanks (Comly 1987; Johnson et al. 1987).

Poor or damaged well casings have been shown to increase the likelihood of nitrate contaminating well water (Comly 1987; Johnson et al. 1987).

Methemoglobinemia most often affects infants less than six months in age, primarily because infants possess much less oxidizable hemoglobin than adults, so a greater percentage of their hemoglobin is converted to methemoglobin. This greatly decreases the blood's ability to carry oxygen. Other possible reasons are that nitrite ions may be more strongly bound by infantile hemoglobin due to the immaturity of certain enzymes. The kidneys of infants also have inferior excretory power which may favour retention of nitrite for longer periods of time.

Some authors (Avery, 1999; L'hirondel and L'hirondel 2002) have challenged the importance of nitrate in drinking water as a risk factor for methemoglobinemia. They have proposed that the current nitrate standard might be safely raised to 15 to 20 mg/L with no increase in methemoglobinemia (Knobeloch et al. 2000). Cofactors such as diarrhea and respiratory diseases are also believed to increase the occurrence of methemoglobinemia (Shearer et al. 1972; Shuval and Gruener 1972).

Since 1945, over 2,000 cases of infant methemoglobinemia have been reported in Europe and North America. Of these cases eight per cent of the affected infants died (Rail 1989); however, problems can be severe as shown in a 1950 Minnesota case study where 144 cases of infant methemoglobinemia resulted in 14 deaths over a 30-day period (Johnson et al. 1987). Though an isolated occurrence, it demonstrates that nitrate concentrations in well water can rapidly reach fatal levels and the issue of nitrate contamination cannot be ignored.

Cancer and Nitrates

Nitrates in food and drinking water represent a real human health risk. After nitrates are ingested they are converted into N-nitroso compounds by a process called nitrosation. There is consensus about the strong carcinogenic effect of N-nitroso compounds in humans based on animal testing. N-nitroso compounds are potent animal carcinogens, inducing tumors at multiple organ sites including the esophagus, stomach, colon, bladder, lymphatics and hematopoietic system (Bogovski and Bogovski1981); however, there is no consensus about the health risks associated with nitrate intake, and the need for measures to reduce drinking water nitrate concentrations (Ward et al. 2005; WHO 2007).

While many studies have attempted to link stomach and gastrointestinal cancer to nitrate water intake, results have been mixed, with some studies showing positive associations, many showing no association, and a few showing inverse associations (Cantor 1997; van Loon et al. 1998). The inconsistency in research findings suggests that nitrate may not be the sole cause of elevated regional gastric cancer mortality rates, but it does appear to be a significant contributing factor.

The incidence of non-Hodgkin lymphoma and colon cancer was significantly elevated among men and women exposed to public water supplies at nitrate levels of 4.5 to 11.3 mg/L (Gulis et al. 2002). A long-term Nebraska case-control study of non-Hodgkin lymphoma incidence (Ward et al. 1996) found a significant positive association between the average nitrate level in public water supplies and the disease. The risk of developing non-Hodgkin lymphoma was elevated two-fold in the highest quartile of nitrate (4.0 mg/L); however, no such association was found in a recent study of non-Hodgkin lymphoma in Iowa with similar exposure levels (Ward et al. 2004). In direct contrast, a case-control study of non-Hodgkin

lymphoma incidence in Minnesota (Freedman et al. 2000) found an inverse association amongst those with the highest level (> 1.5 mg/L).

A positive correlation between nitrate levels in public water supplies and prostate cancer mortality was found in Spain, but no relation with bladder and colon cancer (Morales-Suarez-Varela et al. 1995).

In Iowa, a cohort study involving older women (Weyer et al. 2001) reported a 2.8-fold and 1.8-fold increased of risk of bladder and ovarian cancers, respectively, associated with long-term average nitrate levels in water in the highest quartile (> 2.46 mg/L). Inverse associations for uterine and rectal cancer were also found, but no significant associations for non-Hodgkin lymphoma, leukemia, colon, rectum, pancreas, kidney, lung cancer and melanoma.

Iowa case-control studies of bladder (Ward et al. 2003), brain (Ward et al. 2004), colon and rectum (De Roos et al. 2003), and pancreas cancer (Coss et al. 2004) found no association between cancer risk and average nitrate levels.

Case-control studies in Germany (Steindorf et al. 1994) and Nebraska (Ward et al. 2004) were unable to find any association with long-term average nitrate levels in public water supplies and adult brain cancer. A study of childhood brain cancer measuring nitrate levels in water supplies many years after the pregnancy (Mueller et al. 2001) found nitrate and nitrite were not associated with risk; however, a study of women in western Washington State who had used private wells as their drinking-water source during pregnancy, had a significantly increased risk of brain cancer in their offspring.

A possible relationship between high maternal methemoglobin levels and spontaneous abortion has been described (Schmitz 1961); however, relatively few studies have examined the relationship between water nitrate levels and stillbirths, premature birth or intrauterine growth retardation. Results in these studies have been inconsistent, suggesting that there is no true effect of water nitrate on reproductive outcomes at the water nitrate levels examined. However, the results of these studies may have been confounded by the differing periods over which nitrate exposure was assessed, varying levels of water nitrate between studies, or differences in exposure rates to other cofactors.

Inconclusive results have also been found in studies evaluating drinking water nitrate and congenital malformations in offspring. Four studies (Arbuckle et al. 1988; Brender et al. 2004a, 2004b; Croen et al. 2001; Dorsch et al. 1984) found positive, minimal or no effect on risk associations between drinking water nitrate and congenital malformations. Exposure to nitrate in drinking water at concentrations above the 10 mg/L maximum contaminant level was associated with increased risk for anencephaly (Croen et al. 2001).

Evidence from animal studies has suggested that high doses of nitrate can inhibit iodine uptake, inducing hypertrophic changes in the thyroid (Bloomfield et al. 1961). Studies in the Netherlands found that drinking water where nitrate levels were at or above the maximum contaminant level was associated with thyroid hypertrophy (van Maanen et al. 1994) and genotoxic effects (van Maanen et al. 1996) in humans. Animal studies have also provided evidence that N-nitroso compounds can harm beta cells in the pancreas (Longnecker and Daniels 2001). Some epidemiologic studies (Kostraba et al. 1992; Parslow et al. 1997; van Maanen et al. 2000) have shown a positive correlation between drinking water nitrate levels and the incidence of type 1 childhood diabetes when nitrate levels were below the maximum

contaminant level. Associations have also been found between water nitrate exposure and increased blood pressure (Pomeranz et al. 2000) and acute respiratory tract infections in children (Gupta et al. 2000).

Conclusions

Any adverse health effects from drinking water nitrates are often attributed to a complex interaction between the amount of nitrate ingested, the ingestion of nitrosating cofactors and precursors, and any pre-existing medical conditions that may increase nitrosation in the host. To complicate matters, effects may be attenuated by inhibitors of endogenous nitrosation, such as vitamin C and alpha-tocopherol. The role of nitrate as a risk factor for cancer and adverse reproductive outcomes needs to be explored further. While studies that have examined the relationship between nitrate levels in drinking water and methemoglobinemia levels in infants have produced mixed results (U.S. EPA 1991), cofactors such as diarrhea and respiratory diseases reportedly increase methemoglobinemia levels (Shearer et al. 1972; Shuval and Gruener 1972). Clearly we should take necessary precautions to protect our water resource from further nitrate contamination.

Environmental Health Implications of Nitrate Pollution

Nitrogen (N) cycling in the form of NO_{3-} is part of a normal, global, biogeochemical process by which atmospheric nitrogen gas (N_2) is fixed by soil microbes or plant root bacteria (*Rhizobia species)* and taken up by plants in the form of NO_{3-}, nitrite (NO_{2-}), or ammonium (NH_{4+}). Nitrogen in plant material is consumed and/or decomposed, then recycled, leached or returned to the atmosphere as nitrogen gas (N_2).

Excessive amounts of nitrogen in the environment can lead to nitrate pollution. The results of nitrate pollution come from the effects of human activities upon normal biotic nitrogen fixation, transformation and cycling of nitrogen. These effects can include atmospheric pollution by N from fossil fuel combustion, and industrial and agricultural activities that lead to increased nitrification and transformation by soil microbes (Burkart and James 1999).

Nitrogen pollution can be characterized as point source and nonpoint source. Nonpoint source nitrogen pollution is generally attributed to agricultural runoff, pasture runoff, urban runoff from sewers or drains, septic leakage, runoff from construction sites or abandoned mines, atmospheric deposition and any land-based activities that generate contaminants (Carpenter et al*.* 1998). (The commission understands that the term runoff can include the leaching of nitrates into the aquifer.) Agricultural pollutants impact waterways, lakes and wetland ecosystems by overloading them with nutrients, particularly NO_{3-} and phosphorus. Agricultural runoff has been named as having the greatest negative impact on river and lake water quality, groundwater contamination, and wetland degradation in the environment (US EPA 1997). Excessive nutrient inputs result in eutrophication where macroalgal overgrowth and dinoflagellate (phytoplankton) blooms deplete oxygen and/or release toxic substances. Ultimately such rapid growth will kill or choke out other wildlife and has been cited as responsible for the destruction of traditional shellfish beds (US EPA 1997). Aquatic life forms are more sensitive to nitrate pollution and recent studies suggest that a maximum level of two mg/L would be appropriate for protecting the most sensitive freshwater species (Carmargo et al., 2005).

Even so, algal overgrowth and dinoflagellate blooms can result from relatively low levels of nitrate contamination (<2 mg/L) leading to large-scale hypoxic, or "dead zones" (Burkart and James 1999). Prolific macroalgal growth (algal mats) has been responsible for a number of large mortality events in the shellfish industry in PEI. In 2006, a large mortality event in New London Bay resulted in major losses of oysters. In 2007, spring mortalities were reported in the Vernon-Orwell system. The principal algal species involved were identified as *Enteromorpha*, *Chladophora* and *Ulva.* In the case of marine animals, a maximum level of 20 mg/L may be acceptable (Carmargo et al., 2005).

All of these effects threaten human and ecosystem health and have a serious impact on rivers, wetlands and groundwater quality (EPA 1997; Carpenter et al. 1998; Burkart and James 1999). Excessive levels of nitrate can also be directly harmful to aquatic life. Aquatic animals exposed to nitrate have been shown to be smaller, take longer to mature or have diminished reproductive success. Under extreme conditions of exposure to nitrates, aquatic animals may die.

In contrast, point source pollutants are concentrated sources or contaminants such as: municipal and industrial wastewater and runoff, runoff from landfills, runoff from concentrated animal feeding operations, and runoff or spillage from waste-treatment sites (Carpenter et al. 1998). Point source pollutants, although more easily monitored and regulated than non-point source pollutants, will also seriously impact water quality and damage riparian ecosystems.

Social and Economic Impacts of Nitrate Pollution

There are many social and economic costs associated with nonpoint source pollution, including the negative economic impacts on those industries that rely upon the harvest of marine life, the damage to recreational resources, degraded aesthetic values, and reductions in the abundance and diversity of marine life. Specific problems often listed include, among others:

- fish kills and the death of other aquatic organisms [3];
- economic losses to commercial and recreational fishing and shellfish harvesting;
- reduced opportunities for water-based recreation and tourism;
- loss of aesthetic quality in lakes, streams and coastal areas;
- significant costs associated with the remediation of damaged habitats (e.g., payments for monitoring, clean-ups and pollution reduction); and
- reduced real estate values.

It should be noted that these negative impacts are framed in terms of the damage that is done to human interests in the environment, and seldom if ever, in relation to protecting the environment for its own sake.

[3] Nitrate levels greater than 2 to 3 mg/L can inhibit growth, impair the immune system and cause stress in some aquatic species.

The PEI Department of Environment, Energy and Forestry has kept records of anoxic events in PEI since 2001. During that time 18 estuaries have experienced re-occurring anoxic events during the summer months. The majority of these anoxic events occur on the “north side” of PEI (Figure 4).

Nutrient loading certainly plays a role in the occurrence of anoxic events, however there are other factors. Some estuaries can tolerate much higher nutrient loads without experiencing anoxia, while others have very small loads and re-occurring anoxia. The rate of flushing of nutrients out of the system plays a significant role. On the north shore the largest tides have a mean of only about one metre while those on the southwest and southeast parts of the province have a range of 1.5 to 1.9 metres. The Charlottetown tides are the largest overall, at up to 2.9 metres.

North shore estuaries are also typically part of a coastal embayment that may have barrier sand dunes or narrow channel entrances which further limit exchange with offshore waters. All of this combines to give some estuaries very long water residence times (which can be defined as the length of time that it would take a molecule of water entering the system from a freshwater stream to leave the estuary). For some north shore estuaries, the residence time can be three to four months long making them prone to phytoplankton and sea lettuce blooms.

The difference in flushing between estuaries, and the resulting differences in tolerance of nutrient loads, means that the same nutrient loading guidelines cannot be used for all estuaries. Site specific nutrient criteria unique to each estuary will be required to protect them from anoxic events. Research is underway to establish the nutrient loading targets for estuaries.

Figure 4. Anoxic events on PEI between the years 2001-2007 (PEI Department of Environment, Fisheries and Forestry

Issues and Recommendations

1. Improving Public Education on Protecting Water Quality

Issue:

Islanders need the information and tools to be able to protect their drinking water and waterways.

Background:

It is important that all Islanders take an active role in understanding the water system on Prince Edward Island, its many watersheds, and the processes which impact watershed sustainability and water quality. Water quality on Prince Edward Island is the responsibility of everyone. Islanders must be given the information and the tools to understand how they may act to protect and manage the water resources in their own watersheds.

Education is viewed as key in helping to influence sound environmental practices and decision-making in Island homes and communities. Initiatives such as the nitrate in drinking water testing clinics raise public awareness and frame nitrate pollution in a relevant, unambiguous and direct manner.

A web-based public data system for surface water quality is already available on the Provincial Government website;[4] however, there is no similar system to report to the public on groundwater quality. A web-based public data system could provide the general public with access to information on the levels of nitrates in groundwater. To preserve confidentiality, while allowing the public to find out the general groundwater quality in their area, a dynamic web-based mapping system is favoured, as it would provide aggregate statistics of well water quality in the area (i.e., community or watershed). The system would ensure that there would be enough data values available to make an average calculation meaningful without divulging specific household results. The well water maximum and minimum values for nitrate levels in each watershed should also be made available, so that arithematic calculation does not obscure the fact that problem wells might exist.

Recommendations:

1.1 It is recommended that the Prince Edward Island Government continue to develop a public education campaign/program to help Islanders understand the importance of making responsible and appropriate personal choices on issues that will affect water quality.

[4] *www.gov.pe.ca/go/watermonitoring*

1.2 It is recommended that the department responsible for the environment provide the public with a web-based groundwater and surface water quality data system. The system would provide the maximum, minimum and average level of nitrate contamination in wells found within each watershed.

1.3 It is recommended that the department responsible for the environment maintain a province-wide well water testing program and that it urge well owners to have their water tested not less than once per year.

1.4 It is recommended that an awareness of the issue of Prince Edward Island water quality and watershed influences must be created among staff and students in schools and teaching facilities. Teaching units, credit courses and environmental curricula specific to Prince Edward Island and its watersheds, should be available in public schools.

1.5 It is recommended that watershed groups be encouraged to play an important role in public awareness and education.

2. Reducing Nutrient Loading From Sewage Treatment Systems

Issue:

Human waste contributes to nutrient loading both through on-site septic tanks and wastewater treatment plants.

Background:

There are three common levels of wastewater treatment – primary, secondary and tertiary. Primary treatment is the removal of suspended solids and organic material typically accomplished through physical treatment. Secondary treatment is the removal of biodegradable matter and suspended solids accomplished through physical, chemical and biological treatment processes. Often disinfection of the wastewater is included with secondary treatment. The removal of nutrients (nitrogen and phosphorous) can be achieved through advanced secondary and tertiary treatment systems.

The final treated effluent can be discharged into streams, rivers and bays or can be used for irrigation. Consideration of the impact on the receiving environment is reviewed by the provincial Department of Environment, Energy and Forestry. Treated wastewater contains levels of nitrogen and phosphorous that can contribute to the eutrophication of natural water bodies along with other sources of nitrogen. A critical aspect to review when considering impact is the overall nutrient inputs to the water body.

In Prince Edward Island, all municipal wastewater is treated to secondary levels. Requirements are outlined in the Atlantic Canada Guidelines Manual, with secondary disinfected effluent. Some of these facilities are aged and require upgrading to meet current standards. Typically, in Prince Edward Island, the choice for treatment has been waste stabilization ponds (lagoons) with disinfection for smaller communities. Some of the larger centres, such as Charlottetown, Summerside, Montague and utilities that had difficulty siting a lagoon system, have mechanical wastewater treatment plants with ultraviolet disinfection systems.

Tertiary treatment provides for a higher level of treatment lowering nitrogen and phosphorous levels. This type of treatment can be achieved through mechanical systems and through wetland systems. The cost to construct, operate and site these facilities restricts their application.

Currently, the Department of Environment, Energy and Forestry is working with two smaller communities investigating the use of constructed engineered wetlands with shallow ponds for bacteriological removal. One benefit of using this type of technology is that wetlands do remove a large proportion of nutrients when properly managed. In the future, these types of systems may be an effective option for smaller flow systems.

Septic fields and lagoon discharge of nitrates add to the nitrate load on the environment. At present on-site septic systems are used to treat wastewater in rural and urban areas. A conventional septic system generally consists of a water tight concrete or polyethylene tank, referred to as a septic tank, and a disposal field consisting of a pipe and gravel or chamber system.

The Walkerton Inquiry prompted Justice D.R. O'Connor to express the following concern:

> "….Throughout this Inquiry, I often heard about the problems related to groundwater contamination from inadequate or old and decrepit septic systems. The issue came up in expert meetings, public hearings, and town hall meetings…..Given these statistics, and considering that septic systems are generally located in rural areas, where groundwater is the principal source of drinking water, inadequate septic systems may present a substantial threat to some Ontario drinking water sources..." [5]

The septic tank is the first stage of the treatment process. Wastewater enters the septic tank where solids settle and are anaerobically digested to reduce volume. The liquid (effluent) flows from the clear zone of the septic tank into the disposal field where final filtration and breakdown of organic and bacteriological material occurs in the soil profile. Generally, the natural soil found in septic systems can remove 99.9 per cent of the bacteria and suspended solids, and 10 to 40 per cent of nitrogen inputs.

In areas of high density housing on small lots and subdivisions where the community is serviced by septic systems, the proportional nitrogen load can be significant. In these areas, reducing nitrogen discharge from this source should be considered.

In some sites, soil conditions or limited space do not permit the installation of conventional septic tank and drain field systems. Alternative septic system designs can be used for new or replacement systems on difficult sites where soil conditions limit soil percolation rate, or other terrain conditions (such as limited space) do not permit the installation of a conventional septic tank and drain field system. These advanced treatment systems offer two advantages. Firstly, they allow the wastewater to assimilate through tighter soils and have a smaller foot print compared to conventional systems. Secondly, these systems can reduce the amount of nitrogen discharged to the groundwater.

The cost of a conventional septic system can range from $6,000 to $10,000 per household. The cost of alternative septic systems can range from $20,000 to $30,000 depending on the selection of the system and the conditions of the site.

When a new subdivision is developed, the impact of those dwellings on the area's existing drinking water and sewage collection and disposal systems must be considered. Subdivisions which will not use existing sewage disposal facilities and which will rely on an individual dwelling septic tank system may cause significant leaching of nitrates into the area's groundwater. The responsible officials of the Department of the Environment, Energy and Forestry must be satisfied that the sewage disposal or collection system proposed for the subdivision will not compromise the area's drinking water. An application for subdivision approval should include a complete plan showing the proposed system for sewage disposal. Effective regulations in this respect ought to be developed.

---

[5] Justice D.R. O'Connor (2002) - *Part Two: Report of the Walkerton Inquiry. A Strategy for Safe Drinking Water*. Chapter 4.4.3. pg. 123. Ontario Ministry of the Attorney General: Queen's Printer for Ontario. *https://ozone.scholarsportal.info/bitstream/1873/7856/1/10300881.pdf*

Recommendations:

2.1 It is recommended that the regulations concerning sewage disposal be reviewed and amended, if necessary, to ensure they provide effective groundwater protection in all subdivision developments.

2.2 It is recommended that wastewater treatment plant effluent analyses be made available to the public.

2.3 It is recommended that municipal sewage systems be upgraded to meet current standards and incorporate disinfection with primary and secondary treatment stages. Environmental risk assessments should be conducted in accordance with the *Environmental Protection Act* on all discharges, to ensure there is no adverse impact on the receiving water. If an environmental risk assessment indicates an adverse environmental impact due to nutrient (nitrate or phosphorus) loadings, then tertiary treatment should be added to the wastewater treatment plant.

3. Supporting Watershed-based Water Management Planning

Issue:

Only a few of the Island watersheds are managed as unified ecosystems.

Background:

The watershed is the most meaningful unit for drinking water source protection planning. Residents of a watershed have a common interest in water quality, regardless of political or other imposed boundaries.

Watershed management plans should protect and restore community watersheds. Planning for watershed restoration and recovery has the additional benefit of helping to build a sense of community by bringing together people with different backgrounds and perspectives to define the future of their area, and educating people about their watershed and the issues it faces. The commission is mindful that inequalities within and amongst watershed groups will create a challenging work environment, and affect the capacity of watershed groups to develop effective working relationships.

Current legislation limiting landownership encourages the clearing of forested lands for crop production making watersheds more vulnerable to nitrate pollution of the surface and groundwater.

By understanding watershed dynamics before irreparable change occurs, harmful impacts on the system can be identified and prevented, and remedial improvements can be incorporated into future plans (Peterjohn and Correll 1984; Lowrance et al. 1985).

Recommendations:

3.1 It is recommended that watershed-based drinking water and surface water quality protection continue to be supported. To ensure planning continuity at the provincial level, Government should contribute funding for watershed planning initiatives across the province.

3.2 It is recommended that the Provincial Government continue to provide “start-up” funding and technical support to enable the development of community-based watershed planning and management systems for all watersheds, including a network for information exchange.

4. Reducing Nitrate Contamination From Cosmetic Use of Fertilizers

Issue:

All fertilizers can contribute to nitrate contamination of groundwater.

Background:

Homeowner use of fertilizers is a relatively small contributor to the overall nitrate contamination of ground and surface water in Prince Edward Island. Nonetheless, the practice of fertilizing lawns is widespread in urban and rural areas and contributes to nitrate contamination of the environment. Provincial and Federal Government offices apply fertilizers around public buildings and in parks. Golf courses apply fertilizers to maintain the aesthetics of their greens and fairways. The potential to over-apply fertilizers in the absence of a soil test is widespread, and this "over-application" will be washed into storm drains and drainage ditches, or leach into groundwater.

In some jurisdictions, the application of fertilizers on lawns has been banned, or else is accompanied by restrictions. Such restrictions do not apply to fertilizers used on agricultural crops, flower and vegetable gardens, or on golf courses. Restricting the use of fertilizers for lawn care would help reduce nitrate loading in the environment, and sensitize Islanders to the environmental impact of fertilizer over-use. Commercial lawn applicators would be required to follow any rules that are developed.

Most Island golf courses use only slow release fertilizers which can be applied at much higher rates and with fewer applications throughout the season. Golf courses want to avoid the growth surge experienced with the use of fast release fertilizers; keeping a large area properly mowed, and therefore playable, becomes impossible. There are three other reasons slow-release fertilizers are preferred:

- economics – relatively short residual response from fast release fertilizers leads to more frequent applications and more fertilizer purchases;
- fast release fertilizers have a high potential for foliar burns; and
- course superintendents are aware of the environmental impact of nitrate leaching and run-off and that this is less likely with the use of slow release fertilizers.

Experience has shown there are best management practices that all cosmetic fertilizer users could adopt to minimize nitrate leaching. These practices apply equally to the cosmetic use of fertilizers by urban and rural homeowners as well as to all golf courses.

Recommendation:

4.1 It is recommended that there be a province-wide policy to reduce the use of fertilizers for cosmetic purposes. A good example of effective management practices in this respect is applied at the Links at Crowbush Cove.

5. Amending Land-holding Legislation

Issue:

With a legislated limited land base, producers argue they are forced to farm environmentally sensitive land.

Background:

The *PEI Lands Protection Act* was enacted some 25 years ago and since then there has been major consolidation in the agricultural sector. A number of watersheds in the province have a high percentage of land devoted to agricultural production. If landowners can exclude environmentally sensitive land in these watersheds from their allowable land holding, a portion of the land in these watersheds could come out of agricultural production, reducing the impacts of agriculture on water quality and improving the potential for increased biodiversity.

In the commission's view, environmentally sensitive land would include, but not be restricted to the following:

- agricultural land that is identified as high sloping in the PEI Sloped Land Inventory,
- land identified as wetlands in the PEI Wetland Atlas,
- land which is reclaimed as wetland,
- land under erosion control structures (terraces, grassed waterways and farmable berms),
- land under permanent grassed headlands,
- agricultural land that is converted to forestry, and
- forested land under an approved management plan with specific minimum standards.

Recent amendments to the *Lands Protection Act* have resulted in land designated under the *Natural Areas Protection Act* (NAPA) being excluded from the land holding limits of an individual or corporation, and being protected for perpetuity for the benefit of all Islanders. However, the commission is of the opinion that further amendment is required to include more land management practices.

Recommendation:

5.1 It is recommended that the *PEI Lands Protection Act* be further amended to allow for the exclusion of environmentally sensitive lands from land holding limits. The definition of "environmentally sensitive land" should include the land identified in this section. This recommendation is conditional upon the implementation of a mandatory three-year crop rotation, without exemptions (see Recommendation 7.1).

6. Protecting and Restoring Wetlands Which Trap Nutrients

Issue:

Natural wetlands have been removed from agricultural fields.

Background:

Wetlands can serve as effective sinks for nutrients that otherwise enter water bodies as runoff and groundwater flow. A riparian wetland is the terrestrial ecosystem formed at the interface between an aquatic and an upland ecosystem adjacent to a body of water. Healthy riparian wetlands have a positive effect on water quality through their ability to:

- purify water by filtering out and absorbing sediments, bacteria, pollutants and excess nutrients as water moves through;
- reduce the risk of flood damage;
- reduce stream bank erosion;
- maintain stream flows;
- support a diversity of terrestrial wildlife and plant species; and
- maintain a healthy habitat for aquatic wildlife.

Wetlands have been shown to be effective nitrogen sinks, trapping up to 80 per cent of mobile nitrates from water entering the catchment area as run-off (Casey and Klaine 2001; Gabor et al. 2004; White and Bayley 2001). Natural wetlands have been drained and put into agricultural production, removing the natural checks and balances that previously protected aquatic ecosystems and preserved the quality of water.

Cost sharing programs have promoted wetland restoration. Many wetland restoration projects in Prince Edward Island, past and present, have been delivered by Ducks Unlimited Canada. Retaining and restoring wetlands has broad societal benefits including improving water quality, air quality and biodiversity. The Provincial Government has been proactive in conserving existing wetlands through legislation and policy. To continue its proactive approach, the Provincial Government needs to interact with watershed management groups and landowners and play a greater role in restoring these essential components of the landscape.

Recommendations:

6.1 It is recommended that the Province and non-government organizations develop funding initiatives to restore, protect, acquire and expand key wetland areas in the province.

6.2. It is recommended that an information and outreach program about natural wetlands – including training and research initiatives – be developed for private landowners.

6.3 Since wetland ecosystems neither begin nor end at landownership boundaries, it is recommended that the Provincial Government take the leadership role in helping in the formation of new partnerships with stakeholders (including watershed groups) designed to further the goal of restoring, protecting, acquiring and expanding key areas to ensure the efficient management of wetlands in the province.

7. Matching Nutrients With Crop Needs to Reduce Nitrogen Leaching

Issue:

Nitrogen leaching from agricultural land to groundwater poses a threat to water quality.

Background:

Managing soil fertility and soil health is very complex. Careful farmers recognize that soil conditions can change across a field and from one community to another. It requires experience to know the practices that will work best for each field.

Careful management of soil organic matter is important. Maintaining high levels of soil organic matter provides a way of storing nitrogen in soil in a form that does not readily leach. Managing production systems so that the conversion of organic nitrogen to the mineral form (mainly nitrate) is closely matched with crop utilization is key to maximizing crop production while minimizing nitrate leaching. Choice of rotation crops and their management, and the timing and intensity of tillage operations are key factors influencing conversion of organic nitrogen to nitrate.

Organic matter also influences a soil's ability to hold nutrients by influencing its cation exchange capacity. The cation exchange capacity is a value given on a soil test report to indicate a soil's capacity to hold cation nutrients, such as ammonium (NH_{4+}) and others. Cation exchange capacity is used as a measure of fertility, nutrient retention ability and the capacity to protect groundwater from contamination.

Regular soil testing provides producers with an inventory of the nutrient status in each field. Understanding the nutrient status of soil is critical when developing a nutrient management plan or nutrient budget and determining which management practices should be selected to optimize crop yield and achieve maximum economic returns.

All nitrogen fertilizers, from organic or inorganic sources, are vulnerable to leaching if not managed carefully. Over-application of some organic material can result in excessive levels of nutrients in the soil, which can harm water quality. Organic certification requires attention to crop rotation, cover crops and soil quality. Organic production systems conserve and limit nutrients, and would not be expected to have excessive amounts of nutrients available for leaching.

The value of reliable soil test results and recommendations depend upon:

- proper soil sampling and sample processing procedures,
- proper soil analysis techniques and sound fertilizer recommendation guidelines,
- confidence in the recommendations provided, and
- understanding and correctly applying the soil management recommendations provided.

The Province currently provides a soil and feed testing service that uses certified analysis techniques and sound fertilizer recommendation guidelines, but a low percentage of producers use this service. Increasing the confidence and knowledge base of producers in best management practices (including nutrient management planning) is most successful through peer learning, when producers come together. The Prince Edward Island Soil and Crop Improvement Association (PEISCIA) Agri-Conservation Club model has proven effective in providing producers with the technical and moral support needed to develop and implement best management practices. The opportunity for peer learning and on-farm technical support were key aspects of the model.

Best management practices generally share similar themes of pollution prevention including:

i) a requirement for reduced inputs for fertilizers, manures and pesticides,

ii) nutrient management plans where fertilizers and manures are applied only in amounts that can be taken up by a crop, and

iii) land management practices that protect the soil resource.

The key management practices which the commission advocates are:

1) Reduction in the amount of fertilizer applied to potatoes: There is clear evidence of the relationship between groundwater nitrate levels and fertilizer application rates. If too much fertilizer or manure is applied, excess nitrogen in the form of nitrates will find its way to surface or groundwater. Nutrient inputs on farms need to be matched with crop nutrient requirements to minimize the over-use of fertilizers and the over-application of manure. In Prince Edward Island excessive nitrogen application is mainly a problem in potato production areas. Calculations based on an application rate reduction from 220 to 185 kg/ha of fertilizer application on potatoes suggest a corresponding 25 per cent decrease in nitrates in groundwater (Savard and Somers, 2007c). Lower fertilizer application rates would result in greater decreases.

   Nutrient management planning aims to optimize crop yield and quality, minimize fertilizer input costs and manure use, and protect soil and water. It involves an inventory of farm conditions and operations, and allocation of nutrient sources to the fields based on farmer specifications, field conditions and operations. All producers have a nutrient management plan, even though many are very informal and emphasize only farm production performance criteria.

   The principles of nutrient management planning are simple and include:

   - applying fertilizer and manure only to make up the difference between what is present in the soil and what is required to achieve the target yield, ensuring cost-effectiveness for the producer; and
   - ensuring the added nutrient is available to the crop by applying at the correct time, and by raising soil pH through lime applications.

   Producer confidence in the reliability of nutrient management planning should be encouraged and producers need to be assured that they are receiving information based on sound science.

2) Increase length of rotations: Based on its research and consultations, the commission is convinced that a mandatory three-year crop rotation in fields under regulated crop cultivation, with no exemptions, would immediately reduce the level of nitrate loading into the environment by removing land from production, and contribute to the quality of the water in our aquifers. This would have an associated positive implication for human health safety. Appropriate and effective enforcement mechanisms would need to be included.

The more frequently potatoes are grown on a specific parcel of land the higher the contribution of nitrates to groundwater from that parcel. Various studies have recommended that row crops, including potatoes, should not be grown any more frequently than once in any three-year period on any field in the province with no exemptions. This practice will protect soil quality, reduce disease pressure and will reduce the potential nitrate leaching to groundwater.

To facilitate a mandatory three-year crop rotation, the *Prince Edward Island Lands Protection Act* must be amended so that landowners will be able to exclude environmentally sensitive land from their allowable land holding limits. Environmentally sensitive lands would only be excluded if the landowner certified that the remainder of their land holdings are and will continue to be farmed in a three-year crop rotation. In this connection see Section 5 of this report.

3) Managing soil organic matter: Groundwater nitrate levels could be reduced by as much as 30 per cent, if Island farmers adjusted their management of soil organic material to promote a reduction in over-winter leaching losses. Some producers have typically applied glyphosate on forage land in September and then in the fall plow their land prior to a year of row crop production. If the forage crop contains legumes, the nitrogen fixed by the plants will mineralize and leach beyond the root zone during the following winter, making it unavailable for the subsequent crop and substantially adding to the nitrate load going to groundwater. Forage land that contains legumes should be plowed in the spring to reduce nitrate leaching and to control wind and water erosion.

Cover crops or trap crops can also tie up some of the residual nitrogen that is left in the soil after potato harvest, thus preventing it from leaching over the winter. Broadcasting a winter cereal several days before crop harvest is an economical and effective method of establishing a cover crop on any field where the row crop is dug (potatoes, carrots).

4) Increasing forest cover: Many watersheds in intensively farmed potato growing areas have more than 50 per cent of their land base in agricultural production. If nitrate levels in groundwater are to be reduced in these watersheds, land clearing should not be allowed to occur where less than a specified percentage (for example, 40 per cent) of the land base is currently in tree cover (forests + hedgerows), and reforestation should be a priority.

Recommendations:

7.1 It is recommended that a province-wide mandatory three-year crop rotation in fields under regulated crop production, with no exemptions, be implemented.

7.2 It is recommended that the departments responsible for agriculture and environment collaborate in the development of a nutrient management/accounting program for all crop and livestock producers. The program should ensure that nitrate levels in the soil during leaching periods are maintained at or below acceptable levels.

7.3 It is recommended that an extension and training program should be provided to producers and/or their advisors with information required to complete nutrient plans/accounts. For example, the PEISCIA Agri-Conservation Club model could be used to assist producers to understand and correctly apply soil management recommendations, to help them to develop and implement their nutrient management plans, and better assist them in their farm production choices, including making those decisions that will reduce nitrate loading in the environment.

7.4 It is recommended that adequate resources be assigned to provide adequate auditing of the program.

7.5 It is recommended that an appeal system be developed to settle disputes between the producer (or their advisors) and the auditor(s).

7.6 It is recommended that a system of realistic financial incentives be developed to facilitate the implementation of the nutrient management/accounting program. Such incentives could include:

- the governments of Canada and Prince Edward Island should continue to support the concept of and priority for programs such as Alternative Land Use Services and that long-term realistic funding be established for investment in environmental benefits provided by the farm community;
- the Provincial Production Insurance program should be modified to include yield losses caused by an altered nutrient management schedule, guaranteeing a level of income based on historical or side-by-side comparison of yield;
- financial incentives such as crop insurance and similar measures that would encourage the adoption of practices that increase the efficiency of nitrogen use, such as improved manure handling/application systems and incentives to increase soil pH through increased use of lime; and
- the Prince Edward Island Environmental Farm Plan program utilizing current information to initiate and promote watershed-based nutrient management planning with a particular emphasis on watersheds that have a high concentration of agricultural activity and/or those where nitrate contamination has been identified.

7.7 It is recommended that a program be established to encourage the removal of agricultural land from potato production in a way that does not adversely impact producer incomes.

7.8 It is recommended that the application of manure, processing waste and other organic matter be prohibited when there is no active plant growth to take up nutrients, especially during the winter months when the ground is frozen or snow covered.

7.9 It is recommended that Government increase financial incentives for manure storage facilities to assist producers in managing manure.

7.10 It is recommended that Government continue to support organic farming and enhance existing assistance programs.

7.11 It is recommended that Government continue to support emerging biosciences especially the development of new high value crops that require fewer inputs and minimal soil tillage.

8. Identifying High Nitrate Areas

Issue:

Some watersheds are already heavily contaminated and significant intervention is required.

Background:

Some watersheds on PEI are already showing significant effects of nitrate pollution. These watersheds can be identified by the higher levels of nitrates in their well water. In the United Kingdom so-called "Nitrate Vulnerable Zones" have been identified and specific farm production practices have been restricted. Nitrate Vulnerable Zones have strict rules on fertilizer application such as not fertilizing at certain times of the year (during the winter when runoff is greatest and uptake by plants at a minimum), reducing the amount of fertilizer used, and changing the times when animal waste is applied to the land (waste must be held in tanks over the period when it cannot be applied).

In PEI, all our watersheds are vulnerable to nitrate contamination and the nutrient management/ accounting program should be used in all areas to prevent water contamination. High nitrate levels in groundwater are found in watersheds with a high proportion of potato acreage in their land use profile (see map in Figure 3).[6] Other watersheds may not be as intensively farmed, but still have wells which exceed safe drinking water limits for nitrate due to contamination from septic systems, or other sources.

Individual contributions to pollution can be minimal but collectively have a significant and adverse effect on water quality. It has been estimated that crop and non-crop agriculture is responsible for 50 to 80 per cent of the total nitrate contamination that occurs in water. Excess nitrates from fertilizer and manure when applied to agricultural land eventually find their way into Island water.[7] Most producers are committed to protecting and enhancing the environment, but collectively, pollution from farms is having a substantial and negative impact on the quality of Prince Edward Island's water.

[6] 2008 Nitrates in drinking water testing clinics. PEI Department of Environment, Energy and Forestry.

[7] DEFRA *Nitrates – reducing water pollution from agriculture http://www.defra.gov.uk/Environment/water/quality/ nitrate/ default.htm:*

EC 2002. The Implementation of Council Directive 91/676/EEC concerning the Protection of Waters against Pollution caused by Nitrates from Agricultural Sources Report COM(2002)407 *http://ec.europa.eu/environment/water/water-nitrates/report.html*

Recommendation:

8.1 It is recommended that the departments responsible for environment and agriculture, working jointly, identify High Nitrate Areas, where national standards for safe drinking water and healthy aquatic systems have been compromised. Since land use is directly correlated with leaching loss, any intervention in these areas will depend on the current situation in each watershed. Special remedial actions in these areas might include:

1) reduction in fertilizer inputs,

2) management of soil organic matter,

3) increased tree cover,

4) reduction in land under potato production,

5) strict controls over all subdivision development, and

6) the encouragement of wetland restoration.

8.2 It is recommended that the nutrient management/accounting program be legislated, regulated and enforced in high nitrate areas.

8.3 To monitor the effectiveness of the nutrient management/accounting program it is recommended that a statistically valid random sample of wells be tested annually in all watersheds, and the results made available to the public.

8.4 It is recommended that alternative septic systems be required in high nitrate areas or on sites where soil conditions limit soil percolation rate.

Conclusions

- Nitrate is one of the most common groundwater contaminants.
- Nitrates are regulated in drinking water primarily because excess levels can cause methemoglobinemia, or “blue baby” disease. Human babies are extremely susceptible to acute nitrate poisoning.
- Other nitrate related health concerns cited in the medical literature include cancer, birth defects, thyroid hypertrophy and genotoxicity.
- Nitrate contamination of surface waters can lead to eutrophication, and related anoxic events in the environment.
- In order of relative importance, the sources of nitrate pollution in Prince Edward Island groundwater are agricultural fertilizers, manure storage and spreading operations, septic systems and cosmetic use of fertilizers.
- There is no one solution to the issue of nitrate contamination in ground and surface water, however mitigating rising nitrate levels in well water through an environmentally responsible system of agriculture is an important step.
- A comprehensive package of educational measures, social marketing approaches, command and control legislation, voluntary compliance and innovative incentives will be required to reduce nitrate pollution in Prince Edward Island ground and surface water.
- Significant intervention will be needed in areas already heavily contaminated by nitrates.
- All sectors of society have contributed to the current problem and all must participate in the solution if the problem of nitrate contamination in our groundwater is to be solved. In order to engage everyone from both rural and urban communities, an educational and information campaign is necessary.

The following recommendations are considered absolutely essential:

Improving Public Education on Protecting Water Quality – It is recommended that the Prince Edward Island Government should continue to develop a public education campaign/program to help Islanders understand the importance of making responsible and appropriate personal choices on issues that will affect water quality.

Reducing Nutrient Loading From Sewage Treatment Systems – It is recommended that the regulations concerning sewage disposal be reviewed and amended, if necessary, to ensure they provide effective groundwater protection in all subdivision developments.

Supporting Watershed-based Management Planning – It is recommended that watershed-based drinking water and surface water quality protection continue to be supported. To ensure planning continuity at the provincial level, Government should contribute funding for watershed planning initiatives across the province.

Mandatory Three-year Crop Rotation – It is recommended that a province-wide mandatory three-year crop rotation in fields under regulated crop production, with no exemptions, be implemented.

Matching Nutrients With Crop Needs to Reduce Nitrogen Leaching – It is recommended that the departments responsible for agriculture and environment collaborate in the development of a nutrient management/accounting program for all crop and livestock producers. The program should ensure that nitrate levels in the soil during leaching periods are maintained at or below acceptable levels.

Identifying High Nitrate Areas – It is recommended that the departments responsible for environment and agriculture, working jointly, identify High Nitrate Areas, where national standards for safe drinking water and healthy aquatic systems have been compromised. Since land use is directly correlated with leaching loss, any intervention in these areas will depend on the current situation in each watershed. Special remedial actions in these areas might include:

1) reduction in fertilizer inputs,
2) management of soil organic matter,
3) increased tree cover,
4) reduction in land under potato production,
5) strict controls over all subdivision development, and
6) the encouragement of wetland restoration.

Next Steps

Although Prince Edward Island historically has had an abundance of clean water, development of the resource has been based on the assumption of unlimited availability. As the first sentence of the Executive Summary of the report of the Earth Science Sector, Geological Survey of Canada (Savard et al., 2007) states:

> "Prince Edward Island land use, water supply infrastructure and water management policies have all evolved under historical assumptions regarding sustainability."

The commission has learned that current levels of nitrates in surface and groundwater has been an increasing source of concern for many Islanders. A level of frustration has been expressed about the fact that the problem has been allowed to reach its current state without effective corrective action being taken. It is the responsibility of all Islanders to ensure this complacency does not persist into the future.

The Provincial Government is responsible for regulating and overseeing the safety of Prince Edward Island's drinking water. Clearly, therefore, the Provincial Government must take the lead to restore, protect and enhance the groundwater of the province, as a natural and public resource. The Government must recognize the essential and pervasive role of groundwater in the social and economic well-being of all Islanders, and its vital importance to general health, safety and welfare. The Government must ensure the groundwater resources of the province be utilized for beneficial and legitimate purposes, that waste and degradation of the resources be prevented, and that the underground resource be managed to allow for maximum benefit of the people of this province.

In order to assist in attaining those objectives, the Province may utilize already existing mechanisms in the *Environmental Protection Act*. Section 4 of that act allows the Lieutenant Governor in Council to appoint an Environmental Advisory Council consisting of not less than 10 and not more than 15 members representative of the public, including representation of the interests of agriculture, tourism, fisheries and industry and one member nominated by the Federation of Prince Edward Island Municipalities.

Section 25(1) of the act allows the Lieutenant Governor in Council to make regulations for the enhancement and protection of the environment.

Recommendation:

9.1 It is recommended that the Lieutenant Governor in Council make regulations permitting the Environmental Advisory Council to:

- review and co-ordinate the Province's policy on groundwater protection;
- review and evaluate the Province's statutes, regulations and procedures relating to groundwater protection;

- review and evaluate the status of the Province's efforts to protect and improve the quality of the groundwater and make recommendations for improving those efforts to protect the groundwater;
- recommend procedures for the better co-ordination among the Province's groundwater programs and local programs related to groundwater protection;
- review and recommend procedures to co-ordinate the Province's response to specific incidents of groundwater pollution and co-ordinate dissemination of information between departments and agencies responsible for the Province's response;
- make recommendations for and prioritize the Province's groundwater research needs;
- review, co-ordinate and evaluate groundwater data collection and analysis; and
- report annually jointly with the Environmental Co-ordinating Committee, to the Premier and to the Legislative Assembly on groundwater quality and on the Province's enforcement efforts.

Section 5 of the *Environmental Protection Act* allows the Lieutenant Governor in Council to establish an Environmental Co-ordinating Committee to be made up of the deputy ministers of such departments as he/she may determine and such other persons as he/she considers appropriate. Ideally, such a committee should, at the very least, include the deputy ministers responsible for environment, health, agriculture, fisheries and aquaculture and tourism.

Recommendation:

9.2 It is recommended that the Environmental Co-ordinating Committee be directed to:

- review, evaluate and make recommendations concerning the Province's statutes, regulations and procedures that relate to groundwater protection;
- review, evaluate and make recommendations regarding the Province's efforts to enforce the *Environmental Protection Act* and generally to protect the groundwater;
- make recommendations relating to the Province's groundwater research;
- review, evaluate and make recommendations concerning groundwater data collection and analysis;
- generally review and evaluate any policies, programs or projects of Government departments and agencies as they relate to groundwater quality and protection;
- update and revise the drinking water strategy to include protection of groundwater from nitrate contamination as such changes become necessary; and
- report annually, jointly with the Environmental Advisory Council, to the Premier and to the Legislative Assembly on groundwater quality and on the Province's enforcement efforts.

Commission on Nitrates in Groundwater
Terms of Reference (July 5, 2007)

Protecting our water resource is a societal priority. Few jurisdictions are as completely dependent on groundwater for their source of freshwater as Prince Edward Island. While farming, forestry, fishing, aquaculture and tourism are important contributors to the economic wealth of this province, they are all dependent upon access to a high quality source of water.

In recent years, human health concerns have arisen about the quality of our drinking water, the natural systems which provide that water, and the aquatic ecosystems that are reliant on that water. One key concern is the threat posed by nitrate contamination of our aquifers and watersheds. There has been a steady increase in nitrate concentrations in some Island streams over the last 20 to 30 years, and more recently, nitrate levels in private wells in some areas of the province have also increased.

Recent public consultations on PEI have concluded that action needs to be taken to address the issue. The commission will focus on recommending solutions.

Terms of Reference

- The Commission on Nitrates and Water Quality will develop a strategy to reduce nitrate concentrations in surface and groundwater.

- The commission will review and assess current research, associated recommendations, and available solutions when developing its strategy.

- The strategy will ensure that:

    i) nitrate contamination in Island surface and groundwater will be brought to acceptable levels as soon as possible;

    ii) residents will be able to rely on high quality natural drinking water; and

    iii) streams, rivers, ponds and estuaries will support a healthy variety of aquatic life.

- Members of the commission will be selected on the basis of personal experience and expertise, and be reflective of a broad cross section of society.

- The commission will be mindful that the solutions will involve Government, landowners, industry and the public working together, with a shared commitment to reducing nitrate contamination in our water.

- The strategy will be implemented through various regulatory instruments, economic policy and education will be a key component of the strategy. Depending on the policy instruments chosen, departments and agencies may work in co-operation, co-ordination and/or collaboration with the private sector in reducing nitrate contamination in water.

- The commission will invite written submissions and presentations on solutions to the problem of nitrate contamination.

- The commission will report to the Premier by June 2008, with the intention of having the report tabled in the Legislature.

Members of the Commission

Hon. J. Armand DesRoches (chair)

Mr. Stuart Affleck of Bedeque, retired potato producer

Chief Darlene Bernard of Lennox Island First Nation

Dr. John MacLeod, Ph.D., retired research scientist, Agriculture and Agri-Food Canada

Dr. Heather Morrison, D. Phil., M.D., Chief Health Officer

Secretariat

Christine MacKinnon, P.Eng.

Dr. Tony Sturz, LL.M., Ph.D.

Appendix 2

List of Submissions (Written)

James and Barbara Munves – Private individuals

N.A. Halliday – Private individual

Dallas Kelly – Private individual

Linda Collin – Private individual

Peter Graham – Private individual

Joe MacDonald – Private individual

Brenda Penak – Bedeque Bay Environment Management Association

Tom Albrecht – Private individual

John Jamieson – Enhanced Environmental Farm Plan

John Gallant – Private individual

Marion Copleston – Private individual

Lorretta Younker – Private individual

Kip Smith – Private individual

Jack Saunders – PEI Department of Communities, Cultural Affairs and Labour

Jana Cheverie and Tom Duffy – Ducks Unlimited Canada

Katherine Dewar – Private individual

Pat Murphy – Private individual

Dr. Andrew Trivett – Southeast Environment Association

Clifford Bernard – PEI Shellfish Association

Leaming Murphy – Private individual

Dr. Martine Savard – Geological Survey of Canada

Roger Henry – Organic Dairy Club

Eric Clements – Mill River Wildlife Association

Brian Douglas – PEI Department of Agriculture

Yves Leclerc, Stephen Moorehead and Gordon Campbell – McCain Foods Ltd.

Gerard Wood – PEI Soil and Crop Improvement Association

Ron Coles – Atlantec BioEnergy

Brandon MacPhail – Private individual

John Baptist D. Jatoe – Private individual

Dr. Daryl Guignon, Sara MacPhail, Angela Douglas – UPEI

Nancy Pierce, Accredited Golf Course Superintendent, The Links at Crowbush Cove

Dr. Irene Novaczek, Raymond Loo, Dr. Michael van den Heuvel, Rob Sharkie, Institute of Island Studies – UPEI

Kevin MacIsaac – PEI Potato Board

List of Presenters

Barry Thompson – PEI Department of Agriculture

Brian Douglas – PEI Department of Agriculture

Ron DeHaan – PEI Department of Agriculture

Tony Sturz – Executive Council Office

Jim Young – PEI Department of Environment, Energy and Forestry

Bruce Raymond – PEI Department of Environment, Energy and Forestry

Neil MacNair and Matt Smith – PEI Department of Fisheries and Aquaculture

Steve Howatt and Mark Douglas – Atlantic AgriTech Inc.

Minister George Webster – PEI Department of Environment, Energy and Forestry

Gary Schneider and Rob Sharkie – Environmental Coalition of PEI

Gerard Wood and John Jamieson – PEI Enhanced Environmental Farm Plan Program

Christine MacKinnon – Executive Council Office

John Colwill and Ian MacIsaac – PEI Federation of Agriculture

Morley Foy – PEI Department of Environment, Energy and Forestry

George Somers – PEI Department of Environment, Energy and Forestry

Mary Lynn McCourt – PEI Department Environment, Energy and Forestry

Clifford Bernard – PEI Shellfish Association

Jim Vaughan, Blaine MacPherson, Robert Coffin and Stephanie Veenhuis-MacNeill – Cavendish Farms

Fred Cheverie and Erica MacIsaac – Souris River Watershed Group

Shane Gabor, Tom Duffy and Jana Cheverie – Ducks Unlimited Canada

Yves Leclerc, Stephen Moorehead and Gordon Campbell – McCain Foods Ltd.

Gerard Wood, Myles Rose, Ivan Johnson and Tyler Wright – PEI Soil and Crop Improvement Association

Dr. Martine Savard – Geological Survey of Canada

Eric Clements – Mill River Wildlife Association

Dr. Larry Antosch – Environmental Policy, Ohio Farm Bureau Federation

David Clark – PEI Department of Environment, Energy and Forestry

Nitrates in Drinking Water Clinics (2007-2008) – Summary

Date	Clinic Location	Total Samples
November 17, 2007	Souris	208
November 24, 2007	Pooles Corner	372
December 8, 2007	New London	227
December 15, 2007	Elmsdale	211
January 12, 2008	Kinkora	417
January 19, 2008	Murray River	111
January 26, 2008	Fort Augustus	144
February 9, 2008	Covehead	251
February 16, 2008	Miscouche	206
February 23, 2008	Richmond	190
March 1, 2008	Hampshire	174

Preliminary Summary – All Clinics

2,511 Samples Total

12% $\leq$ 1 mg/L

45% 1 – 5 mg/L

26% 5 – 8 mg/L

11% 8 – 10 mg/L

6% $\geq$ 10 mg/L

* Maximum acceptable concentration: 10.0 mg/L
Sample test results of 8.0 mg/L or higher at clinics require a free laboratory re-sample test for confirmation.

References

News Releases:
Friday, July 20, 2007 Islanders Appointed to Commission on Nitrates in Groundwater
http://www.gov.pe.ca/news/getrelease.php3?number=5258

Resources:
2007 A Guide to Watershed Planning on Prince Edward Island, Watershed Management Section, PEI Department of Environment, Energy and Forestry.
http://www.gov.pe.ca/photos/original/eef_waterguide.pdf

2007 Consequences of climatic change on the contamination of drinking water by nitrates in Prince Edward Island; Geological Survey of Canada *http://adaptation.nrcan.gc.ca/projdb/pdf/109_e.pdf*

2007 Environmental Advisory Council of PEI *We are all downstream. We are all upstream. We are all part of the watershed.* A Report on the Public Consultations on Managing Land and Water on a Watershed Basis *http://www.gov.pe.ca/photos/original/watershedreport.pdf*

The Province of Prince Edward Island released its first State of the Environment report in June 2003. *http://www.gov.pe.ca/fae/state/index.php3?number=75067*

1999 MacDonald, R. E. (Chair) *Cultivating Island Solutions*. PEI Round Table on Resource Land Use and Stewardship. *http://www.gov.pe.ca/roundtable/index.php3?lang=E*

Advertisement to the general public on the work of the commission
http://www.gov.pe.ca/photos/original/reduce_nitrates.pdf

Medical Literature Cited:
Arbuckle, T.E., Sherman, G.J., Corey, P.N., Walters, D., Lo, B. 1988. Water nitrates and CNS birth defects: a population-based case-control study. *Archives of Environmental Health* 43:162–167.

Avery, A.A. 1999. Infantile methemoglobinemia: reexamining the role of drinking water nitrates. *Environmental Health Perspectives* 107:1–8.

Bloomfield, R.A., Welsch, C.W., Garner, G.B., Muhrer, M.E. 1961. Effect of dietary nitrate on thyroid function. *Science* 134:1690.

Bogovski, P., Bogovski, S. 1981. Animal species in which N-nitroso compounds induce cancer. *International Journal of Cancer* 27:471–474.

Brender, J., Olive, J., Felkner, M., Suarez, L., Hendricks, K., Marckwardt, W. 2004a. Intake of nitrates and nitrites and birth defects in offspring [Abstract]. *Epidemiology* 15:S184.

Brender, J.D., Olive, J.M., Felkner, M., Suarez, L., Marckwardt, W., Hendricks, K.A. 2004b. Dietary nitrites and nitrates, nitrosatable drugs, and neural tube defects. *Epidemiology* 15:330–336.

Cantor, K.P. 1997. Drinking water and cancer. *Cancer Causes Control* 8:292–308.

Carignan, R., Steedman, R.J. 2000. Impacts of major watershed perturbations on aquatic ecosystems. *Canadian Journal of Fisheries and Aquatic Science* 57:1-4.

Comly, H.H., 1987, Cyanosis in Infants Caused by Nitrates in Well Water, *Journal of the American Medical Association,* v. 257, p. 2788-2792.

Coss, A., Lynch, C., Cantor, K.P., Ward, M.H. 2004. Pancreatic cancer and drinking water and dietary sources of nitrate and nitrite. *American Journal Epidemiology* 159:693–701.

Croen, L.A., Todoroff, K., Shaw G.M. (2001) Maternal exposure to nitrate from drinking water and diet and risk for neural tube defects. *Journal of Epidemiology* Feb 15:153 (4):325-31.

DeRoos, A.J., Ward, M.H., Lynch, C.F., Cantor, K.P. 2003. Nitrate in public water systems and the risk of colon and rectum cancers. *Epidemiology* 14:640–649.

Dorsch, M.M., Scragg, R.K.R., McMichael, A.J., Baghurst, P.A., Dyer, K.F. 1984. Congenital malformations and maternal drinking water supply in rural South Australia: a case-control study. *American Journal of Epidemiology* 119:473–486.

Freedman, D.F., Cantor, K.P., Ward, M.H., Helzlsouer, K. 2000. Nitrates in drinking water and non-Hodgkin's lymphoma: a population-based case-control study of men in Minnesota. *Archives of Environmental Health* 55:326–329.

Greer, F.R., Shannon, M., the Committee on Nutrition, the Commission on Environmental Health. 2005. Infant methemoglobinemia: The role of dietary nitrate in food and water. *Pediatrics* 116:784-786.

Gulis, G., Czompolyova, M., Cerhan, J.R. 2002. An ecologic study of nitrate in municipal drinking water and cancer incidence in Trnava District, Slovakia. *Environmental Research* 88:182–187.

Gupta, S.K., Gupta, R.C., Gupta, A.B., Seth, A.K., Bassin, J.K., Gupta, A. 2000. Recurrent acute respiratory infections in areas with high nitrate concentrations in drinking water. *Environmental Health Perspectives* 108:363–366.

Haller, L., McCarthy, P., O'Brien, T., Riehle, J., Stuhldreher, T. Nitrate Pollution of Groundwater. *http://www.reopure.com/nitratinfo.html*

Health Canada, 2007. *Guidelines for Canadian Drinking Water Quality – Summary Table.* Prepared by the Federal-Provincial-Territorial Committee on Drinking Water of the Federal-Provincial-Territorial Committee on Health and the Environment *http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/sum_guide-res_recom/index_e.html March 2007*

Johnson, C.J., Bonrud, P.A., Dosch, T.L., Kilness, A.W., Senger, K.A., Busch, D.C., Meyer, M.R. 1987. Fatal Outcome of Methemoglobinemia in an Infant, *Journal of the American Medical Association,* v. 257, p. 2796-2797.

Knobeloch, L., Salna, B., Hogan, A., Postle, J., Anderson, H. 2000. Blue babies and nitrate-contaminated well water. *Environmental Health Perspectives* 108:675–678.

Kostraba, J.N., Gay, E.C., Rewers, M., Hamman, R.F. 1992. Nitrate levels in community drinking waters and risk of IDDM, an ecologic analysis. *Diabetes Care* 15:1505–1508.

Kross, B.C., Hallberg, G.R., Bruner, R., Cherryholmes, K., and Johnson, K.J., 1993, The Nitrate Contamination of Private Well Water in Iowa, *American Journal of Public Health,* v. 83, p. 270-272.

L'hirondel J, L'hirondel J-L. 2002. Nitrate and man: toxic, harmless, or beneficial? Wallingford, Oxfordshire, UK: CABI Publishing.

Longnecker, M.P., Daniels, J.L. 2001. Environmental contaminants as etiologic factors for diabetes. *Environmental Health Perspectives* 109:871–876.

Morales-Suarez-Varela M.M., Llopis-Gonzalez A., Tejerizo-Perez M.L. 1995. Impact of nitrates in drinking water on cancer mortality in Valencia, Spain. *European Journal Epidemiology* 11:15–21.

Mueller B.A., Newton K., Holly E.A., Preston-Martin S. 2001. Residential water source and the risk of childhood brain tumors. Environmental Health Perspectives 109:551–556.

Parslow, R.C., McKinney, P.A., Law, G.R., Staines, A., Williams, R., Bodansky, H.J. 1997. Incidence of childhood diabetes mellitus in Yorkshire, northern England, is associated with nitrate in drinking water: an ecologic analysis. *Diabetologia* 40:550–556.

Pomeranz, A., Korzets, Z., Vanunu, D., Krystal, H. 2000. Elevated salt and nitrate levels in drinking water cause an increase of blood pressure in schoolchildren. *Kidney Blood Pressure Research* 23:400–403.

Rail, C.D. 1989, *Groundwater Contamination: Sources, Control, and Preventive Measures,* Technomic, Lancaster, PA, p.139.

Schmitz, J.T. 1961. Methemoglobinemia – a cause of abortions? *Obstetrics and Gynecology* 17:413–414.

Shearer, L.A., Goldsmith, J.R., Young, C., Kearns, O.A., Tamplin, B.R.1972. Methemoglobin levels in infants in an area with high nitrate water supply. *American Journal Public Health* 62:1174–1180.

Shuval, H.I., Gruener, N. 1972. Epidemiological and toxicological aspects of nitrates and nitrites in the environment. *American Journal Public Health* 62:1045–1052.

Steindorf, K., Schlehofer, B., Becher, H., Hornig, G., Wahrendorf, J. 1994. Nitrate in drinking water. A case-control study on primary brain tumours with an embedded drinking water survey in Germany. *International Journal of Epidemiology* 23:451–457.

U.S. EPA. 1991. Integrated Risk Information System (IRIS): Nitrate (CASRN 14797-55-8). Washington, DC:U.S. Environmental Protection Agency. Available: *http://www.epa.gov/iris/subst/0076.htm* [accessed 31 May 2005].

van Loon, A.J., Botterweck, A.A., Goldbohm, R.A., Brants, H.A., van Klaveren, J.D., van den Brandt, P.A. 1998. Intake of nitrate and nitrite and the risk of gastric cancer: a prospective cohort study. *British Journal Cancer* 78:129–135.

van Maanen, J.M., Pachen, D.M., Dallinga, J.W., Kleinjans, J.C. 1998. Formation of nitrosamines during consumption of nitrate and amine-rich foods, and the influence of mouthwashes. *Cancer Detection and Prevention* 22:204–212.

van Maanen, J.M., van Dijk, A., Mulder, K., de Baets, M.H., Menheere, P.C., van der Heide, D., et al. 1994. Consumption of drinking water with high nitrate levels causes hypertrophy of the thyroid. *Toxicology Letters* 72:365–374.

van Maanen, J.M.S., Albering, H.J., de Kok, T.M.C.M., van Breda, S.G.J., Curfs, D.M.J., Vermeer, I.T.M., et al. 2000. Does the risk of childhood diabetes mellitus require revision of the guideline values for nitrate in drinking water? *Environmental Health Perspectives* 108:457–461.

van Grinsven, H.J.M., Ward, M.H., Benjamin, N., de Kok, T.M. 2006. Does the evidence about health risks associated with nitrate ingestion warrant an increase of the nitrate standard for drinking water? *Environmental Health: A Global Access Science Source*, 5:26 http

Ward, M.H., Mark, S.D., Cantor, K.P., Weisenburger, D.D., Correa-Villaseñor, A., Zahm SH. 1996. Drinking water nitrate and the risk of non-Hodgkin's lymphoma. *Epidemiology* Sept: 7 (5):465-71.

Ward, M.H., Cantor, K.P., Cerhan, J., Lynch, C.F., Hartge, P. 2004. Drinking water nitrate and cancer: results from recent studies in the Midwestern United States [Abstract]. *Epidemiology* 15:S214.

Ward, M.H., Cantor, K.P., Riley, D., Merkle, S., Lynch, C.F. 2003. Nitrate in public water supplies and risk of bladder cancer. *Epidemiology* 14:183–190.

Ward, M.W., deKok, T.M, Levallois, P., Brender, J., Gulis, G., Nolan, B.T.,Van Derslice, J. 2005. Workgroup Report: Drinking-Water Nitrate and Health – Recent Findings and Research Needs. *Environmental Health Perspectives* 113:1607-1614.

Weyer, P.J., Cerhan, J.R., Kross, B.C., Hallberg, G.R., Kantamneni, J., Breuer, G., et al. 2001. Municipal drinking water nitrate level and cancer risk in older women: the Iowa Women's Health Study. *Epidemiology* 12:327–338.

WHO. 2007. *Nitrate and nitrite in drinking-water*: *Background document for development* of *Guidelines for Drinking-water Quality* WHO/SDE/WSH/07.01/16
http://www.who.int/water_sanitation_health/dwq/chemicals/ nitratenitrite2ndadd.pdf

Environmental Literature Cited:

Burkart, M. R. and D. E. James. 1999. Agricultural – Nitrogen contributions to hypoxia in the Gulf of Mexico. *Journal of Environmental Quality* 28: 850-859.

Buttle, J.M., Metcalfe, R.A. 2000. Boreal forest disturbance and streamflow response: north-eastern Ontario. *Canadian Journal of Fisheries and Aquatic Sciences* 57 (Suppl. 2): 5-18.

Camargo, J.A., Alonso, A., Annabella Salamanca, A. 2005. Nitrate toxicity to aquatic animals: a review with new data for freshwater invertebrates *Chemosphere* 58: 1255-1267.

Carpenter, S., N. Caraco, D. Correll, R. Howarth, A. Sharpley and V. Smith. 1998. Nonpoint pollution of surface waters with phosphorus and nitrogen. *Issues in Ecology* Ecological Society of America. *http://esa.sdsc.edu/.*

Carignan, R., D'Arcy, P., Lamontagne, S. 2000. Comparative impacts of fire and forest harvesting on water quality in Boreal Shield lakes. *Canadian Journal of Fisheries and Aquatic Sciences* 57 (Suppl. 2): 105-117.

Casey, R.E., Klaine, S.J. 2001. Nutrient attenuation by riparian wetland during natural and artificial runoff events. *Journal of Environmental Quality* 30: 1720-1731.

DEFRA *Nitrates – reducing water pollution from agriculture*
http://www.defra.gov.uk/Environment/water/quality/ nitrate/ default.htm

De Jong, R.,Yang, J.Y., Drury, C.F., Huffman, E., Kirkwood, V., Yang, X.M. 2005. Nitrogen. Pages 124 – 130 in Lefebvre, A., W. Eilers, and B. Chunn (eds.). 2005*. Environmental Sustainability of Canadian Agriculture: Agri-Environmental Indicator Report* Series - Report #2. Agriculture and Agri-Food Canada, Ottawa, Ontario.

de Villiers, M. 2003. *Water, The Fate of Our Most Precious Resource* McClelland and Stewart Ltd.: Toronto.

EC 2002. The Implementation of Council Directive 91/676/EEC concerning the Protection of Waters against Pollution caused by Nitrates from Agricultural Sources Report COM(2002)407
http://ec.europa.eu/environment/water/water-nitrates/report.html

Gabor, T.S., North, A.K., Ross, L.C.M., Murkin, H.R., Anderson, J.S., Raven M. 2004. Natural Values: The Importance of Wetlands and Upland Conservation Management Practice in Watershed Management. February. Ducks Unlimited Canada.

Health Canada 1987 Nitrate/Nitrite *http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/nitrate_nitrite/index_e.html#Guideline*

Health Canada. 2008. Canadian Water Quality Guidelines. *http://www.ec.gc.ca/ceqg-rcqe/English/ceqg/water/default.cfm*

Hornbeck, J.W., Kochenderfer, J.N. 2000. Linkages between forests and streams: A perspective in time. In: *Riparian Management in forests of the continental eastern United States*, E.S. Verry, J.W. Hornbeck and C.A. Dolloff (eds). Lewis Publishers, Bocca Raton, Florida. pp 89-98.

Justice D.R. O'Connor (2002) – *Part Two: Report of the Walkerton Inquiry. A Strategy for Safe Drinking Water*. Chapter 4.4.3. pg. 123. Ontario Ministry of the Attorney General: Queen's Printer for Ontario. *https://ozone.scholarsportal.info/bitstream/1873/7856/1/10300881.pdf*

Lamontagne, S., Carignan,R., D'Arcy, P., Prairie, Y.T., Pare, D. 2000. Element export in runoff from eastern Canadian Boreal Shield drainage basins following forest harvesting and wildfires. *Canadian Journal of Fisheries and Aquatic Sciences* 57 (Suppl. 2):118-128.

Lowrance, R., Leonard, R., Sheridan, J. 1985. Managing riparian ecosystems to control non-point pollution. *Journal of Soil and Water Conservation* 40:1, 87-91.

Paradis, D. Ballard, J.-M., Lefebvre. 2007. Watershed-scale numerical modelling of nitrate transport using spatially averaged N inputs pp. 52-65, in Savard, M., Somers, G. (eds.) 2007. *Consequences of climatic changes on contamination of drinking water by nitrate on Prince Edward Island*. Natural Resources Canada – Geological Survey of Canada. Climate Change Action Fund: Impacts and Adaptations Contribution Agreement A881/A843.

Peterjohn, W.T., Correll, D. L. 1984. Nutrient dynamics in an agricultural watershed: observations on the role of a riparian forest. *Ecology* 65:5. pp. 1466-1475.

Savard, M., Somers, G. (eds.) 2007a. *Consequences of climatic changes on contamination of drinking water by nitrate on Prince Edward Island*. Natural Resources Canada – Geological Survey of Canada. Climate Change Action Fund: Impacts and Adaptations Contribution Agreement A881/A843.

Savard, M., Somers, G. 2007b. Mass balance calculations to estimate Nitrate proportions from various sources in the agricultural Wilmot Watershed of Prince Edward Island. In Proc. from the 60th Canadian Geotechnical Conference and the 8th Joint CGS/IAH-CNC Groundwater Conference, October 21 to 24, 2007, Ottawa, Canada, p. 212 to 218.

Savard, M., Somers, G. 2007c. Potential impacts of adaptation of some agricultural practices on nitrate losses to groundwater April 2007. Report submitted to the Commission on Nitrate Contamination of Groundwater.

US Environmental Protection Agency (EPA). 1997. *http://www.epa.gov/OWOW/NPS/facts*

White, J.S., Bayley, S.E. 2001. Nutrient retention in northern prairie marsh (Frank Lake, Alberta) receiving municipal and agro-industrial wastewater. *Water, Air, and Soil Pollution.* 126:63-81.

Vigneault, H., Paradis, D. Ballard, J.-M., Lefebrve, R. 2007. Numerical modelling of the evolution of groundwater nitrate concentrations under various Climate Change scenarios and agricultural practices for Prince Edward Island. pp. 93-109, in Savard, M., Somers, G. (eds.) 2007. *Consequences of climatic changes on contamination of drinking water by nitrate on Prince Edward Island*. Natural Resources Canada – Geological Survey of Canada. Climate Change Action Fund: Impacts and Adaptations Contribution Agreement A881/A843.

Legislation cited

Agricultural Crop Rotation Act R.S.P.E.I. Chapter A-8.01 [pro. Apr.6 /02]

Agricultural Crop Rotation Act R.S.P.E.I. Chapter A-8.01 Regulations

Environmental Protection Act R.S.P.E.I. 1988 Chapter E-9

Lands Protection Act R.S.P.E.I. Chapter N-2

Lands Protection Act R.S.P.E.I. Chapter L-5 Exemption Regulations

Natural Areas Protection Act R.S.P.E.I. Chapter L-5

Glossary

Anencephaly – a lethal birth defect characterized by the absence of all or part of the skull and scalp and malformation of the brain.

Anoxic events (anoxia) – occur in water when oxygen is depleted.

Cation exchange capacity – is the capacity of a soil for ion exchange of positively charged ions between the soil and the soil solution. (A positively charged ion, which has fewer electrons than protons, is known as a cation.) Cation exchange capacity is used as a measure of fertility, nutrient retention capacity, and the capacity to protect groundwater from cation contamination.

Evapotranspiration – loss of water from the soil both by evaporation and by transpiration from the plants growing in the soil.

Eutrophication – the result of excessive nutrients in a lake or other body of water, usually caused by runoff of nutrients (animal waste, fertilizers, sewage) from the land, which causes a dense growth of plant life; the decomposition of the plants depletes the supply of oxygen, leading to the death of animal life.

Denitrification – biochemical conversion of nitrates and nitrites in the soil dissolved in water to gaseous nitrogen.

DNA – the molecules inside cells that carry genetic information and pass it from one generation to the next.

Genotoxicity (genotoxic effects) – describes a poisonous substance which harms an organism by damaging its DNA.

Groundwater – is any water that flows or fills the porous spaces in soil, sediment and rocks beneath the Earth's surface. Groundwater originates from rain, snow melt and ice. It is the source of water for aquifers, springs and wells.

Leaching – involves removal of soluble material from a substance, such as soil or rock, through the percolating action of water

Methemoglobinemia (blue-baby syndrome or MetHb) – is a blood disorder which greatly decreases the blood's ability to carry oxygen. The blood's haemoglobin is converted to methemoglobin which does not carry oxygen. It is frequently associated with high concentrations of nitrate in drinking water supplies. It primarily affects infants less than six months of age.

Nitrate – has the chemical formula NO_{3-}. Nitrate represents the most oxidized chemical form of nitrogen found in natural systems. Nitrate is a negatively charged ion (anion) and so must be paired with a positively charged ion (cation) as in the salts potassium nitrate (KNO_3), or sodium nitrate ($NaNO_3$). Nitrate is one of the most water soluble anions known. The dictionary defines nitrate (noun) as a radical or ion with the chemical formula NO_{3-} or a compound containing the nitrate ion as in salts or nitric acid (HNO_3). Nitrate is also defined as a fertilizer consisting of sodium nitrate or potassium nitrate.

Nitrate Levels – can be expressed as either NO_3 (nitrate) or NO_3-N (nitrate-nitrogen). Nitrate levels above 45 mg/L NO_3 or 10 mg/L NO_3-N may cause significant health problems in humans. 1 mg nitrate-nitrogen/L = 4.43 mg nitrate/L, and one mg nitrite-nitrogen/L = 3.29 mg nitrite/L.

Nitrification – is the biological oxidation of ammonia with oxygen into nitrite followed by the oxidation of these nitrites into nitrates. Nitrification is an important step in the nitrogen cycle in soil.

Non-Hodgkin Lymphoma (NHL) – any of a large group of cancers of the immune system localized in the lymphatic system. NHLs can occur at any age and are often marked by enlarged lymph nodes, fever and weight loss. Most people don't notice the workings of their lymphatic systems; in fact, the only time you may be aware of your lymphatic system is when the lymph nodes (which are sometimes referred to as glands) swell up. Non-Hodgkin's lymphoma is a disease in which cancer cells form in a person's lymphatic system and start to grow uncontrollably. There are many different types of NHL, which can be divided into aggressive (fast-growing) and indolent (slow-growing) types and can be classified as either B-cell or T-cell NHL. B-cell NHLs include Burkitt lymphoma, diffuse large B-cell lymphoma, follicular lymphoma, immunoblastic large cell lymphoma, precursor B-lymphoblastic lymphoma, and mantle cell lymphoma. T-cell NHLs include mycosis fungoides, anaplastic large cell lymphoma and precursor T-lymphoblastic lymphoma.

Precautionary principle or "precautionary approach" – is a way of dealing with uncertainty in the face of risks to health or the environment. In general, it involves acting in such a way as to avoid serious or irreversible potential harm, in the face of a lack of scientific certainty as to the likelihood, magnitude or cause of that harm.

Riparian zone – is the area of land adjacent to a body of water (such as a river, stream, estuary, lake or pond) that influences or is influenced by that body of water.

Surface water – is any water collecting on the ground or in a stream, river, lake, sea or ocean.

Watershed or "water parting" – is a region divided by a ridge of high land dividing two areas that are drained by different river systems.

Wetlands – are generally defined as areas flooded or saturated by surface or groundwater for a period of time sufficient to support vegetation that is typically adapted for life in saturated soil. Wetlands include bogs, marshes, shallows, muskegs, wet meadows, estuaries and riparian zones.

Printed by the Document Publishing Centre
Design: Strategic Marketing and Graphic Design
2008

08PO35-20581