Final Report

Adaptation of Water Resource Infrastructure - related Institutions to Climate Change in Eastern Ontario

A Community University Research Alliance Project
(1999-2003)

between

Université d'Ottawa · University of Ottawa

and the

Federation of Canadian Municipalities
Eastern Ontario Water Resources Committee
St. Lawrence River Institute of Environmental Sciences

by

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M. Robin reviewed all the natural sciences sections i.e. sections 3 to 6 inclusive as well as the Executive Summary and the Recommendations. P. Crabbé is mainly responsible for the remaining sections including the Executive Summary and the Recommendations.

Section 1 of this report is methodological and may be skipped by the hurried reader. Section 2 may be skipped by those who are conversant with the region and the Ontario municipal world. Finally, most of section 8 may be skipped by those thoroughly familiar with municipal public finances, except sectionS 8.5 to 8.7.

Comments are welcome and should be sent to: crabbe@ottawa.ca

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University of Ottawa
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Institutional Adaptation of Water-Related Infrastructures to Climate Change in Eastern Ontario

> "The concept of policy networks (…) is based on the observation that policymaking tends to be fragmented into specific *issue areas*, and that most issues are dealt with by a few actors within small groups of participants from governmental and nongovernmental agencies (…). It describes the close and consensual nature of policymaking and the often blurred relationship 'between the governors and the governed' (…) through channels that are often informal and, almost always, extra-constitutional." (T. O'Riordan *et al*., 1998)
>
> "…risk perceived is risk acted upon." (J.Adams, 1995)

EXECUTIVE SUMMARY

This study deals with adaptation to climate change of water-related infrastructures in the Eastern Ontario region (Province of Ontario, Canada). The study has several unique features. First, it is **interdisciplinary** in that it involves hydro-geologists, environmental engineers, ecologists, eco-toxicologists, geographers, public health professionals, economists, political scientists and lawyers. Second it has **partners from the community**, which are assisting in steering the study. These include the Federation of Canadian Municipalities (FCM), the St. Lawrence River Institute of Environmental Science (SLRIES), and the Eastern Ontario Water Resources Committee (EOWRC). As representatives of these organizations on the Management Committee of the study wear different hats, representation was actually extended to the United-Counties of Prescott and Russell (P & R) and of Stormont, Dundas and Glengarry (S, D & G), which together offer administrative coverage of Eastern Ontario at the municipal level, and to one local Conservation Authority (a watershed agency). Third, it is focused on **institutional barriers and bridges** to local adaptation affecting **small rural municipalities and Conservation Authorities** (CA), and proposes elements of a **community-based adaptation strategy related to water infrastructures**. Water-related infrastructures are broadly defined in this study to include not only engineering structures, but also watersheds and pertinent human and social resources such as health, climate- and water-related expertise and institutions. This study is developed from the reports and discussion from the community-based Eastern Ontario Water Resources Management Study (EOWRMS, 2001), from climate change projections for the Great-Lakes Basin over the current century identified in publications from the last ten years, as well as from original physical climate scenarios based on weather events experienced in Eastern Ontario.

In general, future climate projections point to a continued increase in average temperature (more in the winter than in the summer, especially for night-time minimum temperatures), which will

decrease river water levels, lead to earlier peak flows, and result in longer and more intense heat waves. They indicate a shift to the winter in the distribution of precipitations, while the latter's average level over a year will not significantly change; this shift will result in more frequent and intense summer droughts, and more frequent and intense precipitation winter events in the form of rain rather than snow.

For the study area, anticipated climate change may result in longer growing seasons and a climate shifting progressively, but not necessarily smoothly, to one more similar to that found in northern Virginia.

This study constructed seven **analogue physical climate scenarios**, which combine normal and unusual, but not extreme, ranges of temperature and precipitation, historically experienced in Eastern Ontario. The latter were not intended to cover events with small probability of occurrence; rather, they were intended to represent likely scenarios of climatic conditions, based on record.

Groundwater is of utmost importance to the study region, as it provides over 60 % of its drinking water. An innovative Geographical Information System (GIS) - based hydro-geological model, to be transferred to the community, was therefore constructed to calculate monthly groundwater budget for the CURA climate-change scenarios, using hydro - geological information from the EOWRMS. The results indicate that, on a yearly basis, groundwater resources were not very sensitive to the climate change scenarios. Even with a succession of unusually dry years the groundwater systems get recharged during the snow - melt and rainy seasons (in fact, flooding is more the issue during these seasons). On a monthly basis, the picture is very different. The GIS analysis showed that **some areas are particularly and consistently vulnerable to droughts during the dry summer months**, even during "wet" years, while other regions are vulnerable only during dry years (see maps in section 4.1 of the report). These regions typically correspond to regional aquifer recharge areas (the western and central portions of the study area). Similarly, aquifer vulnerability to contamination was highly seasonal and localized. Aquifer recharge areas were particularly vulnerable during wet periods following dry periods, such as the fall. This suggests that aquifer contamination issues can be mitigated with proper waste management practices, and, in particular, by the proper timing of land application of animal waste. This situation is exacerbated in areas where the surface (unconfined) aquifer is the main source of water. Such areas exist particularly in the extensive esker complex in the central and western portion of the study area (these deposits consist of long winding gravel deposits above or under ground). Groundwater supply issues, being seasonal and local, can also be mitigated with proper management and, in particular, with the monitoring and metering of Permits - to - Take - Water holders. An additional measure to be contemplated could be artificial recharge of the groundwater system in supply - vulnerable areas.

Reduced flow for tributaries of the St. Lawrence and Ottawa Rivers may exacerbate current **water quality** problems in a predominantly agricultural region, especially in the Raisin and the South Nation watersheds. Currently, the state of these watersheds is perceived as good by municipal and CAs' staff. However, the quality, but not the quantity, of both surface water and groundwater, especially as related to organic waste, is definitely one of the CA staff's major concerns. Staff also cites the lack of pertinent data as another concern. A recent study has found

that groundwater tested positive for bacteria in many areas, with counts amplified in areas with intensive agriculture and in areas with dug wells. In any climate scenario, regular testing of water quality should be a priority. In general, nitrate was not found in levels exceeding the guideline, although some wells that were dug, shallow and located in intensive agricultural areas, had high levels of nitrate. The South Nation is one of the most eutrophic rivers in Ontario, containing a large amount of nitrates and methyl mercury. An optimization non-point pollution model applied to the South Nation indicates that Best Management Practices, alone or in combination, are unable to improve water quality to the level of national guidelines without reducing the level of agricultural activities. Though climate change may be beneficial for agriculture in the region, it will require rural municipalities, within their area of jurisdiction, to become more involved with the diffuse polluting impacts of changing agricultural activity through, for example, reductions in nutrient loading (e.g. with the suggested phosphorus credit system), development of vegetated riparian zones, and wetland protection and creation. Also increased corn production (e.g. for subsidized ethanol production in the context of climate change mitigation), would definitely further contribute to the deterioration of water quality in the South-Nation watershed. Apparently, an ethanol-processing plant has been promised to the Cornwall area by the new Ontario Government.

Since extreme events – especially large and more frequent precipitation events – are concomitant with climate change, **water and wastewater treatment plants sizes** may have to be adapted to cope with a larger amount of water and larger and longer peak periods, including peaks for water demand during drought periods. Currently only one mechanized wastewater plant and three lagoon plants are at capacity in the region. To address this capacity concern, various measures may be considered including reduced rainwater infiltration into sewers (frequent in the region) and separation of combined sewers (not common in the region). Upstream basin system equalization for mechanized plants may be considered in order to reduce effluent quality deterioration due to storm events. Management of plant turbidity fluctuations (frequently reported in the region and reported as hard to manage), expected to be more frequent, and distribution systems pressure management to decrease system losses (estimated large in the Long Sault/Morrisburg area) are required. With lower water levels, lower water intakes may be needed; odor and taste problems resulting mainly from lagoon systems may be more frequent and require treatment dependent on water properties. Pertinent data are insufficient, inconsistently recorded and not readily available, preventing the identification of treatment efficiency parameters' sensitivity to weather data. Nevertheless, municipal and CAs staff perceive water quality from treatment plants to be excellent and suggest the data available for this assessment is adequate.

The specific regional **health impacts** of climate change include: heat strokes due to thermal stress; cardio - respiratory ailments due to air quality (particularly smog) worsened by temperature; increase in allergic activity and severity (both outdoor and indoor); risks from unsanitary conditions in case of drought, spread of infectious diseases (West Nile virus), as well as water and food-borne diseases; injuries and, possibly, depression due to some extreme weather events (storm, flood). Warm wet conditions are worst for insect proliferation. Flooded lands used for intensive agriculture have the capacity to contaminate water systems (wells, etc.) with pathogens and chemical toxins (pesticides) due to increased and intense run-off. Floods are able to release stored toxic chemicals from dump-sites, disable sewerage systems, and flood

waters often contain drowned farm animals; so the water is dangerously polluted and requires rigorous treatment before it is fit to drink. Pathogens, such as *E. coli* entering the water supply, can result in serious illness and/or death. The situation in Walkerton, Ontario and the *E. coli* contaminated water was initiated by excessive rain coupled with contaminated run-off from agricultural lands entering the community well.

The counties of Russell and Glengarry should be considered early targeted areas for preventative intervention for environmental health, because of their relatively large proportion of more vulnerable populations, such as small children (Russell) and the elderly (Glengarry). Children are particularly at risk for toxins and pathogens found in water, diets and living environments. The elderly frequently suffer from weakened cardio-respiratory conditions. The elderly are also considered a vulnerable population due to complications, which may be exacerbated by direct and indirect effects of a changing environment. It has been observed that, during and immediately after extreme events, doctors' visits and hospitalization rates increase. The adaptability of the health system should be increased under anticipated climate change to be able to handle an increased number of emergencies and to identify symptoms of, often, locally-foreign disease outbreaks. Cases treated at hospitals are generally one of the following ailments: trauma, gastroenteritis and food poisoning, hypothermia, fatigue, as well as excessive use of alcohol and drugs. The Eastern Ontario Health Unit (EOHU) should conduct epidemiological surveillance and monitoring related to climate change. It has the opportunity to educate through its website on factors associated with climate change health within its Community Health program, with, for example, information on outdoor activity, water use, and agricultural practices. EOHU participates in mandated municipal emergency plans. It can engage health professionals immediately, as their number and the number of medical facilities (including institutions for the elderly or persons with disabilities, and community support organizations) in the region is relatively small. The EOHU can contribute to building up social resilience, such as building the capacity of a community to handle the unexpected, as the latter offers the best social protection even without climate change. EOHU should exploit its awareness that human health is connected with individual behavior, with the overall social context, and economic conditions. The difficulty lies in understanding that behavioral change is always costly, unless the individual perceives that climate change and health information has value. Human health remains the best communication channel between the individual and the environment. EOHU should become the leader in a comprehensive climate risk management plan at the regional level.

Both municipalities and CAs are convinced that climate change is a reality; that it will have significant local impacts, and that local government has significant responsibilities in managing watersheds. However, neither believes that climate change significantly affects their constituents' ability to make a living, and neither authority has taken steps to include climate change in its decision-making criteria. Moreover, municipalities perceive that technological fixes can undo these climate impacts while CAs tend to assign some importance to research on climate change impacts on their watershed.

Climate Change will impact **municipal finances** both on the revenue and the expenditure sides. On the revenue side, as land use or agricultural crops may have to be modified (e.g. more corn, more soybeans, less hay as currently experienced in Northern Virginia), property taxes will be affected either positively or negatively according to the revenue stream generated by the new

land use; user fees could increase considerably if water consumption were charged at its incremental cost (full-cost pricing). Debt dependence may increase if the municipal tax base and/or transfers are not increased. Development charges may also increase if full cost pricing is implemented. Public private partnerships and developer financing should also increase for capital projects due to the new defined 'character' of municipalities as 'business'. If climate change mitigation is being implemented by both provincial and federal governments, provincial and federal transfers to municipalities will increase too. On the expenditure side, environmental services, both capital and operating expenditures can be expected to increase considerably due to required investment in new or replacement of built water-related infrastructure in some municipalities. Environmental services also include water supply, waste water treatment, garbage collection and recycling, storm water system etc. Well water protection expenditures may have to increase as well. Climate change will also affect the transportation expenditures as infrastructures may be affected. Extreme events will also increase the expenditure on protection services and insurance. Ontario municipalities have gone through major changes in recent years. Large scale service realignment has increased the financial burden of the municipalities many folds. Senior governments have long maintained that municipal restructuring or "realignment" (MMAH 1999) programs save money for cash-strapped municipalities. In addition to this, a variety of financial options could be very helpful in redistributing municipal financial priorities: options that could redirect short-term versus long-term funds and spawn partnerships; grants that can impact municipal funding sources and program decisions remain unknown to some municipal administrations. Climate change adaptation should not be seen simply as a new financial burden; rather it should provide another argument for easing municipalities' access to long term financing.

External barriers to local institutional adaptation to climate change are the results of a variety of factors: from municipalities' constitutional status, finances, short-term mandate of their elected representatives, legacy problems, and lack of climate change information pertinent to infrastructure (particularly, in this study's context, to water-related infrastructure). Despite their perception to the contrary, municipal responsibilities for water resources management are limited to "collecting information, interpreting (provincial) policy, delivering (provincial) policy programs and responding to emergencies" (Ontario Low Water Response Plan, 2001). **Internal barriers** pertain to management culture by crisis, conflicts about priorities, and among levels of local government. They also result from the absence of lifecycle planning for manufactured infrastructure, inadequate management of water resources within the area of municipal competence, and insufficient by-law enforcement. Municipalities lack databases about regional built infrastructures and suffer from insufficient expertise at all levels, both of which increase their dependency on outside consultants. Municipalities often mistrust the information they obtain about climate change.

Bridges overcoming external barriers pertain to citizens' participation in municipal decision-making, adequate climate change information and adequate municipal mandate. Municipal constituents perceive themselves more and more as stakeholders not only in matters pertaining to the public municipal domain but also in traditionally private matters concerning local land use. They need credible climate change information targeted at the local level, which would be perceived as valuable by its potential users; the benefit of planned adaptation needs to be identified. University researchers, who are underutilized by local governments, could be of

assistance in building this bridge particularly through collaboration with local newspapers that seem to be a significant source of local information. The increased constitutional mandate recognized by the Supreme Court, and federal interventions in infrastructure financing offer new opportunities to municipalities in taking adaptation initiatives. The new Ontario Municipal Act, and other needed revisions to provincial legislation pertinent to municipalities advocated by professional organizations, are potential bridges to adaptation as well. These revisions are especially important since municipalities tend to rely on the Province more than on the Federal Government for pertinent information. In order to fund new water infrastructure, municipalities need to be able to expand their tax base, use innovative institutional forms such as corporations, and new forms of borrowing rather than the current "pay as you go" method, which is more appropriate for maintenance and replacement projects than for new ones. **Bridges overcoming internal barriers** are administrative (e.g. acquisition of Permits - to - Take - Water), informational (e.g. use of GIS), managerial (e.g. emergency preparedness), planning (e.g. risk management), liability (e.g. due diligence in infrastructure design), closer relationship with the Medical Officer of Health, communication of valuable information to citizens, citizens' participation, and, generally, appropriate combination of climate policy instruments.

CAs, being composed of representatives from each municipality located in a particular watershed, are ideal institutions to handle, through an ecosystem approach, water quantity and quality problems at the watershed level. To make sure that stakeholders' interests are represented, some CAs created stakeholders' committees, which, in practice, work very cooperatively. CAs are also vehicles for intergovernmental cooperation and provincial water policy; for example, the Ontario Ministry of the Environment has entered into partnership agreements with CAs concerning drinking water quality monitoring for groundwater. **CAs are ideal instruments for climate change education and adaptation** because of their greater emphasis on the ecosystem approach, their greater reliance on local knowledge, and their perceived ability to influence scientific research. However, the Ontario Municipal Restructuring Program granted municipalities responsibility for water-related built infrastructures. Municipal Councils are often assisted by committees composed of volunteer professionals with expertise on specific municipal problems. These venues are ideal to educate committee members about local climate change impacts and to explore local adaptation to climate change.

The EOWRMS report indicated that much of the **water and wastewater built infrastructure** in the region requires upgrading and is in need of capacity increase to face demographic pressures especially in the North-West part of the region. Therefore, it is essential that climate change be taken into consideration in the renewal and expansion of these infrastructures, including the reduction (up to 15 %) of water losses in the distribution system (especially significant in the Long Sault/Morrisburg area). The need for infrastructure expansion can be significantly dampened (up to 40 %) by, and the needed expansion funded through volumetric (or full-cost) demand management. The latter is composed of a fixed charge corresponding to the incremental cost of linking a house or business to the distribution system and a variable charge, which should be increasing with water consumption. Water consuming efficient devices, such as low-flow home devices, may reduce water demand as well (up to an additional 10 %). Wastewater recycling is another conservation measure for agricultural land and golf courses. Permits - to - Take Water, new applicants as well as nearly expired ones, require especial attention and should be considered revenue generating, since they are granted for large volumes of water, and may

benefit from a precautionary approach seemingly adopted by some tribunals in Ontario. In time of water scarcity, water rationing measures imposed or advocated by the municipality or CAs may be required and have been used in the area. Major water users, such as golf courses, may benefit from some voluntary water conservation certification programs.

Small Eastern Ontario rural municipalities and, to some extent, CAs need to progressively develop a **strategy for adaptation** of water-related infrastructures to climate change. This strategy should be integrated with both their planning and operations. It should be elaborated, preferably, at the regional/watershed level and in collaboration with the Federation of Canadian Municipalities (FCM), the Association of Municipalities of Ontario, and other professional organizations. Planned adaptation is likely to be less expensive than reactive adaptation to climate events, such as the 1998 ice storm, the 2001 and 2002 droughts, and possibly the Walkerton crisis, which are expected to become more frequent and more intense in the future. Planned adaptation may not be independent of mitigation measures, which will soon be required from municipalities by the Federal Government. These measures are likely to affect energy efficiency (buildings) and solid waste management (methane emissions). FCM offers voluntary programs, which allow municipalities to become aware of and to reduce their Greenhouse Gas emissions. To be able to develop an adaptation strategy, municipalities and CAs should ensure that they have access to credible climate change expertise that universities and higher level of government can provide them with. Their senior staff should conduct, on the basis of this expertise, in collaboration with NGOs, the insurance industry and the public, an environmental and financial vulnerability assessment of their water-related infrastructure; it should identify vulnerability alleviation measures and business opportunities if any as well. It should send practical messages to each professional group (councillors, treasurers, engineers, planners, etc.). GIS are likely to be indispensable tools for this vulnerability identification and alleviation exercise. Municipalities and CAs should benchmark themselves against best practices, and create verification mechanisms, whereby adaptation progress can be assessed and cost-saving adaptation measures, promptly implemented. Because insurance companies have incurred huge losses from weather-related events in the last decade, it may be extremely difficult for municipalities to become insured commercially against climate-related risks, other than residual risks (which, being surprise events, should be covered by federal or provincial disaster funds in any case). Direct access to reciprocal insurance (e.g. OMEX) related to climate events across the country, and emergency lines of credit may be substitutes to private sector insurance. The municipal insurance portfolio composition should be left to municipalities to decide on the basis of the opportunity cost of funds. Co-operation between the insurance industry and municipalities is needed to assess risk-reducing adaptive measures taken by municipalities. A socio-economic climate change scenario analysis is also needed to assess the potential burden of financial risk to municipalities.

RECOMMENDATIONS

Recognizing that climate change is an additional stress on Eastern Ontario water-related infrastructures, on top of the increase in the number of households, agri-business, industrial and recreational changes, and existing pollution loadings, we offer the following recommendations to complement the Eastern Ontario Water Resources Management Study (EOWRMS) recommendations:

To Municipal Council

1. Embrace **climate change adaptation** as a **new municipal concern** and seek cost-saving opportunities by **acting early** upon it.
2. Continue to **support the activities of the Eastern Ontario Water Resources Committee (EOWRC)** on water-related infrastructures as it is the best venue for regional cooperation.
3. Ensure that the municipality has **access to sufficient available expertise** to deal with all aspects of climate change relevant to its community.
4. Continue to undertake, possibly within the municipality's official plan, a thorough **vulnerability assessment** of the municipality's current and probable financial and environmental risk exposures to climate change.

   This requires each municipality to:

   a. Identify on a map the areas of the municipality, which are the most sensitive to climate change, for example, to drought (**Hazard mapping**);

   b. Continue to use a **Geographic Information System** (GIS), which is an indispensable tool to do the mapping of water and water-related infrastructures and to their management, starting with EOWRC recommendation 34;

   c. Continue to extend EOWRMS to climate change, as done in this study, and implement EOWRC recommendation 2, 16, 18 and 26, in particular,

      i. Identify areas where there is a need for location specific groundwater and surface water quality/quantity protection resulting from historical or current land-use;

      ii. Identify agricultural land in proximity to sensitive areas;

      iii. Assess risks of aquifer and well contamination.

5. Examine thoroughly in collaboration with NGOs and the public, possibly within the municipality's official plan, the **opportunities** which climate change may present for new

and expanded business activity (for example, ethanol, tourism, etc.) and/or cost reduction from business. Emphasis should be on local economic benefits in order to gain community and municipal support.

6. Develop, announce and implement a **Strategy on Climate Change**, that is integrated into the municipality's overall planning and operations activities, within a watershed and agro-ecosystem perspective. It requires:

   a. **Incorporation of best practice mechanisms for monitoring and assessment of climate change exposure at the earliest stages of the Strategy;**

   b. Formal levels of **accountability** to monitor and report to Council, constituents and the Province on the municipality's progress in addressing climate driven business-risks and opportunities;

   c. A review of the existing **regional governance structure** for water-related infrastructures from data collection and analysis to adoption of measures (see EOWRC recommendation 35);

   d. **Emergency response spill clean-up** plans for areas considered at high risk of water contamination (EOWRC recommendation 23).

7. Ensure that the Strategy is:

   a. Based on a clear **vision**

   b. **Doable**,

   c. **Viable** in the long-run

   d. **High profile**, and

   e. Has a **champion** from the local area, who keeps it moving at both **the political and staff** level

8. Ensure **Community ownership of the Strategy** for its long-run success**;** this requires:

   a. **Support from community leaders**

   b. Continuously **re-engaging support at the working level**

   c. **Community engagement** on any, even unrelated, issue

9. Take into consideration the size (number of inhabitants) of the municipality in determining the degree of formality for **the organizational structure for the Strategy.**

10. Since the Federation of Canadian Municipalities has programs (PCP, LAP) to assist municipalities for climate change **mitigation** and since adaptation measures are not

independent of mitigation measures, as soon as municipal mitigation measures will be mandated by the Federal Government:

a. Construct an **inventory** of the municipality's emissions (50 % of GHG emissions originate in municipalities territory (Municipalities Issue Paper, 1998));

b. Establish an emissions **baseline,** against which to gauge the municipality's emission trends

c. Make emissions **projections**

d. Establish realistic **targets** for emission reductions, and

e. Examine the practicality and affordability of **early mitigation measures**

f. Calculate, verify through a third party auditor, and **register** GHG emissions savings or **offsets**.

11. Confer a **leading role on Conservation Authorities** in the risk-management of climate change adaptation, and adequate corresponding resources to manage climate change adaptation of **watershed infrastructures.**

12. Confer a **leading role on Municipal Committees** in the identification of needed expertise, data requirements, champions and organizational structure for the elaboration of the Climate Change Strategy.

13. Confer a **leading role on the Eastern Ontario Health Unit** (EOHU) in the risk - management of climate change adaptation because of its:

a. **Ability to communicate to the public** climate change-related messages through the environmental determinants of health;

b. Involvement with the municipalities in formulating **emergency plans** due at the end of the next calendar year;

c. Responsibilities towards **vulnerable populations**.

14. Determine infrastructure service standards and what constitutes **due diligence** at the infrastructure design stage.

15. Develop an adequate **combination of measures** (including the ones required for mitigation).

16. Require that the municipality adopts site - specific and regional best practices whenever available. Consider climate change and implement EOWRC recommendations 3, 11, 13, 14, 15, 18, 21 and 26, namely:

a. Identify **existing** groundwater and surface water resource and land use (including nutrient, pesticide, and sediment) **management programs** on a watershed and agro-ecosystem basis including sewage treatment and discharge, animal waste and its application, and review various non-point pollution source reduction program from a climate change adaptation perspective;

b. Assess broadly the **benefits and costs of existing and proposed management programs** to determine their effectiveness and equity among stakeholders;

c. Determine the **need for program changes**;

d. **Develop measures** to reduce the risks of contamination, such as: reduction in nutrient loading through phosphorus credit system, development of vegetated riparian zones, wetland protection and creation, and limits on agricultural intensification (corn for ethanol, hog - farms, etc.);

e. **Mimimize impacts** of road salt and snow dumping practices.

17. Reaffirm EOWRC recommendation 9 and 31 in a climate change perspective, i.e. evaluate various **water efficiency** measures for major water consumer groups in a watershed and implement the most cost-effective ones, such as metering Permits – To - Take - Water, and adopting increasing volumetric tariffs. These measures should be extended to all water consumers eventually.

18. **Identify and promptly adopt** adaptation and mitigation measures, whose early adoption will save the municipality money in the long-run.

19. Increase the level of **cooperation regionally** among the United-Counties of Prescott & Russell, and the United-Counties of Stormont, Dundas and Glengarry in mitigation, adaptation, and climate risk-bearing initiatives. The co-operation should be extended to the United Counties of Leeds - Grenville, the City of Cornwall, the City of Ottawa, the Rideau Conservation Auhority and Mississipi Valley Conservation, as well as with the Province, once the latter's mitigation and adaptation commitments are established.

20. Increase the level of **cooperation with the insurance industry** to be able to demonstrate the efficacy of the municipality's climate strategy and of its vulnerability alleviation measures, to identify remaining "hot spots", and to agree about what constitutes residual risk.

21. Increase the size of some water and wastewater treatment plants and update some others to enable them to handle large and more frequent precipitation events while, at

the same time, applying **increasing volumetric** tariffs and other water conservation measures to help finance needed capital expenditures.

To the Eastern Ontario Water Resources Committee (EOWRC) and Conservation Authorities

22. Assess **climate change risks to all water-related infrastructures** and, especially, assess the effectiveness of **stormwater management** methods locally and regionally within a watershed context (EOWRC recommendation 29).

23. Take climate change into account and collaborate with the province whenever establishing and implementing programs for collecting **data,** and implementing EOWRC recommendation 1, namely data on:

a. **Surface and groundwater quantity and quality on a watershed basis;**

b. **Human water-taking and discharges on a watershed basis**,

c. **Limitations on resource development**

d. **Inter-relationships between upstream and downstream communities** on a watershed and sub-watershed basis (EOWRC recommendation 4 and 5).

24. Conduct a **regional projection of future water demand** assuming best practices on a subwatershed basis and develop corresponding **water supply** plan (EOWRC recommendation 28).

25. Recommend **early adaptation measures** to protect:

a. **Groundwater**, wherever its available **quantity** is vulnerable to some climate scenarios; measures may include artificial recharge of groundwater in vulnerable areas

b. Both surface water and groundwater **quality** from agricultural pollution through adequate data gathering, adoption of computer models and decision-support systems.

26. **Measure baseflow** to determine the origin of flow in **dry - weather** periods (EOWRC Recommendation 8).

27. Install and **monitor**:

a. Multi-level piezometers (Monitoring wells) at locations of high **groundwater sensitivity** and areas of regional groundwater recharge (areas of regional recharge are believed to be located along the divide between the South Nation and the

Raisin River systems, and in the adjacent Rideau River basin); this will provide information of utmost importance on the supply side, i.e. actual recharge values, instead of the educated guesses presently used in most groundwater studies.

b. Multi-level piezometers at surface-water gauging stations; this would provide extremely important information on **surface water – groundwater interactions** and on vertical groundwater movement at these locations. Other methods, such as electrical conductivity surveys, can also be used to provide additional information on the interaction.

28. **Sample periodically** the monitoring network, perhaps every year, for **major constituent chemistry and water quality** parameters; and perhaps, every few years, for isotopic composition. This will help monitor water quality and it may also provide important information on the natural evolution and origin of groundwater.

29. Reaffirm EOWRC recommendation 24 about carrying out **public education** and awareness to increase public understanding and action, through behavior understanding, around surface and groundwater management and protection under climate change including: well head protection, water testing, septic tank and tile field maintenance, water efficiency, nutrient management, as well as decontamination.

30. Offer **well and septic system inspection and remedial services** to the population concerned.

To the Eastern Ontario Health Unit (EOHU)

31. Emphasize the climate change dimension in **emergency plans** being currently developed.

32. Conduct **epidemiological surveillance and monitoring.**

33. Improve **communication** strategies with the public as to make the information valuable and practical.

To the Province

34. Revise, monitor and adopt a precautionary approach to the **Permit – to - Take - Water** (new ones as well as renewals) and transform it into a revenue - generating instrument.

35. List climate change as a **Provincial Interest** under Section 2 of the Planning Act and incorporate climate change into the Provincial Policy Statement.

36. Modify the regulatory environment defining **infrastructure standards** according to climate change requirements and allow them to be spatially differentiated according to climate change regional projected impact.

Volume I Synthesis Report

Section 1 Introduction[1]

1.1 The Grant Program that Funded the Study

The Social Sciences and Humanities Research Council of Canada (SSHRC) Community University Research Alliance (CURA) program is premised on an equal partnership between organizations from the community and the university.[2]

The objectives of the CURA program are:

- To enhance mutual learning and horizontal collaboration between community organizations and universities;
- To contribute to the social, cultural and/or economic development of communities;
- To enrich research, teaching methods and curricula in universities, and reinforce decision-making and problem solving capacity in the community; and
- To enhance students' education and employability through diverse opportunities to build their expertise and work - force skills in an appropriate research setting.

The 4 - year CURA pilot project of the University of Ottawa (1999-2003) dealt with adaptation of water resource infrastructure-related institutions to climate change in Eastern Ontario. It had three objectives:

1) The production of an impact assessment blueprint which identifies climate change as an additional stress, on top of demographic and land use changes, on water resources;

2) The application and critical analysis of the blueprint in terms of institutional adjustments required to increase municipal capacity to manage the physical relationships between existing and anticipated cumulative stress on water supply/demand; and

3) The development of a freshwater sustainable partnership network among the University and various partners such as the St. Lawrence River Institute of Environmental Sciences (SLRIES), the Eastern Ontario Water Resource Management Committee (EOWRC), and the Federation of Canadian Municipalities (FCM) (Crabbé *et al.*, 2002).[3]

As the project evolved, the impact assessment blueprint turned into a regional climate change strategy for water-related infrastructures and the institutions which govern them.

[1] This section was contributed by P. Crabbé.
[2] http://www.sshrc.ca/web/apply/program_descriptions/cura_e.asp#a
[3] http://www.cura.uottawa.ca.

1.2 Local Institutional Adaptation of Water-related Infrastructures to Climate Change

Adaptation to climate change is to be local as well as global since climate impacts are expected to be locally differentiated (IPCC, TAR, WG II, *Summary for Policy Makers*, 2001, section 2.7). A multidisciplinary group of researchers at the University of Ottawa has selected the eastern portion of the Eastern Ontario region in Canada for the development of a regional adaptive strategy to climate change[4]. The university is located within the region and has developed over the last decade collaborative ties on environmentally-oriented projects with the eastern portion of the region (Crabbé *et al*., 1997). The adaptation strategy is mainly focused on water-related infrastructures and institutions. It has been led by the University, but developed in partnership with local actors (municipal, watershed and agricultural interests' representatives) and the Federation of Canadian Municipalities (FCM), which has been proactive in climate change mitigation at the municipal level through voluntary programs (see *infra*, 2.4.2). None of the municipalities from the selected area has joined the FCM voluntary mitigation programs. None, up to now, has considered adaptation to climate change a priority or developed governance initiatives to respond to or anticipate climate change. The same can be said of Conservation Authorities (CAs), which are sub-watershed institutions, mainly responsible for flood and water quality protection; these institutions are mainly funded by municipalities (see *infra*, section 10).

Adaptation, for the purpose of this study, is defined as policies (e.g. water conservation) and actions (e.g. expand the size of a mechanized wastewater plant) or measures (a combination of policies and actions), which, taking climate change as given, will reduce the latter's regional actual or projected impacts in a given area or, at least, the vulnerability of some infrastructures to these impacts (Smit *et al*., 1999). **Vulnerability** means to be prone to or susceptible to damage or injury (Blaikie *et al*., 1994, p.9). **Mitigation**, for the purpose of this study, is defined as a set of policies and actions or measures aiming at slowing down and, possibly, preventing further climate change (*ibid.*). Federal Government policies aimed at implementing the Kyoto Protocol are mitigation policies. Though both Federal and Provincial Ministers of Energy and Environment have agreed to address adaptation issues, no Canadian adaptation policy has been publicly discussed or issued yet.[5]

For most people, in their every day life, local government is the most salient political actor. It implements and enforces national and provincial policies through its police force (e.g. emission vehicles), inspectors, medical officer of health (e.g. beach closure), and supplies essential services such as drinking water, garbage collection, etc. Local government plays a fundamental role in land-use, urban density, etc. 50 % of GHG emissions take place on the territory of municipalities (Municipal Issue Paper, 1998). Climate change impacts will be mostly felt and differentiated at the local level. If climate change policies are to be effective at the individual

[4] Eastern Ontario is variously defined by government agencies. The Health Unit of Eastern Ontario covers the same areal extent as the current study area (EOHU, 2000). However, Government of Ontario socio-economic and tourism documents calls Eastern Ontario a wider area of Ontario, which is located east of a vertical north-south line just west of Algonquin Park and includes the geographical area of the current study (e.g. http:// www.smartgrowth.gov.on.ca).
[5] Joint Meeting of Energy and Environment Ministers, Charlottetown, P.E.I., May 21, 2002, Communiqué. (http://www.nccp.ca/NCCP/pdf/final_english.pdf)

and household level, local government will have to play a key role because it can foster informal networks of expertise and cooperation among local businesses, local schools, colleges, universities, libraries, NGOs, churches, and other social groups i.e. policy networks (O'Riordan *et al.*, 1998).

1.2.1 Climate Change as Endogenous Risk

Climate change is a risk very similar to the one of a car accident. The risk of automobile accident is an endogenous risk, whose level depends on our actions to some extent; it is also a risk against which one can never insure completely even under no-fault insurance. This is why there are policies (e.g. speed limits) and individual behavioral incentives (e.g. deductibles), which reduce and endogenize the risk. Of course, the way one drives, avoiding "dangerous" behavior, influences the risk as well. Note that dangerous behavior is socially dangerous, i.e. to oneself and to others. Policies and behavior mitigate the risk of a car accident, i.e. reduces its likelihood. One also adapts to the risk of a car accident by requiring air bags for example, i.e. by decreasing the impact of the accident in terms of injuries; injuries are decreased only to the passengers of the car that is equipped with the bags. Both mitigation and adaptation are generally required components of a strategy to reduce car injuries, whenever eliminating the risk completely or adapting to it completely would be either impossible or prohibitively expensive. Moreover, because "dangerous" has societal ramifications, individuals will not undertake, by their own behavior alone to mitigate the risk completely; this is because the benefits of danger avoidance - a public good in economic parlance - cannot be fully appropriated by the mitigating individual. This is why car insurance is mandatory.

The risk of climate change is an endogenous risk as well, risk against which one can never insure completely. This why we need mitigation policies (e.g. reduce GHG emissions) and societal and individual behaviors (e.g. driving less polluting vehicles), which will reduce the likelihood of "dangerous" climate change. Again, "dangerous" is a societal outcome. Adaptation policies and societal (e.g. better institutional design) and individual (e.g. adopting drought-resistant crop varieties) behaviors, which decrease the impacts of climate change, are needed as well. These provide benefits mainly to the ones who undertake adaptation, while mitigation provides benefits to society as a whole. Mitigation alone cannot eliminate the risk of climate change completely and adaptation alone cannot reduce the climate change impacts completely if only because one does not understand fully how climate change operates; generally, mitigation or adaptation alone would be prohibitively expensive. As in the car accident example, individuals will not undertake to mitigate the risk completely by their own behavior alone. This is because the benefits of danger avoidance cannot be fully appropriated by the mitigating individual. Danger avoidance is a public good.

Both risks (car accident and climate change) are endogenous to society to the extent that their level can be controlled through policy and societal and individual behavior. Actually, economists claim that most risks, which affect society and individuals, are endogenous because one is able to influence them; one is also able to insure against a few of them only and often incompletely. Insurance consists in transferring resources from a good state (a sequence of premiums without risk occurrence) to a bad state (the compensation when the risk materializes).

Mitigation is a form of insurance. Assessment of an endogenous risk cannot, therefore, be separated from its management since the risk is management - dependent. We adapt by reducing the severity of the impact (improve the outcome) of a bad state of nature by transferring resources, which would be available in a good state, to a bad state (self-insurance); this is done through behavioural decisions, production decisions (e.g. change the size of a water treatment plant) and consumption decisions (e.g. reduce water consumption). Both adaptation and mitigation are necessary components of an integrated endogenous risk reduction policy; both affect the risk and the costs and benefits of reducing it. Economic reasoning requires that society spends on each component up to the point where the last dollar spent brings about the same net monetary benefit. Since mitigation provides a public good while adaptation provides a private good, mitigation must be undertaken by society as a whole (universality through taxation) while adaptation can be left to individuals or groups of individuals (Kane *et al*., 2000).

1.2.2 Adaptation and Mitigation as Mutually Dependent Strategies

Adaptation and mitigation may be complementary, substitutable or independent of each other. For example, a farmer could overcome the decline in agricultural productivity under climate change by using more fertilizers, which increase GHG emissions. This is a case, where more adaptation would require more mitigation, an example of complementarity. If adaptation and mitigation are not independent, assuming separation will lead to undervaluation of the net benefits of risk-reducing activities and to a less than required level of these activities because costs will not be minimized. This is the case for policies favoring spending on adaptation rather than on mitigation, while climate knowledge uncertainties are being resolved; these policies are often advocated by the private sector. Moreover, risks may be transferred from one collectivity to another if mitigation and adaptation efforts are incompatible with the ones taken by another collectivity. When adaptation and mitigation are substitutes for each other, there exists a trade-off between the two: a little more (less) adaptation means a little less (more) mitigation according to which increase (decrease) is cheaper (more expensive). Adaptation reduces the costs of impacts and thus reduces the benefits of mitigation, when the former takes place, if the two strategies are complementary. Moreover, since, in any case, individual citizens will adapt to some extent to the risk on their own, their efforts have to be taken into consideration in public investment on mitigation. Taking the two options – mitigation and adaptation - into account at the same time may reduce the overall cost of a risk reduction policy, be it for car injuries or climate change (Kane *et al*., 2000).

Though adaptation and mitigation for climate change may be substitutable, they are never perfect substitutes for each other since mitigation will always be required to avoid "dangerous" climate change as required by the 1992 United Nations Framework Convention on Climate Change (Yohe *et al.*, 2000). However, adaptation contributes to the definition of "dangerous", if it is not independent of mitigation.

If the weather becomes more variable under climate change (more extreme events), the dependence between adaptation and mitigation is relevant as well. Increased variability will directly affect a climate strategy mainly based on mitigation but also affect indirectly adaptation

strategies; these, in turn, will influence the level of mitigation by feedback, according to whether they are complementary or substitutes (Kane *et al*., 2000).

Since it is agreed that implementation of the Kyoto Protocol will not mitigate climate change to any significant degree at least until 2012 (end of Kyoto first budget period), adaptation measures, even if they are independent of mitigation, are or will be required for decades to come (because climate change depends on GHG concentrations rather than GHG emissions); they will be required at the global as well as at regional levels, since climate change impacts and vulnerabilities tend to be regional (e.g. Mc Kibbin *et al*., 2002). Even within a province such as Ontario, different regions have to be defined for climate change adaptation purpose.

1.2.3 Eastern Ontario Water-related Infrastructure Institutions' Adaptive Capacity and Vulnerabilities to Climate Change

The smallest region of interest to this study, for which impacts have been projected, is the Great-Lakes Basin. One has to remember that these projections are simply downscaled versions of impacts projected by Global Climate Models (GCMs) and, therefore, subject to model uncertainties (Hilborn, 1987). Municipalities, as governments closest to the people, may be the ones to have to act on adaptation, either because of the subsidiarity principle, which delegates to the lower level of government the more local issues or because of residual responsibilities. Indeed, differentiated impacts and vulnerabilities may exist at a much smaller spatial scale than the Great-Lakes Basin.

The term "infrastructure" used in this study is a more vernacular version of the economic term "capital". Therefore, one must distinguish between built infrastructure (e.g. water treatment plants), natural infrastructure (ecosystems), human infrastructure (education, health and personal security), and social infrastructure (institutions and other forms of collaborative structures). While the three first forms of infrastructure are relatively straightforward, the last one deserves some explanation as it plays a central role in shaping mechanisms of resource distribution and in conditioning means of access to resources (Pelling, 1998). Social infrastructure (or social capital) is defined as the integrating features of social organisation such as trust, norms and networks that facilitate social coordination and co-operation for social benefit, and which are affected by culture and human-environment interactions (Pelling, 1998; Aidger *et al.*, 2001). It may be measured in quantity and quality through the measurement of cooperation with a defined social group facing specific climate change pressures (e.g. farmers). Quantitative measures may refer to the number of people or households who coordinate their adaptative actions. Quality refers to such features as inclusiveness, transparency and accountability of decision-making institutions (Pelling, 1998).

Adaptation can be carried out by individuals or by systems, such as institutions, ecosystems, etc. We will not be concerned in this report about biological adaptation of organisms, animal or plant populations or ecosystems to climate change. Our focus is the human-use system, individuals and social groups such as municipalities.

A county/municipality ability to develop and implement a comprehensive strategy towards climate change may be called its **adaptive capacity** (or resilience). Adaptation can take many forms; it may be technological (e.g. increasing the size of mechanized wastewater plants), institutional (e.g. adoption of emergency measures) or behavioural (e.g. providing incentives to farmers for the adoption of drought-resistant crops) (Smit *et al*., 2000). It is the institutional and behavioural capacities which are of interest to us in this report since technological adaptation is not location specific in Canada. Adaptive capacity of a county/municipality is a function of various factors: the range of available technological options; the available resources and their distribution across the municipal population; the structure of critical institutions and the criteria for decision-making; the human and social infrastructures; the access to risk-spreading mechanisms; the ability of decision-makers to manage credible information and their own credibility; the public's perception of the source of the impact and of the significance of the impact to its local manifestations (Yohe *et al*., 2002). The larger the adaptive capacity, the wider are the adaptation options. Of course, adaptive capacity evolves over time and it is the factors which determine the process of adaptation which are important to understand rather than any measure of the adaptation potential (Adger *et al*., 2001). Adaptation by individuals or groups is constrained by the resilience of the human and natural systems in constant co-evolution, i.e. by their adaptive capacity to external shocks (*ibid*).

The **vulnerability** of an individual or human system, such as a county/municipality means the degree to which the latter is susceptible to injury, damage or harm (sometimes called hazard or exposure) from climate change (e.g. susceptibility of its water-related infrastructures to drought hazard).[6] Vulnerability is the coupling of a natural process (climate change) with a social process (Adger *et al*., 2000). Like the risk of climate change, vulnerability and adaptive capacity are endogenous attributes to the human-use system. Though the bio - physical impacts of climate change are relevant to all the water - related infrastructures in this report, it is the socio - institutional implications of these impacts which are mainly of interest to us. Accordingly, vulnerability is a social construct with, a generally negative connotation, and is not a natural state (Aidger *et al.*, 1999; 2000; 2001). The lower the adaptive capacity, the higher is the vulnerability. "By 'vulnerability' we mean the characteristics of a person or group in terms of their capacity to anticipate, cope with, resist, and recover from the impacts of a hazard" (Blaikie *et al.*, 1994, p. 9). Though vulnerability is more manifest in time of crisis, it is a chronic and pervasive attribute (Aidger *et al.*, 2001). It is a current state of weakness which might limit the capacity to respond to future stress (*ibid*.). The **cost of vulnerability** is the cost of an adaptation strategy plus the cost of unavoidable residual risks (IPCC, WG II, c. 18, 2001; Yohe *et al*., 2002). "In the broadest sense, vulnerability occurs because livelihoods and social systems are exposed to stress and are unable to cope effectively with that stress" including the risk of slow recovery (Adger *et al*., 2001, p.21; Adger *et al*., 1999). One can distinguish between individual vulnerability and collective vulnerability. Individual vulnerability depends on access to resources, the diversity of income sources, as well as the social status of the individuals (or households) in a community (Adger *et al.*, 2001). Collective vulnerability is determined by

[6] Around the 1980's, the field of hazard research merged with the fields of risk analysis and food security (e.g. Sen, 1981). The term "coping" was preferred to the term "adaptation" in hazard research to underline the difference between biological adaptation and cultural adaptation (Burton *et al*., 1993). One outcome of the merge of these three literatures with the climate change literature is the lack of widely agreed upon terminology (e.g. NRCan, 2003).

institutional and market structures, the entitlements of groups to call on resources, on infrastructures, income, government policies (social security, insurance, etc.), and social networks (*ibid.*; Pelling, 1998). Collective vulnerability involves interactions at various spatial scales, from the municipal to the federal level (*ibid.*). Since vulnerability is intimately tied to adaptive capacity, vulnerability is also a process whose dynamics needs to be understood.

Sensitivity means the degree to which an individual or a system is affected by or responsive to climate change stimuli (e.g. response of water supply from groundwater to a lower level of surface waters due to climate change) (Smit *et al*., 2000). The most vulnerable systems are the ones with greatest sensitivity and lowest adaptive capacity (IPCC quoted in Smit *et al*., 2000). Again, sensitivity is endogenous to the human system.

The vulnerability of a system to climate change is a function of the hazard (e.g. drought) to which it is exposed, of the system's sensitivity, and of its adaptive capacity.[7] "Vulnerability is a measure of the enforced exposure to critical stress, or hazard, combined with the restricted capacity to cope" (Adger *at al.*, 2000, p.165). Vulnerable people or communities face events beyond their control and sometimes, beyond their comprehension (*ibid.*). Therefore, information regarding the spatio-temporal scale of the hazard is required to assess the magnitude of vulnerability. Access to information shapes people's relationships with hazardous environments. The possession of information is central to power and planning and thus to local government. Therefore, people's participation in local government is essential to allow them to adapt their own living environment to change (Pelling, 1998). Climate change mitigation is beyond the control of any single community while adaptation to localized water scarcity is well within its purview if the community is informed of potential local impacts of climate change. On the other hand, current measures for adapting to uncertain long-term impacts are of a precautionary nature and should be robust, i.e. provide benefits no matter which climate scenario materializes (Aidger *et al.*, 1999).

Hazard-mapping is the assessment of the physical (e.g. drought) or biological (e.g. bacteria) triggers of the hazard (e.g. water unfit to drink) (Blaikie *et al.*, 1994, p.225). Note that the hazard (harm) rarely results from climate change alone. The hazard itself may be endogenous to some extent. For example, assuming that the 2003 B.C. drought is due to climate change, the way forest fires have been suppressed in the past, certainly had an impact on the severity of to-day's harm and thus on the sensitivity of BC forests to drought (Smit, 2003).

There are two approaches to adaptation: a top down scenario-based approach and a bottom-up vulnerability approach. The top down approach focuses on future and long-term consequences (necessarily uncertain) of climate change identified in the literature, while the bottom-up one focuses on current and historically experienced conditions (Smit, 2003; Adger *et al.*, 1999). The vulnerability approach engages stakeholders much more than the top-down one. Our study partakes in the two. It takes the vulnerability approach to the extent that all its scenarios have been historically experienced and that the study focuses on current adaptation needs and opportunities in a cost effective perspective, including autonomous or spontaneous adaptation. It takes the top down approach to the extent that the stakeholders have not been the driver for this

[7] For a critique of this functional relationship and a deeper discussion, see K. Chen (2003). Exposure in the hazard literature tends to be synonymous with hazard.

study and that published future scenarios and thus long-term impacts have been taken into consideration as well.

Exposure to variability and to extreme events is an important source of vulnerability; systems will experience and respond to these before they respond to climate. Exposure to variability allows the selection of adaptive strategies, which will work now and in the future, thereby facilitating their adoption because of their immediate benefits (Adger et al., 2001). Weather (temperature, precipitations, wind, cloud cover, etc.) is inherently variable over several spatio - temporal scales. Climate is an average of the weather over a period of time, often taken to be 30 years (Harvey, 2000). Adaptation involves a reaction to both climate and weather. A local community can normally cope with weather variability unless consequences become significant i.e. fall outside the coping range. In this case, new adaptation strategies are required which expand the coping range (Yohe *et al*., 2002). One may adapt to the mean of weather characteristics, to extreme events or to cumulative effects beyond a coping range, which may itself change with adaptation. Adaptation to the mean requires adaptation to extreme events since the whole distribution shifts with the mean.

The unexpected 1998 Ice Storm which caused about Can $5 billion damage in Eastern Canada was an extreme event, which, according to the literature on climate change, is expected to become more frequent and more intense in the future. It was vividly experienced in the area of investigation. The 2001 and 2002 Eastern Ontario droughts were milder forms of extreme events. The 2000 Walkerton water quality crisis had circumstantial ties to climate changes in that *E. coli* contamination occurred after a wet period succeeding a dry one. Climate is often assumed to change slowly with respect to the weather; however, recent historical evidence has confirmed that severe climate change can occur in less than a decade (Weart, 2003).

Adaptation evolves through two main mechanisms which affect individuals and institutions, namely social learning and policy learning. "Social learning can be thought as a composite of individual adaptation, such that adaptation comes about through activities which depend on the participation of group members in discourse, imitation or shared collective and individual actions" (Adger *et al.*, 1999, p. 257)[8]. For example technology diffusion depends on price signals which affect individual adaptation, but also on social interaction (e.g. imitation). Institutions constrain or facilitate social learning. They also serve as conduits for perceptions of vulnerability. Policy learning refers to the adaptation to external change by formal institutions, which attempt to retain and strengthen their own objectives and their domination over existing socio-economic structures. Policy learning can be done through the formation of new coalitions of advisors and technical knowledge (Adger *at al.*, 1999). Institutions are persistent, sustainable and resilient social arrangements depending on legitimacy, agenda setting, and the environmental risks which resonate with the institution's agenda, and on social capital or infrastructure. The latter is the integrating features of social organisation such as trust, norms and networks affected by culture and human-environment interactions (Aidger *et al.*, 2001).

Adaptation can be autonomous or planned. Autonomous adaptation occurs without conscious decisions, usually over a very short time frame. For example, moving into the shade, when it is

[8] This definition of social learning differs from the one given by Lee (1992), i.e. a combination of adaptive management (management for learning rather than optimization) with the political process.

very hot outside, is autonomous adaptation. Installing air conditioning in a dwelling is planned adaptation because it requires a longer lead time. Adaptation can be reactive or anticipatory. Reactive adaptation waits until the climate change impact materializes to respond to the stress, while anticipatory adaptation anticipates the impact (Smit *et al.*, 2002). Adaptation to the ice storm was reactive. Changing emergency procedures and the electricity distribution network to withstand heavier weights in case of ice storm is anticipatory adaptation. This study deals with **planned anticipatory institutional adaptation** that, for short, we will call planned adaptation.[9]

Adaptation depends on credible information. Adapting to current conditions is likely to reduce the overall costs of climate change within an adaptation dynamics perspective, where current vulnerabilities condition future ones.

1.2.4 Why a Regional Planned Institutional Adaptation Strategy for Water-related Infrastructures?

This climate change adaptation study, when it looks carefully at water quantity impacts on groundwater resources under various climate scenarios, concludes that negative impacts are highly localized at least for extreme scenarios of temperature, precipitation and their combination, whenever historically experienced (see section 4). This is no excuse for policy inaction, however.

First of all, these highly localized areas of water quantity vulnerability deserve precautionary measures (Precautionary Principle).

Second, as climate change is a cumulative impact on top of demographic, economic development pressures and environmental degradation, which affect both water quantity and quality, additional pressures may push water resources to a state, which may require much more resources for rehabilitation than needed for their protection (hysteresis). In other words, there may be no-regret measures, i.e. measures worth adopting whether or not climate impacts occur, which could be adopted, e.g. water use efficiency (Carpenter *et al*., 1999).

Third, adaptive management to climate change is part and parcel of sustainable management of all natural infrastructures. Many municipalities subscribe, at least in principle, to sustainable development (http://kn.fcm.ca , August 28, 2003).

Fourth, in the knowledge economy, human infrastructure is the best guarantor against vulnerability; household income and individual health will allow individuals to shield themselves, to some extent, from climate change impacts.

Fifth, communities can shelter themselves as well, by educating their members, by protecting the most vulnerable, by taking adequate adaptive measures, and by building social resilience i.e. the ability to cope with generally unanticipated and undesirable events.

[9] A dynamic analysis of the modes of coping can be found in hazard research (e.g. Burton et al., 1993).

Sixth, there is an a priori argument that early adaptation will be more flexible and cost-effective than late measures.

Seventh, municipalities will be mandated by the Federal Government to take mitigation measures against climate change. Mitigation measures to be adopted will be largely discretionary (Government of Canada, 2002). Mitigation and adaptation are two policy instruments or rather sets of instruments, which are generally not independent from each other as argued above (Kane *et al*., 2000). "Adaptation is a necessary strategy at all scales to complement climate change mitigation efforts" (IPCC, TAR, WG II, *Summary for Policy Makers*, 2001, section 2.7). In other words, municipalities need to develop a comprehensive strategy towards climate change, taking their particular circumstances into account. This strategy may be able to identify business opportunities resulting from climate change (e. g. agriculture for ethanol or bio - diesel, shift in cash crops, tourism, etc.).

Finally, there is evidence that the institutional set-up is a key factor against vulnerability. How do we determine whether an institutional arrangement is appropriate to face exposure to climate change? Appropriateness is determined by whether institutional changes are legitimised within the internal and external constituencies and stakeholders of the institution and by whether their perceptions of the risks and interventions are timely and anticipatory. Only real events (another ice storm, another drought, another *E. coli* outburst) can put the institutions to the test (Adger *et al.*, 1999). Appropriateness requires institutional learning in order to shift climate change adaptation from the periphery to the core of people's concerns, linking climate change adaptation to their everyday concerns in a fashion which is at the same time credible and perceived as valuable by them and their local government representatives. This shift requires shared scientific knowledge (hazard-mapping), windows of opportunity offered by real events, and small incremental but strategic steps (O'Riordan *et al*., 1998). Informal local policy networks formed around the issue of climate change adaptation and around existing local institutions with a limited number of participants with shared values and interacting frequently are a communication channel capable of changing institutional mindsets progressively and leading to these incremental steps. These networks should not be so conspicuous as to provoke negative reactions and opposition (*ibid*.).

The process begun through this report is somewhat related to risk assessment and management in that the latter is an iterative process (of consultation, identification and communication of risks, formulation and implementation of strategies), which involves the relevant actors (municipalities, provincial government, federal government, business, NGOs, and private citizens as both actors and beneficiaries) at every stage of the process. Risk assessment/management is also an organizing framework that tries to optimize or, at least, to set up priorities and be cost-effective in its selection of strategies for risk management (reduction e.g. through private insurance, avoidance through preventative measures, and hedging e.g. through reciprocal insurance). The process allows for the inclusion of new information as it becomes available (Bruce *et al*., 1999). The process includes but is not limited to the formulation of emergency plans, recently required from municipalities by the Government of Ontario. These emergency plans offer the opportunity to take into consideration climate change risks such as the ones resulting from extreme events (floods, fires, diseases, etc.). However, they do not suffice, as risk assessment/management requires long-term strategies to be included in the

planning process of municipalities and risk-reducing measures to be taken in its everyday operations, and goes well beyond the design of purely reactive emergency responses.

This study begins by examining the context of the needed adaptive strategy (section 2). It reviews the available literature on the Great-Lakes Basin projected impacts and formulates climate scenarios (section 3), which are applied to the natural infrastructure, both groundwater quantity and quality (section 4), and surface water resources (section 5). Scenarios are applied to water-related built infrastructure (section 6). The literature on climate change and health is then reviewed to project possible impacts of climate change on the human infrastructure (section 7). Failing to take adaptive measures will lead to financial consequences for municipalities (section 8). Attitudes and values of municipal and watershed actors about the state of watersheds, climate change, information networks, etc., were surveyed and some contributing factors to adaptive capacity, identified (section 9). Barriers to institutional adaptation and potential bridges related to social infrastructure are examined and an inventory of innovative water-related institutions is conducted (section 10). A review of municipal policy instruments for adaptation is undertaken (section 11). A regional adaptive strategy for the study area built upon some of the determinants of adaptive capacity is then suggested in the last section and recommendations proposed for discussion by local governments and civil society (section 12).

References

Adger, W.N., P.M. Kelly and N.H. Ninh, *Living with Environmental Change; Social Vulnerability, Adaptation and Resilience in Vietnam,* Routledge, 2001.

Adger, W.N. and T. O'Riordan, Population, Adaptation and Resilience in O'Riordan, T. (2000), *Environmental Science for Environmental Management*, 2nd ed., Routledge, 149 – 170.

Adger, W.N. and P.M. Kelly, Social Vulnerability to Climate Change and the Architecture of Entitlements, *Mitigation and Adaptation Strategies for Global Change*, vol. 4, p. 253 – 266.

Blaikie, P., T. Cannon, I. Davis and B. Wisner, *At Risk, Natural Hazards, People's Vulnerability, and Disasters*, Rutledge, 1994.

Bruce, J., I. Burton, I.D. M. Egner and J, Thelen (1999), *Municipal Risk Assessment: Investigation of the Potential Municipal Impacts and Adaptation Measures Envisioned as a Result of Climate Change*, Global Change Strategies International.

Carpenter, S.R., W. Brock, and P. Hanson (1999), Ecological and Social Dynamics in Simple Models of Ecosystem Management, *Conservation Ecology*, 13(2):4, http://www.consecol.org/vol 13/iss2/art4

Chen, K. (2003), *Methodological Notes on Vulnerability*, *http://www.clarku.edu/departments/hero/Presentations/Vul_note_kchen.PDF*

Crabbé, P., S. Findlay, R. Needham and S. Raman (1997), *Ecosystem Recovery on the St. Lawrence: Final Report*, Institute for Research on Environment and Economy, University of Ottawa, March 31.

Crabbé, P. and C. Mioc (2002), *Canadian Communities and Climate Change Impacts and Adaptation*, October, Unpubl. Mnss.

Government of Canada (2002), *Climate Change Plan for Canada*, http://www.climatechange.gc.ca/plan_for_canada/plan/index.html

Harvey, L. D. D. (2000), *Global Warming*; *The Hard Science*, Prentice-Hall 2000

Hilborn, R., Living with Uncertainty in Resource Management, *North American Journal of Fisheries Management*, 7(1987), 1-5

IPCC (Intergovernmental Panel on Climate Change) (2001), *Third Assessment Report, Working Group II, Adaptation, Impacts and Vulnerability, Summary for Policy-Makers*, Cambridge University Press and http://www.grida.no/climate/ipcc_tar/wg2/010.htm

Kane, S.M. and J.F. Shogren (2000), Linking Adaptation and Mitigation in Climate Change Policy, in S.M. Kane and G.W. Yohe, *Societal Adaptation to Climate Variability and Change*, Kluwer (repr. from *Climate Change*, vol. 45, N^0 1, 2000).

Lee, K. (1992), *Compass and Gyroscope*, Island Press.

Mc Kibbin, W. J. and P.J. Wilcoxen (2002), The Role of Economics in Climate Change Policy, *Journal of Economic Perspectives*, Spring, vol. 16, number 2, p.107-129.

Natural Resources Canada (NRCan) (2003), *Adaptive Capacity: An Overview*, Draft circulated at the Mont-Tremblant Adaptive Capacity Workshop, November.

O'Riordan, T., C.L. Cooper, A. Jordan, S. Rayner, K.R. Richards, P. Runci and S. Yoffe (1998), Institutional Framework for Political Action, in S. Rayner and E.L. Malone, *Human Choice & Climate Change*, vol. 1, Battelle Press, p. 345 - 439.

Pelling, M. (1998), Participation, Social Capital and Vulnerability to Urban Flooding in Guyana, *Journal of International Development*, vol. 10, 469-486.

Sen, A. K. (1981), Poverty and Famines: An Essay on Entitlement and Deprivation, Clarendon.

Smit, B., I. Burton, R.J.T. Klein and J. Wandel (2000), An Anatomy of Adaptation to Climate Change and Variability, in S.M. Kane and G.W. Yohe, *Societal Adaptation to Climate Variability and Change*, Kluwer (repr. from *Climate Change*, vol. 45 , N^0 1, 2000), 223-51.

Smit, B. (2003), *Impact and Adaptation Research Methodologies*, C-CIARN Technical Workshop, Montreal., May 12.

Weart, S. (2003), The Discovery of Rapid Climate Change, *Physics Today*, 56, iss. 8 (August), p. (http://www.physicstoday.org/vol-56/iss-8/p30.html , August 28, 2003)

Yohe, G. and R.S. J. Tol (2002), Indicators for Social and Economic Coping Capacity – Moving Toward a Working Definition of Adaptive Capacity, *Global Environmental Change*, 12, 25 – 40.

Yohe and F. L. Toth (2000), Adaptation and the Guardrail Approach to Tolerable Climate Change, in S.M. Kane and G.W. Yohe, *Societal Adaptation to Climate Variability and Change*, Kluwer (repr. from *Climate Change*, vol. 45 , N^0 1, 2000),103-128.

Section 2 Context

2.1 Geographical Area[10]

The geographic area selected (about 5,000 km^2) for this local climate adaptation study is the eastern portion of the Eastern Ontario region of the Province of Ontario (Canada), which is mainly rural and located in the Great-Lakes Basin; more precisely, it is composed of the United-Counties of Prescott and Russell (P& R), and the United-Counties of Stormont, Dundas and Glengarry (S, D & G; see figure 2.1 and 2.2). It is bordered to the East by the Province of Quebec and to the west by both the United-Counties of Leeds and Grenville, and further North, by the City of Ottawa, which are also part of the Eastern Ontario region but not of the study area. It is bordered to the North by the Ottawa River and to the South by the St. Lawrence River. It contains two sub-watersheds: one large one, the South-Nation River watershed, a sub - watershed of the Ottawa River, and a small one, the Raisin River watershed, which is a sub - watershed of the St. Lawrence; the Rideau Valley watershed to the North-West of the area was not included as it was the object of a separate water resources assessment. A small portion only of the South-Nation watershed is located on the territory of the City of Ottawa. The latter (which counts nearly .8 million inhabitants) has been left out of the study, as well as the City of Cornwall (which counts about 47,000 inhabitants) because the study is focused on small rural municipalities. 59 % of land use in the area is agricultural and 60 % of drinking water is from groundwater. The balance of drinking water comes from the St. Lawrence, the Ottawa and the South-Nation Rivers.

The reasons for selecting this small geographic region were twofold: first, it was the object of a recent major hydrological study called the "Eastern Ontario Water Resources Management Study" (EOWRMS), which did not take climate change into account (CH2M HILL, 2001); second, it has seized upon the opportunity to collaborate with the successor local community-based committee responsible for implementing the EOWRMS recommendations. This Eastern Ontario Water Resources Committee (EOWRC) is formed by county (or upper-tier municipality), municipality (excluding Cornwall but including representation from Ottawa for the reason indicated above), and the two Conservation Authorities' representatives, as well as major agricultural interest groups (see figure 2.3).

[10] This section was contributed by P. Crabbé.

Figure 2.1 Map of the Region with Watersheds

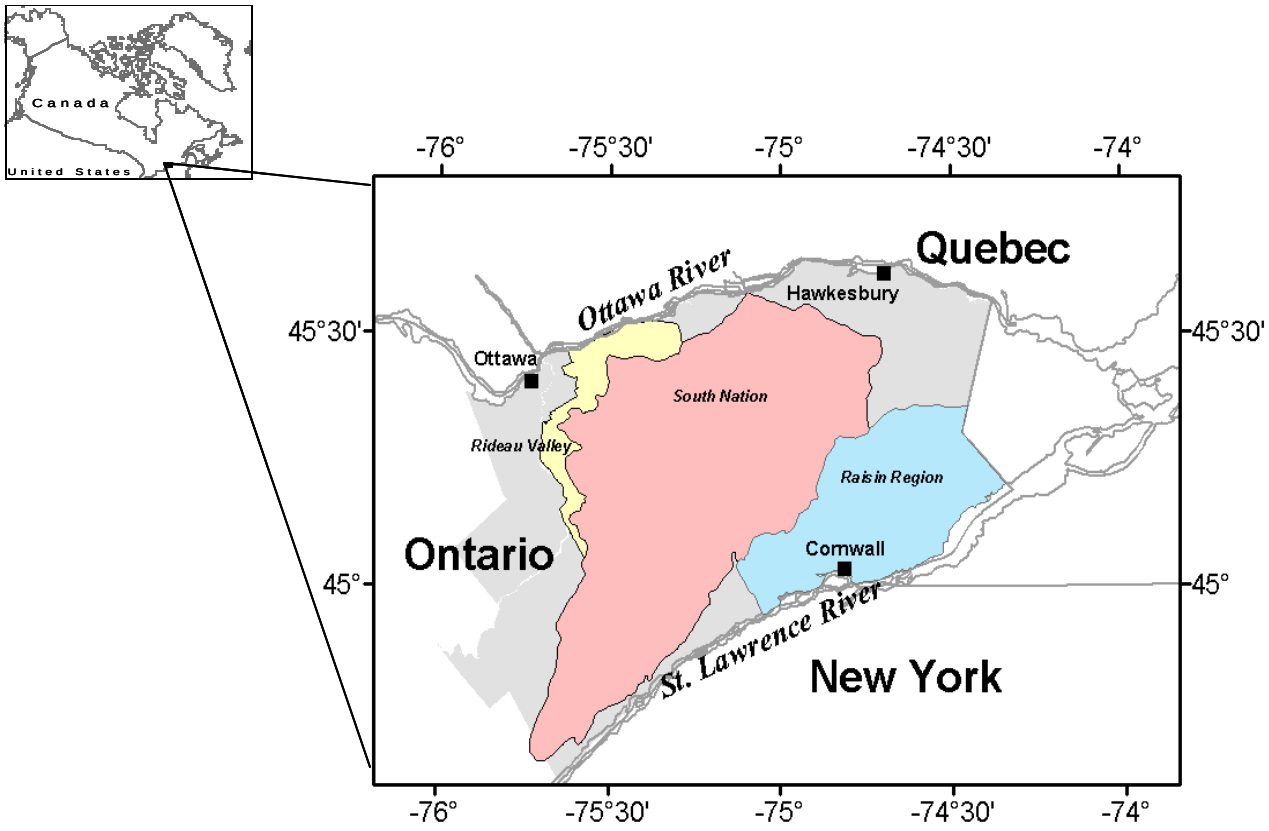

Figure 2.2 Map of the region with Upper Tier Municipalities and major population centers

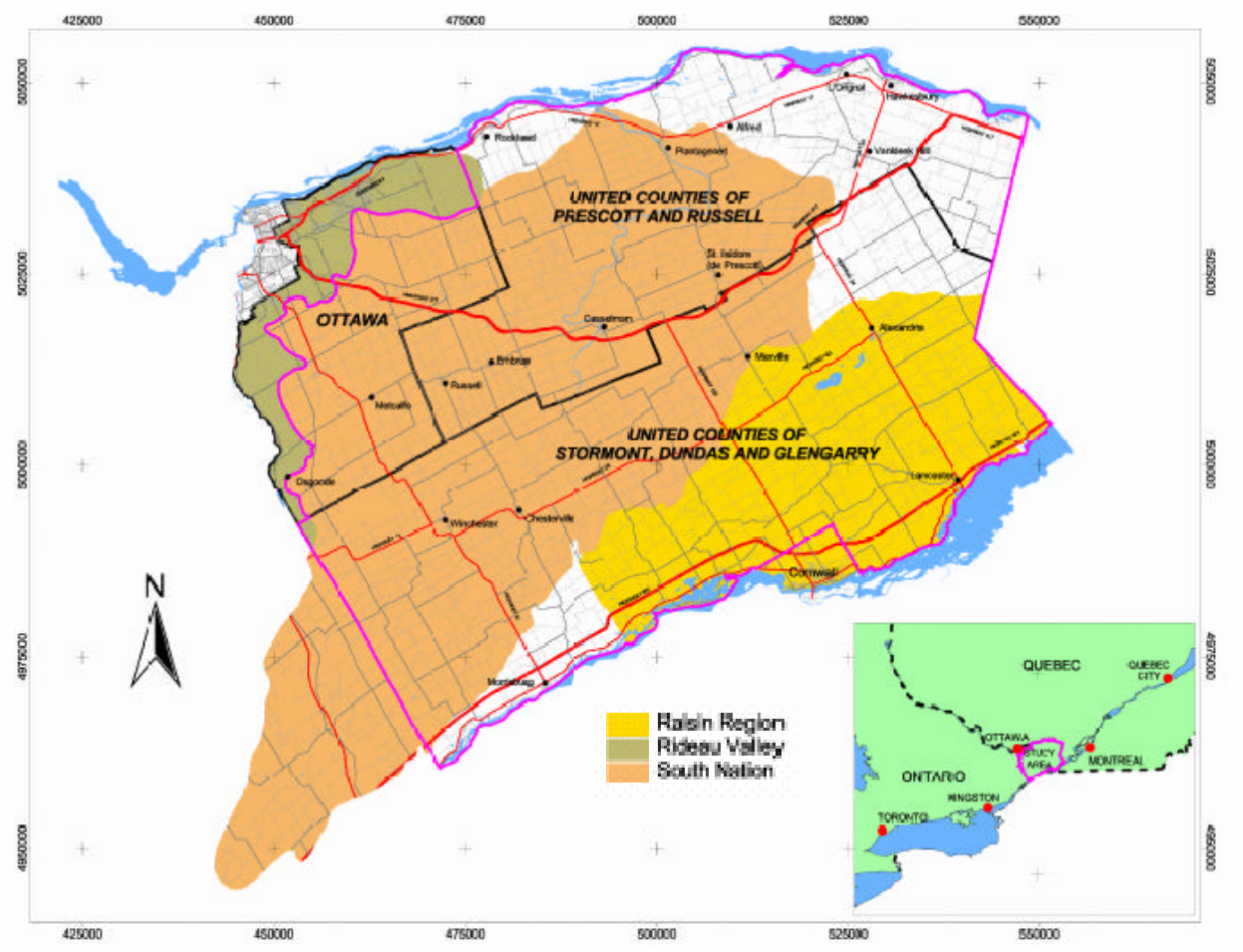

Figure 2.3 Map of the study area with municipalities

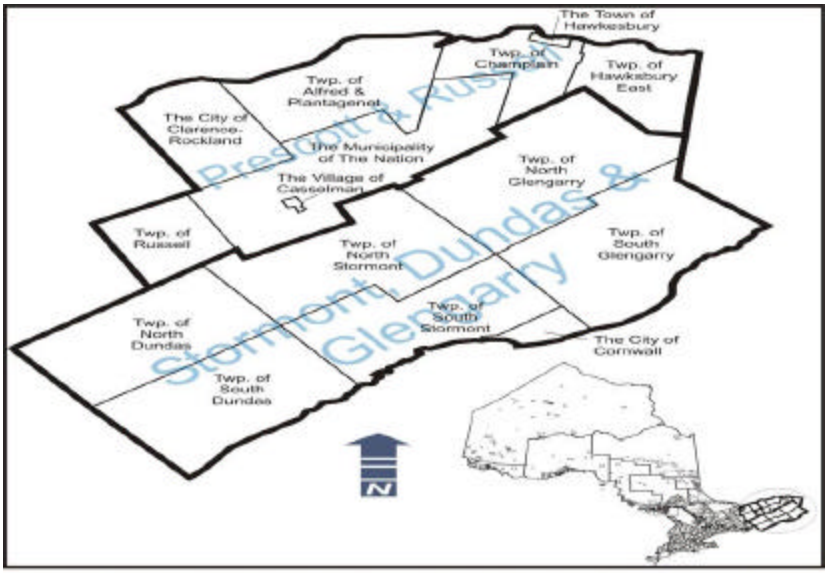

FIGURE 1: UPPER AND LOWER TIER MUNICIPALITIES IN THE EASTERN ONTARIO STUDY AREA

2.2 Demographic Characteristics[11]

The population of the region (including Cornwall) was 186,000 inhabitants in 2001 with 109,500 in the United-Counties of Stormont, Dundas and Glengarry (S, D & G;) and 76,500 in Prescott and Russell (P & R). It has increased by 21% in 20 years (1981-2001) and by 1/3 over thirty years (1971 – 2001), mostly south and east of the City of Ottawa, especially in Russell, whose population has nearly tripled over the last 30 years under the economic attraction of the City of Ottawa and its urban sprawl (table 2.1 and figure 2.4). The population of P & R increased by 73 % in thirty years (1971 – 2001) while the one of S, D & G increased by only 15 % over the same period. A significant percentage of the population growth has occurred between 1986 and 1991 because of the increase in migratory balance, which peaked in 1992-93. The latter is mainly due to intra-provincial migration, which is more significant than the international or inter-provincial migration, and which is much higher in P & R than in S, D & G. The population of the region is expected to increase to about 245,000 (14 %) by 2010 (table 2.3). Urbanization, as a land use change from agriculture, affected mostly the area immediately east of Ottawa and the vicinity of Cornwall. The latter has a population of about 47,500 inhabitants, which has decreased by 3.5% over the last five years, while the surrounding areas' population tended to increase. Cornwall was not included in this study, which focuses on small rural municipalities. Jointly, the United-Counties encompass 14 rural municipalities, the largest being Clarence-Rockland with about 20,000 inhabitants and the smallest, Casselman, with about 3,000 (EOHU, 2000, 2001; Aurelson *et al.*, 2003). From 1951 to 1996, the rural population has diminished while the urban one has increased due to the decreasing number of farms in the area.

[11] This section was contributed by P. Crabbé and D. Lagarec.

Table 2.1 POPULATION CHANGE IN EASTERN ONTARIO 1971-2001

	Subdivisions	1971	1976	1981	1986	1991	1996	2001	%2001-1971
Prescott-Russell		**44119**	**48835**	**52777**	**57620**	**67183**	**74013**	**76446**	**73.2**
	Alfred	5901	6225	6401	6676	7377	8315	8593	45.6
	Nation	7499	8795	9922	10725	12161	13361	13509	80.1
	Clarence (TP)	8238	9712	9922	12410	15753	18633	19612	138.1
	East Hawkesbury (TP)	2842	2895	9922	2788	3159	3296	3415	20.2
	Hawkesbury (T)	9484	9789	9922	9710	9713	10162	10314	8.7
	Champlain	5998	6482	9922	7539	8361	8375	8591	43.2
	Russell (TP)	4157	4937	9922	7772	10659	11877	12412	198.6
Stormont-Dundas-Glengarry		**95239**	**98950**	**101127**	**102262**	**107841**	**111301**	**109532**	**15**
	North Glengarry	9716	9965	9979	10041	10675	10801	10599	9.1
	South Glengarry	8764	9305	10248	10946	11971	12649	12700	44.9
	North Dundas	8082	8760	9239	9851	10661	11064	11014	36.3
	Cornwall (C)	47116	46121	46144	46425	47137	47403	45640	-3.1
	South Stormont	7912	8677	9404	9479	11008	11584	11941	50.9
	North Stormont	5630	5701	5663	5748	6159	6900	6855	21.8
	South Dundas	9375	9747	9707	9772	10230	10900	10783	15
Eastern Ontario		**139358**	**147785**	**153904**	**159882**	**175024**	**185314**	**185978**	**33.5**
Ottawa		**471931**		**546849**	**606639**	**678147**	**721136**	**774072**	**64**

Figure 2.4 Population Changes in Eastern Ontario 1971 - 1996

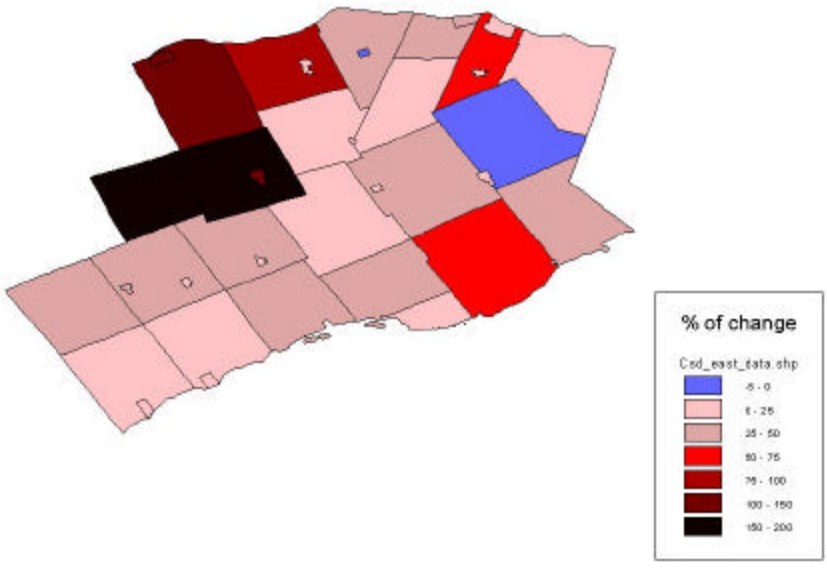

Table 2.2 PLACE OF WORK FOR POPULATION OVER 15 - 1996 CENSUS

		AT HOME	CSD OF RESIDENCE	SAME CD	OTHER CD
PRESCOTT-RUSSELL	MALES	11.3	17.3	19.1	41.7
	FEMALES	10.6	22.3	21.9	42.7
S-D-G	MALES	11.4	37.3	27.3	13.9
	FEMALES	10.3	43.2	31.6	11.2

CD : Census Division
CSD : Census Subdivisions

Table 2.2 shows the place of work for males and females in 1991 and 1996. Census Subdivisions (CSDs) correspond to towns or villages or townships, and Census Divisions (CDs) to counties. It appears than in P & R, more than half the working force over 15 years of age works in a county different from the county of residence, and that their percentage has increased from 1991 to 1996. This reflects the number of people who commute daily to Ottawa for work. The situation is the opposite in S, D & G.

About 1/3 of the population is francophone (mainly concentrated in P & R where their proportion exceeds 2/3 of the population).

Overall, recent (since 1986) changes of family structure are characterized by a reduction of family size and a growing number of single-parent families. As a result the number of households is increasing faster than population growth. For example, between 1986 and 1996, the population of the city of Cornwall has increased by 2.1% compared to an 11.6% growth of households. In S, D & G and P & R, the figures are respectively 8.8% and 28.5% for the population increase and 17.6% and 38.0% for households. This means that the need for dwellings increases faster than the population and contributes to water consumption increase.

Both young and old are vulnerable to the health effects of climate change; so are people with low income. The county of Russell has the largest proportion of children less than 9 years old (17 % in comparison to 14 % for the area as a whole) and the one of Glengarry has the largest proportion of elderly (16 % in comparison with 13 % for the area as a whole). In S, D & G, the elderly were making 10.4% of the population in 1971 and 14.9% in 1996; in P & R, the figures were lower, 9.1% in 1971 and 10.4% in 1996. About 10 % of the elderly of the area live in institutions. 13 % of the population has less than grade 9 - education (10 % for the Province of Ontario as a whole; 17.5% in Prescott, which has a 5% lower average county income than the area average) and 14 % has a university degree (24 % for the Province of Ontario as a whole; 17.5% in Russell). The unemployment rate is slightly larger than the provincial average and is the lowest in the county of Russell (which has a 14 % larger average county income than the area average), and the highest in the county of Stormont, which includes the city of Cornwall. Poverty is also larger in Stormont as well as the proportion of children (under 6) and of elderly living in poverty (EOHU, 2000, 2001).

It is difficult to forecast the evolution of major population characteristics. One can expect, for example, that the proportion of people over 65 or the number of households will continue to increase over time. It is also reasonable to expect the population in the vicinity of Ottawa to have a higher proportion of members in the labor force, and of children under 15 than in the rest of the area. As long as Canada's population increases, it is logical to expect a population increase in Eastern Ontario, albeit not uniform everywhere. Table 2.3 compares the actual annual population changes between 1996 and 2001 and those forecasted by EOWRMS (2002). In P & R, the population increase has been only .66 % per year compared to a 2.03% forecast, the growth being grossly overestimated for the townships closest to Ottawa by a factor of 3 to 5. In S, D & G, a growth of between .5 and 1.3 % was predicted, while a decrease has been observed in almost every township. For Ottawa, the actual population increase has been slightly higher than forecasted (1.47 % against 1.3%). Population projections for P & R to 2019 indicate an overall increase of 45.8 % to 75.3% relative to 1996, while, for S, D & G (excluding Cornwall), the average increase is forecasted to be 23.5% to 2021.

Table 2.3 ACTUAL AND FORECASTED POPULATION CHANGES IN EASTERN ONTARIO 1996-2001

ACTUAL AND FORECASTED POPULATION CHANGES 1996-2001						
	Subdivisions	**1996**	**2001(Actual)**	**Actual Annual Increase (%)**	**2001 (Forecast)**	**Annual Increase % (forecast)**
Prescott-Russell		**74013**	**76446**	**0.66**	**81541**	**2.03**
	Alfred-Plantagenêt	8315	8593	0.66	8423	0.26
	Nation-Casselman	13361	13509	0.22	14110	1.1
	Clarence-Rockland	18633	19612	1.06	22075	3.7
	East Hawkesbury	3296	3415	0.7	3408	0.7
	Hawkesbury (T)	10162	10314	0.3	10256	0.2
	Champlain	8375	8591	0.5	8835	1.1
	Russell	11877	12412	0.9	14007	3.6
Stormont-Dundas-Glengarry		**111301**	**109532**	**-0.31**		
	North Glengarry	10801	10599	-0.38	11527	1.3
	South Glengarry	12649	12700	0.08	13287	1
	North Dundas	11064	11014	-0.09	11443	0.7
	Cornwall (C)	47403	45640	-0.74		
	South Stormont	11584	11941	0.61	12126	1
	North Stormont	6900	6855	-0.14	7079	0.5
	South Dundas	10900	10783	-0.22	11440	1
Eastern Ontario		**185314**	**185978**	**0.07**		

Source: EOWRMS, 2001.

2.3 Land Use and Economic Activity[12]

The region is strategically located within the triangle formed by three large cities, each endowed with an international airport: Ottawa, the nation's capital, in the North-West, Montreal in the East and Toronto, the capital of the province of Ontario, in the West. It has excellent

[12] This section was contributed by R. Alam, P. Crabbé, D. Lagarec and M. Woodrow.

transportation access by road, rail, and sea. It is located between the Ottawa river to the North and the St. Lawrence seaway to the South; it is served by highway #401, which runs directly east-west through the south of the region, highway #416 to Ottawa at its west end, and highway #417 to Ottawa/Montreal to the North. It is linked to the US and New-York state by an international bridge in Cornwall, which also contains port facilities as does Iroquois to the West. In addition to its strategic location, the area offers some other advantages. It is a low cost business centre, with some of North America's lowest wage rates, land prices, and office lease rates. It also boasts a strong municipal infrastructure (including telecommunications), with excess capacity in water, sewer and landfill facilities. The workforce is productive and stable, and boasts one of North America's highest rate of bilingualism, which makes it an ideal location for business call centers. The region's economy is driven by the agricultural sector, which has the capability of raising high value crops (see tables 2.4 – 2.8). Dairy farming and cattle raising are the most popular agricultural economic activities (table 2.7). Many food-processing companies have chosen the area to establish themselves due to the proximity of feedstock, and of regional, provincial and international markets. They also take advantage of Alfred College located within the region, which provides training in agriculture and food technology, and of research facilities located in Ottawa at Agriculture Canada. A thriving future in bioproducts, bioprocessing and agriculture technology awaits the region says a local website. Regional product outcomes include cosmetics, energy, commercial enzymes, food and feed additives, vitamins, nutraceuticals, food & beverage items, and chemicals. Regional processing capabilities include raw material transformation, fermentation, drying, laboratory services, packaging, warehousing and distribution. Cornwall is the largest manufacturing centre in the region and Domtar paper products, the largest single employer. The manufacturing sector has always played a key role in the region's industrial development with Hawkesbury acting as a hub. In February 1995, the Hawkesbury area had more than 33 manufacturing companies employing close to 3,200 workers. The proximity of the area to Ottawa has prompted the development of several regional industrial parks. The business friendly environment and institutions for future development with detailed future plans and the high quality of life with year-round fishing, swimming, boating, golfing, snowmobiling, hiking, bicycling, snowshoeing activities have made this region a very promising future economic growth area.[13]

Agriculture is the life source of the area. Agricultural activity occupies approximately 60% of the land area; all types of forest cover 39% of the area while 1% is water and 1% is urban area (figure 2.5). The Larose plantation forest is the largest contiguous forest in Eastern Ontario. Over the past fifty years (1951-1996), the number of farms decreased by over 60% but the percentage of land cultivated has increased from 54% in 1951 to 71% in 1996 in P & R, and 49% in 1951 to 67% in 1996 in S, D & G (see figure 2.6 and table 2.4 below).[14]

[13] Most of the material for this paragraph comes from local websites. The websites for each county lists all the industries by sector including the number employed (www.sdg.on.ca and www.prescottrussell.on.ca).

[14] In addition, Agriculture Canada's website provides a broad overview of agricultural land use and practices in Eastern Ontario. Figures 2.5, 2.6 and table 2.4 are based on the 1996 Canadian Census of Agriculture, prepared by Statistics Canada (http://sis.agr.gc.ca/cansis/nsdb/detailed/on/webpages/zipfiles.html).

FIGURE 2.5: LAND USE - EASTERN ONTARIO

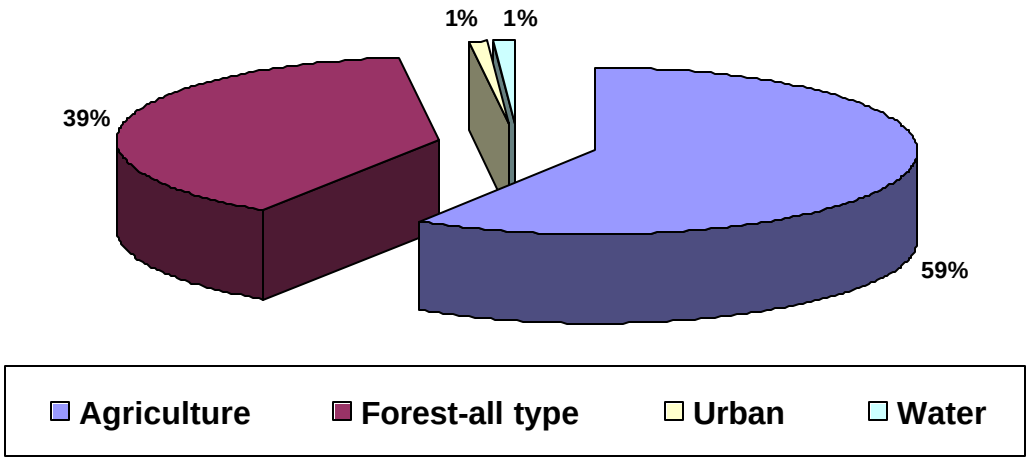

Figure 2.6 CHANGE IN FARM LAND AREA 1971-1996

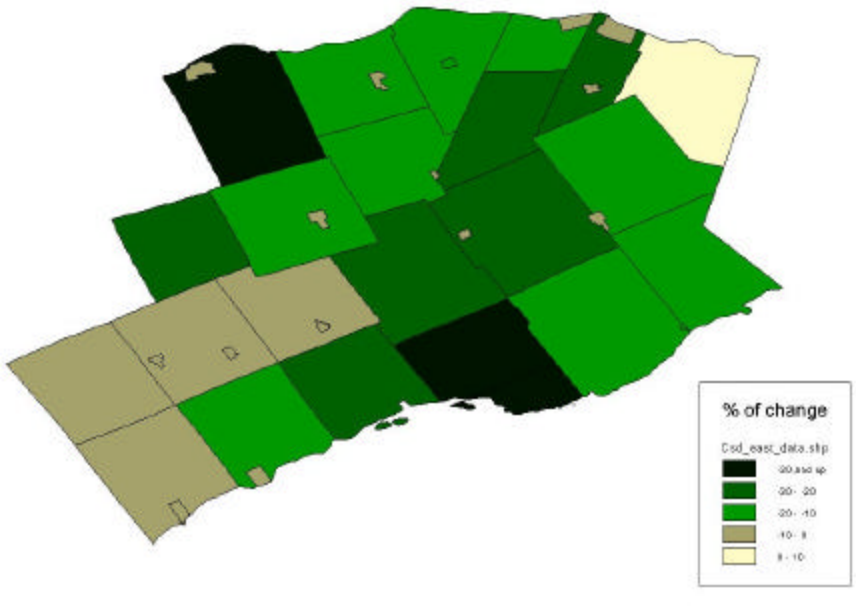

TABLE 2.4 Land Cover - Eastern Ontario

	Prescott and Russell		Stormont, Dundas and Glengarry		Total	
	ha	**%**	**ha**	**%**	**ha**	**%**
Corn	23,919	11.9%	40,963	12.6%	64,882	12%
Soybean	10,757	5.3%	19,283	5.9%	30,040	6%
Grain	7,975	4.0%	10,186	3.1%	18,161	3%
Hay	67,243	33.4%	101,631	31.2%	168,874	32%
Bare	14,874	7.4%	16,353	5.0%	31,227	6%
Agriculture – Total	**124,768**	**62%**	**188,416**	**57.8%**	**313,184**	**59%**
Coniferous	6,325	3.1%	19,180	5.9%	25,505	5%
Deciduous	38,050	18.9%	61,666	18.9%	99,716	19%
Mixed	10,709	5.3%	19,383	5.9%	30,092	6%
Open/Space	2,520	1.3%	7,278	2.2%	9,798	2%
Unclassified	15,345	7.6%	25,081	7.7%	40,426	8%
Forest – Total	**72,949**	**36.3%**	**132,588**	**40.7%**	**205,537**	**39%**
Urban Areas	**2,516**	**1.3%**	**1,958**	**0.6%**	**4,474**	**1%**
Water	**875**	**0.4%**	**2,891**	**0.9%**	**3,766**	**1%**
TOTAL (ha) (%)	**201,108**	**100%**	**325,853**	**100%**	**526,961**	**100%**

Adapted from Eastern Ontario Water Resources Management Study - Table 6-1

Agricultural land values have increased by over 30 % in the last two years.[15] Since these values are recorded from between farmers' transactions, the urban shadow effect from the City of Ottawa, where residential land values have increased in the same proportion over the same period, contributes a small factor only in the overall explanation of this increase.[16]

The most valuable crop is clearly corn (about $110 million gross revenue in 2002; table 2.5), followed by soybean (about $ 45 million in 2002; table 2.6), followed by hay (about 3.5 million in 2002; table 2.8). Milk production is the least productive activity in terms of gross revenue (about $350,000 based on a gate price of $.5/l. in 2002; table 2.7).[17] Droughts affected the region in 2001 and 2002. Their impact is reflected in corn yield mainly for the corresponding years (table 2.5).

The ice storm had a severe impact on the maple trees in the area. Estimates by Statistics Canada put losses in the maple syrup production at up to 50% of Eastern Ontario's $4 million per year industry over the next 10 years (Beshiri, 1999, p.188; Woodrow, 2002)

[15] C. Isenburg, Ontario Land Assessment Corporation, "2003 Preliminary CVA Highlights and MPAC Updates" , Presentation at the 2003 Richmond Hill meeting of the Municipal Finance Officers' Association of Ontario.
[16] Ibid.
[17] The milk gate price was obtained from the Fraser Institute, 2001.

Table 2.5 Harvested Area, Yield per Acre and Total Production of Grain Corn for Eastern Ontario Counties, Eastern Ontario and Ontario

		Prescott and Russell United Counties	Stormont, Dundas and Glengarry Counties	Eastern Ontario Region	Ontario
1998	Harvested Area	45.600	108,900	243,100	1,840,100
	Yield/Acre/Bushel	136	137	132.7	128.8
	Total production (000 Bu)	6,202	14,919	32,250	237,000
1999	Harvested Area	44,500	100,000	241,000	1,800,000
	Yield/Acre/Bushel	135	136	131.6	128.3
	Total production (000 Bu)	6,008	13,600	31,715	231,000
2000	Harvested Area	44,000	98,000	229,000	1,680,000
	Yield/Acre/Bushel	77	85	83.3	105.1
	Total production (000 Bu)	3,388	8,330	19,070	176,500
2001	Harvested Area	51,800	117,200	274,100	1,960,000
	Yield/Acre/Bushel	106	98	97.6	103.1
	Total production (000 Bu)	5,500	11,500	26,750	202,00
2002	Harvested Area	58,100	108,300	256,950	1,910,000
	Yield/Acre/Bushel	118	119	113.9	102.4
	Total production (000 Bu)	6,867	12,846	29,271	216,000

Source: Ontario Ministry of Agriculture and Food

Grain Corn Price ($/Bushel)

Years	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Ontario price $	3.34	3.00	4.64	3.88	3.66	2.99	2.84	3.22	3.44	3.96

Table 2.6 Harvested Area, Yield per Acre and Total Production of SoyaBeans for Eastern Ontario Counties, Eastern Ontario and Ontario

		Prescott and Russell United Counties	Stormont, Dundas and Glengarry Counties	Eastern Ontario Region	Ontario
1998	Harvested Area	26,000	60,000	146,300	2,100,000
	Yield/Acre/Bushel	46	47	44.5	41.0
	Total production (000 Bu)	1,196	2,280	6,516	86,000
1999	Harvested Area	30,000	68,000	162,900	2,125,000
	Yield/Acre/Bushel	44	43	41.1	40.5
	Total production (000 Bu)	1,320	2,924	6,690	86,000
2000	Harvested Area	34,000	77.500	180,500	2,235,000
	Yield/Acre/Bushel	36	36	36	38
	Total production (000 Bu)	1,224	2,790	6,502	85,000
2001	Harvested Area	30,000	4,000	184,400	2,250,000
	Yield/Acre/Bushel	24	28	24.3	21.1
	Total production (000 Bu)	730	110	4,400	47,000
2002	Harvested Area	42,150	60,950	158,050	2,065,000
	Yield/Acre/Bushel	32	33	32.4	33.9
	Total production (000 Bu)	1,354	2,040	5,128	70,000

Source: Ontario Ministry of Agriculture and Food

Soybeans Price ($/bushel)

Region	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Ontario $	8.15	7.43	8.8	10.07	9.16	7.58	7.17	7.07	7.31	8.50

Source: Ontario Ministry of Agriculture and Food

Table 2.7 Milk Shipments to Milk Processing Plants by County, Ontario (litres)

	Prescott	Stormont	Russel	Eastern Ontario	Ontario
1998	105,784	61,484	69,145	697,309	2,515,573
1999	111,313	63,702	71,886	712,022	2,525,831
2000	111,825	62,728	71,697	696,443	2,490,951
2001	111,849	62,978	72,597	702,589	2,539,223
2002	110,076	59,846	72,175	689,622	2,539,562

Source: Ontario Ministry of Agriculture and Food

Table 2.8 Harvested Area, Yield per Acre and Total Production of Hay for Eastern Ontario Counties, Eastern Ontario and Ontario

		Prescott and Russell United Counties	Stormont, Dundas and Glengarry Counties	Eastern Ontario Region	Ontario
1998	Harvested Area	63,5000	110,850	553,550	2,350,000
	Yield/Acre/Bushel	2.1	2.5	2.0	2.1
	Total production (000 Bu)	218	254	1,232	4,700
1999	Harvested Area	94,000	70,000	542,000	2,110,000
	Yield/Acre/Bushel	2.2	2.5	2.3	2.3
	Total production (000 Bu)	196	245	1,349	5,100
2000	Harvested Area	106,000	80,000	614,500	2,240,000
	Yield/Acre/Bushel	2.2	2.3	2.3	2.4
	Total production (000 Bu)	184	244	200	272.3
2001	Harvested Area	89,000	98,000	593,000	2,190,000
	Yield/Acre/Bushel	2.1	2.1	1.9	2.1
	Total production (000 Bu)	140	200	1,040	4,400
2002	Harvested Area	104,000	101,500	618,000	2,265,000
	Yield/Acre/Bushel	2.5	2.4	2.3	2.3
	Total production (000 Bu)	149.9	272.3	1261.6	5,250

Source: Ontario Ministry of Agriculture and Food

Hay Price ($/Tonne)

Region	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Eastern Ont. $	66	68	69	103	125	97	84	78	80	84
Ontario $	69	72	74	101	115	108	89	80	77	99

Source: Ontario Ministry of Agriculture and Food

Promoters from Quebec, where new hog farms are forbidden, intended to purchase 8 farms in Ontario (eventually 13) at an agricultural land price well above market prices. They purchased one farm in Cum[18]berland, East of Sarsfield with the intent of raising 2800 hogs. They were stopped by a municipal by-law, which limits the number of animals on hogfarms to 1090 (while

[18] "The divisional Court found that the farmers building permit was in order and that the city [of Ottawa] could no longer hold up construction of the hog – production operation" (*Ottawa Citizen, Sarsfield hog farm can go ahead, p. B1 and B7, Nov 26 2003).*

awaiting the implementation of the Nutrient Management Act; see section 2.5.4.3 *infra*). The permit was granted in mid-October 2002. However, the case in currently in the courts. The promoters also intended to purchase a property to raise 3000 hogs in Dalkeith, East of Hawkesbury but the permit request was turned down by the Municipality of North Glengarry.[19]

The Seaway Valley Farmers Energies Cooperative Intends to build and operate an ethanol production facility in Cornwall. The administrative complex of the project is already built.[20] The project, if successful will process approximately 6.6 million bushels of corn per year into 66 million litres of ethanol for use in fuel application. This will have impact on the corn production in the region and on agricultural pollution. As corn is a fertilizer-intensive crop, it will increase water quality concerns in the region.

2.4 Partners[21]

Originally, our project had two partners, to whom a third, non-existent at the beginning of the study, was added on.

2.4.1 The Federation of Canadian Municipalities (FCM)

FCM regroups over one thousand municipalities across Canada. It has been very proactive in the area of climate change mitigation and has suggested the theme of adaptation to the University of Ottawa research team.

In Canada, the transition to sustainability (including the adaptation to climate change) is a process managed mainly by municipalities and other structures of local government and sometimes supported by the federal government (http://kn.fcm.ca). One of the most important FCM initiatives to increase sustainable communities' capacity and to encourage community initiatives in the context of climate change mitigation is Partners for Climate Protection (PCP). PCP is a partnership between the Federation of Canadian Municipalities (FCM) and the International Council for Local Environmental Initiatives (ICLEI), and is supported by the Government of Canada. Its central objective is to support community sustainable development across Canada (National Climate Change Process 2000: 24; http://www.fcm.ca/scep/support/PCP/pcp_index.htm). PCP helps municipal governments prepare and implement local climate action plans and its ultimate goal is to support municipalities in reducing greenhouse gas emission from municipal operations by a suggested 20 percent below 1994 levels, and in reducing community-wide greenhouse emission by a suggested six percent below 1994 levels within ten years of joining the program. However, municipalities are expected to adopt targets that are realistic for their communities. FCM Local

[19] http://www.canaanconnexion.ca/hogfarm.shtml
http://www.agrinewsinteractive.com/fullstory.htm?ArticleID=5302&ShowSection=Front%
http://www.orleansonline.ca/pages/archive41.htm
http://www.orleansonline.ca/pages/archive31.htm
[20] www.glen-net.ca/ethanol/highlite.html and the Standard Freeholder, Jan 04, 2004.
[21] This section was contributed by P. Crabbé.

Action Plan (LAP) focuses on both goals – its objective is to encourage and to motivate community residents to take action to reduce greenhouse gas emission as well as municipal government to reduce emissions from municipal operations (FCM, Local Action Plans, 2002; http://www.fcm.ca/scep/case_studies/action_plans/action_plan_index.htm).[22] (Crabbé *et al.*, 2002)

FCM undertook a "Municipal Infrastructure Risk Project: Adapting to Climate Change" whose overall goal was "to raise awareness among municipal governments of the potential impacts of climate change, the risks to municipal infrastructure, and the adaptation strategies needed to respond to these risks". It intended to identify, through case-studies, changes needed to regulations, by-laws and legislation to adapt municipal infrastructure to specific climate change impacts, and to communicate results. The six case-studies were related to sea level rise (Charlottetown, PEI), drought and water Availability (Swift Current, Sask), hydrological change (S, D & G and P & R; this CURA project), flood response and landslide (La Baie, Qc), permafrost change (Norman Wells, NWT), and forest fires (Hinton, Ab). Lack of funding prevented FCM from completing the study in its entirety. However, this study and the one for Charlottetown are still ongoing.

2.4.2 The St. Lawrence River Institute of Environmental Sciences (SLRIES)

SLRIES was established in 1996 as an incorporated, not-for-profit, charitable organization based in Cornwall and dedicated to environmental research and education on large river ecosystems. It has its roots in the St. Lawrence Remedial Action Plan. It serves as a common ground where communities (environmental, industrial, scientific, educational, Canadian, Mohawk, and American) exercise together their responsibility to a great river for the benefit of the communities which live around it. The chair of its board sits on various environmental committees. (SLRIES, http://www.riverinstitute.com)

2.4.3 The Eastern Ontario Water Resources Committee (EOWRC)

As indicated above, EOWRC is the successor committee to EOWRMS, responsible to implement the latter's recommendations (CH2M HILL, 2001). EOWRMS was established in 1998. The study partners were the federal Agriculture and Agri-Food Canada department (provider of the Geographic Information System data), the Ontario Ministry of the Environment (MOE; the major funder of the study), and the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA), South Nation Conservation (SNC), and the Raisin Region Conservation Authority (RRCA), which both contributed financially and in-kind (project management and staff), the United-Counties of Prescott and Russell(P & R), and of Stormont, Dundas and Glengarry (S, D & G), and the City of Ottawa (CH2M HILL, 2001, p. 1-1), which contributed financially, EOWRMS's mission was:

[22] FCM's Green Municipal Enabling Fund and Green Municipal Investment Fund have been funding climate change mitigation and other environmental projects. None of these projects have climate change adaptation as a primary objective.

"Working with Eastern Ontarians to develop a common understanding of regional resource issues [*water and related land resources*], and a strategy to use comprehensive information and analysis to manage these resources for sustainable development" (CH2M HILL, 2001, p. 1-2). More specifically, it was to gather information to ensure a safe drinking water supply on a regional scale on a cost effective basis.

2.5 Legal Framework

2.5.1 The Current Ontario Municipal Framework[23]

2.5.1.1 The New 'Business Model' for Municipalities

In Ontario, the municipal world has been completely transformed since 1995. The number of municipalities has been drastically reduced through voluntary or forced amalgamation; their management has been made more flexible, transparent and accountable; their responsibilities have been increased through the downloading of some provincial responsibilities in exchange for the Province assuming the cost of elementary and secondary education. Ontario drastically reduced the number and powers of local school boards and removed their taxation power entirely. To fund its newly assumed education funding responsibility, the Province imposed a province-wide uniform tax on residential property, amounting initially to about ½ of the total residential property tax; the contribution to the funding of education from commercial and industrial properties is determined differently. The province has phased out a number of municipal grants such as for public transit. "It has been impossible to find a solid rationale for the transfer of these new funding responsibilities to the municipal sector. The transfer process appears to have been driven solely by the provincial desire to make its assumption of additional school funding revenue-neutral" (Kitchen, 2003, p. 31). The revenue neutrality of the transferred responsibilities was expected to be shored up by increased cost-effectiveness of municipal services through amalgamation. Note that the province reserves to itself the setting of the standards for the provision of the downloaded services (Kitchen, 2003). While the Ontario government has tried to maintain revenue neutrality, that objective has clearly not been achieved for many municipalities (Tindal *et al*., 2000, p. 16). Furthermore, the fiscal neutrality objective has impaired disentanglement (decentralization) initiatives and brought forth more entanglement (confusion!) because of some shifted functions that are unsuited to the local level. Actually, a clear principle for disentanglement was put forward by the 1992 Report of the Nova Scotia Task Force on Local Government. It says: "Property services [e.g. police and roads] should be supported by property taxes and delivered by municipal government. People services [e.g. welfare assistance] are the responsibility of the provincial government and should be financed by general provincial revenues. Both orders of government should continue efforts to reallocate the delivery and financing of services recognizing this basic principle" (quoted in Tindal *et al.*, 2000, p.214).[24] The Ontario government has downloaded responsibilities, which are beyond the capability of the municipal system (Tindal *et al*., 2000). The government also

[23] This section was contributed by P. Crabbé and M. Ait-Ouyahia.
[24] Disentanglement is extensively discussed in Tindal *et al*., 2000, c.8.

embarked on a very aggressive campaign to force amalgamations, with the intention of creating large enough units to be able to handle this download (Tindal *et al*., 2000, p. 224).

"The changes affecting local governments are part of a larger pattern of developments affecting all levels of government which in turn, are being driven by international economic forces. The most pronounced manifestation of these changes is a diminished role for governments - all governments - and a enhanced role for the market place and for private and individual decision making" (Tindal *et al.*, 2000, p. 1). The increasing independance (more responsabilities and less provincial transfer payments) drives municipalities to behave more in a business-like fashion. However, not all municipal functions are geared around services (Tindal *et al*.,2000). Municipal functions consist in delivering local public goods as well. Municipalities must not neglect their political role. "They must find the means to blend the best and most suitable of the business tools and techniques with enhanced democratic principles and practices" (Tindal *et al.*, 2000, p. 23). The attention and energy devoted to amalgamations should be used to improve the processes followed by municipalities (Tindal *et al*.., 2000). Municipalities must find ways of managing costs instead of cutting expenditure, i.e. reducing costs without decreasing or even getting better service standards. Many cost management programs give incentives to municipal staff to get more involved in cost saving. However, these programs require a good relation between members of council and staff, a staff used to work in teams even through the different functions and levels within the municipality; they also require substantial cost accounting data. Municipalities can also find new ways to increase revenues. Moreover, "the traditional model of the municipality as a self-sufficient provider of all services needed by its residents is giving way to a new model of the municipality as service arranger, as an enabling authority which draws upon resources from varied sources and stresses collaboration and joint ventures" (Tindal *et al*., 2000, p. 195). These developments press municipalities to redesign their organizational structures.

These new structures that are being developed, called "new business model" or "new public management" put a great emphasis on performance and accountability. However, if efficiency measures are given priority over community concerns, short-sighted decisions will be taken. "Municipalities exist to serve. That means taking into account the views and concerns of all citizens, not just propertied or business interests. It means being efficient where possible, but also being prepared to provide services or programs which aren't necessarily cost-effective, if they are needed to address a public need. It means being mindful to the bottom line but also dedicated to the public interest" (Tindal *et al*., 2000, p. 372).

One in every nine dollars of government spending in Canada originates in municipalities; more than 80 % of the Canadian population resides in municipalities and counties (FCM, 2001b). Yet the responsibilities and authority of local governments continue to resemble in major respects the framework established for Ontario communities by the 1849 Baldwin Act. Municipal governments are created through provincial statute and may take responsibility for only those areas of activity the province wishes to grant them explicitly.[25] Section 92(8) of the Constitution Act, 1867 gives the provinces exclusive control over municipal institutions (FCM, 2001b). Although the new 2001 Ontario Municipal Act, which came into effect on January 1, 2003,

[25] Judicial decisions, notably the important Supreme Court of Canada decision in *Hudson v. Spraytech* have, in recent years, accepted a more liberal or generous interpretation of certain municipal powers.

recognizes municipalities as "responsible and accountable governments" (s.2) with authority to protect municipal assets, and confers on municipalities "capacity, rights, powers and privileges of a natural person" (s. 8) in ten spheres of jurisdiction "to be interpreted broadly" (s. 9), these powers are constrained by myriads of regulations (Russell, 2003). Natural person powers mean "the same powers as a person has to conduct day-to-day business without specific legislative authority" (Kitchen, 2003). The new Ontario 'Municipal Act' updates the legislation in certain areas and codifies practices that had developed over the years. A large volume of professional literature has subsequently appeared to identify particular changes and developments (Auerback *et al*., 2003; Mascarin *et al*., 2003). "Rather than deregulating the municipal governments, the draft legislation [for the 2001 Municipal Act] further enhances the command of the province over the municipalities" (FCM, 2001b, p.3). The Association of Municipalities of Ontario (AMO) estimates that 150 pieces of legislation govern municipalities in the province in addition to the Municipal Act (FCM, 2001b). "While a number of these were incorporated into the 2001 Municipal Act, the operations of local governments remain subject to important decisions made in the provincial context in connection with planning, environmental assessment or waste management legislation" (Tindal et al., 2000, p. 48). The 'Municipal Act 2001', that came into force in January 1, 2003, also states that "The Province of Ontario endorses the principle of ongoing consultation between the Province and municipalities in relation to matters of mutual interest" (quoted in Tindal *et al*., 2000, p. 245). On December 19, 2001, a three-year Memorandum of Understanding between the Ministry of Municipal Affairs and Housing and AMO states that both parties are committed to cooperative efforts, prior consultation on legislation changes, information sharing and regular meetings. However, it is arduous for AMO to act as one voice because of the wide variety of municipal circumstances in Ontario, especially because of the heavy representation of small and rural municipalities in AMO. This situation "maintains an arrangement in which the Ontario government can claim that it consults with municipalities, while also knowing that the municipal input to this consultation is inherently constrained " (Tindal *et al.* , 2000. p. 245).

Whether the new Municipal Act entails the expansion or restriction of municipal powers remains to be seen. However, the new Act is intended to be more understandable, better organized, more flexible, less prescriptive, and more comprehensive than its predecessor (Kitchen, 2003). One of the objectives of the 'Municipal Act 2001' was to improve municipal flexibility and local autonomy so that municipalities could suitably deal with and react to local economic, environmental and social issues in their communities without having to find, first, the authority to act in an existing regulation. The natural person powers are essentially powers of business corporations. Municipalities can hire employees, enter into contracts, provide and charge for good and services, purchase land, dispose of assets, etc. However, these powers can only be used within the spheres of jurisdiction (s. 11) or under a specific power to be described below.

2.5.1.2 Upper-Tier and Lower - Tier Municipalities

Intermittent reorganization of local governments into regional or related configurations have occurred from time to time in Ontario history, often in conjunction with efforts to enhance planning capacity or to achieve potential economic efficiencies. Ontario has currently three systems of municipal government: a two-tier county system, a two-tier regional system, and a

single-tier system. Though the three forms of government occur in southern Ontario, only the two-tier county system and the single–tier system matter for Eastern Ontario. After the 1995 Ontario elections, the new provincial government initiated a series of municipal amalgamations and annexations, which reduced the number of Ontario municipalities by nearly half. Ontario has 22 counties (2 in the study area: the United-Counties of Prescott and Russell (P & R), and the United-Counties of Stormont, Dundas and Glengarry (S, D & G), 8 regions (none in the area) and 417 cities (3 in our study area: Clarence-Rockland, Cornwall, and Ottawa), towns (1, Hawkesbury), villages (1, Casselman) and townships (6 in S, D & G and 4 in P & R). The Municipality of the Nation and townships (rural lower tier municipalities) are regrouped into counties (upper tier municipality). The Upper Tier or County Council itself is composed of the elected Mayors (sometimes called Reeves) of the townships or lower-tier municipalities within county boundaries (Aurelson *et al*., 2002). Cities that chose not to be part of the county system are single-tiered municipalities. They are responsible for all municipal services. This is the case of Cornwall. Lower-tier municipalities are responsible, through grand-fathering, for most municipal services. When the provincial government downloaded some of its responsibilities on municipalities, such as social housing, workfare, public health, land ambulances, provincial roads, etc., it transferred corresponding funding responsibilities (50 % in case of land ambulances) to counties. Moreover, in order to benefit from economies of scale, municipal services traditionally provided by lower-tier municipalities were transferred to counties. These include: roads, police, some emergency services, and solid waste management. The split of financial revenue between counties and lower-tier municipalities is roughly even. Amalgamation among lower-tier municipalities was voluntary in the region and benefited from a one-time provincial grant to cover the cost of the process; amalgamation was imposed on the new city of Ottawa (Kitchen, 2003). The participation of local government representatives in the work of Conservation Authorities (CAs) is also of direct relevance to certain aspects of this report, notably opportunities for watershed management initiatives in response to Climate Change (see *infra*).

2.5.1.3 Spheres of Jurisdiction and Municipal Powers

Municipal governments are generally responsible for the basic local infrastructure services according to the 10 spheres of jurisdiction identified by the new Municipal Act, which include the municipal powers that existed on December 31, 2002 (Russell, 2003). These are: highways; parking (except on highways); transportation systems; waste management; public utilities (includes drinking water and wastewater services); culture, parks, recreation and heritage; drainage and flood control, excluding storm sewers; structures (e.g. bridges, culverts), including fences and signs; animals; economic development services. In addition to these ten spheres, specific powers (more restricted than the spheres and more traditionally prescriptive) are granted to municipalities in seven pertinent areas: health, safety, smoking, pits and quarries, and public nuisance; natural environment (tree by-laws, site alterations); retail business; licensing as related to health and safety, nuisance control, and consumer protection; two-unit houses; trailer and trailer camps; sale of land. These powers are restricted because they are considered as overlapping with provincial jurisdiction and, therefore, leading possibly to over-regulation. The requirement of public notices for new by-laws within the ten spheres and the areas of specific

powers is significant in terms of citizens' participation (Russell, 2003). Allocation on infrastructures to spheres of jurisdiction and municipal powers is listed below:

1) Natural Infrastructure:
   - Some forests
   - River banks
   - Trees
   - Site alterations
   - Animals

2) Built Infrastructure:
   - Highways
     - County roads (built for interregional traffic)
     - Municipal roads (built for lighter intra-regional traffic0
     - Including transferred provincial roads
   - Transportation systems
   - Parking except on highways
   - Airports, marinas and docks
   - Structures:
     - Dams and weirs for flood control,
     - Drainage (excluding storm sewers), culverts
     - Bridges,
     - Fences and signals
   - Landfill sites for solid waste
   - Pits and quaries
   - Public utilities including water and wastewater treatment facilities and lagoons [26]
   - Multipurpose paths, trails, and sidewalks
   - Culture, parcs, heritage, and recreation including playing fields, trails, community centres
   - GIS
   - Emergency Plan Infrastructure (firestations, land ambulances)
   - Two-unit houses, trailer and trailer camps, social housing
   - Sale of land: land use controls and enforcement, zoning regulations, building codes, including building densities and height limits, and infrastructure standards, retrofitting existing structures

3) Human and Social Infrastructure
   - Health and safety
   - Essential and emergency services (fire, medical)
   - Consumer protection

[26] Since November 2000, under the electricity deregulation legislation, the city of Cornwall has sold its electric utility to a private company. The city was able to use the proceeds of the sale in any which way it saw fit. The private company operates completely independently of Council. The company's rate increases must be approved by the Ontario Energy Board (Kitchen, 2003).

- Nuisance (e.g. odor)
- Social services (child care, social housing, health programs related to prevention, land ambulances)
- Capacity building
- Early warning systems to improve preparedness
- Public education and information, e. g. through social marketing

2.5.1.4 Report on Municipalities Performance

Ontario is the first province in Canada to require, as of 2001, a report to taxpayers on municipalities' performance in service delivery each year by June of the following year. Performance indicators require measures of unit cost and of output. This is to allow benchmarking for the purpose of managerial accountability, staff productivity improvement, assessing technical efficiency (minimize inputs for a given output) and effectiveness (extent to which an activity contributes to the achievement of a goal e.g. citizens' satisfaction) of service and provide for more realistic budgets. Initially, the government program consists of broad measures in eight municipal service areas: garbage, sewage, water, police, transportation and land use planning. Examples of indicators for sewage are: operating costs for sewage and stormwater per km. of sewer lines, operating costs for treatment and disposal of sewage and stormwater per cubic meter treated, number of sewer-main backups per km. of sewer line, test results for sewer operations, number of hours when untreated or partially treated human sewage was released into a lake or natural water course. Examples of indicators for water are: operating costs for water treatment per million litres of water treated, operating costs for water distribution per km. distribution pipe, percentage of water produced which is not billed, test results for water treatment plants and distributions systems, number of breaks in water mains per km. of water pipe, number of days when a boil water advisory issued by the medical officer of health and applicable to municipal water supply was in effect. An example for land use planning might be percentage of agricultural land preserved (Kitchen, 2003).

The fiscal framework within which municipal governments operate is, however, tightly controlled. The authority to spend and to raise revenues derives from provincial legislation and regulation. More and more municipal governments are facing increasing costs and dwindling revenues, triggered by: the offloading of provincial responsibilities, rapid growth, shrinking inter-governmental transfers, regulated caps on tax increases and heightened expectations from their citizens (Aurelson *et al*., 2003; Alam *et al*., 2002).

Despite the importance of federal government decisions for municipal operations, the federal government rarely interacts directly with municipalities and its involvement is not always welcome. "In almost every case, however, the federal programs were introduced without regard to their impact on the local level. Municipalities had no opportunity for advance consultation and little hope of obtaining adjustments after the fact" (Tindal *et al*., 2000, p. 227).

2.5.2 Federal Government Water Quality and Management Initiatives [27]

Without venturing too far into the Canadian constitutional labyrinth it is noteworthy that significant pieces of federal legislation have potentially important applications in relation to water management decision-making at the local level. Although it has never been utilized to its potential, the *Canada Water Act* establishes a wide range of possible actions in relation to water management. An agreement dating from 1983 and involving Canada, Ontario and Quebec respecting Ottawa River Basin Regulation is of most immediate relevance to the study area. Data collection and modeling research carried out under the supervision of the Ottawa River Regulation Planning Board is credited with mitigating the potential impact of spring flooding in 1999.

Statutes intended to provide for environmental assessment in connection with certain designated federal interests or to ensure some measure of protection for endangered species are other prominent examples of relevant federal legislation, as is the *Canadian Environmental Protection Act, 1999 (CEPA).* The possibility that road salt might be regulated as a toxic substance or otherwise controlled under CEPA has obvious implications for local government operations affecting winter transportation. Provisions of the federal *Fisheries Act* are also of direct relevance.

Further with regard to water quality, Walkerton and North Battleford inspired the federal government to re-state its interest in such questions in the Speech from the Throne to open the 37th Parliament of Canada in 2001:

> "The Government will also lead in developing stronger national guidelines for water quality by enhancing scientific research and continuing its collaboration with partners. Drawing on expertise within the Government and from across Canada, it will significantly strengthen the role of the National Water Research Institute."

Federal ventures into water quality, including drinking water, have not, however, proven particularly fruitful, as we have recently seen two unsuccessful federal attempts to enact a Safe Drinking Water Materials Act. The first of these, Bill C-76 died on the order paper when the June 1997 election was called. When re-introduced as Bill C-14, it was described as follows:

> "This enactment provides for the certification and regulation of drinking water materials. It sets out the procedures governing the appointment of persons authorised to certify those materials, allows for the adoption of standards necessary for their certification, creates offences relating to the manufacture, importation or sale of those materials and provides for measures to protect the public against those materials if they pose a risk to human health."

Bill C-14 met the same fate as its predecessor. A current Health Canada initiative calls for amendments to federal regulations on bottled water, where there is a great deal of uncertainty affecting consumers (HC, 2002a).

[27] This section was contributed by J. Benidickson.

Although unsuccessful to date, the forgoing federal water quality measures are at least understood to be constitutionally viable, in contrast with a private bill introduced to the Senate in February 2001, which proposed that "water from a community system for human consumption" would be included within the definition of food for purposes of regulation under the federal *Food and Drugs Act*. This measure, though subject to considerable constitutional uncertainty when put forward, at least illustrates that a potential for very significant federal involvement in municipal water supply systems has been contemplated.

In terms of municipal preferences, however, it would appear that federal financial contributions rather than legislative intervention are the priority. There is a very substantial shortfall between the federal government's current infrastructure funding commitment of $ 2.65 billion for the 2000-2006 period and an estimated municipal requirement for some $ 50 billion for water facilities and wastewater treatment over the next decade. If some portion of the shortfall can fairly be described as part of a climate change adaptation strategy that will actually help to reduce long - term costs, the supporting arguments may be stronger than in the case of expenditures attributable exclusively to neglected housekeeping.

The availability of federal financing is also relevant on the disaster relief side, where costly experience with the Red River flood of 1997 ($815 million) and the Saguenay flood of 1996 ($1.6 billion) stimulated federal interest in measures that could alleviate taxpayer expenditures in the event of future similar catastrophes. Follow-up work released earlier this year by the federal Office of Critical Infrastructure Protection recommends consideration of several significant options, including, for example, the introduction of user-pay fees for those occupying areas at risk from flooding.

The federal legal context involves one further set of considerations, which may come to influence governmental responses to climate change impacts on water management. New norms or environmental values including bio-diversity, precaution, prevention, sustainability, and ecosystem management have appeared in federal legislation during the past decade or so. The most recent of these, the Precautionary Principle, merits some discussion.

In 1990 a formulation of the precautionary principle was adopted in the Bergen Ministerial Declaration on Sustainable Development:

> "In order to achieve sustainable development, policies must be based on the precautionary principle. Environmental measures must anticipate, prevent and attack the causes of environmental degradation. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation."

This principle has already found its way before the Supreme Court of Canada in a legal decision discussed below. Variations of the precautionary principle are now found in certain pieces of Canadian legislation, notably the Canadian Environmental Protection Act (CEPA), and inter-departmental consideration of the operational implications of the concept are ongoing (Kumar *et al.*, 2000).

The principle has also begun to appear in the provincial context, in the Ontario Ministry of Environment's Statement of Environmental Values, for example, where it is formulated as follows:

> "The Ministry will exercise a precautionary approach in its decision-making. Especially when there is uncertainty about a risk presented by particular pollutants or classes of pollutants, the Ministry will exercise caution in favour of the environment."

In this context, as well, the practical and concrete significance of the precautionary principle is already subject to scrutiny and evaluation.

2.5.3 Provincial Government Water Management/Environmental Authority[28]

Approximately half a century ago, water supply and management arrangements in Ontario encountered a series of severe challenges. Certain areas of the province experienced extensive flooding associated with the 1956 Hurricane Hazel, while other regions were disturbed by the implications of drought-like conditions which had occurred intermittently over a number of years. Two major legal challenges profoundly altered the wastewater treatment side of things when a landowner named Annie Stevens and a farmer named Burgess obtained court injunctions against the existing sewage discharges of Richmond Hill and Woodstock, respectively. About two hundred Ontario communities faced very similar legal consequences (Benidickson, 2000).

Intense concern at the provincial level led to the creation in 1956 of the Ontario Water Resources Commission. The modern foundations of Ontario's water management arrangements were subsequently elaborated within the context of the *Ontario Water Resources Act*. This legislation, pre-dating other environmental measures such as the *Environmental Protection Act* and the *Environmental Assessment Act*, has recently been prominent again in the context of a series of reforms to provincial water management arrangements.

In the past five years, Ontario has experienced more changes to the regulatory framework for water management than at any time since the formative crises of the 1950s. Many of these developments have significant implications for local government thinking about climate change.

A number of examples illustrate this phenomenon.

1) A proposal by the Nova Group from Sault Ste. Marie to export water in bulk from the Great Lakes generated a public controversy that led to new regulation governing Permit - to - Take - Water decisions (OWRA s. 34).

2) In the immediate aftermath of the Walkerton tragedy, drinking water quality objectives were transformed into legally enforceable standards by means of regulation.

[28] This section was contributed by J. Benidickson.

3) Ongoing revisions to the Municipal Act culminated in new legislation now being implemented.

4) Implementation of recommendations flowing from the report of Mr. Justice Dennis O'Connor who headed up the Walkerton Inquiry continues. Highlights of that process include nutrient management legislation[29] and legislation enacting new measures to ensure the safety of drinking water systems [30] in the province.

5) Outside the regulatory and legislative framework, we have seen increasing interest on the part of citizens and community groups and NGOs in water quality and management questions. Many Eastern Ontario residents will be familiar with litigation involving the city of Kingston initiated by the Sierra Legal Defense Fund on behalf of an interested citizen. Other related examples of this development include the establishment of the Lake Ontario River Keeper Association and a new Ottawa Riverkeeper, both modeled on the Riverkeeper network previously developed in the United-States.

6) The authority of local governments to act in environmental matters was under consideration by the Supreme Court of Canada, where in the decision in *Hudson v. Spraytech,* some recognition was given to the precautionary principle as formulated in the Bergen Convention. Without determining the status of the principle in Canada, Justice L'Heureux Dube noted that the pesticide by-law under scrutiny in the case "respects" this principle of international law, adding that "in the context of the precautionary principle's tenets, the Town's concerns about pesticides fit well under the rubric of preventive action." The Hudson decision, and another judgment the previous year in a case known as *Racal Trucking* are understood to have enhanced the status and autonomy of municipal governments in implementing the mandates conferred upon them under provincial legislation. In *Racal Trucking*, Justice Major of the Supreme Court stated that:

> "Courts must respect the responsibility of elected municipal bodies to serve the people who elected them and exercise caution to avoid substituting their views of what is best for the citizens for those of municipal councils."

7) The Supreme Court's methodology in considering the existence of the precautionary principle in international law and the possible applicability of the concept in the Canadian context has been the subject of considerable criticism (Van Ert, 2001). It is noteworthy nonetheless, that, in various forms, the precautionary principle is either being implemented or considered for implementation in Canada (Abouchar, 2001). In so far as this process, however tentative and uncertain, reflects a shift in underlying public and official attitudes towards environmental protection, it is a potential influence of great significance on water management decisions.

The legal environment is therefore surprisingly dynamic. Although immediate attention has naturally focused on specific obligations incorporated in recent enactments and with the financial

[29] Nutrient Management Act, 2002, S.O. 2002 c.4
[30] Safe Drinking Water Act, 2002, R.S.O. c. C-32

implications of those measures, there are opportunities for municipalities now seeking to secure the well - being of their inhabitants against the prospect of water - related challenges associated with climate change.

The Walkerton Inquiry, which followed the Walkertown *E. coli* contamination of May 2000, has had a profound influence on water management in Ontario. Even before the completion of the O'Connor Report, steps were taken to place aspects of existing water quality guidelines and testing on a regulatory footing. Subsequent to the report, a number of its recommendations were implemented by means of the Safe Drinking Water Act. Follow-up work carried out by an Advisory Committee on Watershed - Based Source Protection Planning (Government of Ontario, 2003) has furthered a discussion, inspired by the Walkerton incident, of watershed based initiatives to enhance source protection. This discussion has helped to focus attention on the allocation of responsibilities between local governments, CAs and provincial officials. The watershed focus and the role of municipalities within that framework is also central to Nutrient Management legislation, which was enacted after a period of development in the aftermath of concern that the Walkerton tragedy was in part a consequence of adverse agricultural practices on the water supply.

In addition to legislative activity affecting municipal authority in ways relevant to the challenge of adapting to Climate Change, policy initiatives have occurred. Two principal strategies might be contemplated. One addresses the availability of responsive measures that could be taken in the event that extreme weather events do indeed produce disruption, possibly amounting to an "emergency."[31] The alternative strategy seeks to identify and to implement more systematic measures, especially in the nature of planning and conservation, that could reduce the potential for disruption and limit the degree of local vulnerability to the impacts of climate change.

2.5.3.1 The Provincial Drought Management Framework

Other researchers have assembled and analysed historic data or have made projections concerning the water supply implications of climate change in the region and the province more generally.[32] The possibility of shortages in some of these projections establishes a basic context within which public officials will wish to develop and implement response programs. This is precisely the scenario that stimulated the creation of the Provincial Low Water Level Response Task Force in May 1999. The newspaper headlines that month stated "Ontario faces water rationing" or "Lakes drop, fires rage with record low rainfall"[33] The Ontario Low Water

[31] Provincial legislation defines "emergency" as a situation or an impending situation caused by the forces of nature, an accident, an intentional act or otherwise that constitutes a danger of major proportions to life or property. Pursuant to existing legislation, local governments are already expected to formulate emergency management programs and emergency plans, including consideration of facilities and infrastructure at risk in the event of an emergency.

[30] See Walkerton II, 8

[31] *Globe and Mail* 20 May 1999; *Globe and Mail* 7 May 1999

Response Plan is an interdepartmental initiative following a period of lower than average precipitation in 1998 and 1999.
A low water response plan requires a definition or designation of low water conditions so that matter was addressed in the report of the Task Force. Citing the relevance of individual perceptions in the context of drought, the report set out elements or characteristics of a definition of low water conditions:

a. below normal precipitation for an extended period of time (3 months or more), potentially combined with high rates of evaporation that result in lower lake levels, streamflows or baseflow or reduced soil moisture or groundwater storage;
b. streamflows at the minimum required to sustain aquatic life while only meeting high priority demands for water, water wells becoming dry, surface water in storage allocated to maintain minimum streamflows, and
c. socio-economic effects occurring on individual properties and extending to larger areas of a watershed or beyond

It may be noted in passing how dependent the application of these provisions is on an adequate scientific foundation to support the use of such concepts as "normal precipitation" and minimum streamflow to sustain aquatic life. As climate change impacts affect these considerations, continuing developments will have to be factored into the operational understanding of the framework concepts.

The provincial plan also conceptualized three distinct levels of low water conditions:

- Level I -a potential water supply problem
- Level II -a potentially serious problem
- Level III -failure of the water supply system to meet demand, resulting in progressively more severe and widespread socio-economic conditions

Depending upon the level identified, emergency measures consistent with the *Emergency Management Act* (RSO 1990 c. E.9) are anticipated. These involve initiatives by various provincial ministries, CAs and municipal governments. Most of the relevant initiatives depend upon the classification of water use priorities according to three broad categories: essential, important, and non-essential.

The provincial low water response plan that appeared in May 2001[34] endeavors to distinguish provincial and municipal responsibilities this way:

> "The province provides overall direction and coordinates policies, science and information systems and emergency support. At the local jurisdiction, the emphasis is directed to collecting information, interpreting policy, delivering policy programs and responding to emergencies."

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[34] A more extensive description of these developments is set out in a research memorandum prepared by Michael O'Neil (2002).

It is unnecessary here to describe details of the low water response plan. The existence of the plan, however, serves to highlight the difference between responding to acute low water conditions and measures that could be implemented more gradually and progressively to prevent or forestall shortages in the first place.

Local responsibilities, carried out within the context of provincial direction and coordination, are expected to include program delivery and emergency response.

Level II droughts were experienced in the region in both 2001 and 2002.

2.5.4 Municipal Government Water Management Initiatives and Opportunities[35]

2.5.4.1 Water and Sewage Facilities

In 1998, Ontario municipalities owned and operated about two-thirds of the water and sewage facilities in the province (table 2.9). About one third was owned by the Ontario Clean Water Agency, which is a provincial crown agency created under the Ontario Water Resources Act (OCWA). In 1993, OCWA took over, responsibilities of the Ministry of Environment (MOE) and the Ontario Water Resources Commission (OWRC) for the operation, maintenance and management of water and wastewater facilities. The agency's Environmental Management System (EMS) is based on the international standard ISO 14001. In S, D & G, 9 facilities are municipality-owned and 5, OCWA-owned (personal communication).

Table 2.9 Operators of Water Distribution and Sewage Treatment Facilities in Ontario

(Numbers approximate -- March 1998)		
Operator	**Water treatment facilities**	**Sewage treatment facilities**
Ontario Clean Water Agency	123	234
Municipalities	519	209
Private Companies	15	11
TOTAL	657	454

Source: www.greenontario.org/strategy/water.html

With the introduction of the Water and Sewage Services Improvement Act, 1997, the provincial government encourages the municipalities to own all water and wastewater facilities so that they

[35] This section was contributed by M. Ait-Ouyahia and J. Benidickson.

can be fully responsible for local delivery of all water and sewage services. OCWA will transfer all provincial ownership to municipalities. However, to ensure a smooth transition period, OCWA continues the operation and maintenance of these works for the municipalities.

2.5.4.2 Drinking Water

In May 2002, Commissioner O'Connor drew up recommendations to ensure the safety of drinking water across Ontario in Part II of the Walkerton Inquiry Report. These recommendations had a great influence on the creation of the Safe Drinking Water Act, 2002 (SDWA), the Sustainable Water and Sewage Systems Act, 2002 (SWSSA), and the Nutrient Management Act, 2002 (MNA).[36]

50 of the 93 recommendations made in the Walkerton Inquiry Report have legislative authority under SDWA. The Act widens the scope of existing policy and introduces new instruments to protect drinking water in the province. Two key components are the requirement of a municipal drinking-water license and a standard of care for municipal owners. Neither of these components are presently in effect. Statutory standards of care already exist in the Ontario Environmental Protection Act and the Ontario Water Resources Act. The SDWA establishes that each person who has oversight responsibilities for municipal drinking water systems must exercise 'a level of care, diligence and skill' and 'act honestly, competently and with integrity to ensure the protection and safety of users of municipal drinking water system'. Guidelines to assist municipal officials are being developed and the standard of care will come into force when the guidelines are in place.

Moreover, the new licensing regime is under development. In order to obtain a license, municipalities will be required to hold a:

1) Permit - To - Take - Water,

2) Drinking water works permit,

3) Operational plan approved by the Ministry of Environment (MOE),

4) Operating authority accredited by a Ministry-approved Drinking Water Quality Management Standard similar to ISO 14,000, which is under development (Commissioner O'Connor recommended that municipalities should have an accredited operating authority by 2006), and

5) Financial plan (under the Sustainable Water and Sewage Systems Act, 2002).

[36] For SDWA et SWSSA see:
http://www.ene.gov.on.ca/envision/gp/4478e.htm
http://www.e-laws.gov.on.ca/envision/news/2003/050501b.htm
http://www.ene.gov.on.ca/envision/water/fact1.htm
http://www.e-laws.gov.on.ca/dblaws/statutes/english/02s29_e.htm

In the meantime, all municipal drinking water systems are required to obtain an approval and a Permit - To - Take - Water from MOE. The previous regulation, which required that all municipal systems obtain a drinking water works permit from MOE, is still in force.

The new Drinking Water Systems Regulation (O. Reg. 170/03) replaces the Drinking Water Protection Regulation for Larger Waterworks (O. Reg 459/00) and the Drinking Water Protection Regulation for Smaller Waterworks Serving Designated Facilities (O. Reg. 505/01) that were enacted under The Ontario Water Resources Act. The SDWA includes also 8 supporting regulations. The new regulation establishes 8 categories of drinking water systems: 4 are municipal and 4 are non-municipal. Among the municipal drinking water systems, the new regulation includes a new category of smaller municipal systems serving less than 100 residences. Each category has specific requirements that must be met. One of them, which is to use a licensed and accredited laboratory for drinking water testing services, has been effective since October 1, 2003. The standards for water testing are still high as under the previous regulation, however the owners and operators of municipal drinking water systems must sample and test drinking water in a frequency designed to reflect the size of the population served and the needs of each of the eight categories. As with the previous regulation, owners and operators must report adverse test results to both the medical officer of health and MOE. The standards for water testing are listed in the first supporting regulation, the Ontario Drinking Water Quality Standards regulation (O. Reg. 169/03).

SWSSA is the responsibility of MOE; however its implementation includes collaboration with SuperBuild and the former Ontario Ministry of Municipal Affairs and Housing (OMMAH). The act provides the framework for both water and wastewater infrastructure funding. In Part Two Report of the Walkerton Inquiry, Commissioner O'Connor states:

"Over the long term, safety depends on stable and adequate financing to maintain the water system's infrastructure and its operational capacity to supply high-quality water consistently."

Therefore, under the SWSSA suppliers must account and report on the full cost of providing water and wastewater services and they must prepare and carry out plans for recovering the full cost to ensure that suitable financing is available for water and sewer infrastructure over the long term.

2.5.4.3 Nutrient Management

The Nutrient Management Act, 2002 implements some others of Justice O'Connor recommendations.[37] For exemple, recommendation 11 states:

"The Ministry of the Environment should take the lead role in regulating the potential impacts of farm activities on drinking water sources. The Ministry of Agriculture, Food and Rural Affairs

[37] For NMA: http://www.ene.gov.on.ca/envision/land/nutrient_management.htm

should provide technical support to the Ministry of the Environment and should continue to advise farmers about the protection of drinking water sources."

The Act is therefore the responsability of the Ministry of Environment and Energy (MOEE) and of the Ministry of Agriculture and Food (OMAF). It contains amendments to the Environmental Protection Act, the Highway Traffic Act, the Ontario Water Resources Act and the Pesticides Act. It also contains important amendments to the Farming and Food Production Protection Act. These amendments ensure coherence and give better recognition to the standards. The NMA implements a regulatory framework for nutrient management and other related farms practices in the province to protect the water and the environment in rural Ontario. The Act is accompanied by a 13-part regulation, which states standards, and four protocols, which gives more details.

"The nutrient management regulation and related protocols deal with these topics:

- Nutrient Management Strategy (NMS)
- Nutrient Management Plan (NMP)
- Short-Form NMS/NMP
- Approvals
- Land Application
- Outdoor Confinement Areas
- Siting and Construction Standards
- Sampling, Analysis and Quality of Nutrients
- Training and Licensing
- Role of Local Advisory Committees." (OMAF)

New livestock farm, superior or equal to 5 Nutrient Units[38] (NU) or large live stock farm, superior or equal to 300 NU, have to develop a Nutrient Management Strategy (NMS) and/or a Nutrient Management Plan (NMP). The motivation behind the latter, is to find a good equilibrium between maximum nutrient uptake by crops and minimal environmental impact. NMS describes how operators of livestock farm are managing materials. The regulation has been in effect since September 30, 2003, except for already existing large livestock farms, which have until July 1, 2005 to meet the requirements of the new legislation. Other types of farms will not be covered by the regulation before 2008. The NMS and the NMP must be approved by OMAF. However, new livestock farms that are worth less than 150 NU do not require provincial approval, unless they use non-agricultural source materials. (see table 2.10)

[38]A nutrient unit is the amount of manure that gives the fertilizer replacement value of the lower of 43 kg (95 lbs.) of nitrogen or 55 kg (121 lbs.) of phosphate. Tables 3.2.1 and 3.2.3 in the Nutrient Management Protocol (June 30, 2003) contain the data one will need to determine the number of NU one is managing (OMAF).

Table 2.10 Municipal and Provincial Areas of Jurisdiction for Farms Applying Agricultural Source Prescribed Materials

<table>
<tr><th>New Livestock Farms</th><th>Expanding Livestock Farms</th></tr>
<tr><td rowspan="2">Provincially approved Nutrient Management Strategy/Plan required by Province if equal to or greater than 300 NU</td><td>Provincially approved Nutrient Management Strategy/Plan required by Province if equal to or greater than 300 NU</td></tr>
<tr><td>Municipal approval may be required under Nutrient Management Plan By-laws for farms of less than 300 NU</td></tr>
<tr><td>Nutrient Management Strategy/Plan required by Province if between 5 & 150 NU*</td><td rowspan="2">Nutrient Management Plan By-law generally exempt small operations from approvals</td></tr>
<tr><td>Nutrient Management Strategy/Plan not required if less than 5 NU</td></tr>
</table>

*"New" livestock operations which are smaller than 150 NU and which apply non-agricultural source materials to their farm units will be required to have provincial approval of their nutrient management plans

The table applies only to approvals required under the Nutrient Management Act and Municipal Nutrient Management By-laws.

All other applicable laws shall apply. Please refer to section 11 of the regulation for the phase-in requirements for agricultural operations (referred to in this document as "new" and "expanding")

Source: http://www.zorra.on.ca/nmaninfo.pdf

The Act will assist municipalities in their responsibilities for land use planning and building code approvals. Municipal nutrient management by-laws will be progressively replaced by new standards. In the meantime, the former coexist with the provincial regulation.

A Local Advisory Committee may allow people facing a problem to resolve it at the local level without having to call on the Province. However, a Provincial Advisory Committee, named by the province, will be in charge of the more difficult issues and of the implementation of the NMA. Municipalities may already have a local advisory committee or they are encouraged to form one by OMAF. "The new legislation enables local advisory committees to be involved in:

- mediation and conflict resolution
- nutrient management education, and
- consultation with the municipality." (OMAF)

Besides, a local advisory committee must consist of a majority of farmers and, at least, one non-farmer and one representative of the municipality.

Moreover, there is a lot of controversy about the NMA and its proposed regulations, especially concerning the hog industry. Since Quebec has a moratorium on new mega hog farms, Quebec

promoters try to expand their operations in Eastern Ontario. These large-scale hog farms are a real danger for the quality of drinking water and a threat to the family farm. The Citizens for the Environment and Future in Eastern Ontario (CEFEO), and the Christians Farmers Federation consider that the NMA has many defects. According to the CEFEO: "For one thing , the new legislation does not protect family farms and sometimes imposes measures that are too strict for them. At the same time, however, the legislation does not protect the health of the people of Ontario, because it does not provide adequate protection from the serious potential effects of intensive hog industries. Those industries must be dealt with separately; they need to be regulated as what they are - industries, not as what they are not - farms."[39] The Christian Farmers Federation lists seven failings of the NMA.[40] One of them is that the new legislation gives too little responsibilities to the municipalities. Another is that: "Ontario is too diverse for a one-size fits all approach."

2.5.4.4 Water Source Protection

To complete Justice O'Connor recommendations, a Water Source Protection Act will soon be introduced. The first Recommendation of the Report is:

> "Drinking water sources should be protected by developing watershed-based source protection plans. Source protection plans should be required for all watersheds in Ontario."

An Advisory Committee was designated in November 2002 to prepare a framework for source water protection. The report, which contains 55 recommendations, was ready in April 2003. The report 'Protecting Ontario's Drinking Water: Toward a Watershed-based Source Protection Planning Framework' has been posted for public review and comment.

Amendments to Ontario's *Municipal Act* and measures incorporated in the province's *Safe Drinking Water* legislation have understandably commanded the attention of local officials.[41] These legislative initiatives embody a number of concrete obligations and entail in some respects onerous and immediate financial implications. While local officials naturally feel constrained in these circumstances and may very well balk at the prospect of confronting longer term adaptation issues associated with global warming, there are a number of opportunities for measures to be taken that may be tailored at least in part to anticipated impacts. Some of these will entail collective municipal action and collaborative work with provincial agencies, while other more local and independent initiatives might be imagined. Several of the possibilities, including water rationing, planning and watershed management measures, demand management and more informal steps oriented around public education will be briefly outlined in section 11.4.

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[39] http://www.creekwebsite.org/NewsItems/year2003/news03035.htm
[40] http://www.creekwebsite.org/NewsItems/year2003/news03030.htm
[41] The latest legal references include Chipman, 2002; Auerback *et al*., 2003; Mascarin *et al*., 2003.

2.5.4.5 Conclusion[42]

Different legal instruments and different uses of those instruments are likely to be appropriate depending upon whether the climate change scenarios are in some way locally distinctive, in contrast to a situation in which the world, though different from historic norms, looks pretty much the same in Cornwall and in Kenora. In other words, the scenarios share the same hazards or characteristics for many communities. A locally distinctive scenario is more likely to place particular and special demands on local authority than a widespread scenario. In the latter case one imagines a greater willingness on the part of senior governments to implement - through legislation and financing - measures that would facilitate local adaptation since they will not be hearing simply "We need this" but instead "We all need this." In other words, to the extent that the risks and challenges of climate change are expected to be borne broadly, senior governments are more likely to facilitate legal and institutional changes on a comprehensive basis.

If municipal adaptation initiatives generate major spillovers, either positive or negative, even on a regional basis, then the Province should intervene, possibly, to set up some regional governing structure to internalize these spillovers or externalities. If on the other hand, impacts are expected to be more localized and random in nature, senior governments may be less willing to facilitate preventive and adaptive strategies and more inclined to rely on responsive or emergency measures. In local public finance, this is called the "disentanglement" problem. Invoking the principle of subsidiarity, all local issues should be steered by municipal governments, which are more attuned to local citizens' preferences, unless the services they require generate substantial spillovers or demand income redistribution. This is why social expenditures are typically a provincial responsibility (see Tindal *et al*., 2000 for alternative views). Steering does not imply necessarily service delivery. A social service may be more efficiently delivered at the local level, if economies of scale are not significant, because of better knowledge of particular circumstances and a more competitive environment for cost-effectiveness, even though policy-making should be done at the provincial level. If a province insists in setting standards for some local services, it should then produce the service. According to the benefits - received model of public finance, whoever benefits from the service pays for the service.

Climate adaptation is likely to generate spillovers, which may not extend to the province as a whole but may extend to portion of the Great-Lakes basin for example. Better water management in quantity and quality has a regional impact. Therefore, an organization like EOWRC should be extended to the United-Counties of Leeds and Grenville (South – Nation watershed), to the cities of Cornwall, Ottawa, the Rideau Valley watershed, and the Mississipi watershed. Under adaptation of water resources infrastructures, all those who directly benefit from adaptation should pay for the adaptation service. For some other adaptation benefits such as emergency services, it will be sometimes difficult to identify who benefits from the service; therefore, the service should be funded under municipal general revenue. Intermunicipal agreements are difficult to administer especially for public goods and lead to discontent when they are not limited to upper-tier municipalities (Kitchen, 2003). EOWRC may hold the key to lead us out of these difficulties (see Recommendation 18).

[42] This section was contributed by J. Benidickson and P. Crabbé

2.5.5 Emergency Plans[43]

Emergency Plans are a regional responsibility since the Emergency Readiness Act, December 2001. 7 municipalities of S, D & G and 8 in P & R will be integrated into a comprehensive plan at the regional level. Since April 15, 2003, under the Emergency Management Act, municipalities in Ontario are required to develop and implement an emergency management program for their communities. The emergency management program is prepared with the guidance and help of Emergency Management Ontario (EMO), which is under the jurisdiction of the Ministry of Public Safety and Security.[44] The four components of an emergency management program are: 'mitigation/prevention, preparedness, response, and recovery.'

According to Emergency Management Ontario:

> "Emergency management programs are divided into three levels: essential, enhanced and comprehensive. Each community must have, as a minimum, an emergency management program at the essential level. A community should then seek to progressively develop its program until the comprehensive level is reached. A comprehensive emergency management program is the best way to protect public safety and create disaster-resilient communities. A comprehensive community emergency management program also contributes to the protection of public health, the environment, property and economic stability."

Communities must complete the program at the essential level by December 2004; the enhanced program should be implemented for December 2005, and the comprehensive program by 2007.

To prepare a program at the essential level, first a community coordinator of emergency management must be named and a community committee of the emergency management program must be created. Each municipality has to identify and estimate the various hazards and risks to public safety that could give rise to emergencies. The municipality must also identify the facilities and other elements of the infrastructure that are at risk of being affected by emergencies. When all risks are identified an emergency plan must be formulated. The emergency plan must provide the necessary services during an emergency, the procedures and the manner in which employees of the municipality and other persons will respond to the emergency. Annual training programs and exercises must be conducted to evaluate the emergency management plan. Municipalities are also required to develop and carry out community program to raise public awareness. At the comprehensive level neighbouring communities must have mutual aid agreement.

There is here a good opportunity to include climate change related emergencies in the plan. The current regional plans are really frameworks that identify the roles and responsibilities of those

[43] This section was contributed by M. Ait-Ouyahia and M. Woodrow

[44] Personal communication with Daniel M. Holmes, Emergency Management Coordinator of Champlain and Alfred & Plantagenet and for EMO:
http://www.mpss.jus.gov.on.ca/english/pub_security/emo/backgrounders/bg_emanagement_02/10/2003

involved. The transition period is an opportunity to ensure that emergencies related to climate change are not only built into the plan but also into any accompanying regional information for householders. Section 9 of the new act provides standardized guidelines for the preparation of emergency plans across the province. The fourteen steps outlining how to prepare an emergency planning for community officials are listed below:[45]

Step 1: Form a Committee
Step 2: Identify the Risks
Step 3: Co-operate with Other Agencies
Step 4: Compile a Resource Directory
Step 5: Develop a Notification System
Step 6: Decide Who Does What
Step 7: Develop a Management and Control Structure
Step 8: Design a Communications System
Step 9: Integrate Plans Developed by Other Agencies
Step 10: Write the First Draft
Step 11: Test the First Draft
Step 12: Revise the Plan
Step 13: Have the Plan Approved by Council and Promulgated
Step 14: Tell the Public About It

Scoping Issues Concerning Risk Reduction to All hazards in Canadian Non-Urban Communities (Haque, 2000) commissioned by the Office of Critical Infrastructure Protection and Emergency Preparedness is a useful emergency-planning tool for rural area (Woodrow, 2002).

References

Abouchar, J. (2001) "Implementation of the Precautionary Principle in Canada," in T. O'Riordan, J. Cameron and A. Jordon, eds. *Reinterpreting the Precautionary Principle*, London: Cameron May, 235-267.

Alam, R. and P. Crabbé (2002), Local *Financing for Adaptation Measures to Climate Change*, Department of Economics, University of Ottawa, unpubl. Mnss.

Auerback, S. and A. James (2003), *The Annotated Municipal Act* , Carswell.

Aurelson, I., Burhoe, D.A., and R. D. Needham (2003), *Rural Municipalities and Climate Change Preparation: Bridging Mechanisms for Adaptation*, Department of Geography, University of Ottawa, unpubl. Mnss., March.

Benidickson, J. (2002) *Water Supply and Sewage Infrastructure in Ontario, 1880-1990s: Legal and Institutional Aspects of Public Health and Environmental History*, Issue Paper for the Walkerton Inquiry (Toronto)

[45] http://www.emergencymanagementontario.ca; http://www.elaws.gov.on.ca/DBLaws/Statutes/English/90e09_e.htm

Beshiri, R. (1999), How farmers weathered the ice storm '98' in *Canadian Agriculture at a Glance/ Un coup d'oeil sur l'agriculture canadienne*, Statistics Canada, Ottawa, December.

CH2M HILL (2001), *Final Report. Eastern Ontario Water Resources Management Study (EOWRMS): United Counties of Prescott & Russell, Stormont, Dundas, Glengarry, City of Ottawa.*

Chipman, J. (2002), *The Ontario Municipal Act: A Comprehensive Guide* (Canada Law Book);

Conservation Council of Ontario, http://www.greenontario.org/strategy/water.html

Crabbé, P. and C. Mioc (2002), *Canadian Communities and Climate Change Impacts and Adaptation*, October, Unpubl. Mnss.

Eastern Ontario Health Unit (EOHU)(2000), *Statistical Report on Health*, http://www.eohu.on.ca/index_english.htm

FCM (Federation of Canadian Municipalities) (2001b), *Early Warning: Will Canadian Cities Compete?*, Report prepared for the National Roundtable on the Environment and the Economy, May.

Fraser Institute (2001), *The Perfect Food in a Perfect Mess: The Cost of Milk in Canada*.

Haque, Emdad *and al.*, 2000, *Scoping Issues Concerning Risk Reduction to All hazards in Canadian Non-Urban Communities*, Final report, Emergency Preparedness Canada within the Canadian Framework for the International Decade for Natural Disaster Reduction, March 20.

Health Canada (HC) (2002) *Making It Clear, Renewing the Federal Regulations on Bottled Water: A Discussion Paper, August.*

Kitchen, H. (2003), *Municipal Revenue and Expenditure Issues in Canada*, Canadian Tax Foundation, n0 107.

Kumar, A., I. Burton, and D. Etkin (2000), *Managing Flood Hazard and Risk: Report of an Independent Expert Panel* (Canada. Office of Critical Infrastructure Protection, Research Report 2000: DO10) http://www.ocipep-bpiepc.gc.ca/research/scie_tech/disMit/Man_Fld_Haz/2000-D010_e.asp

Mascarin, J. and C. J. Williams (2003), *Ontario Municipal Act, 2001 and Commentary*, Butterworths.

Needham, R.D. (2002), *The Informed Opinion of Municipal Officials: Infrastructure Administration, Planning and Management in Eastern Ontario*, FCM, June 2001

O'Neil, M. (2002), *Adaptation Strategies/Response Options re Global Warming, unpubl. mnss.*

Russell, W.D.R., *Russell on Roads*, 2003 (forthcoming)

Tindall, C.R. and S.N.,Tindall (2000), *Local Government in Canada*, 5th ed., Nelson.

Van Ert, G. (2001) The Problems and Promise of Spraytech v Hudson, xxxix, *Canadian Yearbook of International Law*, 371-385.

Woodrow, M. (2002), *Climate Change and Health: A Local Perspective; Focusing on Eastern Ontario*, Unpubl. Mnss., Institute of the Environment, University of Ottawa, 2002.

Section 3 Projected Physical Impacts of Climate Change and Climate Scenarios

This study does not make climate projections for Eastern Ontario. The areal extent of the region under investigation is simply too small and regional climate models are still in their infancy. Global Climate Models (GCM) use grid size of roughly one degree square, i.e. a size more than twice the areal extent of the area of investigation. Even if the geographical area were larger, downscaling GCMs is fraught with problems. To circumvent these problems, we built local climate scenarios based on coupled temperatures and precipitation levels, which were recorded in the region over the last century; some of these scenarios were relatively rare but not unique. In the following two sections, we apply these scenarios, to some extent, to both water quantity and quality. Whenever these scenarios cannot be applied directly to the issue covered in the following sections, we rely on climate projections for the Great-Lakes Basin published in the literature. We first review this literature and then move on to the description of the scenarios selected.

3.1 Projected Physical Impacts of Climate Change as Related to Water Resources: a Literature Review[46]

There are three recent sources for climate change projections for the Great-Lakes Basin (UCS-ESA, 2003; USGCRP (Sousounis *et al.*), 2000; Environment Canada (GLSLB (Lavender *et al.*), 1998); see also Bruce, 2002 for the Canadian model CGCM1). These sources all note that recent annual average temperatures are growing warmer than the long-run trend, that winters are getting shorter (by about one week since the 1900s), and that heavy rainstorms are becoming more common in the Basin. The growing season starts earlier (beginning of April) since the 1960's and ends later since the 1980's (end of October).

Projections for the Great-Lakes Basin (about 1 million square kilometers), including the area of investigation (about 5,000 square kilometers), are based on downscaling Global Circulation Models (GCM), including the Canadian models (CGCM1 and CGCM2) that have "predicted reasonably well the changes that have occurred over Canada to date" (Bruce, 2002, p. 5).[47] The word "projection" is used intentionally instead of the word "prediction" because GCM's are simulation models based on physical laws applying at the planetary scale rather than statistical models based on past data.[48] Data is simply used to validate the simulation model. Climate projections are Greenhouse Gas (GHG) emissions scenario-dependent. GHG scenarios are hypothetical constructions involving plausible future demographic, economic and political planetary situations, which result in a certain amount of GHG emissions, and are agreed upon internationally (IPCC, 2000).

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[46] This section was contributed by P. Crabbé.

[47] The other GCMs are the United Kingdom Hadley Models (HadCM2 and HadCM3) and the US National Center of Atmospheric Research Parallel Climate Model (PCM). The quote applies to CGCM1. Both the CGCM1 and the HadCM3 recreate the current conditions well but indicate "slightly different" impacts (USGCRP, 2000, p. 19). UCS *et al*. uses PCM and HadCM3. Generally, the three sources agree qualitatively; this is why UCS *et al*., being the more recent assessment, is given in this section more weight for the quantitative projections.

[48] For a good primer on GCMs, see www.cics.uvic.ca and Harvey, 2000

Downscaling GCM projections from the planetary level to the regional scale is a difficult and, by no means, precise exercise. Moreover, climate variability and uncertainty increase as the area under consideration grows smaller (UCS-ESA, 2003). While there is a reasonable degree of qualitative agreement among the different GCMs, temperatures and precipitations projected to a specific year do not necessarily correspond because of the specific features of each of the models. Therefore, a combination of some GCM's with historical data has been used by some of the sources indicated above. Ouranos, a climate change group from Quebec, is currently building a regional climate model for Canada and the Northern U.S., which is not a downscaled version of a GCM; its first results are due in 2004 only and its ability to project for the area under investigation is several years away (Décoste, 2003; A. Bourque, personal communication).

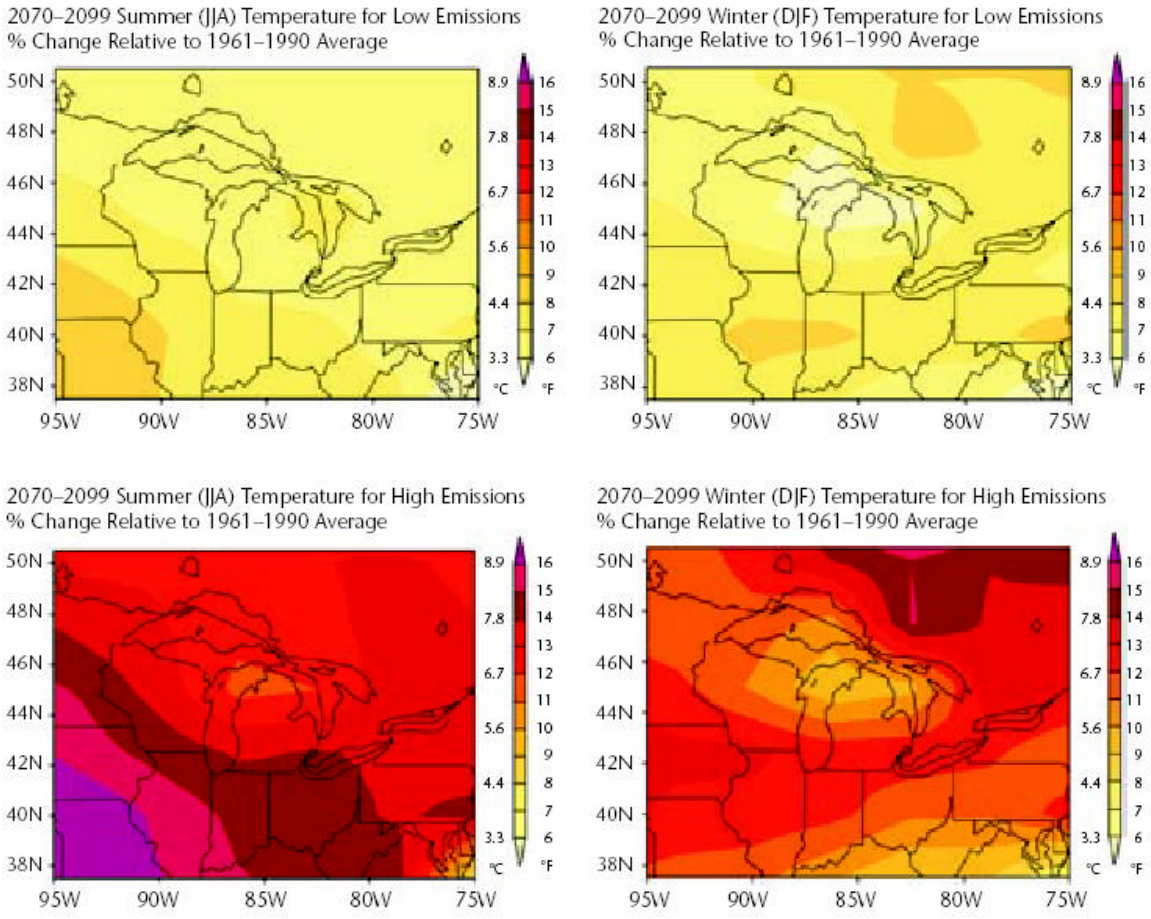
A comparison among the three recent sources of projections models for key climate variables for the Great- Lakes Basin is offered in table 3.1. Climate in the Great-Lakes region is highly variable at time scales going from year to year to decades. This makes climate change projections even more uncertain (UCS-ESA, p.12). Global Climate Models' projections consistently anticipate an increase in air temperature for the area of investigation from 1.5 to 2 degrees Celsius in spring and summer (more at night than during daytime) by 2025-35 (UCS-ESA, 2003). By the end of the century, the temperature may even be higher according to the emission scenario (high or low) adopted: 3 to 5 C^0 temperature increase for the low emission scenario and 5 to 8 C^0 for the high one. Summer temperatures are expected to increase even more under the high emission scenario and slightly less for the low emission one (UCS-ESA, 2003, p. 17). The temperature increase will result in longer and more intense hot spells (Bruce, 2002). Average annual precipitation is projected to increase slightly in the area of investigation over the century (10 to 20 %). However, precipitations in winter and spring are anticipated to increase considerably, up to 50 % higher in winter (more in rain than in snow (Bruce, 2002))

Table 3.1 Comparison of the Values of the Main Physical Impacts Affected by Climate Change in the Three Studies

	EC (Lavender)	**Michigan (Sousounis)**	**UCS**
GCM	CGCM2	CGMC1 and HadCM2	PCM and HadCM3
Temperature	Increases	increases (more in CGCM1)	increases
Evapo-transpiration	Increases	increases	unchanged
Precipitation	depends on methodology	models conflict	increases slightly (more in winter)
Runoff	depends on methodology	decreases	unchanged (decreased in summer)
Soil moisture	Reduced	increases	increased in winter, decreased in summer

than in summer during which they might decrease in the same proportion (UCS-ESA, 2003). This will affect agriculture and pastures negatively. Paralyzing snow falls and freezing rain events are expected to be more frequent; heavy rainfalls of short duration are projected to be more frequent under warmer conditions (Bruce, 2002). Increase in rain intensity results in increased water runoff, both urban and agricultural, with impacts on sewers and freshwater (Bruce, 2002). A lowering of the Great- Lakes and other lakes' level, of the level of the St. Lawrence River and its tributaries, and a general drying up of the region, due to increased evapo - transpiration is also expected. This, in turn, may affect groundwater recharge. Projections to 2050 for the Great-Lakes region, based on the CGCM1, suggest a decrease of 19% in groundwater level and in its contribution to stream flow (Bruce, 2002). A lowering of water levels coupled with warmer temperatures is expected to increase the bio-accumulation of contaminants in the food chain.

Figure 3.1 Projected Increase in Temperature in the Great-Lakes Basin

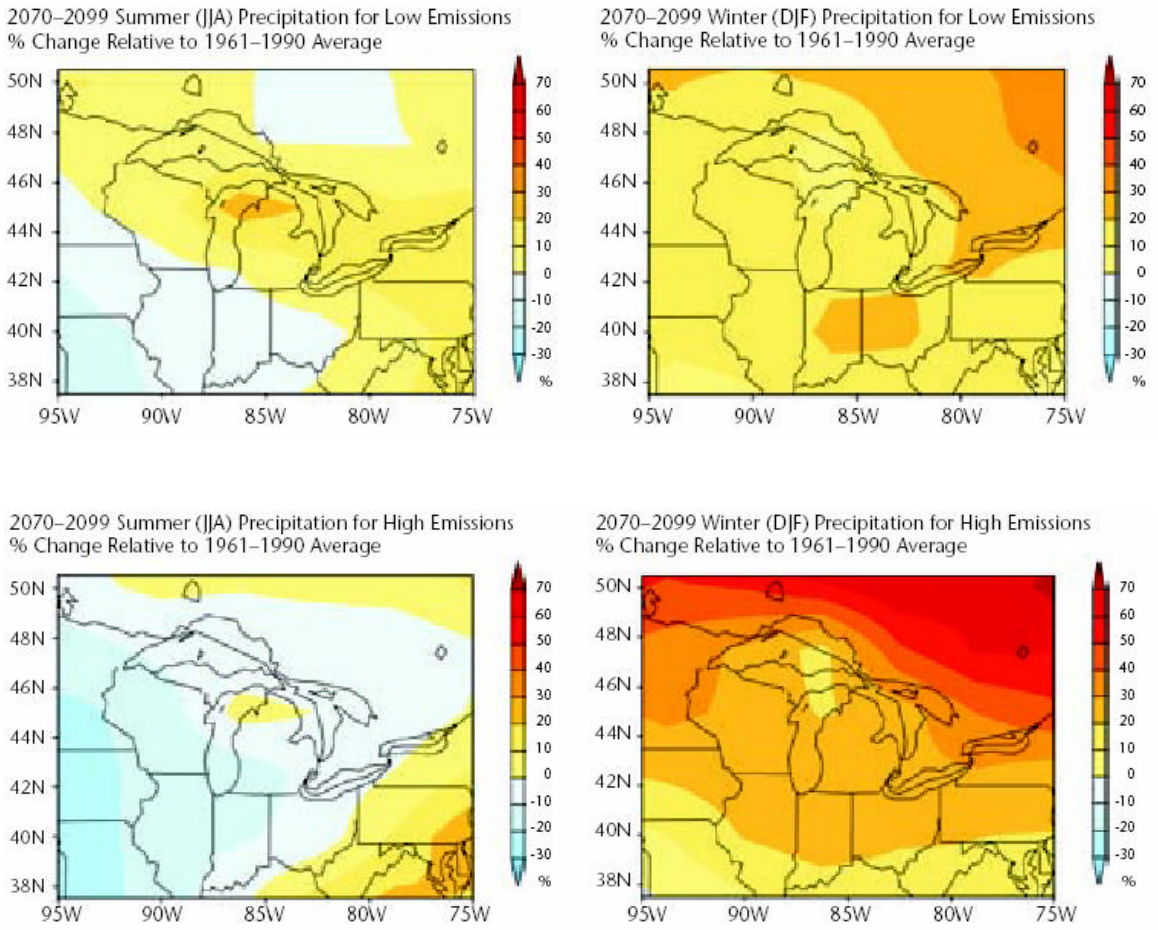


From: http://www.ucsusa.org/greatlakes/pdf/confronting_climate_change_in_the_great_lakes.pdf
Page 38 (Fig. 10)

"By 2030, southern Ontario summers may feel more like those in upstate New-York and, by the end of the century, similar to those in northern Virginia to-day"(UCS-ESA, 2003. p. 19)

Figures 3.1 and 3.2 give projections for temperature and precipitations in summer and winter for the end of the century according to two world GHG emission scenarios, a high emission scenario and a low one (UCS-ESA). Emission scenarios must not be confused with the temperature/precipitation scenarios to be examined in the next section. Emission scenarios lead to impacts in terms of temperature and precipitation projections based on GCMs for which emissions are inputs. Temperature/precipitation scenarios are based on past experience in the region and not the results of impacts projected from models.

Figure 3.2 Projected Increase in Precipitation in the Great-Lakes Basin



From: http://www.ucsusa.org/greatlakes/pdf/confronting_climate_change_in_the_great_lakes.pdf
Page 40 (Fig. 12)

3.2 Climate Scenarios[49]

Two general approaches to regional future climate projections are used: downscaled Global Climate Models (GCM) and past analogues.

The first, which uses GCMs, are run using conditions expected in the future as input to the model. For example, increased greenhouse gases (GHG) emissions can be specified in the model and the resulting climate patterns compared to a simulation run under current emissions conditions. Differences in climate patterns between those produced under greater CO_2 concentrations and the present are "forecasts" of climate impacts due to global warming. These models are similar to the ones used to provide weather forecasts. They have received considerable attention and form the basis of our identification of global warming as a problem. When these models are run using CO_2 amounts expected in the future, they find that temperatures over Canada are expected to increase. Ontario is expected to be warmer in both summer and winter than it is to-day. These results are important to society, as they indicate that we need to be prepared for these changes. However, for the purpose of the present small-scale study, GCMs are not easy to use. First, these climate models are global in scale. Typically, the spatial resolution is of the order of several degrees of latitude and longitude (i.e. more than 10,000 km^2). They are designed to reproduce the global climate with some accuracy, but not necessarily the local conditions. Second, there are many global climate models available; many countries and some universities have different versions of these available for research. Although most climate models are in general agreement about global phenomena, they disagree at a regional scale, and it is not clear at this time which model is most accurate. Third, in order to use the data for regional impact studies, the results must be "downscaled" to that region. How to do this is the subject of intense research, and there is not, at present, a universally agreed-upon methodology to do this. For the current study, we felt that a second approach was more useful.

The second approach is the use of past analogues. The data from the past century is analyzed to study the natural variability of the climate. Scenarios can be developed based on this data (instrumental analogue). Some advantages of this methodology are the following (Houghton *et al.*, 2001). First, this method can be easily applied at any scale from local to regional to global. Second, we are assured that the scenarios are realistic, as they have occurred; the data are available and we can analyze its statistical properties; the data are consistent and many parameters are available. Disadvantages are the following. If the future includes climates that have not occurred, we would have no way to analyze these conditions and could underestimate the real climate variability. This is particularly important if "surprises" occur in the future (GCMs are subject to the same objection). Second, another disadvantage is that the available climatic record is short (a century in our region; 150 years in some parts of Europe) and this may not be long enough to capture a sufficient proportion of the natural variability. Therefore, any conclusion from this study should be tempered by the observations that conditions in the future may be more extreme than those studied below. Despite these disadvantages, we decided, in accordance with some of the literature, to use past analogues in order to avoid the methodological difficulties with downscaling. "This further supports the arguments that initial steps in impact are better served by regional scale scenarios that are plausible perturbations of

[49] This section was contributed by N. Lemay and K. Gajewski.

the current climate, and which access the future climate envelope, sidestepping factors such as optimal downscaling solutions" (Hewitson, 2003, p. 337).

3.2.1 Methods

This study analyzed the climate data from southeastern Ontario. We analyzed essentially the 20th century, specifically climate data from the years 1891-1998. Note that 1999 and 2000, the warmest years on record, were not available at the time this study was performed.

Although there are several meteorological stations reporting data in Eastern Ontario, most have short or discontinuous records. Short records may not be truly representative of the range of variability of the climate system of the region. Another problem is a practical one. When data series are discontinuous, that is, data is not recorded for some time periods, this makes any statistical analysis more difficult. However, in major centers – for example when the climate station is at an airport, there are few missing data because of the importance of this data for the user.

The majority of the analysis was performed on the data from Ottawa Experimental Farm, as it is the longest series in the region. Some analyses were also performed on data from Morrisburg, to verify the results we obtained from Ottawa. We first determined how representative Ottawa was of the climate of the region. We computed the correlation of the monthly temperature and precipitation from several stations from within the region to those of Ottawa. As well we correlated the record from Ottawa to those from Montreal and Maniwaki. All correlations were very high, suggesting that **Eastern Ontario is acting as one climate region**, and data from Ottawa can be used to represent the entire region.

Therefore, the data from Ottawa was exhaustively analyzed to quantify its trends and variability. This included some innovative ways to quantify the variability of the daily temperature and precipitation. Results are detailed in Lemay (2002)

3.2.2 Results

Of the many results obtained from this study, several can be noted
(note that our data ended in 1998):

- With some exceptions, warmest decades tended to occur in the latter part of the 20th century, whereas the coldest were in the earlier part. Driest decades were in the mid century and the wettest toward the end.
- The 1990s contained the 4 warmest years of the 20th century. Coldest years occurred in the early part of the century. The warmest year was a full degree warmer than the coldest year.
- The diurnal temperature range is decreasing since the 1920s, due especially to an increase in minimum daily temperature (e.g. nighttime).
- Key season for high precipitation was summer, except for the 10 driest years, where both spring and summer were drier.

- Average growing season is 192 days. There is a tendency later in the century to start the growing season earlier and to end it later.

For scenarios, we are more interested in extreme years than in trends. For this we stratified the data by comparing statistics of the ten warmest, coldest, driest and wettest years.

- Seasons responsible for producing extreme years are winter and spring.
- The ten warmest years had more days with higher mean daily temperatures (> 20°C or > 15°C) and fewer days with lower mean daily temperatures (< -25°C or < -30°C)
- The mean daily temperature was similar in the driest and wettest years.
- During the warm years, the growing season tended to begin around the 96th day, while it began around the 114th day only during the cold years. The growing season tended to end later as well.
- The total amount of precipitation has not changed over the 20th century, and averaged 142 precipitation events per year. In the 2nd half of the century, there were more days with precipitation, although the amount per event was lower.
- There was no apparent relation between the length of the growing season and precipitation amounts.

In warmer years, precipitation events tend to be more extreme. The increasing trend in the temperature since the 1970's is mainly due to an increase of minimum temperatures in every season.

The above results provide a description of the Eastern Ontario climate during the 20th century.

3.2.3 Scenario Development

For the purpose of further hydrological analysis, several scenarios were developed. After computing the mean of the entire series, extreme years were considered as being years in which both the value of temperature and precipitation were either lower than the 20th or higher than the 80th percentile of a normal probability distribution around the historical mean (the 1 in 5 (20%) probability or less). Then the data were searched for scenarios that would have significant impacts on the region. Warm (cold) temperatures and wet (dry) periods were defined as the ones, which exceeded 80 % (were less than 20%) of, either the recorded temperatures or average precipitations. For example, a wet spring followed by a summer drought is one such scenario. A dry spring, followed by a dry summer is another significant scenario as there may be insufficient recharge of the groundwater, causing moisture stress for plants and insufficient water in the streams.

When two recorded years qualified as unusual, the most recent was selected for the corresponding scenario. Most unusual scenarios apply to spring and summer. In spring, precipitation is important for water budget allocation. Summer precipitation is important to offset evapo - transpiration.

Seven scenarios were considered (see Table 3.1 and figures 3.2 and 3.3). The first scenario is simply an average year used as baseline (either 1941 or 1909). The second scenario is

characterized by a warm winter, wet spring and dry summer – a fairly common occurrence. The severity of the scenario impacts depends upon the recharge rate of the aquifer during the spring. The third scenario is a warm winter, dry spring (minimal recharge) and dry summer leading to water scarcity. The fourth scenario is a wet winter, warm and wet spring; it explores the possibility of excess water in the spring leading to floods and contamination of groundwater. The fifth scenario is characterized by the longest growing period without rain followed by a large precipitation event. Groundwater is then exposed to hazards; surface waters are then subject to flash floods and provoke erosion. The sixth scenario is composed of a spring and summer, both warm and wet, which stimulate algal growth in surface water, insect populations and affect agricultural yields; it also affects spring flooding and erosion. This scenario may be beneficial for the recharge of deep aquifers and the dilution of pollutants in streams. The last scenario is composed of spring and summer, both cool and wet.

Table 3.1 Scenarios year and seasons

	Temperature	Precipitation	Year
1	Average year	Average year	1941 or 1909
2	Warm winter	Wet spring, dry summer	1991 or 1983
3	Warm winter	Dry spring & summer	1966
4	Warm spring	Wet winter & spring (spring floods)	1973 or 1991
5	Warm summer	Dry periods followed by heavy rain	1975
6	Warm spring & summer	Wet spring & summer	1973
7	Cool spring & summer	Wet spring & summer	1956

from N. Lemay, 2002, table 8-1, p. 163.

Figure 3.1 Selection Criteria for Unusual Scenario

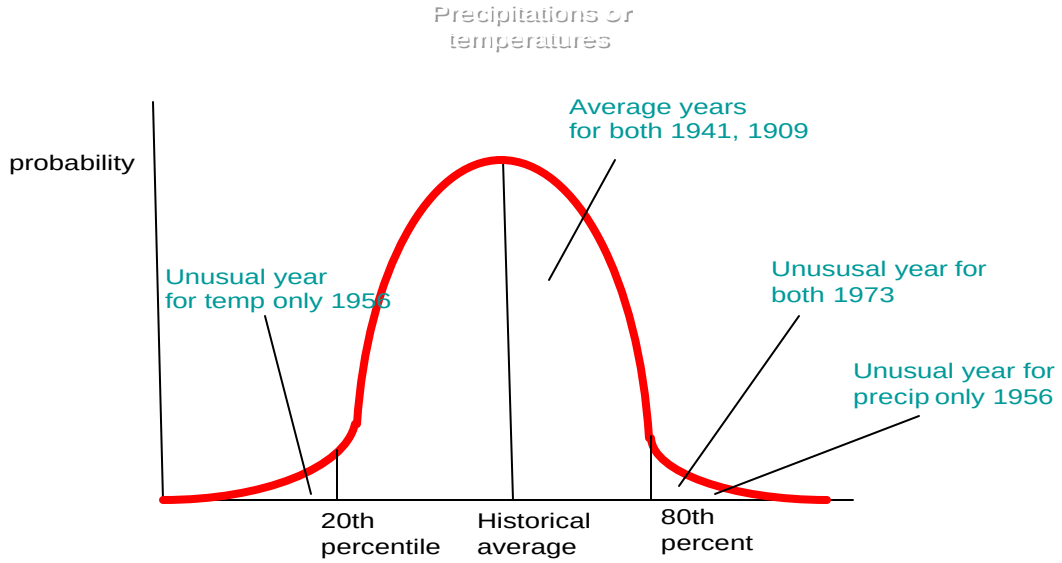
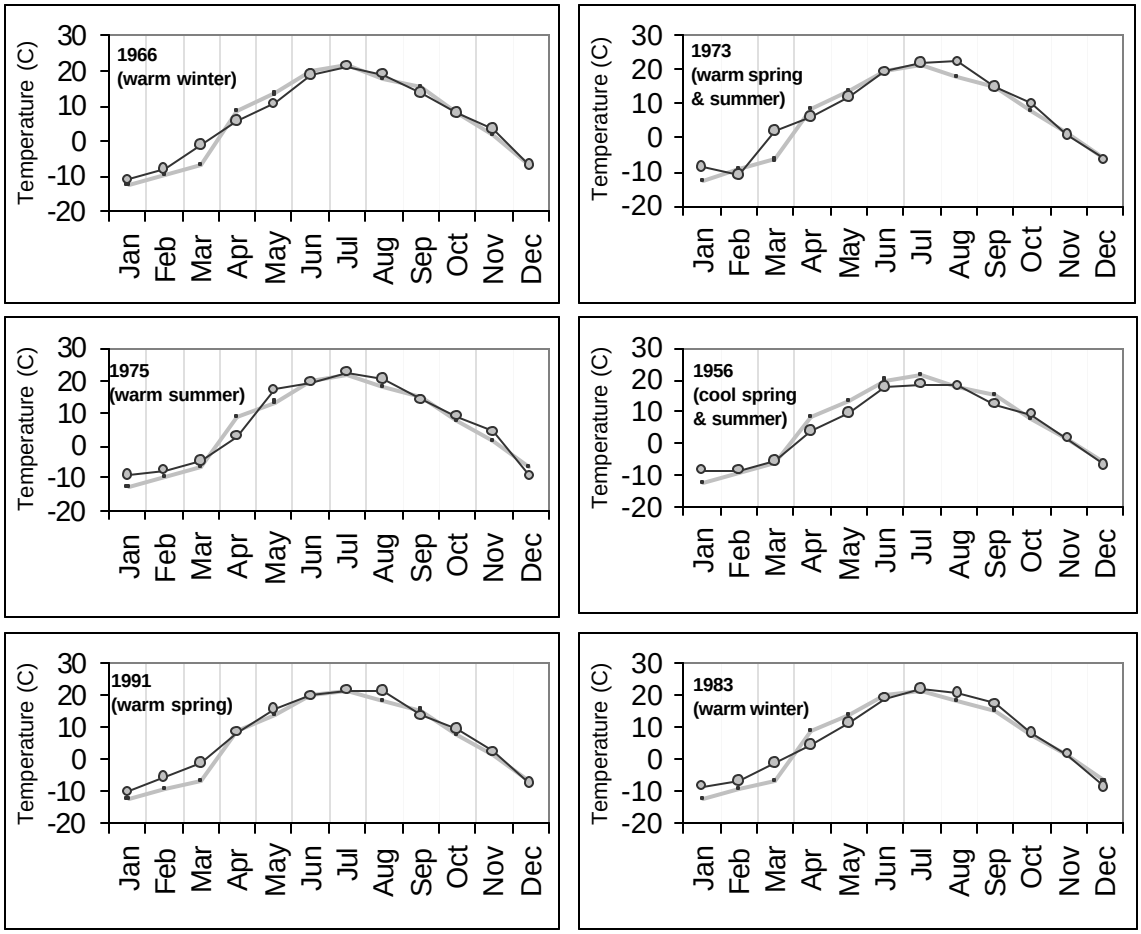
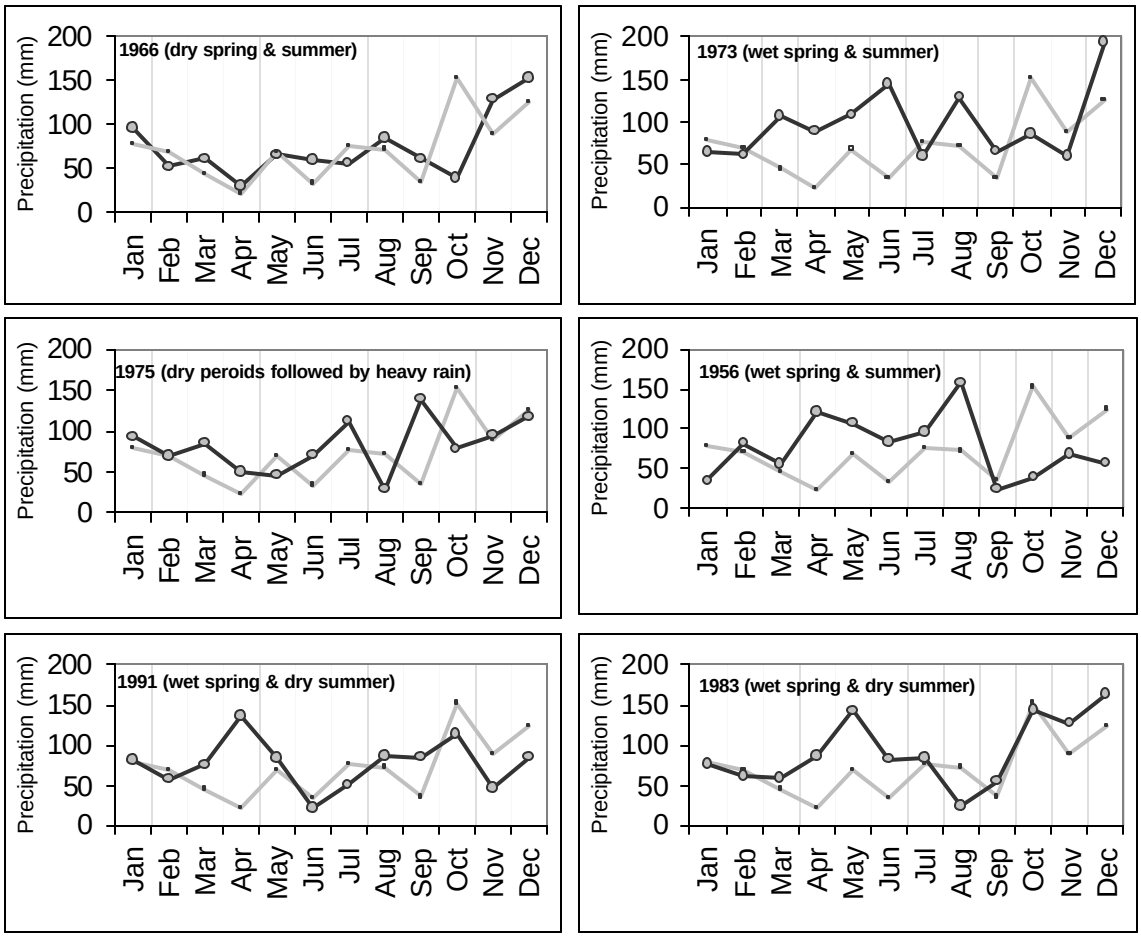


Figure 3.2 Scenario Temperature Compared to "Normal" scenario



Monthly mean temperature for scenarios
Gray lines joining small squares indicate "NORMAL" scenario temperature (1941)
Black lines joining large circles indicate actual temperatures for each scenario experienced in a given year.

Figure 3.3 Scenario Precipitation compared to "Normal" scenario



Monthly mean precipitation for scenarios
Gray lines joining small squares indicate "NORMAL" scenario precipitation (1941)
Black lines connecting large circles indicate actual precipitation for each scenario experienced in a given year.

3.3 Conclusion

Eastern Ontario is well-defined as a homogeneous climate region in terms of experienced temperature and precipitation. As indicated in section 1.2.3, exposure to weather variability is an important determinant of vulnerability because systems adapt first to weather before they respond to climate. Scenarios, based on past experience over the last century, capture average or common weather conditions while five of them characterize unusual, but not extreme, conditions in terms of both temperature and precipitation. These five scenarios lead to potential local

impacts, respectively either hazardous such as water scarcity, floods, flash floods and erosion, or beneficial such as the recharge of deep aquifers. How the climate of the entire Great- Lakes Basin evolves over the century depends much on the GHG emission and, therefore, on the socio-economic scenario adopted for the entire planet. The larger the emissions, the larger the average temperature increase. The larger the temperature increase, the larger the evapo - transpiration and the lower the lakes, watercourses, and groundwater levels. The impact of temperature increases on precipitation, runoff and soil moisture is subject to some disagreement among the Global Circulation Models but thee is some degree of agreement about precipitations likely shifting somewhat to the winter season. The next section examines the scenario impacts on groundwater quantity and quality.

References

Bruce, James P. (2002), *Climate Change Effects on Regions of Canada*, prepared for Federation of Canadian Municipalities, Global Change Strategies International, January 30.

Décoste, R. (2003), *Les changements climatiques au Québec*, Congrès de l'ACFAS, http://www.ouranos.ca

GLSLB (Great Lakes-St. Lawrence Basin Project) Lavender, B., J.V. Smith, G. Koshida, and D. L. Morstch, *Binational Great-Lakes-St. Lawrence Basin Climate Change and Hydrologic Scenarios Report*, Unpubl. Mnss.1998

Harvey, L. D. D. (2000), *Global Warming*; *The Hard Science*, Prentice-Hall 2000

Hewitson, B. (2003), Developing Perturbations for Climate Change Impact Assessments, *Transactions of the American Geophysical Society*, vol. 84, n0 35 (September), p. 337-41.

Houghton, J., Y Ding, D Griggs, M Noguer, P van der Linden, X Dai, K Maskell and C Johnson, eds. 2001. *Climate Change 2001: the scientific basis*. Cambridge University Press

IPCC (Intergovernmental Panel on Climate Change (2000)), *Emissions Scenarios*, Cambridge University Press.

Lemay, N. (2002). *Eastern Ontario Climate: Variability and Trends during the 20th Century*. M.Sc. thesis, Ottawa-Carleton Geoscience Centre, University of Ottawa. 179 pp.

UCS-ESA (Union of Concerned Scientists and Ecological Society of America) (2003), *Confronting Climate Change in the Great Lakes Region*, http://www.ucsusa.org/greatlakes/

USGCRP (United-States Global Climate Research Program), Sousounis, P. J. and J.M. Bisanz (2000), *Preparing for a Changing Climate. The Potential Consequences of Climate Variability and Change, Great Lakes* A Summary by the Great Lakes Regional Assessment Group for the U.S. Global Change Research Program, October, http://www.geo.msu.edu/glra/assessment/assessment.html

Section 4 Scenario Impacts on Groundwater and Adaptation Measures

Natural infrastructure (i.e. groundwater, watercourses) will now be overlaid on the physical scenarios developed in the previous section. Water quantity at the watershed level does not seem to be a current concern for municipal and CAs' staff and the analysis carried out in the next two sections does seem to justify future generalized concerns (see section 9.2.1 *infra*). However, water quality is their top current environmental priority and rightly so as this section will show (see section 9.2.2.).

Groundwater is of utmost importance to the study region, as it provides over 60 % of its drinking water. The study area receives an average of about 930 mm of precipitation annually, of which approximately 420 mm is lost through evapo - transpiration.[50] The remaining 510 mm of water is partitioned between the surface water drainage network and the deep groundwater reserves (EOWRMS, 2001). The sensitivity of groundwater quantity to scenarios is shown to be very dependent on the time scale and spatial scale considered. Groundwater contamination can, therefore, be remedied by management at the appropriate scales. As current well water quality, in terms of bacterial count, is unsatisfactory, climate change can only exacerbate current problems unless these are being appropriately monitored and tackled.

4.1 Groundwater Quantity and Contamination[51]

. An innovative hydro-geological model formulated in a Geographical Information System (GIS) environment, to be transferred to the community, was therefore constructed to calculate monthly groundwater budgets to assess the exposure of groundwater and surface water resources to climate change scenarios in Eastern Ontario.[52] The model uses hydro - geological information from the EOWRMS (CMH2HILL, 2001). Surface to Aquifer Advective Time (SAAT) is introduced in this study as an aquifer sensitivity assessment parameter. A SAAT is defined as the travel time required by water to get from the ground surface to the aquifer, under the monthly prevailing conditions. Other sensitivity indices include Monthly Excess Runoff (MER) giving the amount of water that is unable to infiltrate, as an indicator of flood potential; and Monthly Excess Demand (MED), as an indicator of deep aquifer depletion since deep groundwater takes a longer time to be replenished than surface water.

To estimate the spatial distribution of sensitivity, the monthly water budget maps are compared to identical calculations for the "normal" average year scenario (scenario 1). By both visual and quantitative comparison of these parameters for a specific month and for normal and extreme scenarios, it is possible to find areas, which are:

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[50] Note that the study area for the groundwater quantity study also includes parts of the United-Counties of Leeds and Grenville (about 6,800 km^2), in order to encompass the totality of the South-Nation and Raisin watersheds.

[51] This section was contributed by M. Robin and B. Daneshfar.

[52] The term "vulnerability" is often used in hydrogeology as synonymous with "hazard" or physical "sensitivity". We will use the term "sensitivity" in this section to reflect natural/physical susceptibility to climate change by opposition to "vulnerability" or "sensitivity", which combine the hazard with social events (see section 1.2.3 above).

1) Always hydrogeologically within the sensitive zone based on the above indicators (no matter what the climate scenario is) for a specific month of the year; and

2) Areas, which are within the hydrogeologically sensitive zones only during the extreme scenarios for a specific month of the year.

By overlaying the boundaries of townships and counties it is possible to see which townships or counties are located within the more climate sensitive zones or that are always in sensitive zones. It is then possible to rank townships according to their total sensitive area. This enables planners or municipalities to be aware of the hydro - geological sensitivity of their townships or counties. In addition, within a certain county or township, it is possible to see which regions are hydro - geologically more sensitive. It is important to stress that these calculations are based on the best available data, which may not be adequate for small scale planning purposes, and they should therefore be used only as a means to identify and prioritize field measurements that will enable sound decisions.

The results indicate that, **on a yearly basis, groundwater resources were not very sensitive to the climate change scenarios**: even with a succession of unusually dry years the groundwater systems get recharged during the snow-melt in the spring and during rainy seasons (fall and spring; in fact, flooding is often more the issue in the spring). **Freshwater is, therefore, not a scarce resource in our study area and is not likely to become scarce in the foreseeable future.**

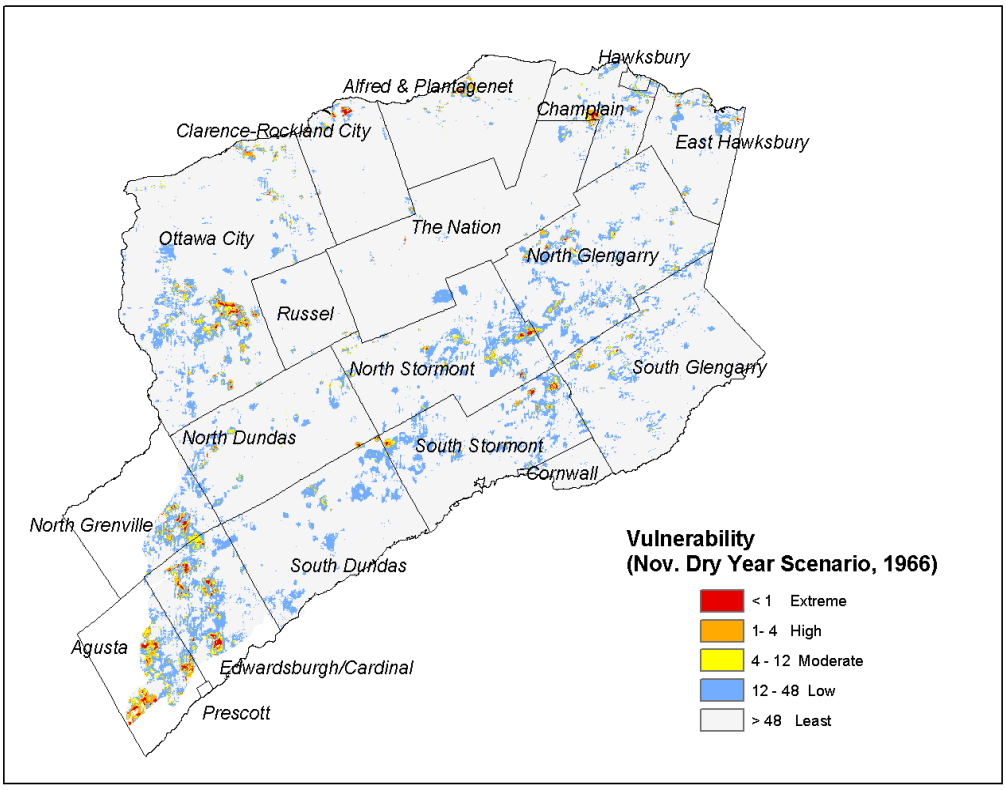
On a monthly basis, the picture is very different. Sensitivity is extremely variable from one month to the next and from one geographic location to the next. The GIS capability was extremely powerful at identifying geographic locations that were particularly sensitive. The GIS analysis showed that **some areas are particularly and consistently sensitive to droughts during the dry summer months**, even during "wet" years, **while other regions are sensitive only during dry years (**see figure 4.2**)**. Sensitivity indicates in figure 4.1 the time required for surface water to travel to the aquifer (SAAT) at a given location using SAAT data for a given month and a given scenario from periods of less than a month (extreme situation) to periods of more than four years ("least"sensitive situation). Alternatively, it indicates in figure 4.2 the additional areas which have become sensitive when one moves from a normal scenario to an unusually dry one. The driest year scenario produced the largest monthly groundwater impact (scenario 3; see figure 4.1, showing areas of drought susceptibility even for the month of November, which would show recharging aquifers in a normal year). It produced small SAATs (large physical vulnerabilities or sensitivities) and large MED values (excess demand) at certain times of the year but the water budget deficits were replenished by the beginning of the end of the following spring. These results are consistent with EOWRMS, the Leeds and Grenvillle Groundwater Study (2002), and the Mississippi Valley Groundwater Study (2003), which all indicate that water demand is actually a small percentage of the net available water on a yearly basis (CH2M Hill, 2001L; ongoing Renfrew County Mississipi-Rideau Groundwater Study, 2003[53]). The regions to the west of our study area (United Counties of Leeds-Grenville and the Mississippi Valley) and the western portion of our study area are believed to be recharge areas

[53] http://www.mvc.on.ca/rmrgroundwaterstudy/groundwaterstdy/index.html

for the deep regional aquifer system in our study area. **The policy implication of this important result is that the risk of water shortage for the entire region is small, but the local risk is highly variable.** For instance, the townships of Agusta and Edwardsburgh/Cardinal (United-Counties of Leeds-Grenville) and areas south of the City of Ottawa are the most sensitive under drought conditions.

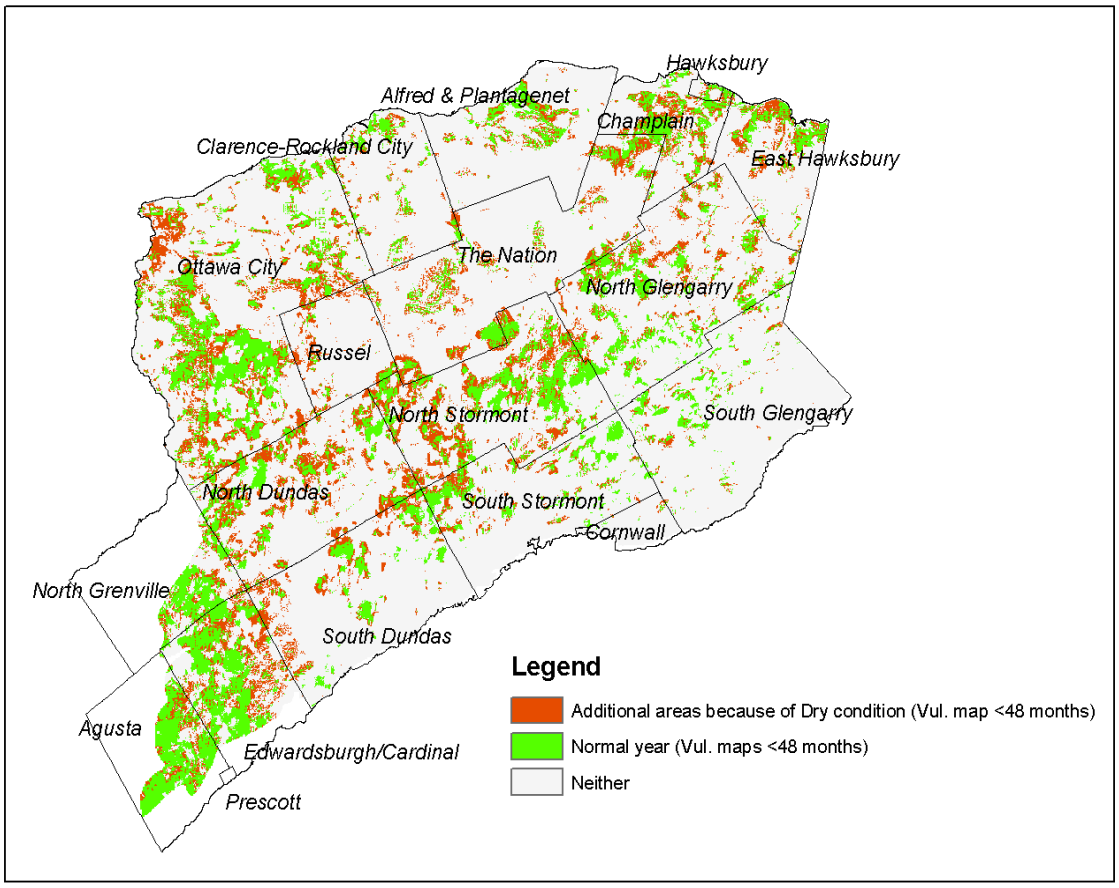
The results from the previous section demonstrate that aquifer sensitivity to contamination was highly seasonal and localized: aquifer recharge areas were particularly sensitive during wet periods following dry periods, such as the fall (scenario 2). This suggests that aquifer contamination issues can be mitigated with proper waste management practices, and, in particular, by the proper timing of land application of animal waste (Recommendation 15 a). This situation is exacerbated in areas where the surface (unconfined) aquifer is the main source of water. Such areas exist particularly in the extensive esker complex in the central and western portion of the study area (these deposits consist of long winding gravel deposits that can be several km. long and that can be partially or completely buried under the Champlain Sea sediments).

Figure 4.1 Groundwater Sensitivity for November of the Dry Year scenario (scenario 3)



The numerical indices are Surface to Aquifer Advection Times (SAAT) for the conditions prevailing in the particular month (this case November); the SAATs, which represent the travel time for surface water to the aquifer, were categorized in five physical vulnerability or sensitivity classes for mapping purposes. The classes are "Extreme" for SAATs taking less than one month; "High" for SAATs varying from 1 to 4 months; "Moderate" for SAATs ranging from 4 to 12 months; "Low" for SAATs ranging from 12 to 48 months; and "Least" for SAATs greater than 48 months.

Figure 4.2 Groundwater Sensitivity for dry-year scenarios (scenarios 2, 3 and 5) and for all scenarios.



Regions in red are vulnerable only in "Dry" climatic scenario and areas in green are always vulnerable independent of climatic scenario (both in "Normal" and "Dry" conditions).

This study demonstrates that GIS can be an extremely valuable tool for watershed managers to examine groundwater supply issues; in particular, it points to the need to calculate water budgets on a much shorter time frame than the usual one-year approach. Groundwater supply issues, being seasonal and local, can be mitigated with proper management. In particular, it is strongly recommended that Permits-to-Take-Water holders be metered and monitored (and perhaps reviewed) as they represent a very large and presently un-quantified parameter in all groundwater studies, including this one (Recommendations 16 and 33). In supply-sensitive areas, an additional measure to be contemplated could be artificial recharge of the groundwater system (Recommendation 24 a). Measures like these have been used successfully by other municipalities in Ontario; for instance, by the Municipality of Waterloo, which draws its water entirely from groundwater.

The maps produced in this study are based on the best available data complemented with professional and scientific judgment and with the powerful tools of the GIS. The maps convey impressions of exactitude and preciseness, when in fact there is considerable uncertainty associated with them (in fact, error and uncertainty propagation in GIS maps is a very active area of research presently (Lowell *et al*., 1999). The proper way to use these maps and the GIS methodology presented here is as sensitivity analysis tools (as was done in this study); they should not be used as a local planning tool without grounding the input data with hard field measurements at the scale of interest. In view of the paucity of high quality hydro - geological field data, it is recommended that a groundwater monitoring program be implemented and maintained for the study area, perhaps under the auspices of the EOWRC. From a groundwater management standpoint, specific measures would include:

- The installation and monitoring of multi-level piezometers (i.e., monitoring well) at locations of high groundwater vulnerability and areas of regional groundwater recharge (areas of regional recharge are believed to be located along the divide between the South Nation and the Raisin River systems, and in the adjacent Rideau River basin); this will provide information of utmost importance on the supply side of the equation, i.e. actual recharge values, instead of the educated guesses presently used in most groundwater studies (Recommendation 26 a).

- As mentioned earlier, the metering of large groundwater users is absolutely imperative. This will provide information on the Demand side of the equation. Eventually, smaller users, including domestic well users should also be metered (Recommendation 22 b).

- The installation and monitoring of multi-level piezometers at surface-water gauging stations; this would provide extremely important information on surface water – groundwater interactions and on vertical groundwater movement at these locations. Other methods, such as electrical conductivity surveys, can also be used to provide additional information on the interaction (Recommendation 26 b).

- The monitoring network should be sampled periodically, perhaps every year for Major Constituent Chemistry and Water Quality parameters; and perhaps every few years for isotopic composition. This will keep a finger on the pulse of the water quality and it may also provide important information on the natural evolution and provenance of the groundwater (Recommendation 27).

4.2 Groundwater Quality: Nitrate, Bacteria, Conductivity and Other Water Quality Variables[54]

While groundwater quantity (previous section) is an important consideration, groundwater quality is also an important issue (as evidenced by the Walkerton tragedy). Consequently, a study of nitrate in groundwater was undertaken.[55] Due to public interest, what began as an investigation into nitrate in wellwater was expanded into a study of drinking water quality in the study area. Samples of well water used as a source of drinking water were collected from self-selected private rural residences in the South Nation River and Raisin Region watershed areas. In total, 54 wells were sampled across an area of 3,000 square kilometres. Since the participants in this study were volunteers, the wells sampled may be biased in favour of wells that are perceived to be clean by their owners. If this is the case, the results presented here are conservative in the sense that the "true" numbers of contaminated wells may actually be greater than the results reported here. On the other hand, municipal and CAs' staff perceive well water to be in good condition (see section 9.2.1 *infra*). Analysis of water consisted of the following: bacterial count (total coliforms, *E.coli*, and background colonies), nitrate determination, dissolved oxygen determination, as well as several other parameters (e.g. conductivity).[56] These variables were studied with respect to land use, type of well, and other contributing information. It has been shown that there is a large data gap on the understanding of groundwater quality in Eastern Ontario and that there are many areas of high aquifer sensitivity (EOWRMS, CH2MHill, 2001; and this study, previous section). Another study has indicated that there are many areas in the Ottawa region that have a high risk for groundwater contamination due to conditions such as sandy soil and a high water table among other characteristics (Waterloo Hydrogeologic and CH2MHill, 2002)

Nitrate is of particular concern. High levels of nitrate in well water can be harmful and even fatal to bottle-fed infants up to the age of three months. The Ontario Ministry of Health advises "for families on wells, no infant up to the age of six months should be fed formula made with water from any well" (Health Canada, 1998). Infants ingesting formula made with water containing high levels of nitrate may develop methemoglobinemia, also called "blue-baby syndrome", a condition that involves an impaired haemoglobin which is unable to transport oxygen to tissues. Symptoms include cyanosis, asphyxia and death (Chambers *et al*., 2001).

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[54] This section was contributed by D. Carberry and D. Lean.

[55] The South Nation River and Raisin Region Conservation Authorities and the St. Lawrence River Institute of Environmental Sciences have been very helpful in the success of this undertaking.

[56] Total coliforms are defined as:

1. all facultative anaerobic, Gram-negative, non-spore forming, rod-shaped bacteria that ferment lactose with gas and and acid formation within 48 hours at 35 degrees C;
2. many facultative anaerobic, Gram-negative, non-spore-forming, rod-shaped bacteria that develop red colonies with a metallic (golden) sheen within 24 hours at 35 degrees C on an Endo-type medium containing lactose; or all bacteria possessing the enzyme B-galactosidase, which cleaves a chromogenic substance. These definitions are not to be regarded as identical; rather they refer to three groups that are roughly equivalent. Their presence in water may indicate faecal contamination (Health Canada, 2003).
3. *E.coli (Escherichia coli*) is the predominant coliform in faeces and the only member of the coliform (and thermotolerant coliform) group exclusively associated with faeces (Health Canada, 2002 and 2003). It is the most specific indicator of faecal pollution, and the possible presence of pathogenic microorganisms.

Pregnant women, adults with reduced stomach activity, and individuals deficient in the methemoglobin reductase enzyme are also at an increased risk for developing methemoglobinemia (Luk and Au-Yeung, 2002).

There are many factors involved in the contamination of groundwater with nitrate; however, agriculture is considered to be the major contributor (Goss and Goorahoo, 1995). Studies show a direct relationship between nitrate concentrations in groundwater and nitrogen fertilization rates and/or fertilization history (Canter, 1997). The combined effects of chemical fertilizers, uncontrolled animal-feeding operations, as well as pesticides and waste contamination through storm and urban runoff are also considered a cause of an increased nitrate concentration in groundwater (Luk and Au-Yeung, 2002). Alteration in risk of waterborne illness may be associated with heavy precipitation, drought, flooding and coastal erosion. Drought increases the demand for water when the supply is significantly reduced and vulnerable (Charron et al., 2003).

The effects of weather should be noted as it directly affects ambient water and temperature regimes, thereby affecting plant water relationships, soil oxygen status, plant growth rates, mineralization and nitrification processes, and ultimately crop yield and nitrate leaching (Power et al., 2001). A report from a recent workshop organized by the Soil and Water Conservation Society, the International Institute for Sustainable Development, and the Canadian Water Resources Association forecasts that Ontario may expect to see an increased overall annual precipitation, reduced snow and increased rainfall, more dramatic weather events, a greater degree of surface runoff and flooding, and less infiltration. At the same time, increased temperatures are expected to create increased evaporation, more than offsetting the increase in precipitation and resulting in a lowering of water levels in the lakes. These lower surface water levels, greater runoff, and greater evaporation could also substantially reduce the rate of recharge of groundwater. These changes, if they occur will have long-term impacts on the quality and quantity of drinking water sources in Ontario (O'Connor, 2002).

Levels of nitrate were selected to make predictions on how nitrate levels may be influenced by different climate scenarios. Oxygen was also measured as it may alter the levels of nitrate (Gomez *et al*., 2002). Oxygen levels were typically very low and in many cases almost totally depleted. This observation along with the low redox conditions can profoundly influence not only the nitrate levels but the biogeochemistry of trace metals and sulfur compounds as well.[57] Such low levels of oxygen could also promote the formation of methyl mercury, which is the most toxic substance to accumulate in food chains. Methyl mercury also exists at fairly high levels in the South Nation River.

The presence of total coliform bacteria in well water is a result of surface water infiltration or seepage from septic systems (Health Canada, 2003). Drinking water that contains less than 10 total coliform bacteria per 100 mL (millilitre) sample is considered marginally safe to drink, but should be re-sampled. If after re-sampling, fewer than 10 total coliforms are detected, the cause of the contamination should be determined and corrective actions taken as appropriate (Health Canada, 2003). Water containing more than 10 total coliform per 100 mL sample should be re-sampled, and if after re-sampling, total coliform at levels greater than 10 is still found, corrective

[57] Redox conditions control metal speciation (toxicity), which in turn will alter the taste, smell and quality of the water

action should be taken immediately (Health Canada, 2003). The presence of *E. coli* in water samples indicate a recent contamination by faecal matter and, therefore, the possible presence of disease-causing bacteria, viruses or protozoa (Health Canada, 2003). Water containing *E. coli* is unsafe to drink, and corrective action should be taken immediately.

Results of this study were classified by land use (strictly residential, agricultural near/bordering on agricultural land, agriculture intensive i.e. which had mixed farming such as livestock and cash crops) and by well type (drilled or dug). Both factors appear to have an impact. The number of samples that tested positive for bacteria increased from strictly residential to agricultural intensive areas. Out of 54 wells sampled, 40 were drilled wells, and 10 were dug wells. Several wells were located near barns, in farming fields, near septic tanks, or inadequately sealed to prevent surface contamination/infiltration. Dug wells generally showed a greater contamination than drilled wells. This is not surprising considering that dug wells are generally shallow wells that draw water from the vulnerable surface aquifer.

Analysis showed that overall, the samples were 57.4.% positive for total coliforms, 7.4% positive for *E. coli*, and 62.9% positive for background colonies. The percentages of samples testing positive as a function of testing site are given in table 4.1. The results for the dug wells are compared to those of the drilled wells in table 4.2. The nitrate concentrations were also included in tables 4.1 and 4.2. The average values did not exceed the maximum allowable concentration (MAC) of 10 mg/L. There were two samples that exceeded the MAC, and they were both taken at agriculturally intensive sites, where the wells were dug and shallow, and the soil was sandy. These two wells had levels of 56 and 15 mg/L.

The main causes for increased levels of nitrate are increased usage of nitrogenous fertilizers, increasing irrigation with domestic wastewater and changes in land use patterns (Soares, 2000). Aquifers particularly sensitive to nitrate contamination are shallow and/or situated in very sandy, porous soils (Chambers *et al*., 2001).

Table 4.1 Comparison of adjacent land use

Sampling site	% of samples testing positive			Average Nitrate concentration (mg/L)
	Total coliforms	*E. coli*	Background colonies	
All	57.4	7.4	62.9	1.95
Strictly Residential	50.0	4.5	68.0	0.16
Agricultural	53.0	11.7	53.0	0.91
Intensive Agricultural	73.0	6.7	60.0	5.75

Table 4.2 Comparison of well type

Well type	% of samples testing positive			Average Nitrate concentration (mg/L)
	Total coliforms	*E. coli*	Background colonies	
Dug	80.0	30.0	90.0	8.46
Drilled	52.5	2.6	56.1	0.342

The majority of the samples had values of nitrate below the MAC. This is probably due to denitrification. Denitrifying bacteria are ubiquitous in nature (Soares, 2000). Dissolved oxygen negatively affects denitrification, and even very low dissolved oxygen concentrations can cause a complete cessation of denitrifying activity (Gomez *et al*., 2002). It was found that most of the samples that had elevated oxygen concentrations, also had a raised nitrate level, although not necessarily exceeding the MAC for nitrate.

The average value for electrical conductivity (EC), a surrogate for total dissolved solids, in the samples was approximately 1073 microSiemens per cm (µS/cm). These values are considered on the low side of the normal range for groundwater.[58] The low values may be an indication of mixing of deeper groundwaters (with higher EC values) with surface waters (with EC values in the less than 100 range). With less precipitation during the summer under climate change, salt level may even be higher.

This study shows that, as conservative estimate, over half of the sampled wells were contaminated with coliform bacteria, and approximately 7.4% tested positive for *E. coli.* This provides a snapshot of the sanitation level of domestic wells in Eastern Ontario, and highlights the need for regular monitoring/testing and maintenance of these wells. Without additional measures the situation can only deteriorate with climate change: Increased demand on the pristine deep groundwater system will exacerbate the water supply issue and increase the downward circulation of groundwater and, consequently, increase the deep aquifer sensitivity. The first step in the prevention of contamination is the proper construction of the well. MOE has put in place a new set of regulations for the construction of wells in Ontario (Regulation 903; www.ogwa.ca). Once a domestic well is installed, its maintenance and upkeep is the responsibility of individual owners. The only recourse, then, is public awareness and education. It is therefore highly recommended that public education and awareness campaigns be carried out to promote water conservation and the proper maintenance and decontamination of wells (Recommendation 28). It is also recommended that a well and septic system inspection and remedial service be offered to the population (Recommendation 29).

After examining the likely impacts of climate change on groundwater quantity and quality, we now turn our attention to watercourses.

[58] Purified water has a conductivity of 0, whereas seawater is in the range of 35 000 µS/cm

References

Canter, L.M., (1997). *Nitrates in Groundwater*. Lewis Publishers. Boca Raton, Florida.

CH2M HILL, (2001), Final Report. *Eastern Ontario Water Resources Management Study* (EOWRMS): United Counties of Prescott & Russell, Stormont, Dundas, Glengarry, City of Ottawa

Chambers P.A., M. Guy, E.S. Roberts, M.N. Charlton, R. Kent, C. Gagnon, G. Grove, and N. Foster, (2001) *Nutrients and their impact on the Canadian Environment*, Agriculture and Agri-Food Canada, Environment Canada, Fisheries and Oceans Canada, Health Canada and Natural Resources Canada. Ottawa, Ont. 241 p.

Charron, D. F., Thomas, M. K., Waltner – Toews, D., Aramini, J. J., Edge, T. Kent, R. A., Maaront, A.R. Wilson, J. (2003) Vulnerability of Waterborne Diseases To Climate Change in Canada: A Review, in S. E. Hrudey, Ed., *Drinking Water Safety: A Total Quality Management Approach*., Proceedings of the International Conference on Water and Health, Sept 23 – 25, 2002 Ottawa, Ontario.

Gomez, M.A., E. Hontoria, J. Gonzalez-Lopez (2002). Effect of Dissolved Oxygen Concentration on Nitrate Removal from Groundwater Using a Denitrifying Submerged Filter. *Journal of Hazardous Materials*, B90. 267-278.

Goss, M.J. and D. Goorahoo (1995). Nitrate Contamination of Groundwater: Measurement and Prediction. *Fertilizer Research*. 42: 331-338.

Health Canada (1998), *Well Water Contaminants: Results from PEAS. Farm Family Health*. Health Protection Branch. Ottawa. Health Canada Website.

Health Canada (2002), *Water Quality Activities*. Health Canada website.

Health Canada (2003). *What's in Your Well? A Guide to Well Water Treatment and Maintenance. Fact Sheet*, Healthy Environments and Consumer Safety Branch. Ottawa.

Lowell, K. and Jaton, A., Ed. (1999), *Spatial Accuracy Assessment: Land Information Uncertainty in Natural Resources*, Laval University

Luk, G.K., W.C. Au-Yeung (2002) Experimental investigation on the chemical reduction of nitrate from groundwater. *Advances in Environmental Research* 6: 441-453.

O'Connor, D.R.O (2002) Part 2 *Report of the Walkerton Inquiry A Strategy for Safe Drinking Water*. Ontario Ministry of the Attorney General. Queen's Printer for Ontario.

Power, J.F, R. Wiese and D. Flowerday (2001). "Managing Farming Systems for Nitrate Control: A Research Review from Management Systems Evaluation Areas". *J. Environ. Qual.* 30:1866-1880.

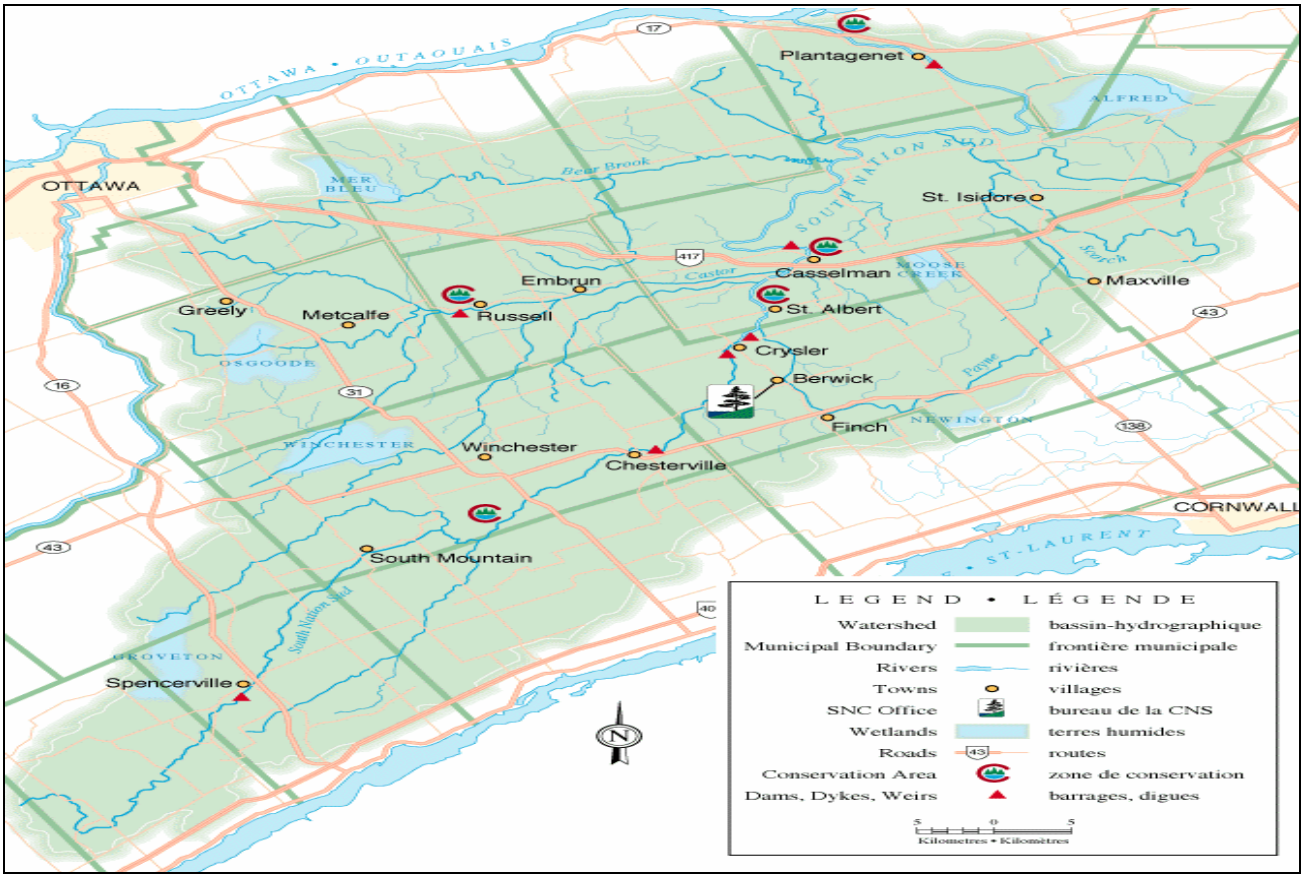
Soares, M.J.M (2000). Biological Denitrification of Groundwater, *Water, Air, and Soil Pollution*, 123: 183-193.

Waterloo Hydrogeologic and CH2Mhill (2002). Preliminary *Evaluation of Relative Aquifer Vulnerability*. City of Ottawa: Ottawa.

Section 5 Scenario Impacts on Surface Waters and Adaptation Measures

Analyses of historical records from which analogue physical scenarios, such as the ones developed in section 3, can inform on the potential response of aquatic systems to climate change. Both municipal and CAS' staff are currently concerned about organic waste pollution and agricultural runoffs are one of their main environmental priorities; both agencies express concern about the adequacy of related data (see section 9.2.1 *infra*). This section focuses on records of river discharge and water quality in the South Nation River. These data when combined with empirical models of river ecology and with information gathered on the current health of the South Nation provide predictions of the possible future states with respect to water quality and ecosystem ecology under climate change scenarios.

Figure 5.1 The South Nation Watershed



This section of the study was limited to the South Nation Watershed because of the relative abundance of data for this watershed and also because the study focuses on processes, which are applicable to all watersheds of the study area. The South Nation watershed consists of an area of roughly 3900 km^2 in Eastern Ontario. The South Nation River (175 km in length, 85m

elevation change) flows in a northeasterly direction from near Brockville (outside our area of investigation in the United-Counties of Leeds and Grenville) to the Ottawa River. The watershed encompasses a wide variety of land uses, particularly with respect to agriculture and forestry. Previous studies indicate that the contribution of non-point sources (NPS) to nutrient loadings is both significant and poorly defined in the region (Gore and Storie, 1993; Wilson, 2000). A recent study of the water resources within Eastern Ontario (CH2M Hill, 2001) and work being conducted by this study illustrate the need for better models and decision support tools for watersheds of this nature, especially for assessing the performance of Best Management Practices (BMP) under various climate scenarios.

5.1 Discharge and Water Quality Relationships[59]

The South Nation River has been monitored for discharge since 1915 at the Plantagenet gauging station and at other stations throughout the drainage basin in subsequent years. It is clear that severe droughts have occurred historically (early 1930s, mid-1960s) and during the last decade discharge has in fact been essentially above the historical (~100 year) average (Fig. 5.2). This is in contrast to the dramatic declines in river discharge that have occurred on the Canadian Prairies since the turn of the century (e.g. the South Saskatchewan River).[60] However, given the projections of various climate change scenarios and past climate, it is clear that the droughts of the 30s are likely to recur.

With summer reductions in flow, one projection is that eutrophication problems (i.e. poor water clarity, increased algal blooms, oxygen declines, fish kills, as well as overall water quality problems) will be exacerbated. Eutrophication is usually the result of increased nutrient levels, in particular phosphorus. In rivers, reductions of flow can also lead to increases in algae since high flow normally leads to dilution of populations that are entrained downstream. However, from analysis of historical data on water quality from provincial water quality monitoring stations (eight in total plus five watershed characterization sites set up by the South Nation Conservation Authority), there is an overall slight positive relationship between discharge and total phosphorus concentrations during summer base flow. This is because much of the change in summer total phosphorus (TP) results from variations in runoff and associated soil erosion. TP is highly correlated with water turbidity, underlying the important contribution of stream bank and soil erosion to in stream TP levels (Haughton 2002).

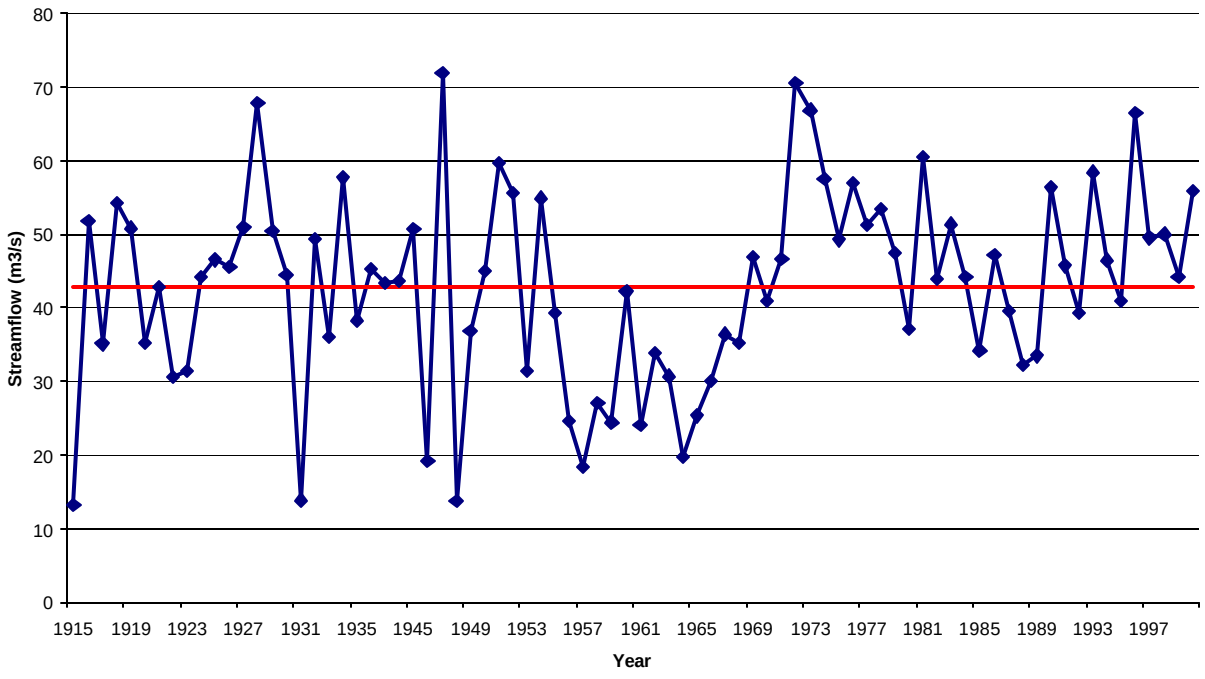
Total nitrogen and nitrate appear less influenced by discharge. For nitrate, this is somewhat surprising given the mobility of nitrate in soils and its tendency to rapidly leach. Peak nitrate levels usually occur in June in the South Nation, which may be more a consequence of the timing of fertilizer applications to fields, rather than to changes in discharge.

With declines in summer flows, both in - stream TP concentrations and turbidity are likely to decline slightly in the river. Although this would represent an improvement in water quality, the declines in flow will lead to changes in algal communities and lead to more floating mats of

[59] This section was contributed by F. Pick
[60] D.W. Schindler U. of Alberta, pers. communication

green algae (metaphyton) and cyanobacteria. The latter at present are not abundant in the South Nation while the former are quite thick in tributaries with low flow from spring to mid-summer. Both cyanobacteria and filamentous green algae can create taste and odour problems for filtration plants (see section 6). In rivers, cyanobacteria are more sensitive to changes in water residence time than changes in nutrient levels. Some cyanobacteria produce toxins. For instance, a cyanobacteria bloom collected from the Rideau River in late August 2002 during a period of low flow and high temperatures (Pick unpub. data) contained microcystin (a hepatotoxin) levels well above World Health Organization standards and that would be detrimental to livestock. Cyanotoxins are a serious human health problem in Australian rivers that tend to be more nutrient enriched, more stagnant and warmer than the South Nation (SN) at present. It is likely that the declines in turbidity will lead to some modest development of attached plant communities in some areas of the river, which would represent a positive outcome.

Figure 5.2. South Nation River Average Stream Flow for Plantagenet Station, 1915-38, 45-2000. Records during WWII were incomplete (1938-45). Squared symbols represent the yearly average with the solid line representing the historical average (42 m^3/s)



5.2 Discharge, Temperature and River Ecology[61]

Unfortunately the historical records of water temperature changes are not as solid as the discharge data. With increases in air temperature and associated shortening of the ice-covered season, water temperature increases in summer are to be expected and periods of high temperature will be prolonged. Historical records from the St. Lawrence River have shown an

[61] This section was contributed by F. Pick

increase in water temperature over the last couple of decades (data from Atwater pumping station, Montreal).[62] Because of a general lack of trees along the South Nation main stem, water temperature is higher than it might otherwise be, given the well established relationship between percent forest cover and stream temperature. Further increases in summer water temperature will aggravate the shift in algal communities to more nuisance populations of floating green algae and potentially toxic cyanobacteria brought about by longer water residence times. Increases in water temperature will further aggravate the low oxygen problems and re-enforce a shift to less desirable fish species such as carp, already present in the River (Haughton 2002). Further analyses of fish distribution records will determine whether the loss of specific sport fish such as bass and pike is likely.

It is well known that increases in temperature will mean that southern species can extend their ranges further north and that reproduction patterns will change. As a local example, a small lake near Ottawa now contains a potentially toxic cyanobacterium, a recent invader of subtropical origin (Hamilton *et al.*, 2003). It requires lake sediments to reach 24 ºC for germination from resting stages; its appearance in Canadian waters is most likely a consequence of warmer conditions.

Although not directly related to climate change but rather to increased boat traffic between and within continents, exotic species such as the zebra mussel have been found in downstream sections of the South Nation. Its invasion has been much less successful in the South Nation than in the Rideau River (Rideau River Roundtable, 2001), for reasons that are not entirely clear but possibly related to less boat traffic as well as to the high turbidity of the SN.

5.3 The Current Ecological State of the South Nation River[63]

Land-use in combination with climate determines river water quality and ecology. In the case of the South Nation, land-use has had a profound impact on the system, beginning with the extensive logging and draining of wetlands at the turn of the century. The South Nation is presently among the most eutrophic rivers in the province of Ontario (Basu *et al.*, 1996) and approaches the level of eutrophication of the most impacted St. Lawrence River tributary, the Yamaska River (Primeau, 1999). Total phosphorus levels are consistently well above the provincial water quality guideline of 30 µg/L (State of the Nation Report, Haughton 2002). In the Scotch tributary of the South Nation, TP levels have exceeded 200 µg/L over the past 5 years and close to half of the TP is dissolved inorganic phosphate and therefore directly available to algae and plants.

Although in most rivers there is a strong correlation between TP concentrations and algal levels during summer base flow conditions (e.g. Basu *et al.*, 1997), in the South Nation this relationship is weak and better predictions of river algal biomass are possible when nitrogen levels are considered (Grenier, 2002). This may be related to the fact that much of the TP in the SN may be bound to soil particles and not immediately bioavailable.

[62] C. Hudon, DOE Centre St. Laurent, pers. communication
[63] This section was contributed by F. Pivck.

In the South Nation, total nitrogen levels are also very high with nitrate often exceeding the total Kjeldhal nitrogen (dissolved organic nitrogen, particulate nitrogen plus ammonium), a situation unusual for surface waters. For nitrate, values as high as 8 mg/L have been found at water quality stations in recent years (Grenier 2002). In contrast the Rideau River for much of its course has nitrate at detection levels and even in the downstream reaches, past the Jock and the city of Ottawa, levels rarely reach 0.5mg/L (Rideau River Round Table, 2001). In the absence of any large urban discharges in the South Nation, high nitrate levels are indicative of widespread fertilizer use in the drainage basin. Of concern here is that there appears to be a great deal of exchange between the river and associated groundwater.[64] Nitrate levels in groundwater are elevated in a number of wells recently tested in the South Nation drainage basin (see section 4.2). In some areas, it is quite possible that the river itself may actually be contributing to high nitrate levels in groundwater during periods of low flow.

It would appear that the South Nation river system overall is not processing nitrate effectively (Alloway, in prep). For reasons that are still not clear, denitrification (and subsequently loss of nitrogen to the atmosphere) that normally occurs at high rates in shallow unperturbed rivers and streams is not operating effectively. This may be the result of the lack of a substantial riparian zone and lack of wetland areas where nitrogen can be effectively retained (i.e. denitrified and lost to the atmosphere). Excess nitrate loading can be a problem for downstream ecosystems. For instance, the widening zone of anoxia in the Gulf of Mexico is attributed to excess nitrate loading from the Mississippi River.

Visible algal blooms are fairly common in summer and oxygen levels in summer on the main stem are frequently at levels stressful to fish (< 4 mg/L at mid-day).[65] Because of the high turbidity, due to algal cells as well as soil particles, water clarity is very poor and there is a general lack of aquatic plants that would be expected in this temperate lowland river. In rivers, attached aquatic plants are desirable as they help consolidate sediments and improve water clarity, oxygen levels and fish habitat. With the exception of some headwater tributaries, the South Nation, like many lowland European rivers has largely lost its attached plant communities. In contrast, the Rideau River in Eastern Ontario, despite a similar discharge and overall gradient, has more modest nutrient levels, better water clarity and hence supports a higher diversity of plants and fishes (Rideau River Round Table, 2001). The Rideau River drainage basin, despite a higher population density has less agriculture and lower livestock densities (Rideau River Round Table, 2001).

5.4 Measures to Alleviate Impacts of Climate Change[66]

Despite perceptions by municipal and CAs' staff that the state of Eastern Ontario watersheds is good, the South Nation River, by Ontario and Quebec standards, is in poor ecological health and would be a candidate for restoration measures irrespective of climate change considerations (see section 9.2.1 *infra* for perceptions). In contrast to the Rideau River, the South Nation is not viewed as having much recreational value but this need not be the case.

[64] M.Robin, pers. comm.
[65] South Nation Conservation and Pick pers. Observations.
[66] This section was contributed by F. Pick.

South Nation Conservation (SNC) promotes the use of recreation areas it manages along the river as well as proposing canoe/kayak routes (www.nation.on.ca). Efforts to restore rivers are usually preceded by a change in perceived values. As societal values change, changes in public policy follow (Meffe *et al.*, 2002). Around the world the perception of rivers as transportation and conduits for waste has changed considerably to the point that, in Europe and parts of North America, meanders are being re-created in previously channelized reaches, dams are being removed and fisheries recovered. A recent initiative on the South Nation to reconnect a small ox-bow lake to the river flow for fish habitat restoration is a local example (www.nation.on.ca).

A healthier river system would help buffer the effects of climate change, both from declines in flow and from extreme events of precipitation and flooding. For the South Nation this means: **1. development of a vegetated riparian zone, 2. reductions in nutrient loading, 3. wetland protection and creation** (Recommendation 24 b)**.**

1. At present with the exception of some headwater tributaries the riparian zone is small to non-existent along the main stem of the South Nation. Even where trees can be found they are usually restricted to a single row. A broad vegetated strip including not just grasses, but trees and shrubs should be actively promoted and protected. Forestry practices normally require buffer strips to be left along river banks when areas are logged, but agriculture is not required to follow similar practices to minimize impacts on aquatic systems. Furthermore, bank erosion due to cattle accessing the river is evident in many sections of the South Nation. Incentives do currently exist for farmers to restrict livestock access and for buffer strip establishment through the South Nation Conservation Clean Water Program (see section 10). However, data on the actual amount of fencing or buffer establishment that has taken place over time are difficult to obtain, as is the case for similar initiatives in the Rideau River watershed (Rideau River Roundtable, 2001). In the absence of a riparian zone, crops, in particular corn, are grown to the edge of the riverbank and corn stalks can be found in tributaries such as the Scotch. The development of a natural vegetated riparian zone will have benefits in reducing nutrient loading, erosion, lowering water temperatures and dampening the effects of extreme events. Such corridors ("ribbons of life") provide important habitat for wildlife, often the only habitats in heavily agricultural landscapes. The recent involvement and partnership of Ducks Unlimited with the SNC in promoting buffer zones should help (see section 10).

2. Nutrients and to a lesser extent herbicides are probably the most insidious pollutants of the South Nation. Much of the nutrient loading comes from non-point sources (90%, EOWRMS, CH2M Hill, 2001) and likely stems from runoff from fertilized fields and livestock operations. Curbing these pollutants is a challenging and ongoing problem throughout Canada (Chambers *et al* 2001). The nutrient management plans for farms recently developed by the Province of Ontario are a step in the right direction but they clearly require the endorsement of the agricultural community to be successful. Focusing on nutrient controls also has the added indirect benefit of reducing pathogen release to surface and groundwater (see section 7). The phosphorus credit system of SNC (see section 10) may also provide some benefits in curbing nutrient loading. However, the credit system needs to be analyzed critically both from a scientific and economic

standpoint as data become available in order to determine if it is having the desired impact on surface and groundwater water quality.

As shown in the Annualized Agricultural Non Point Source (AGNPS) modeling of Best Management Practices (BMP) strategies (see below), nutrient reduction measures and the provision of vegetated buffer strips may not provide immediate improvements to in-stream levels of nutrients. However, changes in algal and plant community structure are likely as described above. Furthermore, it should be noted that reductions in nutrient loading as well as the provision of vegetated buffer strips provide additional benefits, namely the provision of wildlife habitat and biodiversity, along with enhancing the recreational value of the river.

One emerging issue that should be examined critically is that of ethanol production. If biofuels are indeed actively promoted to meet Kyoto Protocol targets in Canada, ethanol derived from further corn production will have undesirable impacts on water quality in the region, both surface and groundwater.

3. Wetlands serve several functions in landscapes, and have been referred to as "natural kidneys" because of their role in regulating flow and filtering pollutants. Artificial, constructed wetlands to treat urban, industrial and agricultural wastes have been designed with both these functions in mind. The basin of the South Nation once had extensive wetlands and, in some areas, over 80% of original wetlands have been lost (Haughton et al. 2002). Currently they represent only 4.7% of the landscape. There are a number of Areas of National Scientific Interest (ANSI) wetlands in the South Nation watershed that are among the finest in the Ontario. Stringent protection of existing wetlands (Alfred, Winchester, Moose Creek and what is left of the Newington bog) is necessary. If possible active re-creation of wetlands should be encouraged to provide relatively inexpensive purification of agricultural wastes (including runoff) and serve as hydrological buffers against floods and droughts. The constructed wetland at Dinard, serving a dairy farm, is an example of a low cost operation for treating manure wastes that has been ongoing successfully for several years now. From modeling studies, it appears that several small wetlands in a landscape have a bigger impact than one large wetland in protecting water quality and providing hydrological buffers during floods and droughts.

5.5 Modeling Best Management Practices[67]

Best Management Practices (BMPs) were investigated in order to find out whether they would alone or in combination improve water quality on the South Nation under climate scenarios developed above (Section 3). The work presented here combines the use of the dynamic Annualized Agricultural Non Point Source (AnnAGNPS) pollutant loading model, developed by the U.S. Department of Agriculture and the dynamic water-quality model, CE-QUAL-RIV1 which was selected due to its riverine nature and its close linkage to the AnnAGNPS concept of a channel network ((Binger *et al*., 2001; US Army Corps of Engineers, 1995).

[67] This section was contributed by G. Parker, R. Droste and K. Kennedy.

Software utilities were developed to facilitate populating the watershed model with data and to improve parameter estimation. The connected models simulate nutrient loading from a series of cells along a dendritic (leaflike) system of reaches, where water quality processes are simulated. While previous studies subdivided the area into a hundred cells or so, the simulations conducted with use of the new utilities considered several thousand cells (3100) for each simulation run. The AnnAGNPS output processing tools were then further supplemented with tools to automate the linkage of model results to the water quality components.

The models, once linked, were calibrated to the available data, and a case matrix focusing on predicting the feasibility of BMPs' effectiveness within the context of climate change was constructed and simulated. Results of the work were then further analyzed through use of water quality criteria and stress conditions for fish species within the river network. The policy question addressed is the following: "What are the potential benefits of implementing agricultural BMPs throughout the South Nation watershed, and will they continue to be effective under changing climate conditions?"

A utility was developed permitting the use of a genetic algorithm (GA) in conjunction with the models so as to evolve a population of near-optimal solutions to the calibration problem. An additional benefit of the GA approach towards model calibration was that it generated a population of solutions whose diversity can be used to qualify the results. Good candidate solutions of distinctly different nature can be derived, and subsequently contrasted and compared.

Table 5.3 Weather Scenarios Considered for Surface Water

Weather Scenario	Description	Data Type
	Average (Synthetic)	GEM
1	Average	Historical (1909)
4	Warm Wet Year	Historical (1973)
3	Warm Dry Year	Historical (1966)
7	Cold Wet Year	Synthetic[1]
	Cold Dry Year	Synthetic[1]

[1] These scenarios are based on an amalgamation of historical data

Figure 5.3a Total Monthly Precipitation for Climate Scenarios

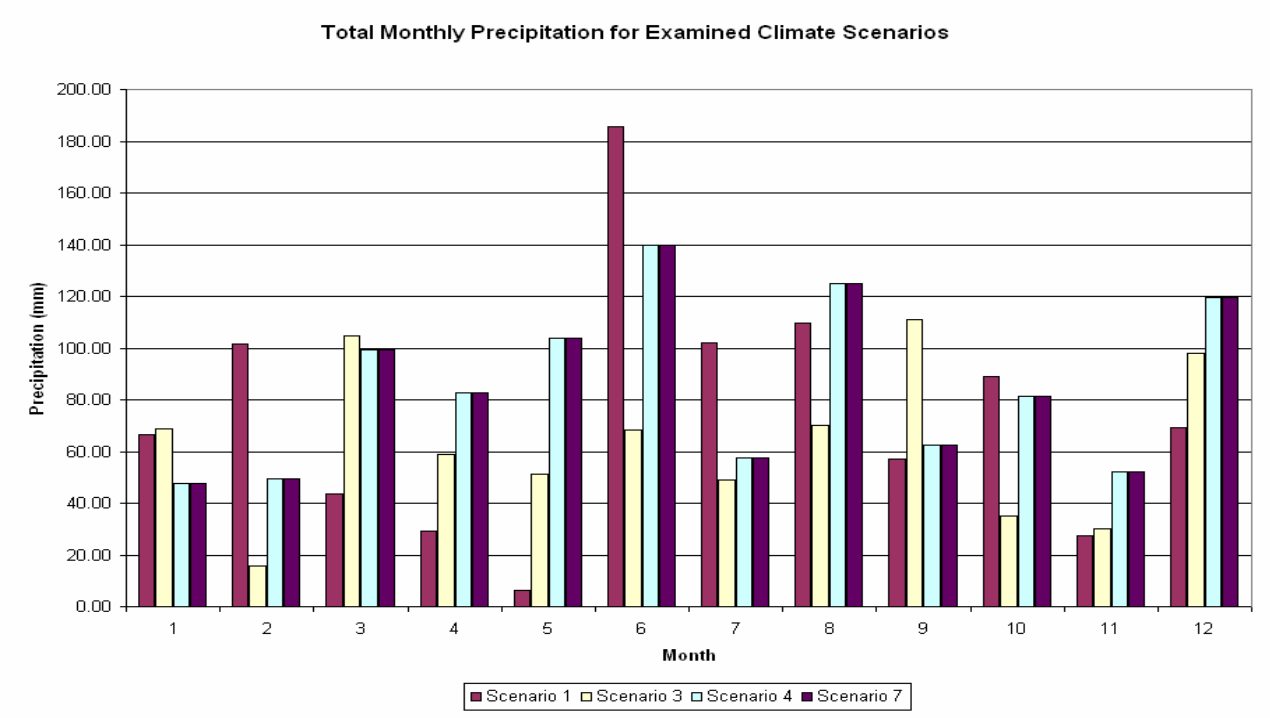
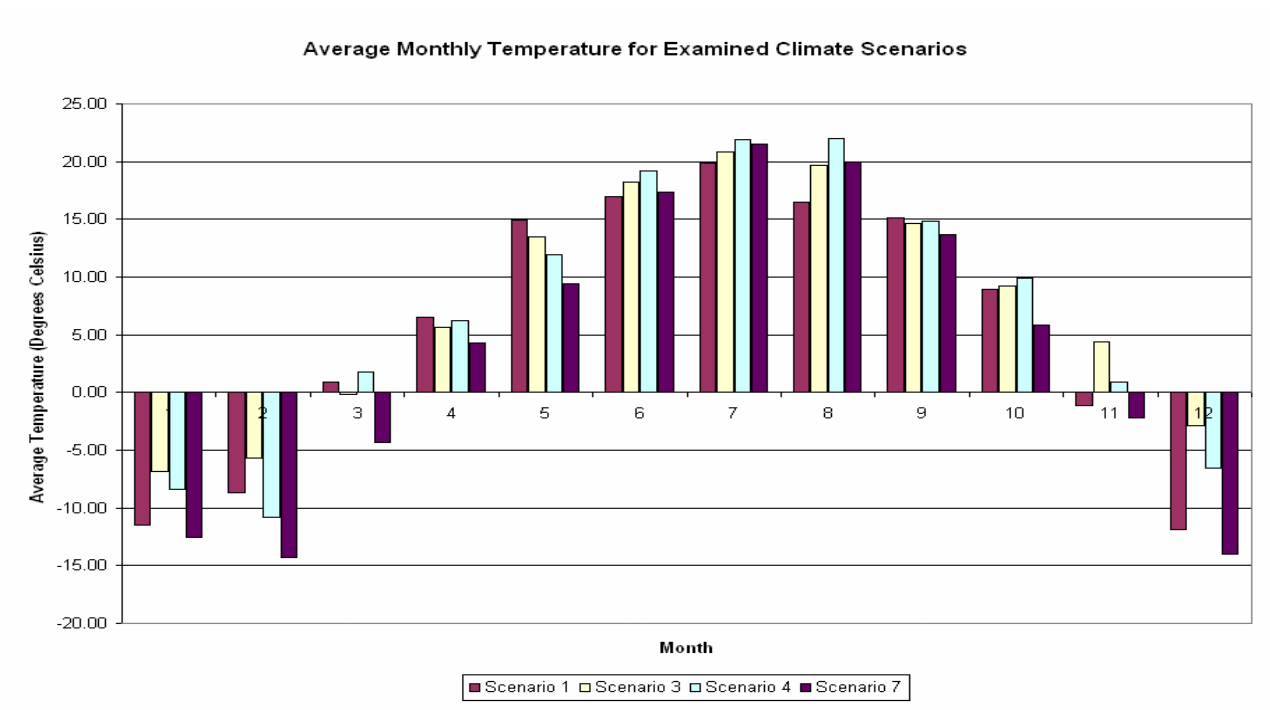


Figure 5.3b Average Monthly Temperature for Climate Scenarios



The AnnAGNPS package includes a synthetic weather generator, GEM, which generates data based on historical values for nearby weather stations (Binger *at al*., 2001). A synthetic 'typical' year generated by GEM was included in our analysis as a scenario, for further comparison. Note that only analogue scenarios 1, 3, 4, and 7 were used (see Section 3). The final climate scenario presented in table 5.3 is an artificial scenario constructed from historical data to represent a "cold-dry" weather scenario. Scenarios A and B were examined internally by the modelers to test the sensitivity of the AnnAGNPS results and are mentioned here in passing for the sake of completeness. The BMPs considered were: fertilizer application rate (FAR; a proxy for reductions in nutrient loadings), vegetative filter strips (VFS; vegetated riparian zones), stream access of livestock, and reduced tillage.

FAR, expected to be high in the region, was decreased up to 50% through simulations.

VFS are areas placed next to cropland. They are designed to remove sediment from runoff. VFS are planted along streams, ponds, and lakes, and can substantially decrease the amount of sediment reaching the waterways. VFS implementation throughout the watershed was simulated by reducing the sediment loading reaching the river system. The reduction is dependent on the width of the VFS; therefore, several implementations of these systems were simulated.

Stream access (by livestock) is controlled through use of topography, natural barriers, and fencing. A reduction in stream access was simulated through reducing the load of livestock waste going directly into the stream. Waste not going directly into the stream was still considered; however, it was given a typical value per animal type.

Reduced tillage, conservation and no tillage techniques exist in a fairly wide variety of configurations depending on crop type, area to be managed, and so on. To avoid considering one method exclusively, it was decided that the simulation should focus on actual reduction in tillage extent throughout the watershed.[68]

Water quality criteria were taken from the Canadian Council of Ministers of the Environment (CCME) guidelines and used to quantify the results (AES, 1999).
The criteria used are summarized in table 5.4.

Table 5.4 Water Quality Criteria Used during Simulation

	CCME-Based Criteria (mg/L)				
Criterion	**DO**	**NH3**	**NO2**	**TN (as N)**	**TP (as P)**
Minimum	5.5	-	-	-	-
Maximum	-	1.09	0.06	1.0	0.05

Stress scores for fish were developed according to the following table.

[68] There is a dearth of solid scientific data showing the benefits of reduced tillage on phosphorus loading. Reduced tillage is of little benefit if there is no vegetated buffer zone in place.

Table 5.5 Criteria for Generating "Stress Condition" Scores for Fish

Stress State	Stress Score	Dissolved Oxygen Concentration Range	Ammonia Concentration Range	Turbidity Range
Poor	4	< 3 mg/L	> 0.11 mg/L	>110 NTU
Stressed	2	3-5 mg/L	0.07-0.11 mg/L	75-110 NTU
Not Stressed	0	= 5 mg/L	= 0.07 mg/L	= 75 NTU

The following two tables list the management scenarios simulated in the analysis presented here. The results were tested individually over each weather scenario for their effectiveness at minimizing nutrient loading of the river. The computed nutrient loadings were then used in the above-mentioned models to obtain a quantitative assessment of water quality for each scenario. The results were then further examined for overall effectiveness over all 6 climate scenarios listed in table 5.3, including the 4 analogue scenarios.

The time-series outputs of the model results varied considerably between climate scenarios, as should be expected given changing runoff events. Despite these differences, some characteristic results were exhibited over all scenarios examined. It is clear, for instance that the BMPs can potentially offer some improvement of water quality levels through the substantial reductions in loadings; however, these improvements do not appear to be sufficient to meet typical provincial standards by themselves. The high degree of agricultural activity in the watershed precludes the possibility of achieving provincial standards even with good practices.

The FAR and VFS management practices were far more effective across all scenarios than the reduced tillage and stream access approaches, and the potential benefits predicted from the aggregate scenarios including only the top two management practices were essentially identical to those obtained using all four management practices in conjunction. Their effectiveness is highest in the spring months of March and April.

A further benefit of the FAR and VFS management practices is that they address different areas and complement each other well, providing together a broad reduction of nutrient loading classes. Additionally these management practices are quite feasible, both logistically and economically, and can probably be deployed to a reasonable extent throughout the South Nation watershed.

Table 5.6 Management Regime Matrix

Management Regime	BMP implemented
1	BASELINE
2	FAR = 50% decrease
3	FAR = 60% decrease
4	FAR = 70% decrease
5	FAR = 80% decrease
6	FAR = 90% decrease
7	VFS = 3 meters
8	VFS = 6 meters
9	VFS = 9 meters
10	VFS = 12 meters
11	No Stream Access
12	1/3 Stream Access
13	½ Stream Access
14	2/3 Stream Access
15	¾ Stream Access
16	75% Reduced Tillage
17	50% Reduced Tillage
18	25% Reduced Tillage

Table 5.7 Grouped Management Regime Matrix

Management Regime	BMP Implemented
19	All BMPs applied heavily
20	All BMPs applied moderately
21	FAR and VFS applied heavily
22	FAR and VFS applied moderately

The fact that the last decade flows of the South Nation were greater than average does not affect these results, as they are based on a 68 years flow history.

Therefore, these best management tools should be made available and encouraged throughout the watershed, due to the relatively low cost and substantial reductions in pollutant loadings they can provide. However they must not be seen as panacea, and must be considered only partial solutions to integrated watershed management issues. **To attain stream provincial standards, reduction of agricultural activity is implied.**

It has been shown that there is a large data gap on the understanding of groundwater quality in Eastern Ontario and that there are many areas of high aquifer sensitivity (CH2MHill, 2001). Another study has indicated that there are many locations in the Ottawa area that have a high risk for groundwater contamination due to conditions such as sandy soil and a high water table (CH2MHill, 2001).

Conclusions and Recommendations

1. Implementation of BMPs will, of course, improve surface water quality in the watershed. Some of the BMPS are implemented at no or little cost.

2. The BMP implementations considered in this study will not result in a significant reduction in violation of CCME stream quality standards.

3. The BMP implementations are effective at reducing peak stress levels in the river system even in circumstances where average stress levels are not significantly affected.

4. A reduction in agricultural activity must be considered to achieve stream quality standards or the stream should be reclassified.

5. Improvement in treatment of wastewaters from point sources (communities) will not have a measurable impact on surface water quality since the majority of pollutant loads originate from nonpoint sources (i.e., agricultural activity).

6. A comprehensive data set on the South Nation watershed has been assembled and incorporated into the current version of AnnAGNPS. South Nation Conservation and other institutions should continue to use and augment these data with this model to allow more extensive evaluation of scenarios.

7. Furthermore software pre- and post-processing utilities have been developed to automate data handling for AnnAGNPS. It is recommended that full-time qualified personnel in governing bodies in any of the surrounding watersheds apply these tools for similar analyses.

8. A genetic algorithm for calibration of AnnAGNPS and assessment of results has been developed. This tool will be useful to other watershed authorities.

9. The GA-AnnAGNPS tool will also prove particularly useful in examining the potential benefits of highly localized implementations of severe nutrient control practices.

References

AES (Alberta Environmental Service)(1999) *Surface Water Quality Guidelines for Use in Alberta: 1999*; Alberta Environment: Edmonton, AB.

Alloway, C. (in prep.) *Factors regulating nitrogen retention and export in a lowland river drainage network*. MSc, University of Ottawa.

Basu, B. K. & F.R. Pick .1996. Factors regulating plankton abundance in large temperate rivers. *Limnol & Oceanogr*. 41: 1572-1577.

Basu, B. K. & F.R. Pick. 1997. Phytoplankton and zooplankton development in a lowland temperate river. *J. of Plankton Research* 19: 237-253.

Binger, R.and F. Theurer (2001) *AnnAGNPS Technical Processes Documentation Version 2*; USDA-Agricultural Research Service: Oxford, Mississippi.

Chambers P.A., M. Guy, E.S. Roberts, M.N. Charlton, R. Kent, C. Gagnon, G. Grove, and N. Foster. 2001. *Nutrients and their impact on the Canadian Environment*, Agriculture and Agri-Food Canada, Environment Canada, Fisheries and Oceans Canada, Health Canada and Natural Resources Canada. Ottawa, Ont. 241 p.

CH2M HILL, (2001), *Final Report. Eastern Ontario Water Resources Management Study (EOWRMS): United Counties of Prescott & Russell, Stormont, Dundas, Glengarry, City of Ottawa*

Gore and Storie (1993) *Final Report for the Wastewater Allocation Study South Nation River*; South Nation River Conservation Authority: Berwick, ON.

Grenier, S. 2002. *La relation saisonnière chlorophylle a/phosphore et les facteurs de contrôle du phytoplankton dans le basin hydrographique de la Nation Sud,* BSc Honours thesis, Environmental Science Programme, University of Ottawa.

Hamilton, P.B., Ley, L.M., Dean, S. and F.R. Pick.(2003) The occurrence of *Cylindrospermopsis raciborskii* (Woloszynska) Seenay and Subba Raju, in Constance Lake, a new invasive cyanoprokaryote to Canada. Submitted

Haughton, J. 2002. *A State of the Environment Report for the South Nation River Watershed*. BSc Honours thesis, Environmental Science Programme, University of Ottawa. In Appendix. To be posted at www.nation.on.ca/English/wtrmgnt.htm

Meffe, G. et al. 2002. *Ecosystem Management : Adaptive Community-based Conservation*. Island Press. Washington, D.C. pp. 313.

Primeau, S., 1999. Le bassin de la rivière Yamaska: qualité des eaux de 1979 a 1997, section2, dans Ministère de l'Environnement (ed.), Le bassin de la rivière Yamaska : état de l'écosysteme aquatique, Québec, Direction des écosystemes aquatiques, envirodoq n°EN990224, rapport n°Ea-14

Rideau River Round Table. 2001. *State of the River Report: a report on the environmental health of the Rideau River*. www. rideauvalley.on.ca/programs/rrr/rrr.html

U.S. Army Engineers Waterways Experiment Station (1995) *CE-QUAL-RIV1: A Dynamic, One Dimensional (Longitudinal) Water Quality Model for Streams: Users Manual*; Report EL-95-2, U.S. Army Engineers Waterways Experiment Station: Vicksburg, MS.

Wilson, D.J. (2000) *Systems Analysis of Decision Support Systems for Water Resource Users and Planners in Eastern Ontario*; Thesis, University of Ottawa: Ottawa, ON.

Section 6 Projected Physical Impacts of Climate Change on Water and Wastewater Treatment Facilities and Adaptation Measures[69]

The current section assesses the likely impacts of climate change on water-related built infrastructure, namely water and wastewater treatment plants, without explicit reference to the physical scenarios developed in section 3, since water quantity is here the main issue. Though adjustments need to be made, no major impact of climate change is expected in the region for water-related built infrastructure.

6.1 Context

The climate change impacts that are most likely to affect the water and wastewater treatment systems in the study area are: a possible increased frequency of big storm events, a possible increased severity (length) of droughts, and possibly greater evaporation, which will lead to lower stream flows and lower water levels (Pielke et al., 2000; Mimikou et al., 2000; De Loë and Kreutzwiser, 2000). The average annual precipitation is expected to remain the same but precipitations events would shift to the winter (see Section 3).

EOWRMS showed that 63% of the population of the area lives in a rural setting and its water and wastewater needs are served by wells and septic systems, respectively (CH2M-Hill, 2001). EOWRMS included a general survey of the water and wastewater treatment infrastructure serving the city and town dwellers in Eastern Ontario. Surface water for municipal consumption in the study area is primarily extracted from the Ottawa River, the St. Lawrence River and the South Nation River.

6.2 Methodology

The EOWRMS survey was not concerned with climate change. Based on likely impacts of climate change, three separate survey questionnaires were developed by this study: one for water treatment systems, one for wastewater treatment plants, and the last for lagoon systems. The questionnaires were developed to complement the data gathered in EOWRMS, and to identify characteristics that would make the treatment systems susceptible to climate change impacts. A large number of these facilities were visited in order to gather the information identified within the questionnaires. Due to time limitations, for water treatment systems, we concentrated on the ones using surface waters as a source only.

This is a limitation, since several municipalities draw their communal water from wells; however, a number of these communal wells are presently being examined in a series of wellhead protection and contaminant assessment studies in the area (Robinson Consulting, Municipal Groundwater Studies, series of seven reports, 2003).

[69] This section was contributed by V. Paris and R. Narbaitz.

6.3 Survey Results

6.3.1 Water Demand

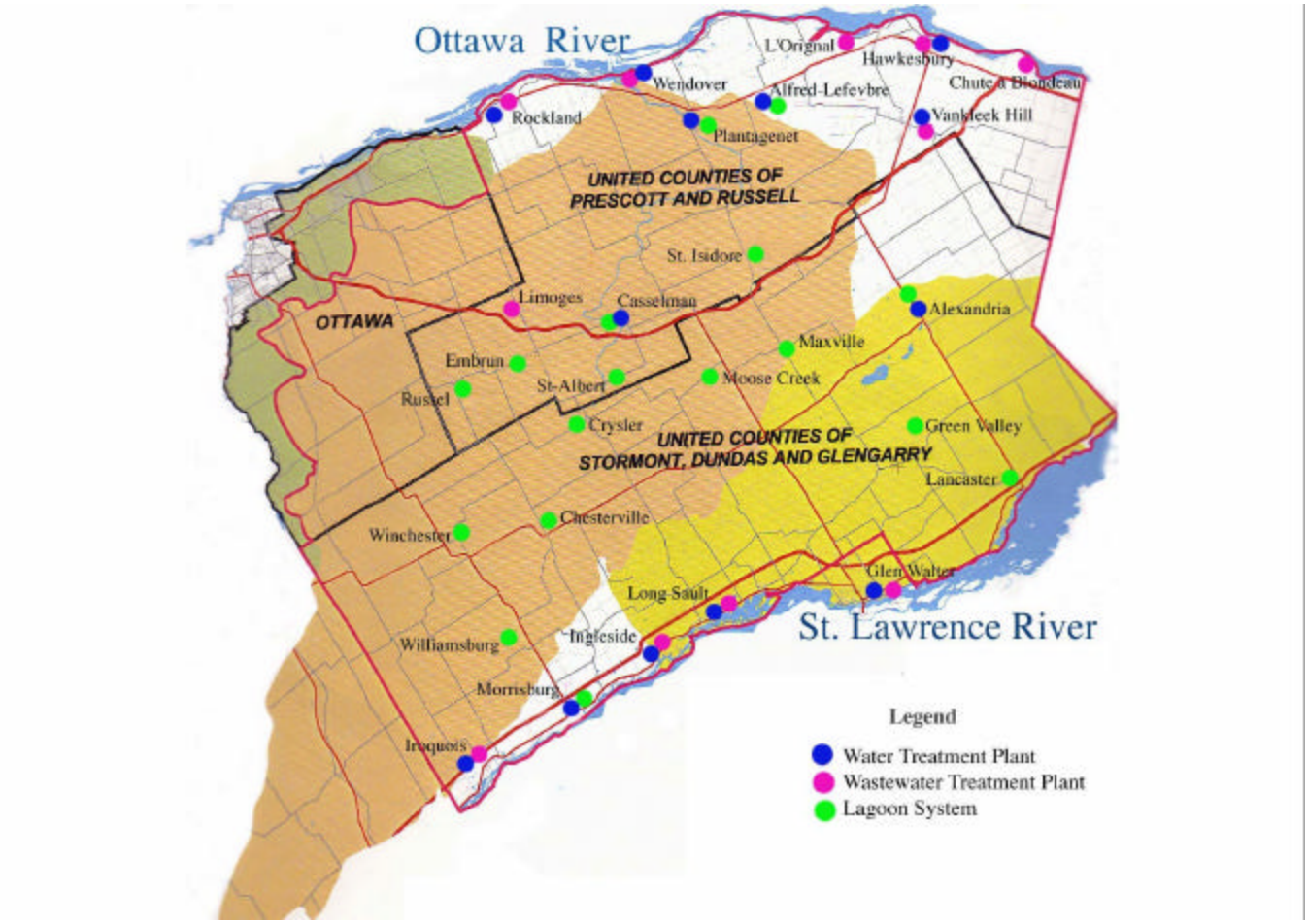
Typical domestic water consumption rates are in the order of 0.4 m^3/day in the study area. Table 7.1 shows that the water demands for Alexandria, Ingleside and Iroquois are fairly high because the water treatment plants provide water for industries (i.e., textile plant (Alexandria), Kraft Foods (Ingleside) and St. Lawrence Corporation (Iroquois)).[70] At Glen Walter, the high per-capita demand is caused by the watering of lawns and gardens. Leakage from the distribution systems is likely to be responsible for the high per capita demand for Long Sault and Morrisburg, as 70 percent of their distribution system was built during the 1950's.

Table 6.1 Surface Water Treatment Plants in the Study Area (after CH2M-Hill, 2001)

Facility	Total Population Served (1996)	Per Capita Demand (m3/day)	Avg. Production (m3/day)	Capacity Utilization
Alfred-Lefaivre	2200	0.482	977	74%
Casselman	2755	0.380	1047	54%
Hawkesbury	12207		15000	50%
Plantagenet	908	0.482	472	41%
Rockland	8100	0.328	2659	61%
Vankleek Hill	1803	0.316	570	21%
Wendover	824			
Alexandria	3500	1.013	3546	80%
Glen Walter	450	0.793	357	88%
Ingleside	1550	1.961	3040	57%
Iroquois	1368	1.988	2720	92%
Long Sault	1820	0.883	1607	43%
Morrisburg	2570	0.975	2507	101%

[70] The closure of the textile plant was announced last October (Ottawa Citizen, Section D, October 22, 2003).

Graph 6.1 Localization of Water and Wastewater Treatment Plants



As seen from table 6.2, most, but not all, communities have metered water systems. In Ingleside, Iroquois, Long Sault and Morrisburg distribution systems, only industries are metered at present. Metering of these distribution systems is planned during the coming year. All systems experience an increased demand during dry periods but this does not necessarily result in water shortage. Surprisingly, some of the systems with lowest excess capacity (i.e. highest capacity utilization) did not report water shortage problems (see table 6.2).

Table 6.2 Surface Water Treatment Plants Survey Results – Capacity and Quality Aspects

Facility	Source	Metering	Storage Reservoir	Scarcity	Increased Demand During Dry Spells	Turbidity Variations	Algae	Taste & Odor	Color
Alexandria	Mill Pond	Yes	Yes	Yes	No	No	Yes	Yes	
Alfred-Lefaivre	Ottawa River	No		Yes					
Casselman	South Nation River	Yes							Yes
Glen Walter	St. Lawrence River	Yes	Yes	No	Yes	No		Yes	
Hawkesbury	Ottawa River	partly	Yes	No	Yes	Yes	Yes	Yes	Yes
Ingleside	St. Lawrence River	partly	Yes	No	Yes	Yes			
Iroquois	St. Lawrence River	partly	Yes	No					
Long Sault	St. Lawrence River	partly	Yes	No	Yes	Yes		Yes	
Morrisburg	St. Lawrence River	partly	Yes	No	Yes	Yes		Yes	
Plantagenet	South Nation River	Yes	Yes	No	Yes	Yes	No	Yes	No
Rockland	Ottawa River	Yes	Yes	Yes	Yes				
Vankleek Hill	Ottawa River	Yes	Yes	No					
Wendover	Ottawa River			No	Yes				

An increase in water demand, mainly caused by watering of lawns and gardens, is expected during the longer and more frequent drought periods predicted with climate change (Creese *et al*., 1996). During these increased demand periods, there is the possibility of insufficient supply to satisfy water demand. The increased demand can be met by either expanding the water supply systems, by reducing demand or by a combination of the two. Water demand can be reduced by implementing water pricing schemes, charging more for larger than average consumption, implementing water savings systems, imposing water consumption restrictions during dry periods, changing the ornamental vegetation to one that is more drought tolerant, implementing wastewater reuse schemes for irrigation, etc. (see section 11)

6.3.2 Water Treatment

Potentially lower water levels, warmer temperatures and longer periods between storms appear to favor additional algal growth in surface waters. Algae cause taste and odor problems, which are expected to increase under the dry scenarios of climate change. Algal toxins may also become a problem.

Many water treatment plants reported significant variations in raw water turbidity and difficulty adjusting the coagulant dose to provide satisfactory removals (Table 6.2). The more intense storms predicted by some climate change scenarios will increase this type of variability. This will result in higher chemical dosages during storm periods and will require more precise monitoring and operator control.

For plants using smaller water bodies, potentially lower water levels may require deeper water intakes.

Water quality from water treatment plants is currently perceived as good by municipal and CAs' staff (see section 9.2.1 *infra*).

6.3.3 Wastewater Treatment

The urban dwellers in eastern Ontario are served by 11 mechanized wastewater treatment plants and 17 wastewater lagoon systems (CH2M-Hill, 2001). The main impact of climate change on wastewater treatment systems is expected to be an increase in wastewater flows during more intense storm events (Creese *et al*., 1996). The magnitude of the impact will depend on the availability of combined sewers (or separate storm sewers) and the extent of the infiltration into the sewers. In small communities served by combined sewer systems, the wet weather wastewater flow can be two, three or four times the average dry weather flow. Such high flows can greatly decrease the wastewater treatment plant ability to remove contaminants. To avoid long term decreases in pollutant removal capacity, many mechanized plants resort to temporary bypassing of a portion of the wastewater during a storm period. In bypassing a portion of the wastewater, part of the flow receives full treatment while the portion by-passed only receives partial treatment. Bypassing, which is not permitted in some US states, can be avoided by enlarging the plant capacity or building an equalization basin upstream from the treatment system.

Most lagoons were designed to discharge annually or semi-annually; they should not be impacted much by higher flow fluctuations. As the total amount of annual precipitation is not expected to change significantly under all scenarios, the lagoons that currently have sufficient capacity should have sufficient capacity (volume) to accommodate climate change impacts. In addition, the higher evaporation rate projected for the future could present a gain of free volume in the lagoons.

The study area mechanized plants are listed in table 6.3. Only one of them has a 100% capacity utilization (i.e. average actual flow rate to design flow rate ratio), indicating that plant expansion is required. Based on plant visits it was established that, except for parts of Hawkesbury, the

communities were served by separate (non-combined) sewers. The survey also showed that in many systems, wet weather flows are very high in spite of separate storm sewers.

Table 6.3 Wastewater Mechanized Treatment Plants in the Study Area (CH2M-Hill, 2001)

Facility	Total Population Served	Capacity (m^3/ day)	Capacity Utilization
Chute a Blondeau		109	62%
Limoges	1300	1073	
Glen Walter	600	525	100%
Hawkesbury	10266	12274	79%
Ingleside	1500	4045	84%
Iroquois	1368		
L'Orignal	1700	955	82%
Rockland	8100	6800	46%
Long Sault	1683	8000	19%
Vankleek Hill	1753	2273	52%
Wendover	984	511	70%

Actual wet weather flow rate to design flow rate ratios (Qww/Qw), presented in table 6.4, confirm the high infiltration in most of the study area collection systems. Some mechanical plants had to use their bypassing capabilities. In the more intense storm events expected with some climate change scenarios, continuous discharge systems will have to by-pass flows more frequently (discharging only partially treated sewage) unless equalization basins are built.

The personnel interviewed reported that their mechanized plants met current effluent criteria, except in one case. The Vankleek Hill plant had problems meeting a special Ontario Ministry of Environment (MOE) ammonia criterion during spring periods.

Lagoons are a very popular form of treatment because of their low cost; however they are not the highest form of treatment. They significantly decrease the number of bacteria and biological oxygen demand but are not as efficient in doing so as mechanized plants (Droste, 1997). In addition, algae are an integral part of lagoon treatment systems and their discharge can cause problems in the receiving waters (Droste, 1997). If additional steps are not undertaken to remove the algae from the effluent before discharge, it may result in a lagoon's effluent that is green in

color. Most lagoons use alum precipitation to remove phosphorus; the latter also removes some of the algae.

Table 6.4 Wastewater Treatment Plants Survey Results

Facility	Receiving Waters	Degree of Infiltration	Qww/Qw	Equalization Capacity	Observations
Chute a Blondeau	Ottawa R.				
Glen Walter	St. Lawrence R.	Moderate	1.47	No	During maximum flow events, bypass is practiced
Hawkesbury	Ottawa River	Unknown	0.73	Planned	
Ingleside	St. Lawrence R.	High	1.12	Yes	
Iroquois	St. Lawrence R.	Unknown		No	New Plant is expected in a near future
Limoges		Unknown			
Long Sault	St. Lawrence R.	High	0.95	No	
L'Orignal	Ottawa River	High		No	During maximum flow events, bypass is practiced
Rockland	Ottawa River	Unknown	1.18	No	
Vankleek Hill	Little Rideau Cr.	Low	2.07	No	Certain years, ammonia criteria is exceeded in spring
Wendover	Ottawa River	Unknown		No	

To minimize the impact that the lagoons effluent have on the receiving waters, most lagoons are operated with annual or semi-annual discharges during periods of high stream flow so as to have large dilution. In addition, early spring discharge, before the algal populations in the ponds explode, helps minimize the algae discharge; however, timing is not always adequate and the spring discharge may have to be postponed.

On the other hand, continuous discharge is helpful in augmenting stream flows during low flow periods, such as those experienced during the summer. Maintaining sufficient stream flow is a critical factor for many aquatic species. Mechanized plants discharge on a continuous basis in such a way, that in terms of stream flow augmentation, they are also preferable to lagoons.

As shown in table 6.5, only three lagoon systems are at or above capacity and need expansion and possibly upgrading.

Table 6.5 Lagoon Systems in the Study Area (after EOWRMS, CH2M-Hill, 2001)

Facility	Total Population Served	Capacity (m^3/day)	Capacity Utilization
Alexandria	3500	6818	
Alfred	1231	1364	150%
Casselman	2382	1364	79%
Chesterville	1563	1046	62%
Crysler	213	810	24%
Embrun	3717	1798	72%
Green Valley	325		
Lancaster	750	1000	
Maxville	800	450	
Moose Creek	158	302	39%
Morrisburg	5140	2273	201%
Plantagenet	908	561	119%
Russel	2422	1000	71%
St-Albert		720	23%
St-Isidore		655	60%
Williamsburg	350	1227	20%
Winchester	2600	1725	83%

Table 6.6 indicates that some lagoons have experienced a range of problems including insufficient capacity, effluent quality problems by continuous discharge lagoons, and algal bloom problems. As discussed earlier, occasional algal-related problems are likely with this type of technology and can only be avoided by upgrading the systems. Potential future ammonia effluent regulations are a concern, particularly as lagoon systems are not capable of reliably removing ammonia effluent. However, strict discharge nutrient (phosphorus and nitrogen) standards are not adequate for the South Nation watershed because the nutrient contribution to the river from wastewater treatment effluent sources is much smaller than that from agriculture (CMH2HILL, 2001).

Table 6.6 Lagoon Systems Survey Results

Facility	Receiving Waters	Degree of Infiltration	Discharge	Observations
Alexandria	Delisle River	High	Continuous	Maximum flows dilute wastewater and improve effluent quality. Ammonia not currently treated, but operating authorities are concerned about upcoming ammonia criteria.
Alfred	Azatika Brook Creek	N/A	Annual	
Casselman	South Nation River	N/A	Seasonal	
Chesterville	South Nation River	High	Seasonal	Algal blooms are always a problem during fall.
Crysler	South Nation River	N/A		
Embrun	Castor River	N/A	Annual	
Green Valley	Beaudelais River	N/A	Annual (March to May)	
Lancaster	Finney Creek	N/A	Seasonal (Apr-Nov)	During drought and heavy heat, discharge stops
Maxville	Scotch River	N/A	Annual (November)	
Moose Creek	Moose Creek	N/A	Annual	If spring flows are low, spring discharge is delayed and algal bloom becomes a problem.
Morrisburg	St. Lawrence River	N/A	Continuous	Quality decreases in August and September.
Plantagenet	South Nation River	High	Seasonal	Insufficient hydraulic capacity causes overflow of the lagoon.
Russel	Castor River	N/A	Seasonal	
St-Albert	South Nation River	N/A	Annual	
St-Isidore	Scotch River	N/A	Annual (May)	
Williamsburg	Mc Martin Drain	N/A	Annual (April)	
Winchester	Henderson Creek	N/A	Seasonal	Seasonal algal bloom which increases SS concentration. High ammonia levels during dry years - attributed to high evaporation and strong sewage because of less infiltration.

6.3.4 Conclusion

Some climate change scenarios predict an increase in the severity of droughts, exacerbating the scarcity of water for those municipalities already experiencing water shortages. Water sources such as the Ottawa and the St. Lawrence Rivers are not expected to suffer extreme decreases in water flows that could endanger their supply to water treatment plants. Plants withdrawing their supply from smaller streams and lakes, such as the South Nation River and the Mill Pond, may have to look for a complementary and/or different source of water in order to meet their demand, especially during periods of hot, dry weather.

All water treatment facilities investigated showed increases in water demand during dry and hot weather. Metering of the distribution systems was found to decrease peak demand by approximately 30% and most communities in the region now meter water consumption. Taste and odor problems from algal growth were found to increase during spring and summer and are likely to be exacerbated by a warmer climate with longer dry periods. High turbidity events during wet periods (spring) or following storms are likely to increase in frequency following more severe rain events. In addition, higher temperatures will lead to higher evaporation rates,

which are expected to decrease stream flows and stream depths. All of these factors will lead to more extensive algal growth, resulting in more turbidity, more taste and odor problems and possibly algal toxins. Presence of rainwater in the study area's collection systems was found to be extensive. Municipalities, that are currently practicing different forms of bypass during extreme flows, will likely increase the quantity of bypassed wastewater during the more severe storms that are expected with some climate change scenarios.

Extreme rain events may affect the treatment of lagoon systems that practice continuous discharge. Intensified rain events will further swell the normal wastewater flow to several times the dry weather flow, likely causing incomplete treatment of the wastewater before discharge. In the case of lagoon systems that discharge annually or seasonally, the volume of wastewater directed to the lagoon should not change significantly except during wet years or wet seasons. In such situations, the maximum capacity of the system could be exceeded creating the need for discharge before complete treatment has occurred or before the end of the period indicated on the facility's certificate of approval. In general, the treatment systems most affected by severe storms are the ones that are operated close to their design capacity. During more severe drought periods, small bodies of water receiving effluent from wastewater treatment facilities will further lose their dilution capacity.

The South Nation watershed is highly eutrophic, and the main source of the nutrients is agricultural runoff and not wastewater treatment effluents (CMH2HILL, 2001). So while it would be desirable to replace lagoon systems with tertiary treatment plants because of the superior effluent quality, this would not significantly reduce the eutrophication problems within the watershed. However, switching to a mechanized treatment plant would reduce the ammonia and the algae discharged, thus reducing algal problems at downstream water treatment plants. As the cost of mechanized wastewater treatment plants is quite significant, it may be wiser to funnel funds to enlarging lagoon systems so that they have significantly more excess capacity to handle extreme rain events.

References

CH2M HILL, (2001), *Final Report. Eastern Ontario Water Resources Management Study (EOWRMS): United Counties of Prescott & Russell, Stormont, Dundas, Glengarry, City of Ottawa.*

Creese, E.E., and J.E. Robinson (1996). « Urban water systems for sustainable development, » *Canadian Water Resources Journal*, 21(3), 209-220

De Loë, R.C. and R.D. Kreutzwiser (2000). « Climate variability, climate change, and water resources management in the Great Lakes, » *Climate Change*, 45, 163-179

Droste R.L, (1997), *Theory and Practice of Water and Wastewater Treatment*, Wiley.

Mimikou, M.A., E. Baltas, E. Varanou., and K. Pantazis (2000). « Regional impacts of climate change on water resources quantity and quality indicators, » *Journal of Hydrology*, 234, 95-109.

Pielke, R.A.Jr. and M.W. Downton (2000). « Precipitation and Damaging Floods: Trends in the United States, 1932-97, » *Journal of Climate*, American Meteorological Society, 13(15)

Robinson Consultants, 2003. Draft Final Report. *Municipal Groundwater Study; The Nation Municipality*. Draft Report Prepared for the Eastern Ontario Water Resources Committee, October 2003.

Robinson Consultants, 2003. Draft Final Report. *Municipal Groundwater Study; Township of North Dundas.* Draft Report Prepared for the Eastern Ontario Water Resources Committee, October 2003.

Robinson Consultants, 2003. Draft Final Report. *Municipal Groundwater Study; Township of South Storemeont*. Draft Report Prepared for the Eastern Ontario Water Resources Committee, October 2003.

Robinson Consultants, 2003. Draft Final Report. *Municipal Groundwater Study; Township of North Storemont*. Draft Report Prepared for the Eastern Ontario Water Resources Committee, October 2003.

Robinson Consultants, 2003. Draft Final Report. *Municipal Groundwater Study; Township of Russell*. Draft Report Prepared for the Eastern Ontario Water Resources Committee, October 2003.

Robinson Consultants, 2003. Draft Final Report. *Municipal Groundwater Study; City of Ottawa*. Draft Report Prepared for the Eastern Ontario Water Resources Committee, October 2003.

Robinson Consultants, 2003. Draft Final Report. *Municipal Groundwater Study; Township of North Glengarry*. Draft Report Prepared for the Eastern Ontario Water Resources Committee, October 2003.

Section 7 Projected Health Impacts and Adaptation Measures[71]

The effects of climate change on human infrastructure or human health are complex because we cannot account for a myriad of ecological and social inputs, or for the influence of future adaptation measures. We also still need to strengthen the epidemiological evidence. The effects of climate change on human health can be classified as being direct and/or indirect effects (McMichael *et al.*, 1996; Martens, 1998; Patz *et al.*, 2000; IPCC, 2001; Last *et al.*, 2001). Simply defined, direct effects occur as a direct result of a climate variable (e.g. increased temperature results in a heat related illness), whereas an indirect effect occurs as a result of a 'mediating factor' (e.g. increased temperature increases the spread of a vector borne disease). Anticipated climate-related direct and indirect changes to the natural, built, social and human infrastructures involve significant short and long-term health risks (see table 7.1). Pursuant to section 3, the specific health impacts of climate change relevant to the area of investigation include: thermal stress, extreme weather events (storm, flood, drought), infectious diseases (West Nile virus), air quality (smog and allergies), and water and food-borne diseases associated with land-use. More specifically, these risks are: 1) increased daily and seasonal temperatures, which have direct links (e.g. heat stroke, etc.) and indirect ones (e.g. foodborne illness); 2) extreme weather event with direct (e.g. injuries) and indirect (e.g. depression) consequences; 3) poor air quality as a result greenhouse gas emissions such as particulate matter and gaseous co-pollutants, which are linked with hospitalizations due to respiratory disease; 4) changes to natural infrastructure, particularly agricultural land use.

Health effects of climate change are not all gloom and doom! Warmer winters would decrease the incidence of the flu. Climate change mitigation efforts bring health co-benefits in terms of air quality, increased transportation security (e.g. speed limits), decreasing thereby the need for adaptative health measures. On the whole though, extreme events bring more bad news than good news.

7.1 Vulnerable Populations

Archaeological and historical evidence of the effects of climate changes in North America indicate that, in general, population groups will cope with anticipated environmental changes. Vulnerabilities are determined by multiple factors, which, in part, may be unique to natural and built infrastructures, to populations and their social infrastructure and to individuals (see table 7.2). This study specifically identified vulnerable populations to be most at risk as a result of factors related to a changing environment.

[71] This section was contributed by P. Carty, P. Crabbé and J. Last.

Table 7.1 Canada's Health Impacts from Climate Change and Variability

Health Issues	Examples of Health Vulnerabilities
Temperature-related morbidity and mortality	- Cold-and heat-related illnesses - Respiratory and Cardiovascular stress - Occupational health risks
Health effects of extreme weather events	- Damaged public health infrastructure; - Injuries and illnesses - Social and mental stress due to disasters - Occupational health hazards - Preparedness and population displacement
Air pollution-related health effects	- Changed exposure to outdoor and indoor air pollutants and allergens - Asthma and other respiratory diseases; - Heart attacks, strokes and other cardiovascular diseases - Cancer
Water- and food-borne contamination	- Enteric diseases
Vector-borne and zoonotic diseases	- Changed patterns of diseases caused by bacteria, viruses and other pathogens carried by mosquitoes, ticks and other vectors
Stratospheric ozone depletion	- Skin damage and skin cancer - Cataracts - Disturbed immune function
Population vulnerabilities in rural and urban communities	- Seniors - Children - Poor health - Low income and homeless - Traditional populations - Disabled - Immigrant populations
Socio-Economic Impacts on Health and Well-being	- Changed determinants of health and well-being - Global burden of illness - Vulnerability and community economies - Health and social co-benefits, and risks of GHG reduction technologies

Source: CCHO, 2002.

Table 7.2 Vulnerability Factors

Risk Factors	Health determinants
Individual factors	- disease status (e.g. pre-existing chronic conditions) - socioeconomic considerations (such as household income, education) - demographic considerations (such as age, gender)
Community factors	- public utility quality and adaptability (such as water/ sewer systems) - food access - information access - local disease distribution and control
Geographical factors	- occurrence of extreme events - extent and distribution of mobile vector borne diseases - rural or urban location and access to resources - environmentally sensitive regions

From the conceptualization of vulnerability due to climate change, several population groups have been identified as being in greater risk than the overall population to bear the burden of impact. Specifically, these are: 1. children; 2. elderly; 3. previously ill; 4. individuals with lower income; 5. Aboriginal populations; 6 urban residents, believed to be at a greater risk than suburban dwellers.

Children are more vulnerable than adults to many health effects caused by environmental factors. Their bodies have a greater surface to volume ratio than do those of adults, and they have a higher metabolic rate. Consequently they tend to gain or lose heat energy more rapidly. Children also tend to be physically more active than adults. As a result, children breathe more rapidly than adults, and they also consume more food and water per unit body weight. This, and their still developing tissues make them both physiologically and anatomically vulnerable especially to temperature extremes and to pollutants (Chance *et al*., 1998). For instance, Raizenne *et al*. (1998) found that hospital admissions for children increased as air conditions worsened. Children are also more susceptible than adults to toxins and pathogens in water and food (CICH, 2001, Wigle, 2001). The situation in Walkerton (Ontario) illustrated this as children were the first indications of the outbreak - two were admitted to hospital and 20 were absent from school as a result of similar symptoms.

The **elderly** are also identified as a vulnerable population due, in part to previous illness and the possible development of physical impairment; as well as inappropriate living conditions and reduced capacity to mitigate environmental/climatic conditions (e.g. air conditioning availability on hot summer days). In general, the ageing process causes a decline in cardio-respiratory

capacity as well as other physiologic impairments, which amplify the effects of extreme temperatures and pollution, or of other stressful environmental conditions (CCHO, 2003).

People suffering from a **pre - existing illness**, or who are immuno-compromised, may be at greater risk to climate change related health effects. The combination of extreme heat and air pollution impact especially people with cardio-respiratory diseases. As well, those with reduced immunity are more susceptible to vector, food and water borne diseases than the general population, and are more likely to suffer from physical stress related to extreme weather and events (CCHO, 2001).

Many associations have been drawn regarding economic status and higher than expected exposure to health risks. There are several social factors that contribute to potential increased health risk from **lower individual and household income**:

- residences tend to be crowded and constructed with poor quality materials;
- residences tend to be located in close proximity to industrial areas;
- insufficient and inadequate clothing;
- lower access to climate control (e.g. heating or air conditioning to cope with extreme temperatures) due to cost, etc.;
- inadequate access to health care;
- incomplete nutritious diets and often **higher exposures to smoking**; and,
- finally, above mentioned factors increase vulnerability to environmental extremes (e.g. poorly constructed housing would be at increased risk of damage during a storm than a house of higher quality).

Eastern Ontario does not contain large urban centres. Although much industrial activity does occur in Cornwall and Prescott (West but outside the area of investigation) it is not anticipated to initiate huge air quality impacts. However, Eastern Ontario is located within the larger United States - Canada (Windsor-Quebec) industrial corridor. This area is noted for poorer quality due to large industrial units, high population and associated air matter.

The counties of Russell and Glengarry must be targeted areas for preventive intervention for environmental health because of their relatively large proportion of small children (Russell) or their relatively large proportion of elderly (Glengarry). The elderly are also considered to be a vulnerable population in this region (see section 2.2). Diseases of aging, including a decline in cardio-respiratory conditions, are believed to become more severe with certain environmental conditions such as extreme weather events and temperatures.

7.2 Health Effects of Climate Change in Eastern Ontario

7.2.1 Temperature-related Morbidity and Mortality

Temperature extremes are likely to increase the risk of morbidity and mortality for those with cardiovascular and respiratory diseases. In Eastern Ontario, the male and female mortality rates for Ischemic Heart Disease (IHD) were the leading cause of death with 28% for males and 25% for females (compared to 24 % for males and 22 % for females for the Province of Ontario). The highest IHD mortality rate is in Dundas County and the lowest in the county of Glengarry (which paradoxically, has the largest proportion of elderly population). For males, the second leading cause of death is lung cancer (9 % in Eastern Ontario (EO) compared to 8 % for the province), followed by Chronic Obstructive Pulmonary Disease (COPD) measuring at 6 % in EO compared to 5 % at the provincial level); and cerebrovascular disease or stroke (5 % for EO and 6 % for the province). For females, the second highest cause of death was stroke measuring 9 % for EO and the province. Female mortality rate for lung cancer is slightly higher at 6 % in EO compared to 5 % provincially). The morbidity rates for IHD, COPD and several causes of cancer are significantly higher than the provincial rates for both sexes**.**

The scientific research on climate change indicates that the frequency of heat waves in North American cities is expected to increase. The number of heat related deaths and visits to the hospital with heat related illness has been continually on the rise, especially in urban centres. Deaths related to heat waves are primarily attributed to cardiovascular and respiratory diseases. Risk factors for heat stress morbidity and mortality are age, urban dwelling, socioeconomic factors and preventative behaviors. Behavioral adaptations to thermal stress include: access and use of climate control technology, activity monitoring, and fluid consumption. The immediate impacts of exposure to extreme heat are dehydration, heatstroke, heat exhaustion, heat syncope and heat cramps (McGeehin *et al.*, 2001). The most common cause of death and acute illness related to extreme heat is heatstroke. Heatstroke involves the significant increase of body temperature and impaired mental abilities (McGeehin *et al.*, 2001). Heat aggravates chronic health conditions such as some heart diseases, stroke, respiratory diseases and diabetes. It can initiate emotional distress often leading to an increase in accidents, suicides and homicides. As the winter climate becomes less severe in Canadian cities, deaths associated with extreme cold will be in decline. The impact of heat waves and extreme summer temperatures depends on how well a population is physiologically adapted to warm climates, and thus on the population's heat tolerance threshold. Therefore heat related mortality rates are likely lower in warm climates than in cooler, Northern climates (IPCC, 2001). Acclimatization to extreme heat is easier in locations where a range of social and technological adaptation practices are in place. However, ecologically speaking, warmer and wetter climates allow vegetation, insects and bacteria to grow longer and develop further. Warmer and damper climates are very supportive to the proliferation of insects and parasites allowing for the increased risk of vector-borne diseases. Increased growth of vegetation also increases the risk of environmental allergic reactions, etc.

Global warming would cause longer and more severe heat waves, encouraging people to wear fewer clothes and spend longer periods outdoors, thus increasing risks of exposure to excessive solar radiation. In the northern hemisphere the incidence of skin cancer could quadruple by the end of this century (de Gruijl *et al.*, 2000), while Slaper *et al.* (1996) project that the global

incidence of skin cancer will reach a maximum around 2060 before beginning to fall. Since exposure in childhood and early adulthood has generally been regarded as a significant factor for skin cancer, it will be prudent to ensure improved protection from UV exposure for children and young adults, at least for the next two generations.

There is a synergistic behavioural relationship between the health effects of climate change and stratospheric ozone attenuation. Farmers and others who work outdoors such as road repair crews wear fewer clothes in hot weather, and therefore have greater exposure to increased UV radiation than in cooler weather. Their risk of skin cancers, including malignant melanoma, is correspondingly increased. This aspect of stratospheric ozone attenuation can be expected to have some impact on rural populations and outdoor workers in Eastern Ontario.

Warmer, wetter weather has important ecological effects. Vegetation, insect pests, and bacteria all flourish. Thus allergenic grasses and weeds proliferate, and the risk of vector-borne and water-borne diseases is increased.

Warmer, wetter weather favours proliferation of insect vectors such as mosquitoes, which breed fast and in great numbers. So do the parasites they harbour. Thus the risk of dangerous vector-borne diseases increases – malaria, dengue, viral encephalitis, rickettsial infections, viral hemorrhagic fevers, etc, can all become more prevalent. There have been several recorded cases in recent years of indigenous malaria in New York and Toronto (Baqi *et al.*, 1998), that is, malaria transmitted to local residents by locally breeding anopheline mosquitoes from a person harbouring the malaria parasite, to someone who has not been exposed to malaria in a malarial region. Some species of anopheline mosquitoes that can transmit malaria are native to North-eastern North America. The risk of acquiring dangerous vector-borne diseases transmitted by culex mosquitoes, a quite different species that cannot transmit malaria parasites, has been increased by the introduction into North America of the Asian tiger mosquito, *Aedes albopictus* which first entered Texas and Louisiana as larvae in pools of water in shipments of used car tires imported from the Philippines for re-treading. More recently this mosquito has been detected in bamboo shoots imported to the North American west coast. This mosquito is very hardy. It can survive harsh northern winters, can breed in very small bodies of water, and it is a vector for several dangerous varieties of viral infection such as West Nile fever, which has been occurring in New York and elsewhere for the past 2-3 summers. West Nile fever is a dengue-like illness. By the summer of 2001 the virus had been detected in birds from Florida to Ontario. Its natural hosts are birds, and it is transmitted from birds to humans by indigenous mosquitoes such as *Culex pipiens*. Tick-borne Lyme disease is more likely to occur in warmer weather – the ticks breed more vigorously, the pathogen they carry (Borrelia species) proliferates more vigorously, and the animal hosts may move into closer proximity to people because of various other associated ecological changes – e.g. deer may be forced to browse in domestic gardens and orchards if their wilderness habitat is encroached upon, or cannot sustain them in changing climatic conditions.

Prediction of ecological effects is, in general, even less free of guesswork. The breeding cycle of insect vectors and the pathogens they carry is shorter at higher ambient temperatures – especially with malaria – but the risk that malaria might become endemic in Eastern Ontario would depend on several other factors, e.g. the presence of a reservoir of persons harbouring the malaria

parasite, failure of mosquito control measures (screens, bednets, insecticides). It is even more difficult to forecast the potential impact of vector-borne bacterial, rickettsial and viral diseases (Lyme disease, Rocky Mountain spotted fever, St Louis B encephalitis, eastern equine encephalitis, hantavirus pulmonary syndrome, etc); and it is quite impossible to make any meaningful statements about the risk of exotic infections not previously reported in this region (Last *et al*., 2002).

Some small terrestrial mammals benefit from warmer, wetter weather. This combination and an early spring thaw in the Rocky Mountains in the late 1990s led to profuse growth of plants that favoured the proliferation of deer-mice, wild rodents that are the natural hosts of the Hantaan virus responsible for hantavirus pulmonary syndrome (HPS), a dangerous and often lethal hemorrhagic fever. As of 2000, there had been 231 reported cases in the USA and 34 in Canada (Drebot *et al.,* 2000). The potential exists for epidemics of this dangerous disease. Although cases in Canada have historically been limited to British Columbia, Alberta and the Yukon, two fatal cases have occurred in Manitoba, and infected deer mice (the only known vector for HPS in Canada) have been found in every province except Prince Edward Island and Nova Scotia (Duncan *et al.,* 1998).

7.2.2 Extreme Events

As indicated in section 3, one of the most significant impacts of climate change in this region will be extreme weather events. Extreme weather events include: storms, floods, and droughts. Extreme weather events have direct morbidity and mortality impacts and indirect effects including post event injury, infectious disease development due to improper infrastructure, depression and related mental and emotional anguish (depression, post-traumatic stress and psychological stress, which decreases individual immunity to infectious disease) due to loss and disruption, and health impacts of adaptation to a new environment in case of population displacement. During this time and immediately after, doctors' visits and hospitalization rates increase. Cases treated at hospitals are generally one of the following ailments: trauma, gastroenteritis and food poisoning, hypothermia, fatigue, as well as excessive use alcohol and drugs.

7.2.2.1 Storms

Severe storms are projected to increase in frequency and severity. A severe storm raises questions of how adaptable the local health care and emergency infrastructure is to respond to the health effects of an event. For instance, the 1998 Ice Storm that covered large areas of northeastern North America with freezing drizzle for 4 days, caused not only direct human health impacts but also impacts on the health infrastructure (LCDC, 1998). A severe storm may cause physical damage and/or flooding which can make it difficult or impossible for the local health care system to provide help to an affected population. During the 1998 ice storm, the hospitals of Eastern Ontario/Western Quebec dealt with an increase of 4.6% in emergency room (ER) visits from the same time period in the previous year (LCDC, 1998). These ER visits were a result of indirect effects of the event such as toxic inhalation (e.g. accidental carbon monoxide or

methanol poisonings), bronchitis and anxiety. Hospital admissions also increased during this time with patients with injuries, pneumonia as well as cardiac and respiratory complications.

7.2.2.2 Floods

Floods account for a large share of natural disaster damage and injury. Communities located in aesthetically desirable or environmentally marginal lands along lake, river and coastal areas tend to be particularly prone to flooding. Like severe weather conditions, flooding seems to become a more common occurrence in Canada (Last *et al*., 2002). Flooding impacts human populations directly with injuries, and can also create a variety of health impacts over the longer term. Flooding causes individual and community displacement exposing individuals to less sanitary environments, inadequate nutrition, increased exposure to infectious diseases. Tuberculosis and other major life-threatening communicable diseases, including severe diarrheal diseases and acute respiratory infections become a greater risk. Any displacement can result in anxiety and depression. Flooding also impacts agricultural lands and associated communities by altering and/or disrupting productivity and local food availability. Flooded agricultural lands can contaminate water systems (wells etc.) with pathogens and chemical toxins increased and intense run-off. Floods can release stored toxic chemicals from dump-sites, often disable sewerage systems, and flood waters often contain drowned farm animals, so the water is dangerously polluted, and requires rigorous treatment before it is fit to drink. Pathogens, such as *E. coli* entering the water supply, can result in serious illness and/or death. The situation in Walkerton and the *E. coli* contaminated water was initiated by excessive rain coupled with contaminated run-off from agricultural lands entering the community well (Walkerton Inquiry, 2002; Krewski *et al*., 2002). Run-off from intensive agricultural developments includes both pathogens and pesticides that can contaminate water sources such as wells, and floods can incapacitate sewerage treatment works, so there is an increased risk of water-borne disease – though the risk is impossible to assess in numerical terms. The pathogens that might be incriminated include both common and uncommon water-borne organisms. The typhoid bacillus, *S Typhi*, is uncommon nowadays, but occasionally occurs, e.g. when someone from an endemic area defecates in a place with inadequate sanitary services. Typhoid is a serious systemic disease with a mortality rate of about 10%. Two high-profile water-borne organisms are *E. coli* 0157 and, *Cryptosporidium*, which may enter domestic water supplies if these are contaminated by human or animal excreta. The former was responsible for the outbreak in Walkerton, Ontario, that caused at least 7 deaths and several thousand cases, leaving some with permanent kidney damage. Cryptosporidium causes diarrhea and can be fatal in immunocompromised persons, e.g. those with HIV/AIDS. An outbreak in Wisconsin in 1993 caused over 400,000 cases. Other water-borne pathogens include viruses (e.g. hepatitis A, polio), bacteria (salmonella, shigella, etc), protozoa (amebae, such *E histolytica*, which causes amebic dysentery, and parasites such as helminths (roundworms, tapeworms, etc, many of which require an intermediate host). Fortunately few are likely to occur in Ontario, although the potential exists for some to be introduced and be sustained if sanitary services should break down (Last *et al*., 2002). Post flood conditions often support the development and growth of molds and fungi aggravating allergic and asthmatic symptoms.

7.2.2.3 Droughts

In contrast, droughts impact the ability of populations/land to produce food. Decreases in water available for sanitation run the risk of unsanitary conditions contaminating food and water supplies and providing an opportunity for infection.

The most currently relevant infectious disease for Eastern Ontario is the West Nile fever. It is carried and hosted in a variety of birds but is transmitted to humans through the mosquito (*culex pipiens*). The latter is very adaptable to cooler climates and has been moving Northward. Reports have located contaminated birds in Southern and Eastern Ontario since 2001. Last year, four dead birds with the virus were discovered in Ottawa and 18 people in Ontario have died from the disease (*Globe and Mail*, May 22, July 14, 2003). Preventative measures consisting in spraying malathion from trucks on mosquito larvae, however, raises other environmental health concerns. There is no known treatment for the virus, which, in 1% of the cases, can cause serious neurological diseases (Ministry of Health and Long-Term Care Web site[72]).

7.2.3 Air Quality

Air contains pollutants that can damage human health. Some of the air pollutants are natural, e.g. mold spores or pollen; others are derived from human activities in agriculture, commerce, industry, or transportation. Air pollutants may occur indoors as well as outdoors Climate Change may alter. Climate change may alter both the kinds and levels of air pollution. It can affect anthropogenic and natural sources of air pollutants, and can influence atmospheric pollutant chemistry and transport processes.

Air quality impacts are two-fold: the impact of increased severity of pre-existing respiratory illness or health conditions aggravated by poor air quality, and conditions that develop directly as a result of exposure to poor air quality.

Ground level ozone plays a critical role in the human health and air quality relationship, as it causes adverse health effects even at quite low levels of exposures (Oxman *et al.*, 1993). Ground level ozone (smog) is a weak atmospheric suspension of sulfuric and nitrous acids, which is caused when fossil fuels emissions interact with water vapour, evident on warm summer days. Smog plays a critical role in the human health and air quality relationship. It has adverse health effects even at limited exposures. Ozone when combined with secondary particulates (air pollutants formed through the air emissions such as volatile organic compounds (VOCs) has severe respiratory and cardiovascular implications. Global warming is believed to increase the number of ambient concentrations of ozone as well as ozone pollution events. Specifically in

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72 http://www.health.gov.on.ca/english/providers/program/pubhealth/westnile/wnv_03/wnv_surveillance.html Other relevant websites for the Nile virus are Health Canada: http://www.hc-sc.gc.ca/pphb-dgspsp/wnv-vwn/ and New-York State Department of health: http://www.health.state.ny.us/nysdoh/westnile/update/2003/wnv_map.gif

Canadian cities, ozone is a risk factor for summer hospitalization. Summertime ozone levels affect various demographic characteristics of the population, particularly the elderly and the very young. Climate change is also predicted to increase forest fires thus exacerbating risk of mortality and morbidity associated with air pollutants. Under climate change, crops may be more at risk for pests and pathogens, thereby, affecting the local food supply

Increased exposure to ozone heightens the sensitivity of asthmatics and individuals with allergies. Pollens are closely associated with climatic conditions. Anticipated climate changes are expected to lengthen the pollen seasons, increasing the risk to chronic asthmatics as well an acute asthma events and other respiratory conditions and diseases. Indoor allergens such as dusts and moulds are believed to be climate sensitive as well. These could affect workers in poorly ventilated barns and poultry sheds (where animals and chickens too are vulnerable)(Last *et al.*, 2002).

Summertime ground level ozone concentrations are related to the frequency of hospital visits in urban areas (Burnett *et al*., 1997; Burnett *et al*., 1998 a, b; Schwartz, 1996; 1995; 1994; Thurston and Hayes, 1994; Pope, 1991; Delfino *et al*., 1994; Spix *et al*., 1998). In Canadian cities, ozone is a risk factor for summer hospitalization (Burnett *et al*., 1998). Illnesses related to summertime ozone level affect particularly the elderly and children under 2 years of age (Burnett *et al* 2001; Dales *et al*, 2000).

Increased exposure to ozone heightens the sensitivity of asthmatics and individuals with allergies (Beckett, 1991; Bromberg and Koren, 1995). Pollen season lengths and daily pollen levels are influenced by weather patterns. Anticipated climate changes may lengthen the pollen seasons, increasing the risk to chronic asthmatics, and may increase the incidence of asthma and of other respiratory conditions and diseases. Pollen levels and other biogenic air pollutants are affected by land use and land use practices. For example, changing farming practices can increase or decrease the pollen count in the air. The considerable increase in the prevalence of asthma over the past 20 years has puzzled paediatricians, allergists and epidemiologists. It may be partly explained by the increased profusion of allergenic weeds, and partly attributable to air pollution – or it may be associated with other factors such as changed habits of children who spend more time indoors watching television rather than playing outside. Indoor allergens such as dusts and moulds are also climate sensitive. Increased discomfort associated with the outdoor climate may increase the time which sensitive people spend indoors, thus increasing their exposure to indoor air pollutants and allergens. The health consequences of indoor environments could be exacerbated by increases in floods, temperature and humidity, and by improperly adopted energy efficiency measures which could increase exposure to indoor pollutants. This is one of several climate-related health problems requiring more research.

Air pollution is not typically limited to urban areas and areas adjacent to industrial regions because some pollutants travel long distances with varying degrees of concentrations. Thus, some Canadian communities are at an increased risk of smog episodes due to the transboundary movement of air pollutant emissions from the US industrial heartland. Climate change may also increase the frequency of droughts, thunderstorms and lightning strikes, which may lead to forest fires, thus exacerbating the risk of illnesses and deaths.

7.2.4 Water and Food-borne Contamination

7.2.4.1 Drinking Water

Variable weather, particularly excessive precipitation and temperature patterns have had measurable impacts on drinking water quality. The days preceding the outbreak of *E. coli* O157 at Walkerton, Ontario were marked by intense rainfall. This, coupled with human error and inadequate planning, overwhelmed the local water treatment infrastructure (Walkerton Inquiry, 2002). Unfortunately, events similar to those at Walkerton are not unusual. In Canada, the number of boil water advisories is on the rise, as are outbreaks of related enteric illnesses. In British Columbia, the number of boil water advisories rose exponentially between 1986 and 1999 (Krewski *et al.* 2002). Although outbreaks of illnesses due to water contamination may not be directly related to climate change, changes in weather patterns leading to floods or droughts may put undue stress on natural water quality and on water and wastewater treatment systems. This means that drinking water treatment and distribution systems will need to adapt to more extreme environmental conditions. An inability of systems to do so will increase the number of boil water advisories and the risk of adverse health effects. The *Report of the Walkerton Inquiry (Part 2)* point out that a number of studies suggested that climate change will be a significant factor in the long term provision of drinking water (Walkerton Inquiry, 2002, p 86). The Inquiry mandated to address the future of safe drinking water in Ontario makes several recommendations (following) in relation to drinking water in a changing climate:

- "preparing water budgets for watersheds to identify the connections between surface and groundwater, areas of vulnerability to water takings and to determine limits for water extraction";
- "improving contingency plans for extreme events";
- "encouraging best management practices in rural areas to reduce sources of pollution";
- "encouraging community-based environmental stewardship".

7.2.4.2 Food Production, Processing, Transport and Storage

Like the water - borne diseases, food borne illness incidence is anticipated to increase. Food production can be directly influenced by climatic variability suffering greatly from drought and wet conditions. Pests and pathogen spread and growth may be influenced by the climate and the adaptive practices of agriculture (IPCC, 2001). Extreme wet conditions can spread contaminants such as *E. coli* as seen in the Walkerton situation where initial contact with *E. coli* originated from a farming practice (Walkerton Inquiry, 2001b). Foods, particularly fruits and vegetables, may be irrigated and/or processed using contaminated water (Pollution Probe, 2002).

Fluctuations in annual productivity in the Canadian prairies impacts the quantity and quality of food production as well as the well-being of the community which supports it. Not only can

direct climate variation influence production but adaptation processes are also having impacts on farming practices perhaps making crops and livestock more or less vulnerable to disease, the indirect impacts of which can be felt in the human food chain.

Food preparation and storage conditions can also be linked to food borne illness transmission. Increases in summer temperatures and the frequency of extreme heat days increase food's exposure to bacteria if food is not stored and refrigerated properly, and through the passing between foods during preparation process. Food preparation concerns were cited in Ottawa-Hull outbreak of *shigella sonnei* from a grocery-store salad during May, 2002 (Canadian Food Inspection Agency, 2002).

7.2.5 Vector-borne Infectious Diseases

The geographic distribution of vectors and intermediate hosts of transmissible diseases is ecologically dependent, in part because climate limits the ability of vectors and pathogens to exist or to multiply in an environment. Vector-borne diseases are therefore sensitive to variations in climate. A warming climate may allow the range of disease vectors and of intermediate hosts of infectious diseases to extend northward and uphill (IPCC, 2001). However, disease transmission among human populations is determined by a complex interrelationship of ecological, geographic, demographic, socioeconomic, behavioral and cultural factors. Therefore, anticipating and modeling the effects of climatic change on disease transmission based on climate scenarios is still highly problematical (IPCC, 2001a).

IPCC (2001) outlines in detail the infectious diseases that are most sensitive to climate changes. Some of these diseases may become more prevalent in North America. Recently, the spread of West Nile virus, Hantaan virus and Lyme disease have raised significant concern. Although the arrival and spread of West Nile fever in the US and Canada is not caused by climate change, the area of infection may be influenced. The virus was merely carried to a suitable new environment where a variety of susceptible mosquito vectors and birds allowed it to become established and to spread. The Hantaan virus is well established in North America, and is carried by wild mice whose urine and faeces can transmit the virus to humans, to whom it can be fatal. In North America, the number of human cases is increasing. Lyme disease and a related illness, called Rocky Mountain Spotted Fever is caused by a bacterium transmitted by a tick which requires rodents and deer as animal hosts. Longer warm seasons and higher average local temperatures may permit increased proliferation of the hosts and vectors (Last *et al*., 2002). The range of the animal hosts and ticks is spreading northward due to a warmer climate. As well, the development of wilderness lands, and increased human outdoor recreation activities have led to an increased contact between humans and ticks. Vector borne diseases can also be transferred by travelers from one ecological region to another.

7.2.6 Health Effects of Stratospheric Ozone Depletion

Several kinds of halogenated greenhouse gases (GHG) contribute to the depletion of stratospheric ozone, and thus increase human exposure to solar UV radiation (IPCC, 2001).

Human health effects of excessive solar ultraviolet radiation include the following (IPCC, 2001):

- Immuno - suppression, enhanced susceptibility to infections and cancer
- Sunburn, loss of skin elasticity
- Basal and squamous cell cancer
- Corneal opacity (cataract)

7.2.7 Health and Well Being

In its widely accepted definition of health, the World Health Organization (1948) suggested that the term "health" means not only the absence of disease, but also the physical, mental, and emotional well-being of individuals and communities. Although mental and emotional health is rarely discussed in connection with climate change, particularly in discussions of the co-benefits of GHG emission mitigation, it can be assumed that long term adaptation to climate change will require greater attention to mental and emotional impacts.

7.2.7.1 Population Displacement

Severe climate conditions may result in population displacement. There are two main health impacts of population displacement: i) those arising from the need to adapt to a new environment, and ii) the adverse results of living in a temporary space such as a refugee camp. These impacts are mostly cumulative. The displacement of a population to a new community or environment may increase the human burden on the local ecosystems, and it may also lead to demand for additional social and health services. Practices adapted to one environment may not be transferable to a different environment. This situation leads to increased physical and psychological stress and requires the acquisition of new skills and practices. This, and the social disruptions and the experience of displacement will affect the health and well-being of displaced persons, e.g. through decreased individual immunity to infectious disease. The health impacts of living in cramped and unnatural conditions, such as a refugee camp, are a result of overcrowding, poor nutrition, improper medical attention and inadequate sanitation and undue stress. Inadequate support by government agencies may lead to dissatisfaction and to political unrest.

7.2.7.2 Perceived Risk

Repeated messages of risk may create perceived notions of risk (both substantiated and unsubstantiated risks). Regardless of the severity of the risk, the implications may influence an individual's or community's quality of life and thus well-being through the awareness of the possibility of risk.

7.2.7.3 Discomfort

An earlier discussion on the health effects of increased temperature and extreme events indicated that there are emotional and mental effects that should be mentioned. For instance, we know that the frequency and severity of summer hot days increase likelihood of cardio-respiratory disease, however, there are less visible effects linked to well being. Discomfort due to lack environmental control, minor physical ailments (such as tiredness), displacement and changes in life-patterns may lead to a range of emotional responses which can include agitation.

7.3 Adaptability of the Health Infrastructure[73]

The adaptability of the health system has to be increased under climate change to be able to handle an increased number of emergencies and to identify symptoms as related to a typically foreign disease and follow-up with treatment.

Ontario Health Units (OHU) administer health promotion and disease prevention programs, inform the public about health options, communicable diseases, immunization, food health, life stage growth and development and education for ages. The study area is under the jurisdiction the Eastern Ontario Health Unit (EOHU). OHUs are given power under the Federal Health Promotion Protection Act, the Environmental Protection Act, the provincial Building Code, Mandatory Health Programs and Services Guidelines. In the context of community water issues, a Health Unit has powers that can range from implementing the Public Beach Management Protocol related to water quality, to testing municipal and residential water and wastewater systems, and to voluntary review of land use applications and permits to draw water. The medical officer of health may declare a medical hazard (Health Protection and Promotion Act, 1990, art.13). The EOHU has the mandate to communicate valuable climate and health information. For instance, the website of the EOHU has the capacity to be a significant source of information (Needham, 2002). The Health Unit has the opportunity to include factors associated with climate change health within community health, outdoor activity, water use, and agricultural practices education (Needham, 2002).

In the study region, there are four hospitals, 117 institutions for the elderly or the handicapped, and about 23 community support organizations (see tables 7.1 and 7.2). There are about 260 doctors of whom 80 are specialists (table 7.3). In 2000, there were 1073 nurses (Registered nurses, Registered practical nurses, Registered nurses extended class) in S, D & G and 296 in P&R (CDHC, 2002). Any education campaign targeting health personnel for climate change should, therefore, be easy to develop.

[73] This section was contributed by M. Woodrow as well.

TABLE 7.1 RESIDENTIAL CARE FACILITIES BY COUNTY AND TYPE OF INSTITUTION

TYPE OF INSTITUTION	STORMONT		DUNDAS		GLENGARRY		PRESCOTT		RUSSELL	
	Number	Capacity	Number	Capacity	Number	Capacity	Number	Capacity	Number	Capacity
Lodging Home	13	561	2	109	7	177	12	598	17	683
Long Term Care Facility	7	610	1	98	3	255	3	266	5	285
Group Home	21	117	6	37	5	33	5	28	8	48
Shelter For Battered Women	1	10	1	9	1	8	0	0	0	0
Correctional Institution	3	21	0	0	0	0	1	10	0	0
Home For Special Care	1	9	1	12	0	0	0	0	0	0
TOTAL	**46**	**1328**	**11**	**265**	**16**	**473**	**21**	**902**	**30**	**1016**

Lodging Home: retirement home for the aged

Long Term Care Facility: nursing home complex

Group Home: psychologically and developmentally handicapped

Shelter For Battered Women: help for women to have a normal life

Correctional Institution: former criminals, help in transition

Home For Special Care: special and developmentally handicapped

The Health Unit must begin to adapt early, by engaging health professionals as soon as possible, as preventative adaptation will be less costly than curative adaptation. It must contribute to building up social resilience, i.e. the capacity to handle the unexpected, as it is the best social protection even without climate change. It should exploit its awareness that human health is connected with individual behavior, with the overall social context, and with economics. Behavioral change is always costly unless the individual perceives that climate change and health information has value. Adaptation must be a local (municipal, county) integrated strategy, which must begin with human health as it is the best communication channel to the individual, who trusts health professionals above all others.

Emergency Plans are a regional responsibility since the Emergency Readiness Act, December 2001. 7 municipalities of S-D-G and 8 in P-R will be integrated into a comprehensive plan at the regional level. There is here a good opportunity to include climate change related emergencies in the plan. The current regional plans are really frameworks that identify the roles and responsibilities of those involved. The transition period is an opportunity to ensure that emergencies related to climate change are not only built into the plan but also into any accompanying regional information for householders. Section 9 of the new act provides standardized guidelines for the preparation of emergency plans across the province. The fourteen steps outlining for community officials how to prepare an emergency plan are described in detail on the Ministry of the Solicitor General website (www.sgcs.gov.on.ca/english/public/emoguide/emo2.html) (see section 2).

TABLE 7.2 COMMUNITY HEALTH AND SOCIAL SERVICES BY SECTOR TYPE AND COUNTY

INSTITUTION/AGENCY/CENTER	Stormont	Dundas	Glengarry	Prescott	Russell
Mental Health Agency	4	0	0	0	1
Nursing and Homemaking Service	1	0	0	0	0
Ambulance Services	0	0	1	0	0
Community Care Access Center	1	1	1	1	1
Community Health Center	1	0	0	0	0
Community Support Services	2	1	0	2	0
Diabetes Support Services	1	0	0	1	0
Hospital	2	0	1	1	0
Public Health Unit	1	0	0	0	0
Substance Abuse Agency	2	0	0	0	0
Women's Shelter Community Support Services	1	1	1	1	0
TOTAL	**16**	**3**	**4**	**6**	**2**

Source: Adapted from HELPS (Ont)-Eastern Ontario Health Unit (EOHU)

TABLE 7.3 PHYSICIANS AND SPECIALISTS BY COUNTY

PHYSICIANS AND SPECIALTY DOCTORS	Stormont	Dundas	Glengarry	Prescott	Russell
Physicians	68	22	12	42	40
Specialty Doctors	50	1	1	19	9
TOTAL	**118**	**23**	**13**	**61**	**49**
County Population	**65,900**	**21,970**	**23,460**	**34,215**	**39,790**
Physicians per capita	0.103%	0.100%	0.051%	0.123%	0.101%
Specialty Doctors per capita	0.076%	0.005%	0.004%	0.056%	0.023%
TOTAL per capita	**0.179%**	**0.105%**	**0.055%**	**0.178%**	**0.123%**

Source: Adapted from HELPS (Ont)-Eastern Ontario Health Unit (EOHU)

Epidemiological and statistical research on health risk assessment, and on risk management, particularly for different regions across the country and for specific vulnerable groups is required. A climate change risk analysis/management framework might be developed for the municipal level taking health as its main driver.

Table 7.4 Public Health Responses to Climate Change

- Disaster preparedness, emergency shelter for displaced populations
- Surveillance and monitoring
  - Food production, distribution
  - Heat-related illness, identifying vulnerable people
  - Health status of migratory populations
- Epidemiological surveillance
  - Water quality
  - Disease vectors (distribution, abundance)
  - Disease outbreaks, epidemics
  - Smog-related illnesses
  - Sunburn, skin cancer, cataract
- Epidemiological and social research
  - Causal and risk factors for asthma, etc
  - Case-Control and Cohort studies (risk assessment, risk measurement)
  - Attitudes towards sustainability, etc
- Public health action
  - Health education, health promotion
  - Advisory messages (TV, radio, etc, e.g. on sun exposure)
  - Standard-setting
  - Care of vulnerable groups
- Public health policies
  - Food and nutrition
  - Research priorities

From Last *et al.*, 2002

Other necessary public health action includes epidemiological surveillance and monitoring, e.g. for occurrence of heat- and smog-related episodes of illness, movements and health status of migratory and refugee populations. Further, we need improved methods of surveillance, e.g. for evidence on the distribution and abundance of dangerous insect vector species, especially mosquitoes. Public health actions must also include improved communication strategies for advice to the public, standard-setting, food and nutrition policies, and establishment and periodic review of research policies and priorities. (table 7.4).

Most people care enough about their health, and the health of their children, to take these challenges seriously, and if presented with the facts and their implications, would probably be prepared to take action. In the short term, policy makers in Canada would be well advised to consider taking cost-effective actions to mitigate the effects of climate change on human health. This involves developing and implementing policies that generate immediate improvements in the health of Canadians, such as those that help improve air quality and adaptations that reduce our vulnerability to current climate stresses. In developing health strategy to cope with climate change, we should abide by the precautionary principle: the "better safe than sorry" approach to assessing and managing health risks, especially those associated with environmental hazards.

References

Baqi, M., K. Gamble, J.S. Keystone, and K.C. Kain (1998), Malaria: probably locally acquired in Toronto, Ontario. *Canadian Journal of Infectious Diseases*, 9, 3, 183-184.

Beckett, W.S., 1991. Ozone, air pollution, and respiratory health. *Yale J Biol Med*. 64(2):167-75.

Burnett, R, Cakmak, S and Brook J. 1998a. The Effect of the Urban Ambient Air Pollution Mix on Daily Mortality Rates in 11 Canadian Cities. *Canadian Journal of Public Health*, 89(3): 152-156.

Burnett, R, Cakmak, S, Raizenne, M, Stieb, D, Vincent, R, Krewski, D, Brook, J, Philips, O and Ozkaynak, H. 1998b. The Association between Ambient Carbon Monoxide Levels and Daily Mortality in Toronto, Canada. *Journal of the Air & Waste Management Association*, 48, 689-700.

Burnett, RT, Jessiman, B, Stieb, D, Krewski, D. 1997. Health effects of ambient particulate matter: A Canadian perspective. In: *Health Effects of Particulate Matter in Ambient Air*. Prague, Czech Republic. Ed Jaroslav J Vostal. April 23 25, 1997.

Canadian Food Inspection Agency, 2002. http://www.inspection.gc.ca/english/corpaffr/recarapp/2002/20020518e.shtml

Canadian Institute of Child Health (CICH), 2001, *Changing Habits, Changing Climate. A Foundation Analysis. Ottawa: CICH*

Carty, P., P.Crabbé, L.Craig, D. Krewski (2002), *Health Effects of Climate Change and Health Co-Benefits Resulting from Potential Kyoto_driven Policies: A Canadian Perspective*, Technical Report developed by the R. Samuel McLaughlin Centre for Population Health Risk Assessment, Institute of Population Health, University of Ottawa.

Champlain District Health Council (HDHC), 2002, *Health System Monitoring Project Report*, http://www.champlainhealth.ca/documents/cdhcmonitoringprojectreporteng.pdf

Chance, G.W. and E. Harmeson, 1998. Children are different: Environmental contaminants and children's health., Canadian Journal of Public Health, 89. *Suppl. 1*.

Climate Change and Health Office (CCHO) (2002), http://www.hc-sc.gc.ca/hecs-sesc/ccho/sitemap.htm

Dales, R.E. , Cakmak, S., Burnett, R.T., Judek, Stan, Coates, Frances and Brook, J.R. 2000. Am. Influence of Ambient Fungal Spores on Emergency Visits for Asthma to a Regional Children's Hospital. *J. Respir. Crit. Care Med.* 162: 2087-2090.

de Gruijl, F.R. and J.C. van der Leun (2000), Environment and health: 3. Ozone depletion and ultraviolet radiation. *Canadian Medical Association Journal*, 163, 7, 851-855.

Delfino, R.J., Becklake, M.R., and Hanley, J.A., 1994. The relationship of urgent hospital admissions for respiratory illnesses to photochemical air pollution levels in Montreal. *Environ Res*.67(1):1-19.

Delfino, R.J., Becklake, M.R., Hanley, J.A., and Singh, B., 1994. Estimation of unmeasured particulate air pollution data for an epidemiological study of daily respiratory morbidity. *Environ Res.* 67(1):20-38.

Drebot, M.A., H. Artsob and D. Werker (2000), Hantavirus Pulmonary Syndrome in Canada, 1989-1999. *Canada Communicable Disease Report*, 26

Duncan, K., T. Guidotti, W. Cheng, K. Naidoo, G. Gibson, L. Kalkstein, S. Sheridan, D. Waltner-Toews, S. MacEachern, and J. Last, 1998: Health Sector. In: *The Canada Country Study: Climate Impacts and Adaptation – National Sectoral Volume*, [Koshida, G. and W. Avis (eds)], Environment Canada, Downsview, pp. 501-590.

Eastern Ontario Health Unit (EOHU)(2000), *Statistical Report on Health*, http://www.eohu.on.ca/index_english.htm

Health Canada, http://www.hc-sc.gc.ca/pphb-dgspsp/wnv-vwn/

IPCC (Intergovernmental Panel On Climate Change), 2001 *Climate Change 2001; Impacts, Adaptation and Vulnerability, Contribution of Working Group II to the Third Assessment Report*, Cambridge University Press.

Krewksi, D., Balbus, J., Butler-Jones, D., Haas, C., Isaac-Renton, J., Roberts, K. and Sinclair, M. 2002. *Managing the Health Risks of Drinking Water*. Walkerton Inquiry Commission Paper.

Last and Chiotti, 2001, Climate change and Health, ISUMA, 2: 4: 62 - 69

Last and Sahni., 2002, Possible Effects of Climate change in Canada and in Eastern Ontario

Laboratory Centre for Disease Control, 1999. *Adverse health events associated with the 1998 Ice Storm: Report of Hospital Surveillance of the Eastern Ontario Health Unit Region*. Canada Communicable Disease Report, 25-17.

Martens, P. 1998 Health and cliamte change, : Modelling the Impacts of Global Warming and Ozone Depletion, , Earthscan.

McGeehin MA, Mirabelli M., 2001. The potential impacts of climate variability and change on temperature-related morbidity and mortality in the United States. *Environ Health Perspect*. 109 Suppl 2:185-9.

McMichael, A.J., A.J. Haines, R. Sloof, and S. Kovats, (1996) Climate change and Human Health, WHO

Needham, R.D. (2002), *The Informed Opinion of Municipal Officials: Infrastructure Administration, Planning and Management in Eastern Ontario*, FCM, June 2001.

New-York State Department of Health: http://www.health.state.ny.us/nysdoh/westnile/update/2003/wnv_map.gif

Ontario Ministry of Health and Long-Term Care , http://www.health.gov.on.ca/english/providers/program/pubhealth/westnile/wnv_03/wnv_surveillance.html

Ontario Health Protection and Promotion Act, 1990, amended 1997.

Oxman, A. D. and Julian , A., 1993. The health impacts of ground-level ozone in Canada. Contract Report No. 3787. Ottawa: Environmental Health Directorate, Health Canada, 50 pp.

Pollution Probe Foundation, 2002. *Adapting Health Infrastructures to cope with Health Effects of Climate Change: A Case Study of the Toronto-Niagara Region*. Pollution Probe Foundation.

Pope III, C.A, Thun, M., Namboodiri, M., Dockery, D., Evans, J., Speizer, F. and Heath, Jr., C., 1995.

Particulate Air Pollution as a Predictor of Mortality in a Prospective Study of U.S. Adults, *American Journal of Respiratory Critical Care Medicine*, 151: 669 - 674.

Patz J A et al., 2000. The potential health impacts of climate variability and change for the United States; Executive summary of the report of the health sector of the U.S. National Assessment. *Environ Health Perspect*, 108:367-376.

Raizenne, M. et al. 1998 Air Pollution exposures and Children 's Health, Canadian Journal of Public Health 85. suppl. 1

Schwartz J. 1994. What are people dying of on high air pollution days? *Environ Res* 64:26-35.

Schwartz J, Dockery DW, Neas LM. 1996. Is daily mortality associated specifically with fine particles? *J*

Air Waste Manage Assoc 46:927 939.

Slaper, H., G.J.M. Velders, J.S. Daniels, F.R. de Gruijl and J.C. Van der Leun (1996)
Estimates of ozone depletion and skin cancer incidence to examine the Vienna Convention achievements. *Nature*, 384, 256-258.

Spix C., Anderson, H.R., Schwartz, J., Vigotti, M.A., LeTertre, A., Vonk, J.M., Touloumi, G., Balducci, F., Piekarski, T., Bacharova, L., Tobias, A., Ponka, A., and Katsouyanni, K., 1998. Short-term effects of air pollution on hospital admissions of respiratory diseases in Europe: a quantitative summary of APHEA study results. Air Pollution and Health: a European Approach. *Arch Environ Health*. 53(1):54-64.

Thurston G.D., Ito, K., Hayes, C.G., Bates, D.V., and Lippmann, M., 1994. Respiratory hospital admissions and summertime haze air pollution in Toronto, Ontario: consideration of the role of acid aerosols. *Environ Res.* 65(2):271-90.

Walkerton Commission, 2002. *Report of the Walkerton Inquiry. The events of May 2000 and Related*

Issues. Part One. Toronto: Ontario Ministry of the Attorney General.

Wigle, 2001. sectoiral Impacts of Kyoto Compliance, W.P. industry Canada, # 34.

Woodrow, M. (2002), *Climate Change and Health: A Local Perspective*
Focusing on Eastern Ontario, Unpubl. Mnss., Institute of the Environment, University of Ottawa, 2002 (Volume II of this Report).

Section 8 Projected Financial Impacts of Climate Change on Municipalities[74]

Climate change impacts will affect the social infrastructure of Ontario. The latter includes its institutions especially its municipalities and their finances. Ontario municipalities have gone through major changes in recent years. Large scale service realignment has increased the financial burden of the municipalities many folds. Senior governments have long maintained that municipal restructuring or "realignment" (MMAH 1999) programs save money for cash-strapped municipalities, yet Rounds (1997) demonstrates that actual cost reduction benefits are the exception rather than the rule. In addition to this, a considerable variety of financial options could be very helpful in redistributing municipal financial priorities: options that could redirect short-term versus long-term funds, spawn partnerships, and grants that can impact municipal funding sources and program decisions, remained unknown to many municipal administrations (Alam *et al.* 2002). Coincident with this latest restructuring period, Eastern Ontario was subjected to a series of extreme climatic events with considerable political, economic and logistical impacts.

1) the Walkerton Crisis of May 2000, in which 7 residents of this Ontario village died and 113 others fell seriously ill from *E.coli* contamination, spawned considerable debate about both provincial and municipal capacity to effectively administer municipal natural resources such as water, and protect public health.

2) the Ice Storm of 1998 and Level II droughts in both 2001 and 2002 have cumulatively spawned debate about municipal capacity to manage or direct economic growth so that climate change impact analogues can be lessened or prevented.

Rather than reaping the intended cost savings of restructuring, reactive responses to the above catastrophes resulted in considerable associated costs for municipalities due to a lack of preparedness. Reactive responses resulted in short-term financial costs to meet immediate needs, but also in long-term costs in terms of credibility and confidence in both municipal and provincial administrations. Critics of the pace and severity of restructuring policies feel the results confirm to some extent the necessity of public involvement in, and scrutiny of the decision-making process (Aurelson *et al*., 2003).

In various Province - wide consultations related to future economic growth policies, both local and provincial stakeholders have expressed the need for capital financing. Capital financing is needed to increase the capacity of the existing water - related infrastructure and to repair and rebuild the existing capacity to meet future economic and demographic needs, for sustainable growth, for mitigating environmental and public health concerns and to avoid any future Walkerton - like tragedy.

In the recently completed urban consultation process, Ontario's urban centres wanted the assurance of long-term funding to support infrastructure. They expressed concern that grants and short-term investments do not allow municipalities to plan for the longer term. Aging infrastructure has become a particular concern for many urban centres. Urban centres meet

[74] This section was contributed by R. Alam, I. Aurelson, D. Burhoe, P. Crabbé and R. Needham.

challenges in maintaining built infrastructure in a state of good repair. Municipalities have asked for more say in identifying their own needs and to be part of the provincial and, especially, federal decision-making processes. There is an important need to maintain accountability to taxpayers and to keep taxes low. They pointed out that the problem is complex, given the challenge of raising additional revenue and many competing priorities.

Another provincial initiative is the 'Smartgrowth' initiative. It was producing planning priorities for different regions of Ontario. Smartgrowth was the Province's strategy for promoting and managing growth to sustain a strong economy, build stronger communities, and promote a clean and healthy environment. The Smartgrowth initiative has pointed out the need for the development of strong local economies that build on inherent strengths, efficient infrastructure and a quality of life that attracts innovation and creativity.

These consultations and initiatives as well as other numerous forums have clearly pointed out the urgent need of the municipalities for capital financing to improve their infrastructure. Climate change adaptation need not be an additional financial burden for the municipalities. Improving the present aging water infrastructure and building new facilities for future demographic, environmental, sustainable growth and economic development needs is sufficient for climate change adaptation too. Climate change adaptation can make the municipal case of need for increased capital funding opportunities a stronger one.

8.1 Recent Municipal Reforms and Changes Which Impact Financial Issues

8.1.1 Local Services Realignment (LSR)

One of the major changes in the municipal world in the last five years in Ontario was a large scale local service realignment (LSR). The LSR was the first major reform initiative to realign delivery and funding of key services between the Province and Ontario municipalities. In 1998, Ontario transferred approximately $2.5 billion in net LSR costs to municipalities. In exchange, the Province provided $2.5 billion in available property tax revenue to fund local services. Major downloads from the provincial government are transit systems, airport maintenance, social housing, family benefit assistance, and roads. Given very little slack tax capacity, municipalities are meeting a real financial crisis.

To ensure the swaps are revenue neutral, the Province provided municipalities with over $500 million in annual community reinvestment funding. Education revenues and expenditures are now assumed by the province. About 50% of the residential property tax goes to education. A fixed dollar amount from commercial properties and one for industrial properties is collected by the Province for education purposes from each municipality. The non-residential property tax rate for funding education varies from municipality to municipality. As a result of these changes, per capita municipal expenditures are 55 % higher in Ontario than in the rest of Canada (2000) and increased by 21 % in constant dollars in 12 years (1988-2000). This has led to

property taxes increasing by about twice as much in Ontario than in the rest of Canada (1988-2000).

The following table shows the provincial-municipal share of burdens in different sectors after the realignment.

Table 8.1 Changes in the Distribution of Responsibilities Between the Provincial Government and Ontario Municipalities Since 1998

Responsibility	Provincial-Municipal Breakdown	
	Previous	Current
General Welfare Assistance		
Benefits	80-20	80-20
Administration	50-50	50-50
Family Benefit Assistance		
Benefits	Provincial	80-20
Administration	Provincial	50-50
Child-care Services	80-20	80-20
Long-term Care	Provincial	Provincial
Hostels	80-20	80-20
Homes for Special Care	Provincial	Provincial
Women's Shelter	95-5	Provincial
Social Housing	Provincial-Municipal	Municipal
Child Welfare	80-20	Provincial
Municipal Transit	33-67	Municipal
GO Transit	Provincial	Municipal
Ferries	Provincial	Municipal
Airports	40-60	Municipal
Sewer and Water	10-90	Municipal
Policing	10-90 in Rural Areas	Municipal
Farm Tax Rebate	Provincial	Municipal
Property Assessment	Provincial	Municipal
Public Health	70-30	50-50
Ambulances	90-10	50-50
Roads	Provincial-Municipal	More Municipal
Gross Receipts Tax	Municipal	Provincial
Provincial Offences	Provincial	Municipal
Residential Education Taxes	School Boards	50-50

Source: Kitchen, Harry M., Municipal Revenue and Expenditure Issues in Canada, 2003 table 17.

8.1.2 Municipal Act

Ontario has introduced a new *Municipal Act* to modernize municipal powers. The new Act gives municipalities "natural person" powers - the same powers as a person has to conduct day-to-day business without specific legislative authority. This Act is intended to give

municipalities more flexibility in dealing with local circumstances and react quickly to local economic, environmental or social changes. It is more flexible, more comprehensive and easier to understand (Kitchen, 2003). Also this act enables municipalities to charge user fees and operate services on a cost-recovery basis where appropriate. This Act is also "criticised on the ground that it continues to impose a significant degree of provincial regulatory power on the municipal governments" (*ibid*., p. 7).

8.1.3 Property Tax Reform

Ontario has been a leader in property tax reform. Properties are divided into seven standard property classes - residential/farm, multi - residential, commercial, industrial, pipe lines, farmlands and managed forests. Farms, conservation land and managed forests are assessed at value in current use and not at market value. The term tax rate replaces "mill rate". The difference between mill rate and tax rate is that a tax rate expresses the amount of tax as a percentage of assessed value, whereas a mill rate refers to the tax dollar amount for every $1,000 of assessment. Municipalities have the ability to set different tax rates for different classes of property, but the ranges of fairness set by the province decrease the flexibility of the municipal government. The Province provides a refundable property tax credit through the personal income tax system for homeowners and tenants with low or moderate incomes. Lower property tax rates (25% of the residential tax rate) apply to owners of eligible farmlands and farm buildings. The province reimburses 100% of property taxes paid by the owners of eligible managed forests and conservation lands. Municipalities also have the power to reduce, refund, cancel or defer residential or farm property taxes. Tax rates are established by upper tier and single tier municipalities. Upper tiers may delegate this authority to their lower tier municipalities subject to certain conditions. Upper tier and single tier municipalities have greater flexibility in setting tax rates than under the former system. The Business Occupancy Tax has been eliminated.

The property assessment system has been changed too. The role played by the Ontario Municipal Board in the property assessment appeals process has been eliminated. This shortens and simplifies the appeal process, saving costs. Assessment appeals are made only to the Assessment Review Board (ARB). Decisions of the ARB may be appealed to the Divisional Court, with leave of the court, on questions of law. The properties are valued in 'current value' and the assessment is done on a three year cycle. The current cycle will end in 2004. The assessment is conducted by the Municipal Property Assessment Corporation (MPAC).

8.1.4 Municipal Restructuring

Another important change that occurred was municipal restructuring. Many small municipalities amalgamated voluntarily. The number of municipalities in Ontario was reduced from 815 to 447 over the period of 1996 to 2001.[75] Municipal restructuring was aimed at cost savings but had significant financial impacts on municipal governments.

[75] Ontario Ministry of Municipal Affairs and Housing, Support Services Branch, "Restructuring Flash News', November, 2001.

8.2 Analysis of Current Trends of Major Municipal Revenue Sources

The following table shows a comparative revenue structure by source of municipal governments in Ontario. The major items of revenue for municipalities are property taxes, user fees and transfer grants from senior levels of government. The benefit-based model of municipal finance leads to the following considerations. Services of a private good nature should charge user fees at marginal cost. Services of a public good nature (e.g. police) should be funded by property taxes since the benefits accrue locally while spillovers to neighboring municipalities should be the target of provincial conditional grants. Unconditional grants are used to insure a standard of service across municipalities (equalization) and fiscal balance. Ontario violates the benefit-based model to the extent that property taxes fund social services (a provincial responsibility), services that generate spillovers, benefits which accrue to non-residents, or services in which the province has an interest. This encroachment violates efficiency, accountability and fairness principles (Kitchen, 2003; see also section 2.5.4.5).

Table 8.2 Local Government Revenue Structure, Ontario[76]

	Ontario		Canada	
	1988 (% of Total)	**2000 (% of Total)**	**1988 (% of Total)**	**2000 (% of Total)**
A. Own Source Revenue	**68.8**	**75.8**	**77.1**	**82.1**
- Property taxes	41.7	49.8	48.6	53.3
- Other taxes	1.3	1.3	1.4	1.3
- User fees	20.0	19.6	20.0	21.3
- Investment income	5.1	4.3	6.0	5.0
- Other own source	0.7	0.8	1.1	1.2
B. Grants	**31.2**	**24.2**	**22.9**	**17.9**
i. Unconditional grants	7.3	3.3	5.8	2.7
ii. Conditional grants				
- federal sources	0.9	0.9	0.7	0.7
- provincial sources	23.0	20.1	16.4	14.5

Table 8.2 above shows that the major share of revenue of municipalities comes from own sources. Within the own source, the property (and related) tax and sales of goods and services (user fees) are the major items. The table shows that the transfers (from other governments) are mainly conditional or for specific purposes. It finally shows the lesser freedom municipalities have with respect to long-term, innovative forms of financing.

[76] Kitchen, 2003

The following table 8.3 shows the human and financial resource summary for the study area.

TABLE 8.3 MUNICIPAL HUMAN AND FINANCIAL RESOURCES, UNITED COUNTIES OF PRESCOTT AND RUSSELL, AND UNITED COUNTIES OF STORMONT, DUNDAS AND GLENGARRY

	Type of Municipality	Population 2001 (% change 1996-2001)	Area km^2	2002 Budget $M	Budget 5-Year Average 1998-2002 $M	Municipal Employees
Prescott-Russell	County (6 hamlets)	76,446 (3.3%)	2002	74.730	72.483	157 FT 88 PT
Alfred and Plantagenet	Township (7 hamlets)	8,593 (3.3%)	391.7	5.361	5.316	22 FT 11 PT
Casselman	Village (1 hamlet)	2,910 (1.1%)	5	5.399	3.498	15 FT
Champlain	Township (4 hamlets)	8,591 (2.6 %)	207	6.790	5.963	23 FT 22 PT
Clarence-Rockland	City (7 hamlets)	19,612 (5.3%)	297	12.607	11.152	65 FT
E. Hawkesbury	Township (3 hamlets)	3,415 (3.6%)	235	2.325	2.236	10 FT 2 PT
Hawkesbury	City (1 hamlet)	10,314 (1.5%)	9.5	11.656	12.055	60 FT
Nation	Township (8 hamlets)	10,599 (1.2%)	657	8.898	8.966	30 FT 20 PT
Russell (1)	Township (3 hamlets)	12,412 (4.5%)	200	n/a	6.534	32 FT 5 PT
Stormont Dundas Glengarry	County (6 hamlets)	63,882 (-1.6 %)	3307	30.054	36.727	55 FT 50 PT
N. Dundas	Township (9 hamlets)	11,014 (-0.5%)	496	9.555	8.235	41FT
S. Dundas	Township (8 hamlets)	10,783 (-1.1%)	503	7.959	7.314	24FT
N. Stormont	Township (10 hamlets) (no wards)	6,855 (-0.7%)	516	2.890	3.201	15 (FT & PT)
S. Stormont	Township (11 hamlets)	11,941 (3.0%)	448	7.383	7.305	23 FT 15-20 PT
N. Glengarry	Township (10 hamlets)	10,589 (-2.0%)	642	8.170	7.731	29 FT

S. Glengarry (2)	Township (15 hamlets)	12700 (0.4%)	605	n/a	7.040	15 FT
Cornwall	City	45,640 (-3.7%)	61.9	126.4	111.6	137 FT

Legend:

FT - Full-Time employees

PT - Part-Time employees

(1) Russell is undergoing internal restructuring. Only available figures are 3-year average from 1998-2000.

(2) South - Glengarry - 4-year average based on budgets from 1998-2001.

n/a - Not available

Sources: Information provided by the officials from each municipality (2002) Data current as of September 2002. Demographic information from Statistics Canada, 1996 and 2001 Census.

As indicated in table 8.3, county (upper-tier municipality) budgets vary between $ 32.5 million and $ 72 million (last 5 years) while lower-tier municipality budgets vary between $ 2 and $ 11 million (omitting the single-tiered city of Cornwall).

8.2.1 Own Source Revenue

8.2.1.1 Property and Related Taxes

This item includes:

General Financing: This is generated through tax revenues and may include borrowing for tax supported capital expenditure. The main source of taxation is property tax. In 2000, property taxes accounted for nearly 50 % of all municipal revenues (Kitchen, 2003). Provincial governments may limit the property tax rate. Furthermore, property tax is highly visible and thus difficult to increase when municipal governments need more tax revenue. Other sources of taxation are very limited. The Canadian Constitution restricts provinces and, therefore, municipal governments to direct taxation. Some municipalities have tried some indirect form of taxation like hotel and motel occupancy tax and gasoline tax.

Reserves: These are the funds transferred either from current operations or property taxes for specific capital projects. Municipalities are allowed to build capital funds using their reserves. They also are allowed to invest their reserve funds.

8.2.1.2 Other Taxes

Development Charges, Local Improvement and Surcharges: Development charges are for growth - related capital charges. These are widely used by fast-growing municipalities, particularly in Ontario. Provincial legislation prescribes the types of infrastructure that may be funded by development charges and regulates the fee structure as well. Local improvement and surcharges are collected directly from benefiting users and used for targeted projects in communities.

8.2.1.3 User Fees

User fees are used for a variety of municipal services. Funding derived from user fees does not cover currently a municipality's cost of operating and maintaining the service. Moreover, the Municipal Act of Ontario enables the Minister to impose conditions and limits on the powers of municipality with respect to the fees that can be charged. This is also true for licensing, another small revenue source for municipal governments. However, user fees are not yet widely and efficiently used everywhere.

8.2.1.4 Investment Income

Excess revenue at the end of each year or the need to build a capital or endowment fund for future capital expenditures induce municipalities to invest in the money and securities market. Large municipalities have better investment opportunities than small municipalities. For this reason, small municipalities are prompted to invest through a pooling investment organization such as the 'ONE Fund'.

The ONE Fund is a municipal pooled investment program that is designed specifically for the public sector and is tailored to maximize returns using a safe investment strategy. The program consists of a Money Market Fund for the short-term investor and a Bond Fund for the longer-term investor.

The ONE Fund is operated by two of Ontario's premier municipal organizations, Local Authority Services Limited (a subsidiary of the Association of Municipalities of Ontario) and the CHUMS Financing Corporation (a subsidiary of the Municipal Finance Officers' Association of Ontario). Both groups understand municipal needs, challenges and unique interests, and champion the cause of municipalities.

The ONE Fund provides municipalities access to a diverse range of securities typically unavailable to the single municipality. This is due in part to the larger buying power created by the pooled resources of the investors. A number of safe securities in the market only trade in large volumes and hence are beyond the reach of the small investor. By pooling resources, every investment in ONE Fund, no matter how large or small, has the advantage of being part of the larger transactions where returns can be higher. In turn each investor benefits by sharing in the larger return based on the amount invested.

Since 1992, Ontario municipalities have had the legislative authority to invest jointly with other Ontario municipalities in approved investments either directly or through an agent. Participation in joint municipal investment funds offers clear advantages to each municipality. By pooling the monies to be invested, larger amounts are available for investment, which generally achieve higher interest rates than individual, smaller investment amounts. The municipality also benefits from increased financial safety through owning a portion of a diversisfied investment portfolio rather than holding a disproportionate share of its investments with just one institution or confined to one specific term. In addition, the funds can retain the services of professional fund managers; it is administratively easy and inexpensive for the municipality to participate in a joint investment fund.

Recent changes to the Municipal Act Eligible Investment Regulation (O. Reg. 438/97, as amended by O. Reg. 265/02) expand the range of eligible investments available to Ontario municipalities to include highly-rated asset-backed securities and highly-rated commercial paper. These changes will provide greater investing flexibility with the prospect of increased rates of return.

However, only those municipalities whose own long-term debt obligations are not rated or rated below levels set out in the regulation will be permitted to invest directly in either of the new instruments. These municipalities will, however, still be eligible to invest indirectly in these securities by way of the ONE Funds, whose Investment Guidelines were amended in January 2003 to include the new instruments.

8.2.1.5 Other Own Source

Debt Issuance: Funds also may be borrowed for infrastructure projects generally in accordance with borrowing limits set by the province. Municipal governments are allowed to borrow for capital projects only, not for operating expenses. Municipal governments are further constrained by spending limits. They also must be careful that capital borrowing does not interfere with their ability to deliver basic services and meet minimum debt payments.

Developer Funding: This is capital expenditure funded by private sector developers and is usually cost-shared. But this mechanism is used very little by Canadian municipalities. Moreover, in many provinces, legislation governing municipal finance imposes strict limitations, which can impede effective public-private partnerships. The recent Municipal Act in Ontario supports this type of private-public co-operations.

8.2.2 Government Transfers

Transfer payments and grants to municipalities constitute a declining share of municipal revenue. Provincial governments provide the bulk of grants and transfers as a source, while the federal government provides significantly less. Federal grants are related to federal responsibilities such as the provision of competitive infrastructures. Intergovernmental grants are mostly 'conditional', attached to specific projects (Specific Purpose) and often requiring

matching municipal funds. This reduces the autonomy and flexibility of local governments. Funds available through short-term programs may distort the priorities of local government. A further risk is the possibility of project cancellation if sufficient guarantees are not in place to ensure funds throughout the life of the project.

8.3 Analysis of Current Trend of Major Items of Municipal Expenditures

As with revenue sources, local government expenditure responsibilities are also tightly controlled. Municipal governments are prohibited from deficit budgeting. They must pay debt through their operating budgets and break even every year. The following table shows distribution of expenditure of municipal governments in Ontario and Canada.

Table 8.4 Distribution of Municipal Government expenditure, Ontario and Canada, 2000

Municipal Services	Ontario	Canada
General Administration	9.4	11.0
Protection	14.2	15.9
Transportation	17.4	19.8
Health	3.3	2.0
Social Services	25.0	12.6
Education	0.1	0.4
Resource Conservation	1.5	2.0
Environment	12.2	14.0
Recreation/Culture	8.4	11.1
Housing	3.5	2.6
Regional Planning	2.0	2.2
Debt Charges	2.8	5.9
Other	0.2	0.5
Total	100.0	100.0

Source: Kitchen, 2003.

The table shows that environmental service, which includes water and wastewater services, is one of the major expenditure items. It also shows that debt service charges are not a large portion of the budget, which indicates the low dependency of municipalities on borrowing

Environmental capital expenditures were the second highest item of capital expenditures after transportation in Ontario (2000). This is the result of increasing urbanization, growing population densities and increasing awareness of environmental issues, especially water quality after Walkerton (sewage and water treatment). From a fiscal point of view, it matters whether future costs can be avoided by undertaking capital expenditures currently on water and wastewater treatment plants and wellhead protection and other precautionary measures. It is quite possible that most of the losses incurred if only reactive measures were taken rather than anticipatory ones, would be in welfare terms (e.g. in case of residential water rationing instead of industrial rationing) rather than in actual dollars. However, if water quality were affected to such an extent that it led to increased morbidity and mortality directly or indirectly, losses in actual dollars (earnings forgone) would be incurred.

8.4 Available Opportunities for Capital Financing

8.4.1 Taxation Options

Expansion of the tax base and tax diversification is able to enhance local infrastructure financing. In Canada, municipalities have limited taxing power. Limited taxing power decreases the local government revenue flow. As local governments have to maintain a balanced budget, constrained powers of taxation also hamper long term planning. Adaptation for climate change needs long-term planning and capital expansion, at least for transitional periods. So, an increased revenue flow is an essential tool for adaptation to climate change. Local government can diversify its taxes. It could, subject to the legal framework and considering secondary impacts, contemplate the introduction of sales tax, business tax, fuel tax, individual and corporate income tax, etc.

8.4.2 Borrowing Options

For long term capital projects, municipalities need regular and reliable financing sources. For the renovation of the existing infrastructure, municipalities will need regular cash flow. They can depend on short and long term borrowing for that purpose. An important concern at the local level with respect to debt financing is the fact that debt must be serviced from future revenues. While costs are spread overtime, a potentially significant portion becomes a fixed obligation, which can constrain local fiscal flexibility. This constraint needs to be measured against the savings generated either by the potential of a capital project to increase the existing tax or user fee base, or to save future expenses. Municipalities are able to use many innovative options to avoid this constraint. Canadian municipalities use 'pay-as-you-go' scheme for infrastructure financing. This scheme is most appropriate for the provision of services to existing infrastructure and for maintenance and replacement projects. But for new large-scale capital projects and for expansion of existing facilities, municipalities need to borrow. Borrowing allows to smooth out the impact of new capital expenditures on ratepayers and beneficiaries. Depending on the trend of the real interest cost, borrowing may also be financially advantageous. Borrowing can ensure intergenerational equity when benefits of the capital

project are spread out over a long time. Traditionally, local governments depended on the bond market for borrowing. Currently there are various financial instruments available to municipal governments for capital financing.

8.4.2.1 Ontario Government Initiatives

OSTAR and Rural Economic Development Program: The government of Ontario has launched this five-year, $200-million Rural Economic Development (RED) program as a component of the Ontario Small Town and Rural (OSTAR) Development Initiative — a two-part, $600-million initiative launched in 2000 to assist rural Ontario. To date, more than $432 million in investment has been generated by OSTAR-RED through 90 projects, including more than $76 million in direct investment by the Ontario government. To help municipalities come into compliance with the new clean drinking water standards, OSTAR' s round one focused on public health and safety. OSTAR-RED is one of a number of programs delivered by the new Rural Strategy, which is designed to help rural communities maximize their potential.

Superbuild: Ontario has started an investment program in municipal infrastructure through Superbuild. Since 1999, Ontario has invested $9 billion to renew public infrastructure. By the end of 2004, public and private investment will total $20 billion, the largest investment of this kind in the province's history. Through Superbuild, over 500 projects have been approved to improve municipal infrastructure, including water and sewer projects.

OMEIFA and Opportunity Bonds: On August 19, 2002, the establishment of the Ontario Municipal Economic Infrastructure Financing Authority (OMEIFA) was announced. OMEIFA's objective is to promote healthy and prosperous communities by providing municipalities with more flexibility in investing in much needed capital infrastructure such as water works, sewer works, roads and bridges and transportation.

OMEIFA will help defray the entry costs into the bond market - especially for smaller and northern municipalities - and allow municipalities to finance more infrastructure than they could finance with individual borrowing programs. It will accomplish this by issuing tax-exempt Ontario Opportunity Bonds, the proceeds of which will be used to provide loans to municipalities at interest rates substantially lower than market rates. OMEIFA expects to be able to lend funds to municipalities at these low rates in part because OMEIFA' s cost of borrowing will be lower than market rates as investors in Ontario Opportunity Bonds will accept a lower rate of interest if the Ontario Opportunity Bonds are Ontario tax-free. Ontario Opportunity Bonds will not be obligations of, and will not be guaranteed by the Province of Ontario.

As well, up to 50 per cent of the interest costs on loans from OMEIFA to municipalities are expected to be subsidized by the Province through subordinated loans to OMEIFA resulting in municipalities paying a lower rate of interest to OMEIFA. The Government of Ontario has announced its intention to provide OMEIFA with an initial $1 billion capital infusion and an additional $120 million for water and sewer projects through the Ontario Clean Water Agency, a Provincial Crown Agency. It is expected that this funding to OMEIFA will be primarily by way of subordinated loans.

8.4.2.2 Federal Initiative for Municipalities

Municipal Rural Infrastructure Fund: Budget 2003 announced that the Government of Canada is committed to a ten-year infrastructure fund by providing an additional $3 billion investment in Canada's public infrastructure. Of this allocation, $2 billion will top-up the Canada Strategic Infrastructure Fund (CSIF), and $1 billion will establish the Municipal Rural Infrastructure Fund (MRIF). While the CSIF will continue to focus on large-scale infrastructure needs in Canada's largest cities, MRIF will focus on local infrastructure priorities in smaller municipalities, including those specific to rural and remote communities. The Municipal Rural Infrastructure Fund will aim to improve and increase the stock of core public infrastructure in service areas such as water, wastewater, culture and recreation. To ensure an equitable balance in the MRIF between Provinces, Territories and First Nations components, each jurisdiction will receive a base allocation of $15 million, with the remaining funds allocated on a per capita basis. 80 per cent of funding under the MRIF will be dedicated to municipalities with a population of less than 250,000. In addition, at least 20 per cent of investments under the CSIF - $400 million - will be allocated to these smaller communities. In total, $1.2 billion from Budget 2003 will directly support infrastructure priorities in smaller communities across the country. The new fund will be cost-shared, with the Government of Canada contributing, on average, one-third of total project eligible costs. Provinces, territories, municipalities will contribute the other two-thirds.

On average across Canada, 50 per cent of funding under the MRIF will target green infrastructure that provide essential health benefits to Canadians and improve the quality of the environment. These projects will include water and wastewater infrastructure, municipal environmental energy improvements, public transit infrastructure and solid waste treatment infrastructure. To ensure maximum benefits to Canadians from infrastructure investments, where possible, projects will be complemented by supportive policies that contribute to the Government of Canada's national objectives of climate change and innovation.

Green Municipal Investment Fund: The Green Municipal Investment Fund (GMIF) is a $200 million permanent revolving fund that will support the implementation of highly innovative environmental projects. Collectively, municipal governments in Canada that implement such projects can have a significant impact on improved environmental performance, particularly in reducing emissions of greenhouse gases. Through GMIF, a municipal government can borrow at the preferred interest rate of 1.5 per cent below the Government of Canada bond rate. Public and private-sector partners of municipal governments are also eligible for loans at attractive rates. GMIF finances up to 15 per cent (25 per cent in exceptional circumstances) of the capital costs of a qualifying project. GMIF can also provide loan guarantees. Loan payback periods may range from four to ten years. GMIF is open to Canadian municipalities and their public sector or private-sector partners.

Environment Canada's EcoAction Program: EcoAction encourages projects that protect, rehabilitate or enhance the natural environment, and builds the capacity of communities to sustain these activities into the future. Projects require matching funds or in-kind support from other sponsors. Priority for funding is given to projects that will achieve results in the following areas: Clean Air and Climate Change, Clean Water, and Nature.

Canada-Ontario Infrastructure Program: The Canada-Ontario Infrastructure Program represents a six-year, $680.7-million federal investment in partnership with Ontario, its local governments, and the private sector. The program's purpose is to invest in urban and rural municipal infrastructure in Ontario; it is expected to stimulate more than $2 billion in capital investments. The objectives of this fund are to enhance the quality of the environment support long-term economic growth, improve community infrastructure, and build 21st-century infrastructure through innovative technologies, new approaches and best practices.

The Canada-Ontario Infrastructure Program complements Ontario's SuperBuild municipal infrastructure initiatives: Ontario Small Town and Rural Development Initiative (OSTAR), Sports, Culture and Tourism Partnerships (SCTP), and Millennium Partnerships. A minimum of 40 percent of Canada-Ontario Infrastructure Program investment will be devoted to Green Municipal Infrastructure. A minimum of 15 percent of Canada-Ontario Infrastructure Program investment will be allocated to projects in rural communities. Canada's contribution shall be up to one third of a project's total eligible cost. Canada's contribution to any proposal will usually match Ontario's contribution.

8.4.2.3 Other Borrowing Tools

More innovative borrowing options are available nowadays and the US local governments have been using these options successfully for the past few years. These innovative options increase the scope of borrowing as well as decrease the financial burden in comparison with traditional bonds. These also increase flexibility. Some of the large Canadian municipalities are also using these instruments. The following are some of the most innovative instruments for long and short-term borrowings.[77]

8.4.2.3.1 *Long Term Tools*

Among the long term tools, most prominent are Zero Coupon Bonds, Compound Interest Bond, Tender Option ('Put') Bonds, Super Sinker Bonds, Floating Rate Bonds and Tax Exempt Bonds. These bonds usually provide tax free income. This arrangement allows the municipalities to offer a lower interest rate on the bond as the buyers are ready to buy it with the lower interest rate for its tax exemption characteristics. Some of them combine the investment multiplying power of compound interest with the income-sheltering feature of traditional tax-exempt bonds. For 'put bonds' and super sinker bonds, the investor has the option to put its bond in for redemption to get its money back before maturity. In return for the right to 'put' the bond, the investor accepts a lower yield. The local government pays a lower rate of interest and consequently incurs less cost than from traditional bonds. The idea of a local government tax exempt floating-rate interest bond is to provide stability for both issuer and the bondholder throughout the life of the bond, particularly in times of interest rate volatility. It is done by changing the interest rate (yield) over the life of the bond, in contrast to the traditional fixed rate, long term bonds which do not change interest rates but whose market values may change when interest rates rise or fall.

[77] The instruments are from a more extensive literature review on local public finance. See Alam *et al*., 2002.

8.4.2.3.2 Short Term Tools

For the short term, there are instruments such as Tax Exempt Commercial Paper (TXCP), Tax Exempt Leverage Lease Financing (TELL) and Tax-Exempt Demand Master Note (TXDMN). There are other innovative bonds like Stripped Coupon Bonds, Stepped Coupon Bonds and Detachable Warrant Bonds which are not used yet in Canada.[78] The introduction of these new and innovative financing tools will depend on the overall financial condition of local governments and the fiscal philosophy. These innovative tools are required because traditional bonds are no longer always suited to market conditions. These innovative tools are a direct result of market uncertainty. An issuer should not turn to new financing techniques if conventional approaches are available and acceptable, and unless it is satisfied that there is sufficient benefit compared to risk. Practical concerns should also be a part of the decision making process. These include political acceptability and public reaction, a government's technical ability to manage and structure creative financing mechanisms, and the legal framework that governs 'capital financing'. Large municipalities may be better able to use these tools than the smaller ones. The smaller municipalities pool their resources to use these tools. But there are still legislative obstacles and provincial restrictions to the use of many of these tools which are for future consideration by municipalities. As manifest in numerous provincial-local consultations, stakeholders have agreed to look for alternative and more efficient capital financing instruments.

8.4.3 Other Financing Options

There are other financing tools and management options available to local governments for financing climate change adaptive measures.

Leasing: Local government can also turn to non-debt methods for financing capital projects. One of the popular methods is 'Leasing'. In this process, a leasing company acts as an intermediary in the agreement and will identify investors who are willing to provide funding for the project in exchange for the pledge of the government's lease payments. The leasing company may sell certificates of participation to investors for a share of the tax-free income stream. Leasing may be an attractive alternative, because in most cases it is not considered debt; leasing agreements are not subject to debt ceilings and voter approval is not required to enter into the agreement.

Value Capture: Value capture techniques may be used to finance infrastructure by using the commercial value created by building infrastructure or by rezoning of land. Value capture is most appropriate in situations where surrounding land value is enhanced through an infrastructure project. This value can be captured by the local government through the use of various financial instruments.

Tax Exporting: If the renewal or expansion of existing infrastructure benefits any adjacent community, the municipality is able to export the tax to that community. The local government can use leasing agreements to export tax. Costs may be exported through the effective transfer of capital cost allowances or depreciation to the lessor, who can then claim such allowances as

[78] The tools are from literature review on local public finance. For a detailed description see Alam *et al*., 2002.

tax deductions. If the lessor is in another jurisdiction, the resulting tax loss falls entirely in that jurisdiction and does not affect local taxpayers.

Public-Private Partnership (PPP): Public private partnership is another widely used process for infrastructure financing nowadays. One of the main benefits of public-private partnership is that they enable the provision of needed infrastructure during periods when the government funding is constrained. Many approaches can be used for private-public co-operation. The Ontario and federal governments have been actively promoting public private partnership for the last five years. Some of the mostly used approaches are as the following.

Build/Operate/Transfer (BOT) is a provision whereby a private contractor finances, designs, builds and operates the infrastructure on land leased on a long-term basis from the municipal government and transfers the infrastructure to the local government upon completion of the lease. Under this approach the infrastructure can be financed 'off balance sheet'.

Privatization is the outright sale of existing infrastructure to the private sector and permanent ownership of new infrastructure by the private sector. Privatization can be accomplished in many ways, including sale to private investor, privatization through share issue or through employee takeover.

'Merchant Facility' is the development of new infrastructure by the private sector completely at the initiative of a private firm, with little or no government involvement except encouragement through tax incentives. This approach may be appropriate for the facilities for which user fees may be charged.

Regional Co-operation: Different public sectors and different regions may co-operate with each other to take adaptive measures in response to climate change. Sometimes small operation of public utilities may not be economic. In these cases, large facilities can be built through regional co-operation to use the economies of scale and then use the facility regionally. There are numerous organizations which can assist municipalities in planning, research and funding. The Federation of Canadian Municipalities, the Association of Municipalities of Ontario, the Rural Ontario Municipal Association, the Foundation for Rural Ontario, the Ontario East Economic Development Commission, the Rural Ontario Council, the Foundation of Rural Living, the Ontario Good Roads Association are the names of but a few organizations which assist municipalities.

Infrastructure Bank: Provincial or federal government can build special purpose 'infrastructure bank' that will support the infrastructure financing of all municipalities.

Emergency - Situation Insurance: Another way of financing climate change related adaptive measures may be to sell insurance to the probable affected citizens and then use the insurance money to build new capacity expansions.

8.5 Insurance

8.5.1 Municipal Dependence on Insurance and the Impacts of Climate Change

Municipalities usually buy liability insurance for their properties and staff. Buying insurance for climate change risks is still a very new concept. Because of the tight budget situation, it will be politically very difficult to convince the elected representatives on municipal councils and their constituents to buy insurance to cover for climate change risks even if insurance products along these lines become available.

Municipalities are meeting challenges in their relations with the insurance sector due to rising claims, rising premiums, increase in litigation and budget cuts. The rising claims and the post - September 11 climate have compelled many municipalities to pay higher insurance premiums. Ontarians and their lawyers are suing local governments at an increasing rate for various liability claims. All local governments are also facing severe budget cutbacks. Cutbacks affect spending on municipal insurance too. Spending reductions affect the insurance industry indirectly as the municipal ability to enforce codes and maintain standards of municipal services decreases. Though, presently, insurance premiums are a small part of the municipal budget and affordable, insurable items of the municipal budget have become riskier.

Ontario municipalities have to insure themselves for different kinds of risks. These include the risks that arise from the liability of their employees, buildings they use and the infrastructures and services they are responsible for. The municipalities are responsible for sewerage systems, water supply, maintenance of roads and bridges, winter maintenance of roads, municipal property, and building inspection. Different kind of liability claims can arise from many of these responsibilities such as sewer backups, burst water mains, water supply problems, winter salting of roads, accidents occurring on road for municipal negligence, accidents arising form municipal property or defects in buildings that have been inspected by municipality for enforcing building codes. The individuals harmed by these hazards may be compensated in other ways, but the trend is for municipal government to be held liable. These hazards are eating up municipal budgets and driving up the insurance premiums. Provinces like British Columbia, Alberta, New Brunswick, Nova Scotia have amended their statutes to give municipalities protection from nuisance liability and from claims related to building inspections or the ownership of municipal property, but the step has not been taken by Ontario.

There may be several impacts of climate change that may affect the insurance status of municipalities. The first is severe weather which includes extreme precipitation, tornadoes, ice storms, hail, drought and flash floods. All these are able to increase the liability claims on the municipalities. Liabilities may arise from sewer backups, water quality related problems, winter accidents, and increased crop insurance claims. There is a very strong possibility of liability claims arising out of farming activity, the run off of cattle faeces entering water courses after heavy rains and polluting streams, rivers and wells used for drinking water purpose. These are able to create Walkerton - like tragedies in municipalities and the liability may fall upon the municipality.

There may be direct insurance impacts on agriculture due to climate change. There may be a greater frequency of drought with reduction in crop yield, greater extreme precipitation event and also likelihood of more frequent hail events. As the temperatures generally warm up, crops, which currently do well in the Eastern Ontario climate could find themselves under stress and there may be a general switch into some new and untested crops with the risk of insurers and re-insurers not getting the rating right on untested crops. There is also exposure of Northward migration of pests that currently do not appear in Canada.

Municipalities are generally dependent on commercial insurance companies for their liability insurance. But increase in catastrophic weather events and increased weather volatility has resulted in huge losses for the insurance industry in the last decade. The worldwide negative impact of climate change on the insurance industry will further affect the premiums. These events will decrease the willingness of the insurance industry to provide coverage to the municipalities. So, conventional sources of insurance are drying up for municipalities even for the limited amount of liability insurance they purchase now, let alone for climate change risks.

8.5.2 Current Opportunities for Municipal Insurance

Municipal risk is currently being managed in different ways: through private insurance brokers, regional insurance pools, reciprocal insurance organizations and self-insurance. Among the private insurance brokers, the Frank Cowan Company is the principal player in the municipal insurance market. Other companies involved are AON Insurance, Marsh and Lloyd's. The problem with private insurance brokers is that they do not deal with municipal insurance exclusively and so the risks from other sectors are transferred to the municipal insurance sector as well. Recently premiums for private insurance companies have skyrocketed due to the world insurance market events. As private companies work on the basis of full risk transfer, the premiums are very high. Moreover, they do not include climate change impacts in their insurance contract or in the company policies.

Another form of insurance practiced in Ontario is the regional insurance pool. It uses an aspect of self insurance, but within a larger framework. Small municipalities which share the same geographical boundary and same risks may join together to pool their risks and self insure themselves. They can in this way spread the risk regionally. The region of Waterloo has such an insurance pool.

Ontario also has a reciprocal insurance organization called Ontario Municipal Insurance Exchange (OMEX). It was formally licensed in 1989 with 5 members and now has over 90 members. It is a risk pooling arrangement. It is a system through which a group of similar and adjacent municipalities exposed to similar risk are able to spread their collective losses by levying a premium against each member municipality sufficient to cover these losses. A reciprocal may be a complete form of self insurance or a combination of self insurance and conventional commercial insurance. OMEX is a complete form of self insurance. It is a non-profit organization and charges lower premiums than conventional insurers. It pays out no profits to its shareholders or commissions to sales staff and is tax exempt. As it specializes in municipal risks, major claims and disasters in other industries like the September 11 event, do

not adversely affect the premium for its members. OMEX follows conservative reserving practices based on a worst-case scenario for large claims. OMEX is a full service insurer providing general third party liability, owned and non owned motor vehicle insurance, errors and omissions coverage including conflict-of-interest exposure, property insurance, crime and boiler & machinery risks. OMEX policies are worded specifically for municipal risks. The good news is OMEX gives consideration to climate change.

Crop insurance is another aspect that will be affected by climate change. In Ontario crop insurance is mainly provided through the federal-provincial arrangement of crop insurance program under the Crop Insurance Act of Ontario. Crop insurance provides farmers with protection against yield reductions caused by natural hazards. As climate change may increase natural hazards, crop insurance claims will increase too. Under the Ontario crop insurance program, the producer is given the option of choosing a coverage level ranging from 70% to 90%. The higher the coverage level, the higher the premium that is required to insure the crop. The federal and provincial governments each pay 25% of the total premium and producers pay the remaining 50%. There is also a premium surcharge and discount system. Discounts apply if the producer's average claim has been less than the average claim rate for the commodity. A surcharge applies if they have been higher. The maximum annual surcharge is capped at plus 10% of the base rate while the maximum annual discount rate is capped at minus 20%. Crop insurance administrative costs are shared by the two levels of governments. It is not reflected in the premium. AGRICORP, an agency of Ontario Ministry of agriculture and Food is responsible for overall administration and delivery of the program.

8.5.3 Policy Suggestions

Municipalities should first decrease ("internalize") their vulnerability to climate change risk by ensuring that the infrastructure under their jurisdiction is upgraded (or is designed, if it is new) to withstand expected extreme events, especially large precipitation events. More provincial and federal funding should be available to municipal governments to upgrade and maintain their infrastructure. Inadequate and poorly enforced building codes are one of the main reasons for large scale catastrophic losses. For example, 25% of the insurance claims for Hurricane Andrew could have been prevented through better compliance with building codes. There should be more funding into the research of improved building materials and construction methods. Federal or provincial governments may play an important role in empowering municipal governments in internalizing climate risk factors by modifying the regulatory environment (defining built infrastructure standards which should be allowed to vary spatially); FCM could do the same on a voluntary basis.

All municipalities should conduct a climate change risk assessment. All municipalities should make sustainability plans for the future and it should include adjustments to climate change impacts. There are already good sustainability initiatives available in Canada. The Greater Vancouver Cities Plus is the best example. It is a 100 year sustainability plan that incorporates economic, social and environmental priorities to better plan for the infrastructure needed to support future growth. Climate change is one aspect of the environmental priorities. The City of Hamilton has a good Infrastructure Asset Management Strategy which maintains GIS mapping

of Water, Wastewater, Storm Water, Roads, Bridges and Traffic programs. By anticipating the urban impacts of climate change and incorporating them into sustainability plans municipalities can strengthen their resilience.

Municipalities also should decrease their dependence on commercial and private sector insurance and should depend more on 'self-insurance', either individually or collectively. Regional insurance pooling is a very good option for small municipalities. OMEX is another good option for Ontario municipalities. Also the private insurance industry should try to introduce municipal risk specific insurances that are free of impact from other industries. The municipalities and FCM should lobby for this. Governments may also ease the reinsurance problems of commercial insurance companies for catastrophic risks by providing reinsurance themselves or promising a line of credit in times of emergencies.

Financial markets may be an alternative source of insurance. Municipalities may introduce new financial market instruments like 'the Act-of-God bond' or 'catastrophe bond'. The return on these bonds may be tax-free and can reduce the financial burden of the municipalities

Both the province and the federal government should build up a natural disaster protection fund. The governments should set aside a certain amount of money for these funds. It can ease the pressure on provincial and federal governments in times of catastrophic events. These funds should be triggered for surprise events only.

Instead of ex-ante arrangements through the insurance or capital market, local governments can also keep the option of a line of emergency credit available in times of emergencies. They can reimburse the amount borrowed when the emergency situation is over. In this way they can decrease the financial burden of saving before the hazard occurs.

Municipal insurance portfolio composition should be left to municipalities to decide on the basis of the opportunity cost of funds. Co-operation between the insurance industry and municipalities is needed as an adaptive measure to climate change. A climate change scenario analysis is also needed to find out the burden of financial risk to municipalities (R.Alam *et al*., 2002).

8.6 Water Specific Financing Options

New investment in aging water infrastructure is required all over Canada not only for climate change adaptation, but also for demographic and development reasons. Canadians have the second highest average per capita water consumption in the world, at more than 300 litres per person per day (FCM 2001a). This level of consumption includes domestic, commercial and industrial uses. Amongst domestic uses, flushing of household wastes constitutes a significant percentage of water use. The EOWRMS study found that 'annual estimated water demand in the study area is 34.3 million m^3 per year i.e. 184.4 m^3 per capita. Together municipalities and private domestic demand account for almost half of the annual water demand in the study area. Future water demand is expected to increase from 12 percent to 30 percent from groundwater sources and from 26 percent to 51 percent from surface water sources. High demand for water together with water loss in the distribution system (greater than 20 percent in many communities)

results in higher than necessary capital, chemical and energy cost (FCM 2001a). There is a large capital demand for rehabilitation and upgrading of the existing water distribution system. EOWRMS found that in nearly the entire study area, both groundwater and surface water infrastructures would need upgrading and rehabilitation. This also includes drinking water infrastructure needs. In Ontario[79] and Quebec[80], provincial government inspections of water treatment facilities over the summer of 2000 have uncovered deficiencies in facilities, testing and operator training. A similar problem occurs with sewage treatment facilities as effluent discharges have a direct impact on the quality of drinking water. 'Rapid growth has also placed a huge demand on existing infrastructure' (FCM 2001a). The Canadian Water and Wastewater Association estimated in 1997 that $4.5 billion in additional investment would be required through to 2012 to bring all water and wastewater treatment plants up to state-of-the-art and to extend central water supply and wastewater collection systems to all residents of municipalities. These figures take into account the expected population growth over this period.

8.6.1 Demand Management & User Prices

Pricing water through 'user price' may serve two purposes. It is able to raise enough revenue for the rehabilitation, renovation and expansion of the water infrastructure, as well as reduce water use and capacity cost by demand management. User fees for water can be either 'flat rate' or 'volumetric rate'. 'Volumetric' user fees for water can have a fixed and a variable portion. The fixed portion will cover the capacity cost of the system. This capacity charge would cover a person's share of the fixed costs of treatment and a portion of his share of the fixed costs of distribution. Also the fixed cost portion should vary depending on the distance to the service area. The variable cost portion should take into account the peak and off-peak demand and the seasonal variation in water demand. So ideally there should be a 'quantity charge', a 'capacity charge' and a 'location charge' for water pricing. Flat rate charges are also in place in many municipalities. Many of them also follow the complex flat rate system that varies with the size of the property, the number of resident etc. The inefficiency of flat rate is that low rate users subsidize the high rate users in this system. The complex flat rate system also incurs more costs than the volumetric user charge. Volumetric charges for water requires water metering and take one of the three forms: constant unit rate, declining block rate or increasing block rate. A constant unit rate is an equal charge per unit of consumption and seldom varies among classes of customers. Declining block rate includes a fixed service charge per period combined with a volumetric charge that decreases in discrete steps or blocks as the volume consumed increases. An increasing block rate is similar to the decreasing block rate structure except that the volumetric charge increases in steps as consumption increases. The municipalities should use either the increasing or the decreasing block rate. But for water conservation, increasing block rate is a better option. Municipalities can also use 'lifeline' rates that provide low rates for low or fixed-income households, or 'vintage' rates that distinguish between new and existing customers, or seasonal or peak-demand rates to reflect increased cost of delivery or a desire to reduce consumption during certain seasons or times of the day. In 1994, Canadian households, paying for water by volume, used on average 263 liters per person per day, 39 percent less water than households paying flat rate, which used 430 liters per person per day (EC

[79] Ontario Ministry of Environment news release, July 28, 2000.
[80] Quebec Ministry of Environment, Press Release, August 18, 2000.

1998).[81] The EOWRMS study shows the impact of residential metering on water demand by the following table.

Table 8.7 Impact of residential Metering on water Demand

	Metered (At least 50% metered, average 97%)	Not Metered (no more than 30%, average 1%)
Average day per capita (L/d)	477	612
Maximum day per capita (L/d)	944	1,286

But if 'capacity charges' and 'location charges' are not used with water metering, the latter may not cover the full cost of water supply. For example, in 1990, it was estimated that water charges covered only 65 percent of the real costs of providing the service in Ontario.[82] So correct pricing consists of setting the price equal to the real marginal social cost of delivering the service. It not only influences demand, but provides the revenue needed to allow municipal governments to maintain, operate and renew water infrastructure. The stability of a long-term infrastructure program depends on full cost pricing.

Some Ontario communities have found that savings can be achieved in a short period of time even where water efficient devices, such as low-flush toilets, have been distributed to residents without charge.

8.6.2 Safe Drinking Water Revolving Loan Fund

The Ontario Municipal Water Association (OMWA) has for some time promoted the creation of a revolving loan fund to assist in the construction or upgrading of public drinking water systems, and government ministries have expressed interest in such a fund. Such a fund would be a major step towards fulfilling needs identified by the Walkerton Inquiry, especially for smaller systems. Two key features of such a fund are: it would act as a strong inducement for communities to make investments needed to ensure safe water systems and annual costs to the Province would be considerably less than equivalent grants made under the Province's past capital grants programs. They propose that the fund could initially apply to public drinking water systems only, for ease and speed of implementation. After some experience has been

[82] Ontario Ministry of Environment, 1990, mimeo.

gained, similar funds could be set up for other high-priority areas – for example, sewage infrastructure and source water protection. Annual government contributions to the fund would be similar to capital assistance grants that have been made for water and sewer, but over time the cost to the government could be only about 60% of the amounts spent on the qualifying projects, owing to the repayments into the fund by the municipalities. The amounts available for projects could be doubled with equal participation by the federal government. However, the effectiveness of the provincial government contributions fund is not dependent upon Federal participation. OMWA advocates user-pay, full-cost accounting for drinking water systems. However, they recognize that because of historical or special reasons, some systems (especially small systems) have come to expect grants for construction or upgrading of water systems. This has been an inducement to keep rates artificially low, and has had the effect of rewarding those who have not maintained their plant in good operating order. OMWA advocates argue that grants should be replaced by low-cost loans. Government contributions to the revolving loan fund could be made annually, just as capital grants were awarded annually. But repayments into the fund by borrowers will increase the amounts available for loans each year. The loans should be tied to performance required by Bill 175 – e.g., contingent upon sound long-term technical and financial plans and adequate rate schedules. The fund should offer very-low-interest or preferably no-interest loans, and there could be flexibility in the timing of repayments. If zero interest were charged, the payback process would seem much less burdensome, and repayments would be seen to go directly to reduction of the outstanding balance.

8.7 Conclusion: Impacts of Climate Change on Municipal Finances

Climate Change may clearly affect the revenue side of municipalities, mainly property taxes. If climate change adaptation requires changing the current type of land use, it may affect the property tax base. Climate change will mainly affect agricultural land use. A new crop mix (e.g. more corn, more soybeans, less hay as currently experienced in Northern Virginia) might be beneficial for agricultural property tax revenues.[83] User fees could be considerably affected if generalized water metering were introduced and water charged at its (increasing) marginal cost. Debt dependence may increase if the municipal tax base and/or transfers are not increased. Development charges may increase if full cost pricing is implemented. Public private partnerships and developer financing should also increase for capital projects due to the new defined 'character' of municipalities as 'business'. If a climate change policy is adopted by the provincial and federal governments too, it will also increase the provincial and federal transfers to the municipalities.

On the expenditure side, it is the environmental services item, which will be the most affected. It includes the water supply, waste water treatment, garbage collection and recycling, storm water system etc. Corresponding capital expenditures on water and wastewater treatment plants will have to increase in some municipalities as indicated in section 6. Well water protection expenditures may have to increase as well. Climate

[83] Assuming, of course, that the provincial laws allow municipalities to collect the additional revenues. This is not the case currently (see B. Chiarelli, "The Property-Tax System: Confusing, Complex, Unfair", *Ottawa Citizen, December 9, 2003, p.*A19*)*.

change will also affect the transportation expenditure as infrastructures may be affected. Extreme events will also increase the expenditure on protection services and insurance.

References

Alam, R. and P. Crabbé (2002), *Local Financing for Adaptation Measures to Climate Change*, Department of Economics, University of Ottawa, unpubl. Mnss.(Volume II of this Report).

Aurelson, I., Burhoe, D.A., and R. D. Needham (2003), *Rural Municipalities and Climate Change Preparation: Bridging Mechanisms for Adaptation*, Department of Geography, University of Ottawa, unpubl. Mnss., March.

Eastern Ontario Smart Growth panel, *Shape the Future*, Discussion paper, Summer, 2003.

Environment Canada Bulletin, June 1998.

Government of Ontario websites: www.omeifa.on.ca
www.omex.org
www.omwa.org
www.smartgrowth.org
www.superbuild.gov.on.ca

Kitchen, H. (2003), *Municipal Revenue and Expenditure Issues in Canada*, Canadian Tax Foundation, n0 107.

Ross, Angus, *Climate Change and Its Impact on the Insurance Industry*, Institute of Catastrophic Loss Reduction (ICLR) Research Paper No. 8, June, 2000.

Rounds, Richard C. (1997), *Changing Rural Institutions: A Canadian Perspective*. Pp. 248: Canadian Rural Reconstruction Foundation in cooperation with the Rural Development Institute.

Section 9 Perceptions and Values of the Local Actors[84]

The *perceptions and values* of local decision-makers become vital to understanding what information they will base their decisions on, the kinds of decisions they will make, and what priorities they will assign to certain adaptive activities. Indeed, the central question posed here is what are the perceptions and values held by decision-makers with respect to managing water resources in the context of climate change? The purpose of this section is to report on the results of our research on how these decision-makers conceptualize public action, responsibility for the environment, the importance of science and the effectiveness of collective action. The particular focus here will be on watershed conditions, research priorities, information sources, levels of influence of the respondents and their views on climate change, their perceptions of the role of governments, and the importance of different environmental issues in their watershed.

9.1 Methodology

In the fall of 2001, a questionnaire was mailed to 187 decision-makers in Eastern Ontario. The decision-makers were broken into two large groups: municipal politicians/senior administrators and Conservation Authority Board members/senior administrators. Both groups were mailed the same questionnaire in both French and English, and asked to return it in a pre-addressed, stamped envelope provided with their questionnaire.

The questions focused on the respondents' views about the quality of their watershed, their certainty regarding this assessment, and their faith in the adequacy of data supporting these views. Respondents were also asked to assign priority levels to different areas of environmental research in their watershed, identify who they turned to for information, identify their involvement in and ability to influence decisions regarding different environmental issues and respond to statements regarding climate change. This group of questions ended by asking the respondent to identify the relative importance of environmental issues in their watershed.

Additionally, basic socio-economic and educational information was collected from the respondents, as was their level of involvement in the community.

9.2 Results

Fifty-three questionnaires were completed and returned by mail, representing 28.3% of the original sample. Of these, 52.8% were completed by respondents in Conservation Authorities, and 47.2% were completed by respondents in municipalities. Municipal politicians/senior administrators responding represented urban municipalities (such as Cornwall or Clarence/Rockland), rural municipalities (such as North Dundas) and regional levels of government (upper tier municipalities such as S, D & G). All three Conservation Authorities were represented in the respondent sample (the Rideau River Conservation Authority was included in the survey as well though its watershed lies North - west of the study area and includes Ottawa).

[84] This section is contributed by D. Leech, L. Juillet and C. Andrew.

Francophone respondents represented 18.1% of the completed sample, with Anglophones making up the balance. Geographically, the respondents were distributed relatively evenly across the area of study. A broad range of economic, professional, and educational backgrounds were represented in the sample. 80% of the respondent sample indicated that they had lived in Eastern Ontario for more than 20 years, implying a high level of knowledge about local issues.

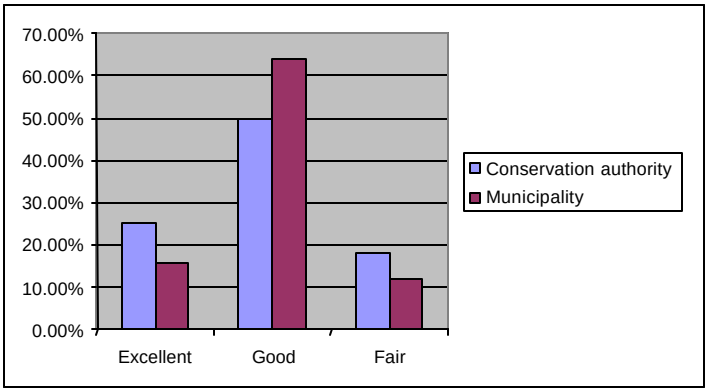
9.2.1 Watershed Conditions

Respondents were asked to indicate their judgment regarding the overall health of the watershed in which they live with respect to eight specific parameters: the health of the fish population, the condition of water in local wells, the condition of water provided by water treatment facilities, the condition of water in local lakes and rivers/streams, the absence of pollution caused by toxic chemicals, the absence of pollution caused by organic wastes and the conditions of wetlands. These parameters serve as a series of general indicators of watershed health.

Generally speaking, both municipalities and CAs indicated that they felt that the condition of the watershed was relatively good. A majority of the respondents indicated that all of the watershed indicators above could be described as fair to excellent. Generally speaking, CA respondents indicated a greater level of confidence in the condition of their watershed than the municipal respondents did. Municipalities, however, were more confident about the data available to them regarding these specific watershed indicators.

It is interesting, given the recent water-related management problems in Canada, that both municipal and CA respondents rated the condition of water from water treatment plants highest among the indicators.

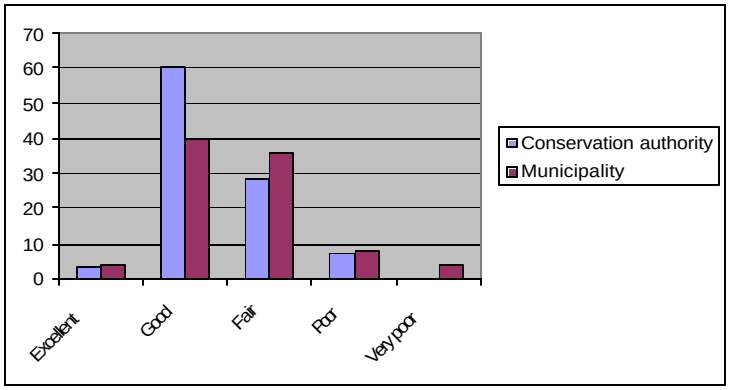
Figure 9.1 Condition of Water from Treatment Plants



None of the respondents indicated that they felt the water from water treatment plants was "poor" or "very poor". It is also interesting to note that both municipalities and CAs rated their certainty about the condition of water from treatment plants and their certainty that they had

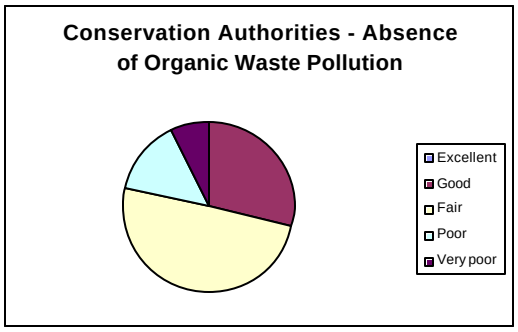
adequate data to support this assertion highest, when compared to their certainty and data for the other watershed indicators. By comparison, the condition of water in the wells found in the study area was rated considerably lower.

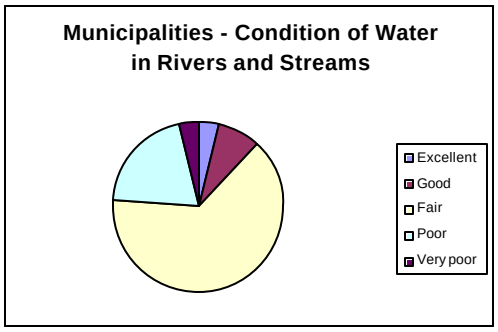
Figure 9.2 Condition of Water in Wells



Municipalities and CAs each identified a different "top concern" with respect to these watershed indicators. For municipalities, the quality of water in rivers and streams was their greatest concern, whereas for CAs, the runoff of organic wastes posed the greatest threat to the health of the watershed.

Figure 9.3 Issues of greatest concern for Conservation Authorities and Municipalities





Although municipalities and CAs identified a different "top concern" for watershed health, the two are strongly related. Indeed, due to the fact that agriculture is the dominant land use in Eastern Ontario, organic waste pollution does become a significant concern for both rural and urban dwellers.

Both municipalities and CAs expressed concern about the adequacy of data related to organic waste pollution and toxic pollution. It is further interesting to note that when asked to add possible indicators, that water quantity was mentioned only by a respondent from the CAs. A CA respondent was the only one to add air quality as a possible watershed health indicator.

9.2.2 Environmental Priorities

Respondents were asked if additional resources were focused on environmental conditions in their watershed, what the relative priority of water use, urban runoff, agricultural runoff, impact of human population growth, water quality, wetlands, fish populations, endangered species and ecosystem management strategies should be. Respondents were also asked to identify any other priorities that they thought should be funded. The respondents ordered these environmental priorities in the following order:

Table 9.1 Ranked environmental priorities

Conservation Authorities	Municipalities
1. Water quality	1.Water Quality
2. Ecosystem management	2. Agricultural runoff **and** water use
3. Agricultural runoff	3.Urban runoff
4.Impact of human population growth	4. Ecosystem management
5.Water use	5. Endangered species
6.Wetlands	6.Impact of human population growth
7.Endangered species	7. Wetlands **and** fish populations
8.Fish populations	
9.Urban runoff	

It is interesting to note that while both CAs and municipalities place water quality highest on their list of research priorities, that municipalities rated it a higher priority than CAs did. It is also interesting to note that when asked to add research priorities to the list, that only CAs added water *quantity* to the list. None of the respondents to the questionnaire added climate change to their list of research priorities.

A number of interesting points may be made about the prioritization of research by the respondents. Of primary interest here is the relative weighting of ecosystem management by the conservation authorities and municipalities. Of the two groups of respondents, CAs showed significantly more interest in ecosystem management. This appears to indicate a greater opening in conservation authorities to ecosystem-wide responses to climate change impacts. The data does appear to support the assertion that CAs are more open to understanding and responding to the impacts of climate change on a scale which is "natural" to this phenomena.

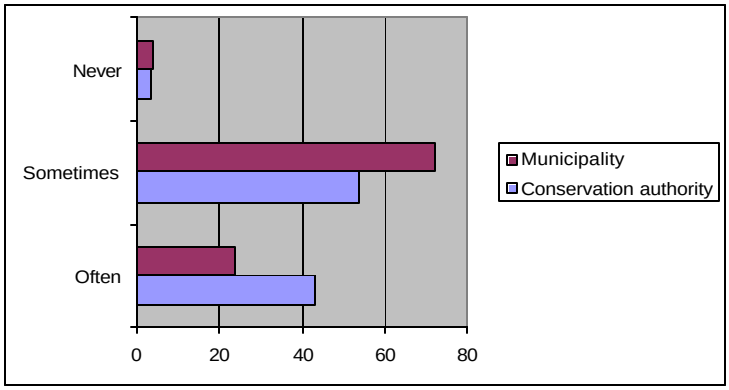
9.2.3 Information Sources of Respondents

Respondents to the questionnaire were asked to identify their sources of information with regards to the condition of their watershed. It is interesting to note that none of the respondents sought information from their sources "often". At the outset, this appears to indicate an important lack of communication between respondents and their sources of information

regarding the condition of their watershed. While it is impossible to make generalizations here, this may indicate a weakened link between decision-makers and the epistemic communities present in Eastern Ontario.

Municipalities and CAs appear to use different networks when seeking information about the condition of their watershed. Generally speaking, CAs tend to be more oriented towards local and regional networks, whereas municipalities turn "upwards and outwards" for their knowledge. As an illustration, conservation authorities turn to local knowledgeable citizens more often than municipalities do.

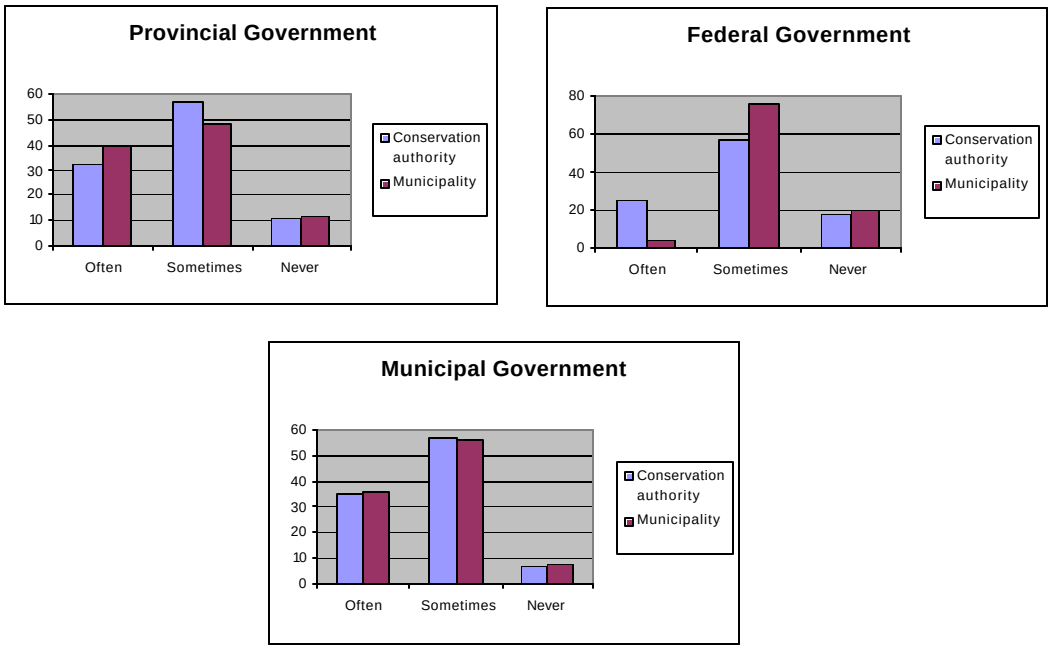
Figure 9.4 Percentage of respondents seeking information from knowledgeable local citizens



CAs are also more like to turn to (local) environmental groups for information. Municipalities, on the other hand, are marginally more likely to turn to private corporations for information about the quality of their watershed.

Municipalities, for their part, rely mostly on themselves and the provincial government for information about the quality of their watershed. Again, this reinforces the idea that municipalities look beyond their local area for information. Interestingly, both CAs and the municipalities showed greater confidence in municipal and provincial governments as a source of information than they did in the federal government. This is evident in the figures below.

Figure 9.5 Sources of Information for Respondents by Level of Government

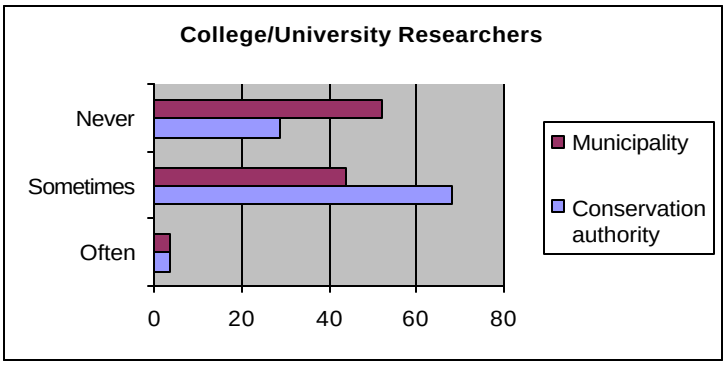


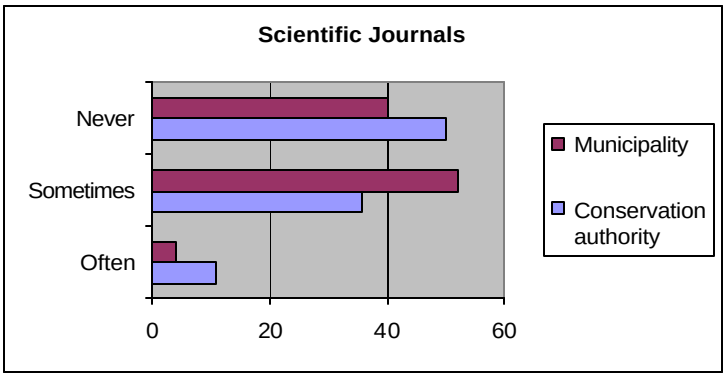
Of further interest, particularly in Eastern Ontario, is the fact that neither municipalities nor CAs turn to Native governments for information about their watersheds. This is notable given the significant involvement of the Mohawks of Akwesasne in many of the environmental initiatives in Eastern Ontario[85]. Finally, of significant importance to this particular study is the low use made of scientific journals and university/college research by the respondents. This is depicted in figure 9.6, below.

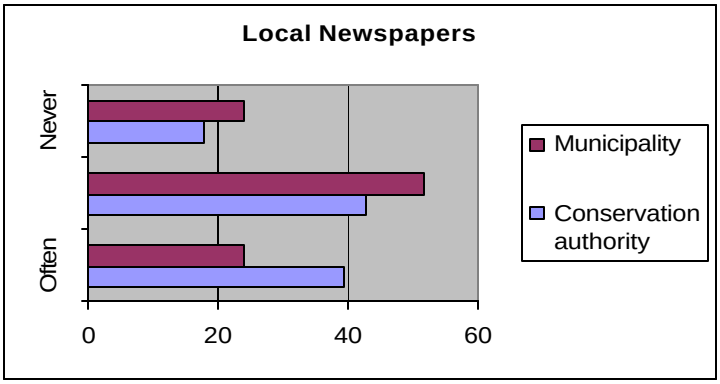
The low use by respondents of both scientific journals and university/college researchers indicates a need to open the channels of communication between municipalities/CAs and the research communities, which can be of use to them. It may also signal a need for greater education and outreach initiatives by researchers studying issues which have a bearing on the health of watersheds in Eastern Ontario. Indeed, respondents indicated a higher reliance on local newspapers as a source of information for the health of their watershed, suggesting that communication about climate change impacts could be effectively transmitted via this medium.

[85] The Eastern Ontario Model Forest (EOMF) is an example of this involvement.

Figure 9.6 Use of College/University Researchers, Scientific Journals and Newspapers for Information







9.2.4 Influence on Environmental Policy-Making

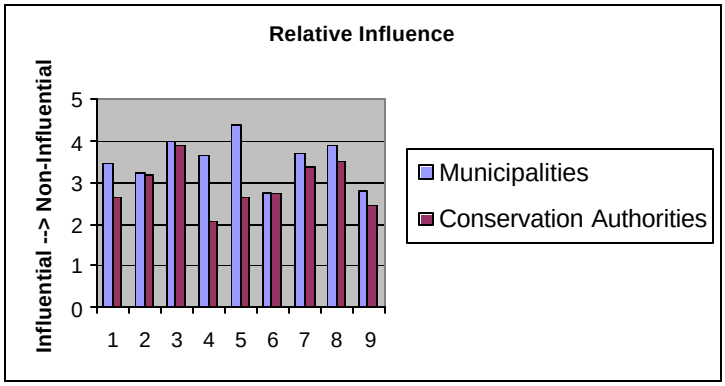
Respondents were asked to indicate how influential they felt their organization was with regards to:

1 making environmental policy with respect to water;
2 making laws with respect to water management;
3 encouraging industrial clean-up and abatement;
4 promoting water related environmental remediation projects;

5 promoting water related scientific research;
6 the making of municipal by-laws regarding water;
7 influencing funding priorities related to water at provincial level;
8 influencing funding priorities related to water at a federal level; and
9 changing public perceptions regarding water resource management.

Both municipalities and CAs indicated that they felt they had a high level of influence on the above areas. This is depicted in figure 9.7 below.

Figure 9.7 Relative Influence of Respondents for Different Issues



The above figure depicts the relative level of influence for each of the nine issues listed above. The scores on the y-axis can be read as follows:

1 = strongly influential
2 = influential
3 = somewhat influential
4 = neutral
5 = somewhat non-influential
6 = non-influential
7 = strongly non-influential

Municipalities clearly felt more influential in the making of municipal by-laws regarding to water (issue 6), whereas conservation authorities felt most influential in promoting water related environmental remediation projects (issue 4). Municipalities felt less influential in promoting water related scientific research, while conservation authorities felt the least amount of influence in encouraging industrial clean-up and abatement. These results appear to confirm the linkage between conservation authorities and local issues, particularly with regards to research and changing environmental perceptions of the public.

It is important to note that conservation authorities felt more confident about their levels of influence in promoting water related abatement projects and promoting water related scientific

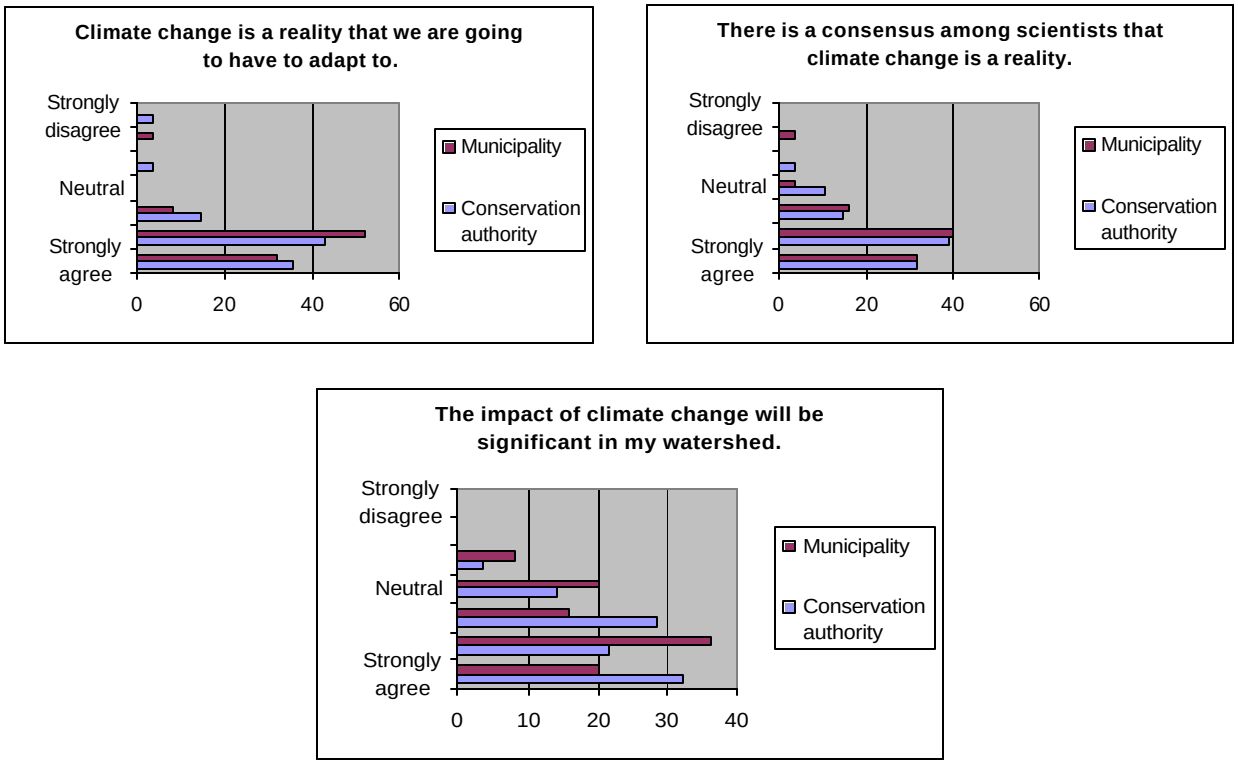
research. This should underline the continued importance of CAs in the management of water resources in Eastern Ontario.

9.2.5 Knowledge and Beliefs with Respect to Climate Change and its Impacts on Livelihoods

Respondents were asked to indicate their level of agreement with nine statements regarding climate change. The intent of these questions was to gauge the knowledge and beliefs of the respondents with respect to climate change and its impact on their lives.

There was a consistently high level of agreement with the assertions that climate change is a reality that we are going to have to adapt to, that there is a consensus among scientists that climate change is a reality, and that there will be a significant impact of climate change on the watershed. It is interesting to note, however, that CAs expressed more doubt about consensus among scientists and more doubt about our understanding of the impacts of climate change, but were more in agreement that the impacts would be significant. The response rates for these questions (expressed in percentages) can be found below in figure 9.8.

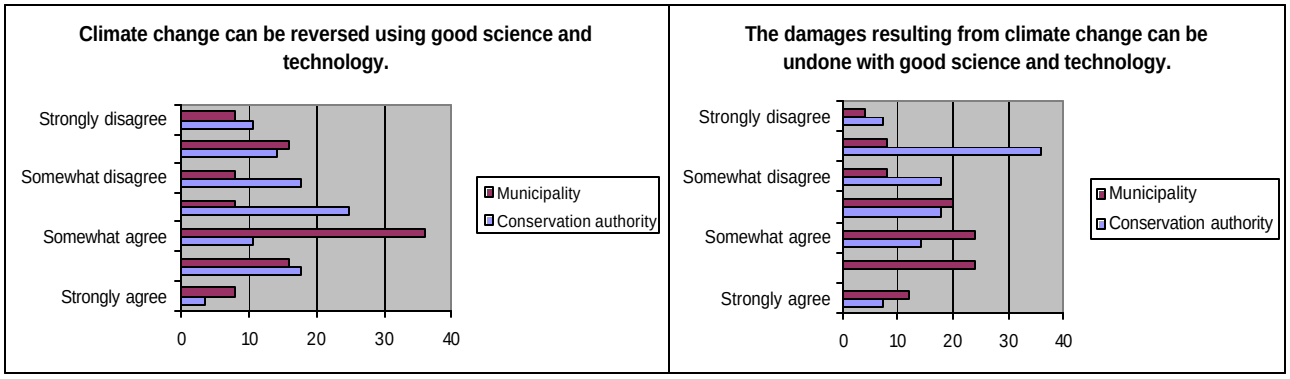
Figure 9.8 Response rates regarding climate change.



Municipalities, for their part, are more confident than CAs in the ability of science and technology to stop or reverse climate change. They are also more confident in the ability of

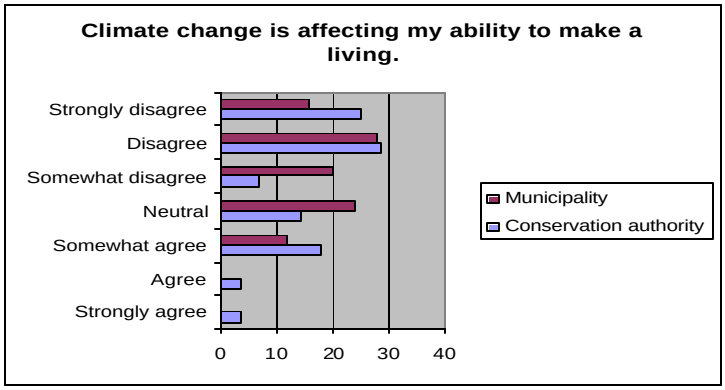
science to repair the impacts of climate change on their watershed. The responses of CAs and municipalities regarding science and technology are presented in figure 9, below.

Figure 9.9 Respondents' views on role of science in climate change impacts.



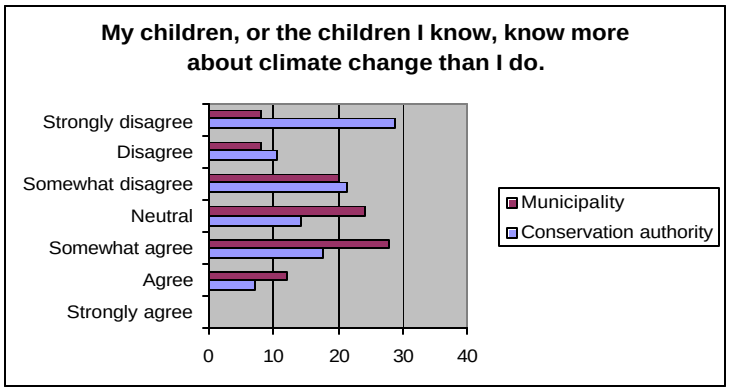
These responses appear to show a greater faith in technology and science within municipalities. While it is encouraging to see this confidence in the role of science and technology from municipal respondents, it is also possible to see how this is in tension with the idea that we should promote "climate friendly" practices in the immediate future, in order to (potentially) avoid the impacts of climate change later. A low number of respondents in both groups believe their ability to make a living is impacted by climate change (figure 9.10, below).

Figure 9.10 Changes to respondents' ability to make a living faced by climate change



Finally, respondents were asked to gauge whether their children (or the children they knew) were more knowledgeable about climate change and its impacts. There was a clear feeling among the respondents that children knew *less* about climate change than they did (see figure 9.11, below).

Figure 9.11 Respondents' views on climate change knowledge in following generation

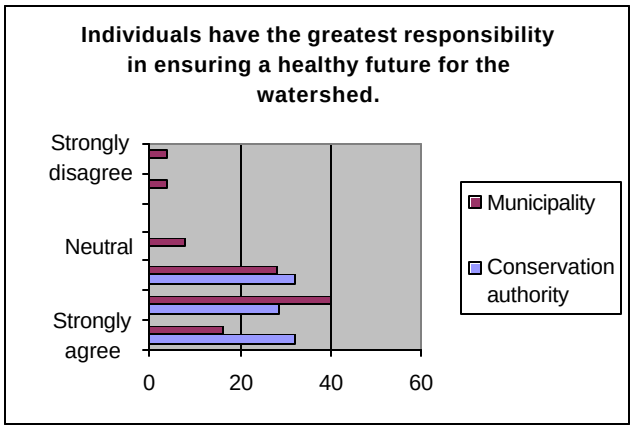


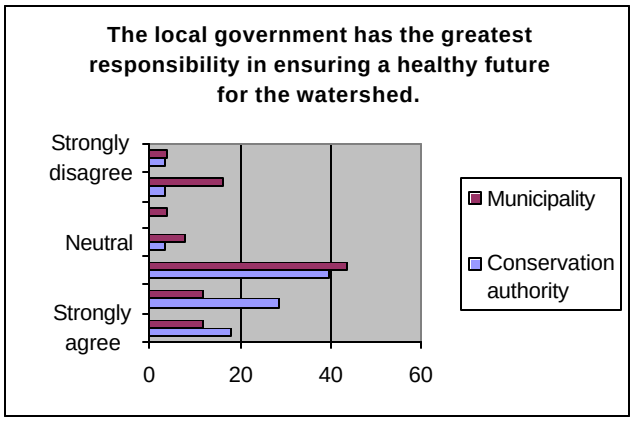
This appears to reinforce the assertion above that better education and outreach initiatives are required regarding climate change and its potential impacts on communities and residents of Eastern Ontario. This education needs to be focused on improving knowledge about climate change impacts in all generations.

9.2.6 The Role of Government

Respondents were asked to react to fifteen assertions regarding the responsibilities of different levels of government for climate change and watershed health, funding for climate change projects and research, institutional capacity and public consultation. As was indicated in the question regarding information sources above, it appears that conservation authorities are much more "rooted" in local networks (see figure 9.12, below).

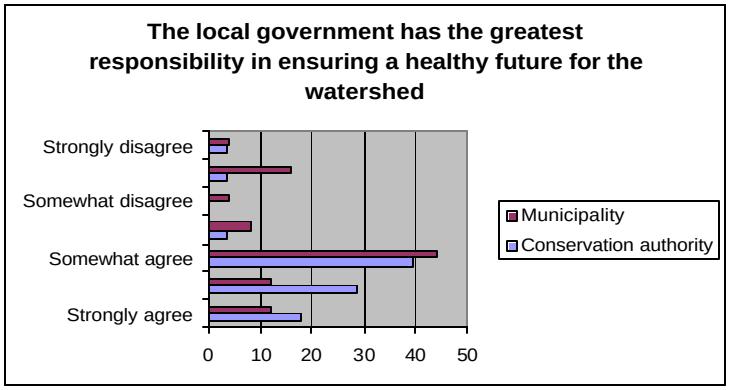
Figure 9.12 Local levels of responsibility for health of the watershed.





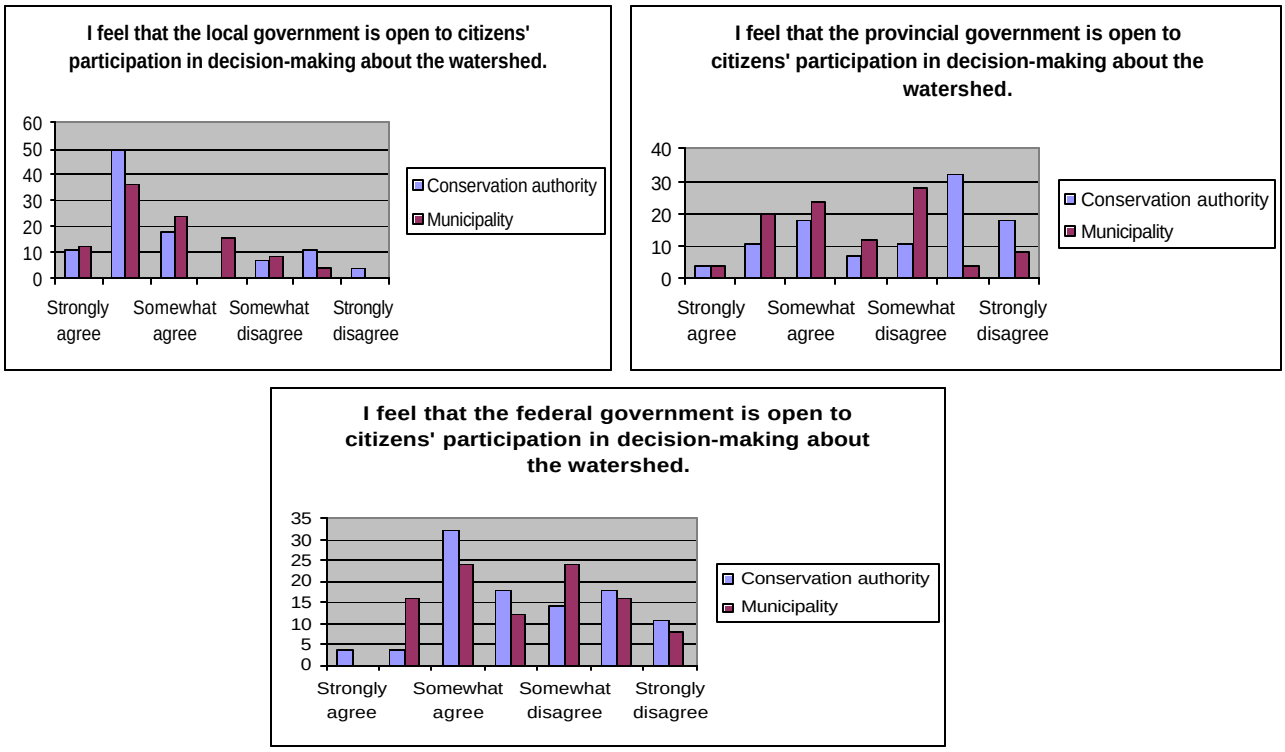
When comparing the level of responsibility of local, provincial and federal levels of government for a healthy future of the watershed, it is also clear that the conservation authorities assign greater levels of responsibility to local governments. Comparing the results for levels of responsibility assigned to the local government shows that CA respondents assign much greater responsibility to local governments than municipalities do. This is depicted in figure 9.13 below.

Figure 9.13 level of responsibility of local government for a healthy future for the watershed.



It is also interesting to note that both the municipal and CA respondents agree that the local level of government is most accessible to them in terms of participation in decision-making regarding the watershed. The openness of the decision-making process at the local, provincial and federal government levels is represented in figure 9.14, below.

Figure 9.14 Openness of levels of government to citizen participation.

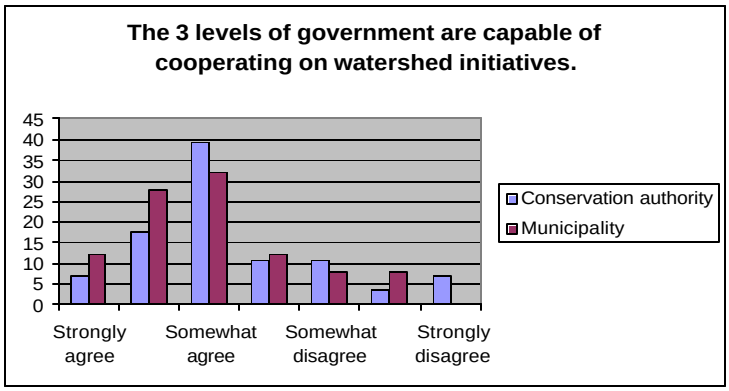


It is also interesting to note that these findings imply that the CAs feel, on the whole, more marginalized in the decision-making processes regarding the watershed at all levels of government. This is particularly so at the provincial level, indicating a significant concern about the lack of access to a level of government that CAs should (if any) have greater access to[86].

Municipalities were also slightly more confident than CAs that the local, provincial and federal governments were capable of cooperating on watershed initiatives. This suggests a concern on behalf of CAs regarding the institutional capacity of governments to effectively address watershed-based issues, such as climate change.

[86] This is because conservation authorities are a creation of, and regulated by provincial legislation.

Figure 9.15 The capacity of all levels of government to cooperate on watershed initiatives.



9.2.7 Importance of Environmental Issues in Watershed

Finally, respondents were asked to indicate the level of importance of fourteen environmental issues in their watershed. Generally, both groups of respondents indicated that all of the environmental issues were of relatively high importance. Both CAs and municipalities indicated that water pollution was of the highest concern on the list. CAs indicated that insufficient funding for the environment was of equal importance to water pollution. Comparatively, municipalities placed insufficient funding for the environment third in their ranking of these issues. Response rates for both water pollution and insufficient funding for environment can be found in figure 9.16.

CAs also indicated a greater concern regarding insufficient knowledge about science in their watershed. This reinforces their preoccupation with science and technology as a means to prevent or mediate climate change (figure 9.9, above).

Climate change was fourth in importance for conservation authorities, whereas it was tenth in importance for municipalities. Response rates for the importance of climate change can be found in figure 9.17, below. This reinforces the differences noted above with respect to climate change, where conservation authorities expressed greater agreement that climate change would have an impact on their watershed (see figure 9.8).

Figure 9.16 Importance of water pollution and insufficient funding for environment.

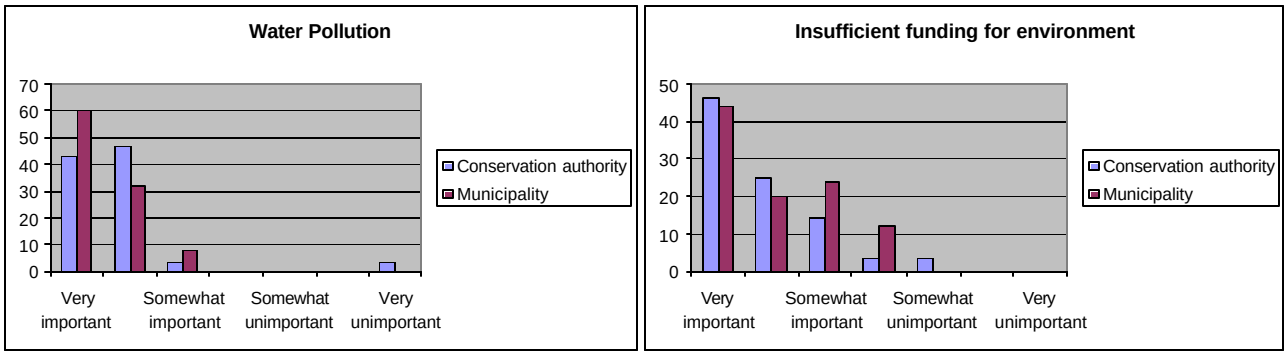
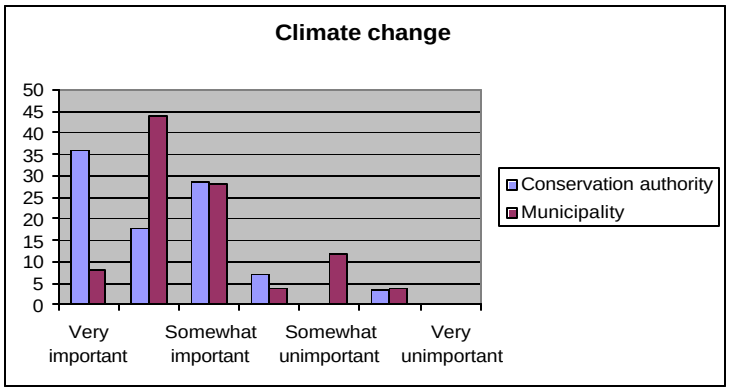
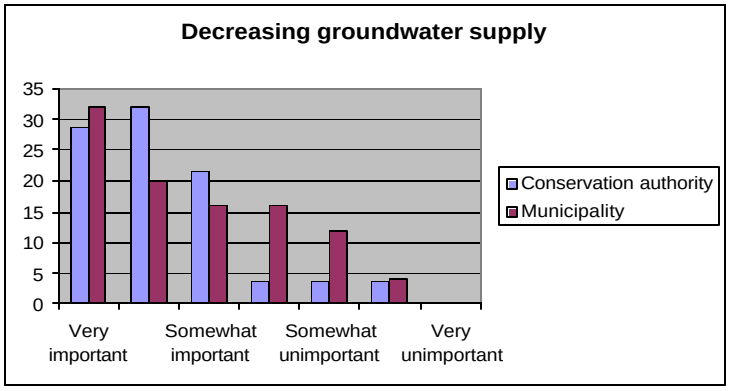


Figure 9.17 Importance of climate change as an environmental issue.



CAs were more concerned about decreasing groundwater supplies, again reinforcing their concerns regarding water quantity above. Response rates regarding decreasing groundwater supply are expressed in figure 9.18, below.

Figure 9.18 Importance of decreasing groundwater supply to respondents.



9.2.8 Conclusion – Possible Reflections for Future Study

Although more analysis is required, several initial observations can be made about the results presented above. The most important of these observations is that CAs appear to be more integrated into and responsive to local watershed issues than municipalities do. Conservation authorities appear to be more implicated in local networks and appear more ready to draw their information from the experience and knowledge present in these networks. Municipalities, on the other hand, appear to be more "outwards and upwards" focused, turning to the provincial government for information and the epistemic networks upon which they rely for decision-making.

It does appear that municipalities are more "techno-centric" than their conservation authority counterparts. This is reflected in municipality respondents' confidence in science and technology as a means of preventing climate change or mitigating its impacts on their ecosystem. It is also reflected in the lower level of concern regarding climate change expressed by municipal officials and politicians.

Finally, CAs appear to appreciate the factors implicit in watershed-based approaches to decision- and policy-making. It is possible that the watershed orientation of CAs rises out of a tendency to reflect on issues at a scale, which corresponds to the ecosystem, and not to administrative jurisdiction. Indeed, it may be that CAs tend more towards reflection, analysis and adaptation at an ecosystem level than municipalities do.

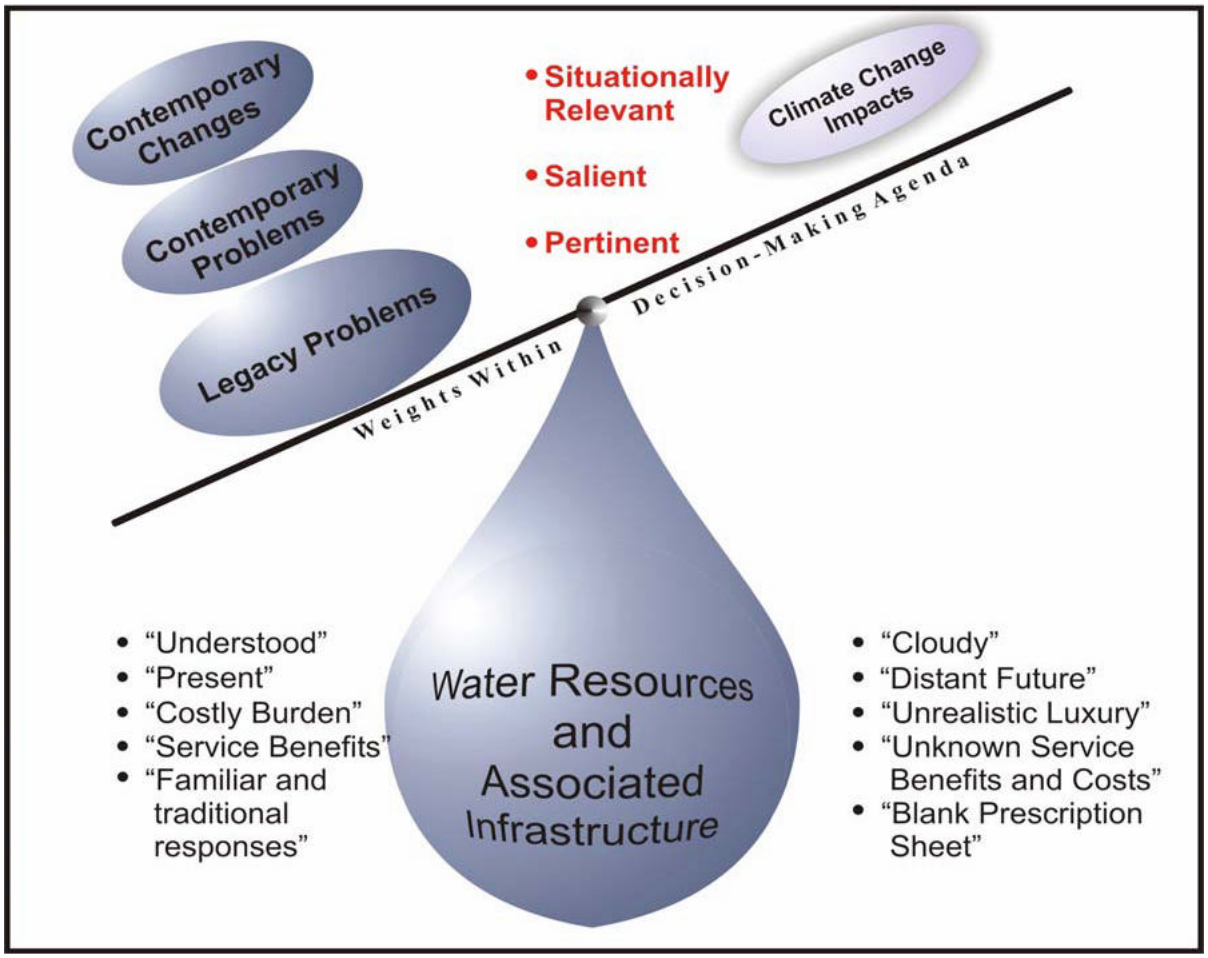
These concluding observations merit further analysis and reflection. Is it true that CAs are "better" placed (in spatial and networking terms) to understand and adapt to climate change? If so, what can we learn from their approach that would enable us to suggest means of building institutional capacity at other levels of governance? Specifically, does a watershed scale orientation of an organization make it predisposed to consider adaptations to climate change more readily than organizations with more jurisdictional spatial orientations?

Reference

Leech, David (2002), *Perceptions and Values of Local Decision-Makers; a Survey*, mnss.

Section 10 Local Institutional Barriers, Bridges and Innovative Water-related Institutions and Adaptive Measures

The business context in which municipal adaptation to climate change imprints itself is nicely described by the following graph provided by R. Needham (R. Needham, 2003):



Climate Change Adaptation is a new issue which enters the municipal world at a time of turmoil resulting from the reorganization of municipalities (roads, social housing, ambulances, etc.), greater demands in terms of accountability (reporting, consultations, etc.), insufficient financial resources for the new assigned tasks, economic globalization (hog farms), urban pressures (expansion of Ottawa), environmental concerns (drinking water, nutrient management, etc.) and greater demands from concerned citizens. In comparison, climate change appears distant and cloudy while climate adaptation is yet a new responsibility for municipalities. **The challenge is not to balance the scale but to merge the issues on the right of the picture with the ones on the left.**

10.1 Local Institutional Barriers and Bridges[87]

10.1.1 Municipal Institutional Barriers

10.1.1.1 External Barriers

Municipalities encounter a number of institutional barriers to climate change adaptation of water - related infrastructures, which are either internal or external. External barriers result from the fact that, in Canada, municipalities are creatures of provincial governments. They enjoy very little autonomy in terms of financial resources, and in terms of water resources and agricultural management despite the linkages between the two. Whether the recent changes to the Municipal Act will enhance their initiative capacity in the area remains to be seen.[88]

The Ontario provincial plan that appeared in May 2001 attempts to distinguish provincial and municipal responsibilities for water management this way:

"The province provides overall direction and coordinates policies, science and information systems and emergency support. At the local jurisdiction, the emphasis is directed to collecting information, interpreting policy, delivering policy programs and responding to emergencies."

Moreover, municipalities inherited a legacy of aging manufactured infrastructures, whose location often conflicts with current development pressures, and of past but currently inadequate planning decisions. The legal framework for municipal capital financing is inadequate especially in limiting access to long-term borrowing.

Municipalities lack information about the impact of climate change on infrastructure design and performance, despite their acknowledged financial vulnerability to climate events. They are overly dependent for information on engineering consultants, who tend to ignore the social context of municipal decisions. Perhaps the main barrier to long term municipal investment in infrastructure projects is the fact that municipal councils are elected for three years only, while being in election mode for the last 9 months of their term of office; this is a disincentive for articulating a long-term planning vision (Needham, 2002).

10.1.1.2 Internal Barriers

Internal barriers pertain to management culture and conflicts, to the absence of lifecycle planning for manufactured infrastructure, to inadequate management of water resources within the area of municipal competence, to lack of enforcement of by-laws and other regulations, and to lack of databases about regional manufactured infrastructures including abandoned ones, such

[87] This section was contributed by I. Aurelson, D. Burhoe, P. Crabbé and R. Needham

[88] One could add municipal planning responsibilities to this list, which are likely to be reinforced by the currently proposed "Strong Communities" amendments to the Planning Act (see "Cities Get More Planning Power", *Ottawa Citizen*, December 15, 2003, Section B).

as old landfill sites and water wells. Small municipalities suffer from insufficient expertise at all levels, which increases their dependency on outside consultants. This leads them to rely overly on technological fixes rather than on management solutions. Conflicts occur between municipal, political and administrative priorities and between levels of local government (between lower tier and upper tier municipalities). Municipal management culture is characterized by management by crisis, which leads them to rely excessively on emergency measures, on inertia, and on oral communication with key persons.[89] Municipalities neglect to take appropriate measures within the ambit of their authority to insure that supply and demand for water match in quantity and quality and to anticipate the impacts of climate change on the current mismatch (e.g. lower water intakes due to expected lowered water level, account for larger rain water events in infrastructure design). Municipalities mistrust the information they obtain about climate change (Needham, 2002; Alam *et al*., 2002).

10.1.1.3 Citizenry as Stakeholder

Local residents increasingly perceive themselves as 'stakeholders' in the municipal debate about what is socially desirable and acceptable for their communities; they find that governments are clearly not doing an effective management job (McDuff, 2001). Numerous studies have confirmed the longing by individuals and groups to have both a voice in, and a closer scrutiny of municipal decision-making, especially the environmental policy process (Benest, 1998; Frewer, 1999; Margerum, 1999; Smith, 1998; Sweeney, 2001). Case studies where participatory approaches have been applied successfully are also numerous (Byron *et al*., 2002; de Loe *et al*., 2002). Benest (1998) feels citizen involvement should be enlisted to advantage in financial decision-making (Beierle *et al*., 2001; O'Neill, 2000, 2001). In any event, in post-Walkerton Ontario, public scrutiny and questioning of local and provincial decision-making have increased manyfold (O'Connor, 2002). And, in addition, climate variability and change have been suddenly thrust into the equation.

It is ultimately clear, for rural municipal governments, that these demands present considerable challenges. It also appears that the latter will not diminish in the near future. The scope of these demands has broadened to encompass not only public resources such as infrastructure, health and schools, fish and wildlife habitat, groundwater, wetlands and hazardous areas, but also private resources such as croplands, livestock and woodlots (Aurelson *et al*., 2002).

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10.1.2 Municipal Institutional Bridges and Municipal Learning

10.1.2.1 Climate Information

In order to attract the attention of small rural counties/municipalities to climate change adaptation, one has to make the climate change information consistent, credible, downscaled at the local level, pertinent to specific municipal infrastructures, their operations, and to their

[89] It is interesting to note that similar internal barriers occur within Norwegian municipalities (L.O. Naess et al., 2003)

managers. This is why it is important to streamline the climate change information pertinent to politicians, administrative officers, planners, economic development managers, public works, road, waterworks, and drainage superintendents, and their professional organizations. The benefits of early adaptation measures vs. reactive ones have to be identified. This requires identification of bridges, which may help overcome the institutional barriers identified at the beginning of this section.

10.1.2.2 Bridges for External Barriers

The bridges related to external barriers are jurisdictional (*Hudson vs. Spraytech* and another judgment the previous year in a case known as *Rascal Trucking* Supreme Court cases, which recognize and enhance municipal competence and autonomy beyond purely delegated provincial powers and give, at least in the former case, some recognition to the precautionary principle); federal intervention in municipal infrastructure financing, financial (potential new sources of municipal revenue), planning (needed revisions to provincial legislation related to municipal planning under climate change), administrative (revisions to the Ontario Municipal Act, facilitate access to provincial funding sources, and pay attention to requests from various provincial professional associations), informational (need to separate the more speculative climate change information from the more certain; identify the local impacts of a hazard within a finite time period; select appropriate means of communication). If the Province considered "climate change adaptation" as a provincial interest and issued a related policy statement that municipal land use decisions have to be "consistent with", additional incentives would be in place for municipalities to begin to consider climate change adaptation, first in their long-term decisions and, then progressively in all their operations (see recommendation 35).[90]

10.1.2.3 Bridges for Internal Barriers

Bridges pertaining to internal barriers are administrative (acquisition by municipalities of water permits to be allocated among users, enhance municipal enforcement functions), informational (use of windows of opportunity to release credible information about climate change; develop GIS based manufactured infrastructure inventory), management (emergency preparedness plans, regional procurement system for equipment needed for infrastructure servicing, public consultation on infrastructure design and location, water metering), related to planning (risk management, watershed, well-head and landfill protection), to liability (infrastructure service standards, due diligence at the infrastructure design stage), to adequate combination of policy tools (including the ones required for mitigation; need to address motives behind behavior), and to health (develop stronger relations with medical officer of health, which should provide health-related climate change messages for politicians, staff and constituents, and provide a regional state of the environment report endowed with community and environmental indicators), and education (which changes values but not behavior) (Needham, 2002; Dietz *et al.*, 2002).

[90] "consistent with" instead of "have regard to" is proposed in the "Strong Communities" Amendment to the Planning Act (see "Cities Get More Planning Power", *Ottawa Citizen*, December 15, Section B).

10.1.2.4 Information and Citizens' Participation as Bridges

A few municipalities (South Stormont and Nation) and two Conservation Authorities (South Nation and Rideau Valley) have established Communications Committees and all but one Eastern Ontario municipality now have developed and maintain an active website. The City of Cornwall has applied for and received provincial government grants to develop an interactive website for ongoing citizens' input in decisions on issues that concern the public. The United Counties of P & R too, have gotten federal grants from Industry Canada for the development of an important GIS database that has the potential of increasing municipal capacity to improve land-use decision-making county-wide. Since land-use patterns impact on water resources, a GIS database also has benefits for improved water management. This type of Community-based initiative is presently being undertaken with considerable success in a number of places (Kellog, 1999). The Upper Tier project, called *Prescott and Russell à la carte*, has necessitated the hiring of specialized staff but has also expanded the scope for educational and community-involvement by making use of high-school student volunteer talents and by initiating projects with a number of benefits: 1) that students gain insight into the relationship between land-use, planning and resource protection; and 2) that staff gathers and provides the data, but does not have to do the time-consuming task of data entry; and 3), that the objective of creating a local GIS expertise through the Internet to allow public input and keep people informed on issues that impact on the environment and quality of life at a regional scale.

10.2 Innovative Water-Related Institutions and Adaptation Measures[91]

10.2.1 Conservation Authorities

Conservation Authorities (CAs) are institutions that originated in concerns about protection of life and property from damage due to flooding. A major cause of this problem was, and still is, a tendency for municipalities to allow building in scenic waterfront lands as well as less expensive marginal areas prone to flooding. Remedial and protective measures inevitably consisted of both structural (dams, dykes, groins, etc.) and non-structural (forecasting, zoning, planning, etc.) means at great costs and with little benefit generally (Lawrence *et al*., 1993; Philippi, 1997; Whipple, 2001). An increasing number of citizens became alarmed, as well, that local decision makers were only protecting the interests of a few homeowners, but were not protecting public interests in water quality and quantity. All levels of government were forced to take action resulting, in Ontario for example, in responsibility for managing and monitoring various aspects of water resources being distributed among a great number of federal, provincial and municipal agencies or departments, such as Fish and Wildlife, Parks, Transportation, Forestry, Commerce and Agriculture (Lawrence *et al.*, 1993). Each agency developed its own policies and regulations according to the quality and quantity of water that each water use required. Jurisdictional roles for the management of water-related issues often overlapped and cooperation was notoriously difficult to obtain. Conflicts inevitably arose (Whipple, 2001). It consequently became increasingly necessary to create institutional arrangements that would

[91] This section was contributed by I. Aurelson, D. Burhoe, and R. Needham

protect the interests of as many water users or stakeholders as possible. It became progressively evident, as well, that the responsible institutional arrangement be as close as possible to the municipalities and to the stakeholders involved for both political and economic reasons. At the same time, municipalities needed specialized and often outside expertise to resolve water quality and quantity problems that growing demand on already stressed watercourses engenders. For example, municipalities had to deal with the prevention of risk and damage from climate events such as flooding and drought at scales they were in no position to handle. At the same time, the scope and complexity of new Federal and provincial regulations and standards required a level of expertise that few municipalities could afford.

10.2.1.1 Legal Foundations

It is in this context that CAs were established in Ontario in 1947 by an Act of the provincial government. The 39 sections of the Conservation Authorities Act define the structure, roles and functions of the Conservation Authority as a body; yet each Authority is composed entirely of local representatives with a local mandate. The CA thus becomes an autonomous, locally-governed organization operating within the legal mandate of this Act to provide a venue for inter-municipal and public-private partnerships, accountability, experience, and consistency in decision making (Conservation Authortities Act 1990).

The Conservation Authorities Act was founded on three basic concepts:

- Watershed as a management unit
- Local Initiative
- Municipal-provincial partnership

10.2.1.2 The Watershed as the Common Management Unit

A distinct Conservation Authority was thus established for each of the major Ontario watercourses with an autonomous mandate to deal with the problems unique to, yet shared within its watershed. Flood forecasting and warning, primarily in the more built-up areas of the province, became, and still is to some extent, one of its primary roles. Yet, this institutional arrangement has made a significant contribution to water resources management through its recognition of the interconnectedness of impacts occurring along any of the many branches that comprise each watershed. Even though impacts may occur in another jurisdiction, all are connected by the watercourse; the Authority is composed of representatives from each watershed municipality. The Act empowered the Authority to undertake programs to further the conservation, restoration, development and management of the natural resources (other than gas, oil, coal and minerals) within its watershed. The watershed is presently being recognized and accepted worldwide as the most appropriate unit in which to manage water and related natural resources. In areas outside CA or watershed boundaries, of course, the Ontario Ministry of Natural Resources District Offices fulfills the mandate.

10.2.1.3 Local Initiative Institutional Structure

In 1947 in Eastern Ontario, the South Nation River Conservation Authority (SNRCA) was the first Conservation Authority to be initiated (http://www.nation.on.ca). Local people from 28 municipalities working together created the SNRCA. Seventeen municipalities are presently represented on the Board of Directors as a result of municipal restructuring and amalgamations that reduced their number since 1998. In addition to forced amalgamations, provincial restructuring also downloaded increased responsibilities on each municipality such as infrastructure construction and maintenance that includes roads, bridges, flood control structures, water and sewer facilities, and waste management (see section 2.5.1).

South Nation Conservation (SNRCA until 1997, now SNC) operates within a committee structure. It has established four Committees (or Advisory Boards) that are multi-stakeholder and represent the watershed interest groups, such as Forestry, Fisheries, Clean Water, and Communications, and municipalities. Municipalities and Groups appoint the members they send. By having this broad representation, the programs or projects that are selected and the decisions that are taken regarding the program outcomes have been decided upon by watershed people themselves and the represented interest groups. It is very much a grass-roots institutional arrangement for managing a watershed within an ecosystem perspective.[92]

The Raisin Region Conservation Authority (RRCA formed in 1963) watershed is smaller in size, with a smaller population in the watershed, smaller membership, and budget (http://www.rrca.on.ca). Yet, it too is expected to provide many of the essential services that other, larger Authorities are expected to provide. It does not provide drinking water however. After 1995, the budgets for CA's were cut by 50% by the provincial government, and the RRCA staff was reduced to 3 full-time and a few part-time employees. The Province's $50 million to CA's was reduced to $ 7M, and, of this, the RRCA only got $160,000. The shortfall was made up by the municipalities.

10.2.1.4 Co-operative Municipal-Provincial Management Process

Conservation Authority funding is provided by the member municipalities through tax levies, by the Province through the Ministry of Natural Resources (MNR) and by the federal government through grant programs. Under the terms of the Conservation Authorities Act, the Authorities acquire most of their operating funds through the granting program set up within MNR. Revenue sources have diversified in recent years, of necessity, as senior governments have downsized and downloaded responsibilities to municipal governments and agencies through the Municipal Restructuring Program. Authorities continue to operate because of the support of watershed residents, member municipalities, and private sector partnerships (SNC Annual Report 1997). But, there have been significant changes of government focus over this period, which have had a profound impact on the way CAs function as well as on some of their roles. Many

[92] Mary-Anne Wilson personal communication Aug. 26, 2002.

new partnerships had to be formed, their roles and functions established and clarified, and a spirit of cooperation among all stakeholders developed. CAs emphasized that this process had a number of positive outcomes and that the spirit of cooperation has been "tremendous." In 1997, for example, SNRCA dropped the words "River" and "Authority" from its name, reflecting a broader, watershed-wide focus, and the emphasis on facilitation rather than on command and control. A number of new federal programs and initiatives have also provided funding for CA programs.

While the size and services offered by CAs differ considerably, their funding comes from similar sources and in similar percentages. For the Rideau Valley Conservation Authority, one of the larger authorities in Ontario just outside the study area, as an example, revenue (2001) comes from the following sources:

- Provincial Government 9%
- General Municipal Levy 37%
- Special Municipal Levy 3%
- Other Sources 51%

Other sources of income include permit fees, planning program revenues, corporate donations, fundraising, Rideau Valley Conservation Foundation contributions, Federal Government money, etc. (http://www.rideauvalley.on.ca).

More recently, however, different kinds of emergencies (e.g. the Walkerton tragedy in May 2000) have forced the provincial government to make available funds and training for those responsible for water monitoring programs. As of 2000, for example, the province has allocated more than $6 million over 3 years to establish a provincial groundwater monitoring network which had not existed for close to 20 years. CAs have consequently signed partnership agreements with the Ministry of the Environment (MOE) for the installation of 101 monitoring wells equipped with dataloggers. Under this project, 380 wells are to have been established by March 2003 (R. Houde, personal communication 2002). The data and information provided by this provincial network will be of crucial assistance in the management of the province's groundwater resources.

Climate variability, since 2000, has reversed priorities from flood control response to drought response in southwestern and southeastern Ontario. Throughout the summer and fall of both 2001 and 2002, as many as 15 CAs were experiencing Level One conditions (preliminary drought conditions) while 10 others were at Level Two (moderate drought conditions), and one at Level Three. MNR thus provided $2,000 in seed money by late summer 2001 to establish local Low Water Response Teams (WRT) to a maximum of $10,000 per CA watershed. Coordination of these WRT Teams was assigned to the CA's as entire watersheds were affected and had to respond as a unit. WRTs play a clearly defined role under Ontario Low Water Response guidelines, Mr. D. O'Grady, General Manager of the SNC said. "A WRT identifies actions needed to manage the drought and implements them. Those actions are intended to maximize water supply while reducing demand. MNR expects our team to develop local

solutions to address local problems."[93] WRT members - which include farmers, representatives of watershed industry, municipalities and other agencies with a stake in area water management - verify the severity of low water levels and discuss possible approaches to voluntary conservation. "We're further ahead than many conservation authorities and municipalities", said Mr. O'Grady, "because our standing Clean Water Committee doubles as our WRT. Some other jurisdictions have to start from scratch." The *South Nation Conservation Water Response Team* met in August and September, 2001 regarding the drought conditions of 2001 when water levels in the South Nation watershed were at least 30 per cent below the lowest summer average.

10.2.1.5 Core versus Non-Core Programs

The 1991 Review of Conservation Authorities programs identified seven (7) core activities:

- Flood Control & Low Flow Augmentation
- Urban & Rural Drainage
- Recreation Areas Management
- Erosion and Sedimentation Control
- Water Quality Management
- Forest Management
- Provision of Extension Services & Conservation Information

But, the 1991 report also identified a number of non-core activities, which were added to the core functions called for by the primary funding agency, the Ministry of Natural Resources. These non-core functions were added by the member municipalities as they identified local needs or resources. Nine of these non-core activities are listed below:

- Water Taking Permits
- Water Supply
- Forest Management on lands other than Conservation Authority lands
- Heritage Conservation
- Surface Water Quality
- Outdoor Education
- Fish and Wildlife Habitat and Biodiversity
- Sewage and Septic Inspections and Approvals

When asked which are their core (Conservation Authorities Act) and non-core (demanded by the municipalities) functions, Managers of each Authority responded that all their program activities are "core." In other words, the fact that particular program "needs" are identified and requested by the municipalities makes them "core" functions of the Authority. There are several reasons

[93] D. O'Grady, personal communication, 2002.

for this: First, the funding provided by the Ministry has been reduced significantly since 1990, and municipalities have been given more of an active role in the funding and management of Authority functions. Second, the Conservation Authority is, according to the Managers, a grass-roots, community-based institution and thus needs identified by the members become intuitively "core" Authority activities or functions.

All CAs identified the need for cooperation with government agencies to develop programs aimed at assessing the extent of the problems and at providing remedial action plans. This is a province-wide issue. Half of the watershed plans identified a multitude of agricultural activities as being a major contributor to degraded water quality.

10.2.1.6 The SNC *Clean Water Program*

The SNC *Clean Water Program* presents an example of the complexity of issues and linkages managers must consider in dealing with an entire watershed. *Clean Water Program* core components that are managed and require staff assigned to them are:

- Livestock Access Restriction
- Manure Storage
- Constructed Wetlands for Wastewater Treatment
- Milkhouse/Milking Parlour Washwater Disposal System
- Shoreline Erosion Protection
- Stormwater Runoff
- Commercial On-Site Wastewater Systems
- Buffer Strip Establishment
- Clean Water Diversion/Barnyard Runoff Control
- Private Sewage Systems
- Private Wellhead Protection
- Fertilizer, Chemical, and Fuel, Storage or Handling
- Plugging Unused Wells

Project costs are shared with landowners up to a maximum grant.

One of the significant attributes of the *Clean Water Program* is its ability to group together a membership of very participative stakeholders representing township agricultural associations, elected and appointed municipal officials, crop and cattle farmers, a few agricultural and industrial partners and Stewardship Councils with quite varied expertise. The Soil and Crop Improvement Associations are partners. These provide training and allocation of Environmental Farm Plan Bonuses ($1,000). The latter provide support, and encouragement as well as awareness. In this way, the *Program* helps build local capacity. For example, in May 2003, the SNC Board reviewed applications from 29 landowners, from which it approved $79,000 for 19 projects, and denied 6 applications only. To deal with the additional requests from landowners in 2002, 4 more farmers were hired to do site visits. To date, 87 landowners have applied for funding. (*South Nation Watershed Update*, June 2002).

10.2.1.7 Ducks Unlimited Partnership

Ducks Unlimited (DU) provides a third-sector contribution, which is not-for-profit and made up of volunteers (i.e., neither public nor business) contribution to local capacity-building. As part of its mandate to protect wetlands and wildlife habitat, the non-profit organization DU set as an objective to provide grants to farmers, who wish to establish buffer strips and plant trees along streams and close to wetlands. The program funding has been applied for by DU under a provincial program (OSTAR) that funds projects for rural Ontario. If the application is successful, about $1 million would go to farmers. Because South Nation's *Clean Water Program* had already established a track record, DU asked SNC to be the first watershed in Ontario to test the project, and the Board agreed at its June meeting (*South Nation Watershed Update*, June 2002).

10.2.1.8 River Access Agreements

All municipalities have now completed agreements with SNC to manage the river access parks in their municipalities. SNC is paying Nation, Russell, Casselman, Alfred, Plantagenet, and North Dundas 50% of the cost to manage the river access parks in their municipalities (*South Nation Watershed Update*, June 2002). In total, the parks cost $14,000 per year only to operate.

10.2.1.9 Phosphorus (Nutrient management) Reduction Program

Of the 38 CAs in the province of Ontario, SNC was asked to be one of four pilot projects for a Phosphorus ($P0_4$) reduction study. This pilot program aims at reducing the principal contributors of eutrophication (nutrient enrichment) and hence algal and weed growth in waterways. CAs, being composed of local residents with specific expertise in water resources management and cost-effective services to local governments and citizenry, are ideal vehicles for such studies. Also, the fact that the South Nation was chosen as one of these four sites is reflective of the progressive attitude of municipalities that comprise that Authority. **It seems, therefore, logical that they be one of the principal vehicles for climate change education and adaptation as well.**

10.2.1.10 Support and Encouragement for Other Local Initiatives

CAs are local organizations, incorporated, which hire staff for core programs. But, there are many other initiatives that relate to or impact on their goals and objectives that they simply cannot manage. If another local group takes one of these initiatives, CAs are in a favourable position to encourage its initiative and sponsor partnering with it. For example, a local non-

profit organization, the Dundas Environmental Awareness Group (DEAG) needed to be sponsored by an accredited local organization to receive and manage funding. SNC agreed to offer this support and actually does the financial management for DEAG. The DEAG Group serves both North and South Dundas. Before amalgamation, it had a Councillor, Don Johnson, on its Board and was able to influence Council to undertake the Blue Box and Hazardous Wastes Programs. It also works closely with the Russell Enviro Team (DANDY). A representative from the Cornwall and District Environmental Association sits in regularly on meetings. [94]

10.2.1.11 Conclusion

Provincial downsizing and restructuring during the mid-1990s removed much of the ongoing support and encouragement from CAs. This hurts the smaller CAs mainly. For example, RRCA, a smaller CA, has, in fact, no funding at all for capital works while its dams and weirs, are in bad need of repairs.[95] As a result, the entire philosophy, which underlies CA programs, came under scrutiny by provincial and local levels of government. Because they were rather unique institutional arrangements, i.e. a blend of local autonomy over water resources and yet a vehicle for provincial water policy, they survived the crisis; they have proven themselves to be bridging mechanisms for a number of partnership-building initiatives between different levels of government (the first sector), enterprising private ventures with a concern for the triple bottom line (economy, environment and society), and third sector organizations. It is for such reasons, that they are able to make valuable contributions in the area of education, generally, and, specifically, to education and adaptation related to climate variability and change.

10.2.2 County/Municipality Council Committees

Municipalities rely on higher levels of government in the public sector for material and knowledge support (county, province, federal government). This support may come at a cost in terms of loss of autonomy and indifference to local circumstances. Therefore, municipalities rely on the private sector as well, especially consultants and business, for advice and special services. However, the latter are for profit and may substitute their own interest to the interest of the citizenry. There is a third sector of society, which is not-for-profit and often made up of volunteers, able to assist elected councils with professional expertise.

The establishment of municipal Committees, Commissions, Boards and Advisory Committees is one of the means whereby these three sectors (public, private and civil society) can and do come together and provide input to the municipal decision-making process. This process has not always led to the most effective, efficient or desirable outcomes.

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[94] Damien Rodriguez attends for Elaine Kennedy.

[95] These are flood control structures mainly; on the Garry River, however, the structure is a water supply dam for a reservoir.

10.2.2.1 Committee Types

The design and establishment of municipal committees is first of all a reflection of the variability in size and physical resources of the municipality, but also of two important constraints. One is the requirement to provide services deemed essential. Therefore, a majority of municipalities have Public Works, Roads or Transportation Committees, Protection to People, Property and Emergency Measures Committees that include fire, police, lighting and signage and the drafting of emergency plans, and, of course, Community Economic Development. The second is the need to provide communication and collaboration among various jurisdictional levels. For example, both larger and smaller municipalities can experience specific problems such as low-income housing requirements, brownfield areas for development, or lagoons at capacity (preventing further development) that require collaboration among and commitment by various jurisdictional levels: municipal, county, province, and community at large.

Another type of committee is less dictated by the essential services constraint than by the desire of the municipality to develop or protect those aspects or characteristics that residents feel important within their particular cultural or physical setting. This latter type allows the municipal administration much more flexibility in drafting the objectives and composition of the committee. As a result, these committees vary widely, both in kind and in representation. A number of townships in each county, for example, have established committees with an environmental protection mandate, such as:

- Water Resources Protection
- Planning Advisory & Waterfront Development
- Water & Land Based Environment (North Glengarry)
- Green-up (North Dundas)
- Beaver Management (North Glengarry)

10.2.2.2 Committee Administrative Structure

Some municipal committees have ongoing mandates, but other committees are *ad hoc* and struck for a specific study or project. For example:

- Embrun Recreation Infrastructure Management (Russell) (1 Municipality and 1 County representative)
- Regional Servicing Study

Municipal committees also can have different institutional or administrative structures. Hawkesbury, for example, distinguish between Commissions and Boards, which have a longer term mandate and require Council member representation to ensure accountability or transparency. For example:

- Audit Committee (Cornwall)
- Low-Income Housing (St. Albert) (Nation)
- Casselman & La Nation Library Commission

- Recreation Sports Palace Committee (North Glengarry)
- Public Library Board of Directors (1 County/Municipality representative and 4 volunteers)
- Hawkesbury Hydro Inc. Board
- Hospital Board (Hawkesbury)

It appears that a majority of municipal committees have terms of office for committee members that coincide with municipal election period, which is three years. But, in order to avoid loss of institutional memory on committees, whose mandates exceed three years, a policy of overlap between terms of office exists so that only a select number of members are replaced with each appointment. Candidates offering to serve on these committees are more numerous just before and after election times, at which time Councils are afforded the luxury of choosing between candidates[96]. Between elections, however, the number of candidates, member participation and Councils' ability to choose from several candidates dwindle considerably. A number of strategies are used in choosing committee composition:

- increase the number of members but keep quorum low in order to ensure quorum if some are absent;
- appoint more lay or volunteer members to assume responsibilities and lighten the load on Council members;
- appoint some municipal staff members as technical advisors;
- appoint non-technical or lay members on Technical Advisory Committees to gain acceptance and representation with the larger community;
- call for volunteers who have experience or skills relative to the committee's mandate;

10.2.2.3 Municipal Culture

Each municipality has its particular culture determined by a combination of elements. For example, in the Township of Champlain, the Committee structure has almost been done away with. In this case, the role and composition of committees has been replaced by a "liaison" structure based on municipal "wards" and all decisions are made by Council and staff with no formal public consultation policy. Council has established only one Committee, Economic Development, but it, too, is composed only of the Mayor, 2 Councilors and two Staff members. The perceptions is that Council was elected to govern and, as each Councilor represents the voice of the individual ward, then this is the appropriate way public input is provided in the decision-making process[97]

Another municipality, North Stormont, too, has chosen not to establish individual committees. As the Township population is small, functions normally assigned to committee are managed by

[96] Mr. Lapierre, Personal Communication 2002
[97] Wilson, Personal Communications, 2002.

Council as a body. However, quite unlike its neighbor, it has chosen to eliminate the "ward" structure entirely. Consequently, Councillors in North Stormont do not represent the interests of their particular hamlet, but rather the interests of the entire Township. Moreover, this small township spirit has led to a communal wastewater system that links all hamlets rather than to the building of expensive individual lagoons. North Stormont's neighbor, the United Counties of P & R, also believes in the sharing of costs through a communal infrastructure, not only at a township level, but at the regional level and has made it a county objective. Oddly enough, one of P & R's own municipalities has argued against its County's regional infrastructure model, and yet has proceeded to create its own communal water supply system at the township level.

Each municipality has a Committee of Adjustment/Minor Variances. In Champlain Township, it is composed of all 5 Council members only. In South Stormont and in Russell, however, it is composed of 5 volunteers only; Council does not review the applications, but considers the committee's recommendations and makes final approval only.

10.2.2.4 Special Committees

Special committees suited to particular characteristics of the municipality are in abundance. Cornwall, for example, has formed a United Counties - Mohawk Akwasasne Liaison Committee, though it only has one Council representative sitting on it and volunteers.

A number of municipalities within the two rural counties of Eastern Ontario are experiencing some growth in land - use and economic activity: South Stormont, Russell-Embrun, Casselman, and especially Clarence-Rockland. These municipalities have one or several planners on staff; they also call on planning consultants and the County Planning Office. The new County Official Plan will replace the individual township Official Plans wherever they existed. Zoning By-Laws will remain within municipal competence nonetheless.

The overlap of roles and tasks between Upper Tier, or County Council and their Committees, and those of the Lower Tier, or Municipal Councils and Committees, does not yet operate smoothly. There is a need to identify new mechanisms, which are more meaningful, more effective and more successful in achieving both the municipality's and the larger community's goals and objectives. For example, in Cornwall the multistakeholder Public Advisory Committee (PAC) that was established under the aegis of the International Joint Commission Remedial Action Plan (RAP) process was re-modeled into a Restoration Council. Its function is to monitor the remedial work identified in the Stage One and Two Reports prepared by the RAP PAC. Today, however, while the work to restore beneficial uses of impaired water resources has barely begun, the City of Cornwall no longer participates in this important Restoration Council's activities. There is reason to be optimistic, however, as a number of partnerships have emerged from the process and are continuing to work toward improved economic, social and environmental conditions.

These committee initiatives are ideal venues for the introduction of steps towards the development of climate change impacts and adaptation county/municipal strategies (Recommendation 11).

The list of all the committees for all the municipal councils of the area of study is included in the following Table 10.1

TABLE 10.1 Committees of Planning and Decision Making in the United Counties of Prescott & Russell and Stormont, Dundas and Glengarry

	Executive Committee	Finance and Administration	Planning Advisory	Economic Development	Protection to Persons & Property	Technical Services: Engineering and Planning	Technical Services: Public Works & Waterworks	Adjustments/Minor Variance	Property Standards	Recreation & Culture	Library Board	Environmental Resources	Emergency Preparedness Planning	Agricultural Resource	Advisory Roads	Municipal Drains	Land Divisions (Subdivisions)	Youth Center	Low-Income Housing	Board of Health	Joint Liaison County/City	Police Services	Other	Other
Prescott-Russell (County) E	E	E			E																			
Alfred and Plantagenet		X	E	E			X	X	X	X	L	X												
Casselman																								
Champlain		E	E	E						E														
Clarence-Rockland		X	X	X																				
E. Hawkesbury										E														
Hawkesbury	X			C	X	X	X			X	C											C		H
Nation						X	X	X	X	X	X					X						X		
Russell			X	X				X		X					X							X		
Stormont Dundas Glengarry (County)	X										X				X		X			X	X	X		A F
N. Dundas																							S_1 R_2 S_2	W_1 G
S. Dundas				X								X											Co	W_2
N. Stormont	E						E			E		E			E								S_1	R_1
S. Stormont			X	E						X			X										R_1	W_2 W_3
N. Glengarry			X	X					X	X		X	X		X							X		
S. Glengarry			X					X	X			X	X	X									R_1	S_3
Cornwall (City)			X										X										W_2 S_4	M_a

10.2.3 Community Stewardship Councils[98]

The goal of Ontario Stewardship, which was developed by the Ontario Ministry of Natural Resources (OMNR), is to promote and develop a responsible way of using private land while ensuring its protection. It seeks to regroup landowners, resource associations and agencies (at the provincial and regional level), community leaders and volunteers to work together for a 'stewardship' management of private land, without legislative control but rather through shared interest, partnership and teamwork. However it must respect the decision-making rights of landowners.

Ontario Stewardship includes 40 Community Stewardship Councils; usually the community is a county, e.g. the Prescott-Russell Stewardship Council and the Resource Stewardship Stormont, Dundas and Glengarry. A Council must comprise "a group of between 8 to 15 people who are: respected members of the community, committed to the program purpose; able to represent the spectrum of landowners and land interests." "Farmers, woodlands owners, cottages and rural property owners" are considered as landowners. "Naturalists, recreationers, loggers and other forest users" are considered to have land interest.

Each council must have:

- administrative guidelines, including appropriate (auditable) means for handling money; this may involve affiliation with an agency that is prepared to provide banking services, such as a CA, county or association
- general operating guidelines
- a general strategy for guidance over two or more years, which includes specific goals and objectives, indication of priorities, candidate activities, and potential opportunities
- a basic work plan for the current year
- a simple means to track community and agency participation and contribution to the attainment of the work plan and council's targets.

Every Community Stewardship Council works with his own Stewardship Coordinator, which is employed by OMNR. His (her) role is to help develop and enhance the relationships and partnerships between the entities involved in order to create a local network, and to participate in the regional-provincial network. She may also be the spokesperson for her council.

Furthermore, municipalities' role in Stewardship Councils is to provide information and education, and to oversee the modifications of the environment. OMNR gives $10,000 every year to each Community Stewardship Councils to lever more money and resources for its activities.

[98] This section was contributed by M. Ait-Ouyahia

References

Alam, R. and P. Crabbé (2002), Local *Financing for Adaptation Measures to Climate Change*, Department of Economics, University of Ottawa, unpubl. Mnss.

Aurelson, I., Burhoe, D.A., and R. D. Needham (2003), *Rural Municipalities and Climate Change Preparation: Bridging Mechanisms for Adaptation*, Department of Geography, University of Ottawa, unpubl. Mnss., March.

Beierle, T. C. and D. M. Konisky, (2001) "What are we gaining from stakeholder involvement? Observations from environmental planning in the Great Lakes." *Environment and Planning C: Government and Policy* 19(4):515 - 527.

Benest, F. (1998) "The Bottom Line." *Public Management* 80(4):10-13.

Byron, I. and A. Curtis (2002) "Maintaining Volunteer Commitment to Local Watershed Initiatives." *Environmental Management* 30(1):59–67.

de Loe, R. C., S. E. di Giantomasso, and R. D. Kreutzwiser (2002) "Local Capacity for Groundwater Protection in Ontario." *Environmental Management* 29(2):217-233.

Dietz, T. and P.C. Stern (2002) *New Tools for Environmental Protection; education, Information and Voluntary Measures*, National Research Council, Washington.

Frewer, L. (1999) "Risk perception, social trust, and public participation in strategic decision making: implications for emerging technologies." *Ambio* 28(6):569-574.

Government of Ontario:
http://www.ontariostewardship.org/
http://www.ontariostewardship.org/PRESCOTT/prescot.htm
http://www.ontariostewardship.org/SDG/splash.htm
http://www.modelforest.net/DOCS/windowwoodlots/SteveWilkins_e.pdf

Kellogg, W. A. (1999) "Community-based organizations and neighbourhood environmetal problem solving: A framework for adoption of information technologies." *Journal of Environmental Planning and Management* 42(4):445-465.

Lawrence, Patrick L., J. Gordon Nelson, and Geoff Peach. 1993. "Great Lakes Shoreline Management Plan for the Saugeen Valley Conservation Authority." *The Operational Geographer* 11(2):26-33.

Margerum, R. D. (1999), "Integrated Environmental Management: the Foundations for Successful Practice." *Environmental Management* 24(2):151-166.

McDuff, M. D. (2001) "Building the Capacity of Grassroots Conservation Organizations to Conduct Participatory Evaluation." *Environmental Management* 27(5):715-727.

Needham, R.D. (2002), *The Informed Opinion of Municipal Officials: Infrastructure Administration, Planning and Management in Eastern Ontario*, FCM, June 2001.

Needham, R.D. (2003), *Climate Change, Barriers to Learning within the rural Municipal, Administrative-Managerial Domain*, Presentation at the SLRIES 10th conference, Cornwall.

O'Connor, D. R. (2002) *Report of the Walkerton Inquiry: a Strategy for Safe Drinking Water*. Ontario Ministry of the Attorney General.

O'Neill J. and C.L. Spash (2000). “Conceptions of value in environmental decision-making" *Environmental Values*. Volume 9: 521 - 536.

O'Neill, John. (2001). "Representing people, representing nature, representing the world." *Environment and Planning C: Government and Policy* 19(4).

Philippi, Nancy. 1997. *Flood Plain Management: Ecological and Economic Perspectives*. Austin, Texas: Environmental Intelligence Unit, R.G. Landes Company.

Smith, G.R. 1998. "Are we leaving the community out of rural community sustainability? An examination of approaches to development and implementation of indicators of rural community sustainability and related public participation." *International Journal of Sustainable Development and World Ecology* 5(2):82-98.

South Nation Conservation (1997), *Annual Report*.

Sweeney, Michael W. 2001. "Broadening democracy in environmental policy processes." *Environment and Planning C: Government and Policy* 19:475-481.

Whipple, William Jr. (2001), "Coordination Between Water Resources Development and Environmental Needs." *Journal of Water Resources Planning and Management* (January/February):1-3.

Section 11 Municipal Adaptation Measures

Municipalities need to develop their own adaptive measures. Measures are a combination of a policy and an action (e.g. volumetric water pricing and water meter installation). To develop their own measures, municipalities need to have plenty of valuable information at their disposal. If the benefits or advantages of a local institution's adaptive actions are perceived to be minute or inconsequential by its members and the public, it will not undertake costly action.

The best combination of measures is as good as the policy capacity of the local institution, whether municipality or CA. The latter can benefit from the dissemination of information about the initiatives and behavior of other local institutions (peer pressure); this disseminated information may then become a standard. Adaptation by local institutions corresponds generally with the theoretical stages of diffusion of a new economic product (Dietz *et al*., 2002).

This is why collaboration with FCM, provincial associations of municipalities (AMO), the Rural Ontario Municipal Association (ROMA), the Association Française des Municipalités de l'Ontario (AFMO), and other relevant professional groups is essential in order to share knowledge and experience. Professional groups include

For Municipal Administrators:

- Association of Municipal Managers, Clerks and Treasurers of Ontario (AMCTO),
- Canadian Association of Municipal Administrators (CAMA),
- Municipal Finance Officers Association of Ontario (MFOA),
- Ontario Municipal Administrators Association of Ontario (OMAA).

For Planners, it includes:

- the Ontario Professional Planners Institute (OPPI) and
- the Canadian Institute of Planners-Insitut Canadien de Planification (CIP-ICP).

For Public Works managers, it includes:

- the Ontario Municipal Engineers Association (OMEA),
- the American Public Works Association, Ontario Chapter (APWA),
- the Ontario Municipal Water Association (OMWA),
- the Ontario Water Works Association (OWWA),
- the Ontario Good Roads Association (OGRA).

For Economic Developers, there is the:

- Ontario East Economic Development Commissions (OEEDC),
- Economic Developers Council of Ontario (EDCO),
- Economic Developers Association of Canada (EDAC),

11.1 Stakeholders

Stakeholders should be involved in each component of a climate change adaptive policy for three primary reasons. First, they may possess valuable information which will assist in refining the design and implementation of adaptation measures. Second, such involvement will enhance the prospects for consensus and consent, thereby promoting compliance. And, third, ongoing participation is desirable in order to increase understanding of the significance of Climate Change.

11.2 Education

Information, even if it is accurate, will be not be used unless it is available to relevant constituencies, it is valuable from their perspective, and applicable in practical ways. The diffusion of valuable information still requires looking for windows of opportunity (e.g. Emergency Preparedness) to ensure its availability. The best way to diffuse this information is to demonstrate for each professional group (councilors, planners, treasurers, engineers, etc.) how climate change vulnerability affects day to day municipal operations and how the implementation of concrete responses might alleviate adverse or uncertain consequences. This could also be done through low risk demonstration projects.

Municipalities tend to rely on the province for information while CAs rely more on local knowledge networks. Newspapers tend to be a significant source of information. Clearly, university expertise is underutilized (see section 9.2.3 above). An innovative partnership between university experts and local newspapers could contribute to the dissemination of relevant and valuable information to the community. A partnership between universities and CAs and municipalities through committees may affect water policy as these local institutions feel they are influential and have the largest responsibility in matters pertinent to water policy (see section 9.2.4 and 9.2.6 above).

11.3 Infrastructure Design

The National Guide to Sustainable Municipal Infrastructure is designed to help municipalities to better manage infrastructure. It is a joined collaboration of Infrastructure Canada (IC), the National Research Council (NRC) and the Federation of Canadian Municipalities (FCM). The guide gathers the best and most sustainable practices for the planning, design and delivering of drinking water, sewer and stormwater systems, roads and transit. However, it does not address climate change concerns. Municipalities can also find management best practices with the Ontario Centre for Municipal Best Practices (OCMBP). The Centre was founded in 2002 by the Association of Municipalities of Ontario (AMO), other municipal associations, and the Ministry of Municipal Affairs and Housing (OMMAH). OCMBP identifies municipalities with best performances, not for rewarding but to acknowledge best practices.

11.4 Water Infrastructure Design[99]

11.4.1 Water Treatment Systems

- Initiatives to **reduce system losses** should be undertaken by municipalities. Possible approaches to reduce water waste include:

    - Rehabilitation of the distribution system to minimize losses;
    - Implementation of a pressure management program for the distribution system. This method consists of controlling the amount of water pressure by decreasing it where it is excessive, and sustaining it where it is weak or unpredictable;

  One way to avoid financial crisis is to stop the system loss in the water distribution system. Water loss in the distribution system is greater than 20% in many communities (FCM, 2001a). It results in higher than necessary capital, chemical and energy costs. The rehabilitation of large parts of the existing distribution system can reduce this loss. The National Research Council (NRC) estimates that Canadian municipalities could save more than $350 million per year by reducing leakage from 25 percent to 10 percent of supply.

- **Additional capacity** for higher and longer peak demand periods drought conditions should be considered when planning for expansion or construction.

- **More turbidity removal chemicals and automated dosage control** should be considered when planning water treatment plant expansions, as the turbidity fluctuations are expected to be more dramatic.

- **Treatment of taste and odor** should be considered for water treatment plants that experience taste and odor episodes. The different techniques for the treatment of taste and odor include:

    - Granular Activated Carbon (GAC)
    - Powdered Activated Carbon (PAC)
    - Ozonation

  The efficiency of a treatment technique is **dependent on the water properties**; therefore a pilot-scale evaluation should be performed before choosing a treatment method.

- **Water reuse** should be considered for water supply to golf courses and agricultural land.

- **Plants feeding on groundwater** sources should be the subject for further study.

[99] This section was contributed by V. Paris and R. Narbaitz

- During the **data** gathering exercise about water and wastewater plants, it became clear that the data was not recorded on a consistent basis, that it was not readily accessible, and that it was **insufficient**.

- Further investigation on water (both raw water and treated water) is needed in order to better predict the potential impacts of climate change on water treatment. **Parameters** such as turbidity, total organic carbon (TOC), pH, color, and odor for raw water and turbidity, trihalomethanes (THM) levels, pH, color, and odor for treated water, should be **monitored over an extended period of time**. An analysis on the parameters trend in reaction to weather data (precipitation, temperature) should subsequently be performed.

11.4.2 Wastewater Treatment Systems

- In upgrading facilities, or constructing new ones, an **increase in peak flows** from intensified rain events should be considered **when evaluating capacity requirements**.

- The presence of rainwater in collection systems should be minimized particularly because of the more severe storm events expected with climate change. The less the system is affected by rainwater, the lower the need for increased capacity to accommodate climate change. The following will help **minimize infiltration problems**:

    - Rehabilitation work on separate sewers that suffer high infiltration;
    - Investigation and elimination of illegal connections to the sewer systems;
    - Separation of combined sewers.

- Because of the large storm flows, the lagoon and mechanized treatment system **capacity** should be **expanded** well before the average flows reach the design flows. In the case of mechanized plants, whenever space is available, **equalization systems** should be added. These steps will help reduce effluent quality deterioration due to storm events.

- Whenever a lagoon system approaches capacity and needs expansion, **conversion to a mechanized** secondary (or tertiary) wastewater treatment plant should be considered. This would not solve the significant eutrophication problems within the watershed, because wastewater inputs only represent about 10% of the nutrient inputs. However, it would reduce the ammonia and the algae discharged, thus reducing algal problems at downstream water treatment plants.

- Because **data** in the study area is **insufficient** and not recorded on a consistent basis, further investigation on **wastewater** (both raw wastewater and treated water) **quality** is needed in order to better predict more specific impacts of climate change on wastewater treatment. An analysis on **treatment efficiency parameters** in reaction to weather data (precipitation and temperature) should be performed.

11.5 Water - related Instruments

11.5.1 Water Quantity-related Adaptive Measures

11.5.1.1 Permits to-Take-Water[100]

The water taking permit process in Ontario was essentially invisible to the public until very recently. Now, following a series of high profile controversies, including a proposed bulk water export from Lake Superior that aroused international concern, permits to-take-water pursuant to the OWRA section 34 constitute something of a battleground. Growing numbers of people now come forward to test or challenge applicants seeking legal authority to remove significant volumes of water from Ontario surface and ground water sources. The proliferation of such challenges is indeed quite striking.[101]

Perhaps the most prominent of the water-taking permit controversies concerns the application of OMYA (Canada) Inc. to take water from the Tay River for use in a facility not far from Perth (*Dillon et al. v Director*, Ministry of the Environment). The Environmental Review Tribunal thoughtfully considered the significance of MOE's Statement of Environmental Values, and in particular its references to such guiding principles as the ecosystem approach, environmental protection and resource conservation. In some respects, the Tribunal's analysis of the limitations in the data available to the ministry represents an application of a precautionary approach to water-taking permits. Data limitations were used to support the tribunal's approval of a cautious and phased in water-taking permit as recommended by the MOE Director.

Although OMYA, the applicant, successfully appealed the Tribunal decision to the Minister of Environment, we have been given some indication of the manner in which the Tribunal will proceed in future water-taking appeal hearings.

In so far as it is reasonable to assume continued increase in demand for water use throughout the study region, notwithstanding uncertainties in long term supply attributable to climate change, then careful consideration of watertaking applications will become increasingly important. This applies not only to new permits but also to renewals, and extensions sought by existing permits holders when the period of the permit approaches expiration.[102]

Permits – To –Take – Water should be monitored in the future. Permits should be revenue – generating and these revenues should be reinvested in water conservation and reuse.

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[100] This section was contributed by J. Benidickson.

[101] See *Soyers Lake Ratepayers Association v Ontario* (Ministry of the Environment) [1999], Ontario Environmental Appeal Board (OEAB), No.9; *Schneider v Ontario* (Ministry of the Environment) [1999] OEAB No. 19; *Goulbourn Wetlands Group v Ontario* (Director, MOE) (2002) 42 Canadian Environmental Law Reports (CELR), New Series (NS) 269; *Niddery v Ontario* (Director, Ministry of the Environment) (2002) 43 CELR (NS) 107).

[102] A one – year freeze on new and expanded industrial water taking permits has been recently imposed by the Ontario Government (*Ottawa Citizen OMYA* not hurt by Water Rules, p. F3, Jan 02, 2004)

11.5.1.2 Water Rationing[103]

A growing number of communities have used municipal by-laws to formalize their understanding of appropriate mechanisms to promote conservation or to respond to low water conditions.

A few examples indicate some existing approaches to municipal water conservation by-laws (Georgina, East Gwillimbury, Kingston, Guelph). Water rationing measures are already imposed in the municipality of North Glengarry in the hamlet of Alexandria.[104] Inspections by fire officials suspicious of mid-summer night violations are not unknown.[105]

For many smaller communities where urban and rural land uses and users are often highly inter-dependent, there is also an important municipal role in ensuring that all sectors are familiar with water management opportunities.

Rural and agricultural users might refer to OMAFRA fact sheets and materials such as *How to Prepare for Irrigation during Water Shortages*, or *Private Water Well Owners - Dealing with Water Shortages*.

Municipalities must ensure that major water using facilities such as golf courses are aware of water conservation arrangements and other environmental protection measures, and are encouraged to adopt them.

The golf course industry itself is becoming attuned to the importance of environmental initiatives. Two environmental certification programs are now operating in Ontario. The Camelot Golf Course in Cumberland is certified under the Audubon Cooperative Sanctuary System of Canada, and the Emerald Links Golf and Country Club in Greely is participating in a pilot project under the auspices of Green Links Eco-Efficiency Services.

The Riverbend Golf and Country Club applied to increase its Jock River water-taking permit from 227,300 litres daily for fifteen days between June 1 and August 31 to 1,136,500 litres daily for one hundred days between April 15 and October 1. That application was rejected in the fall of 2002 by the director of water resources for the Ontario Ministry of Environment. A spokesman for the Ministry explained the decision by noting that "The Jock River is known to experience periods of little or no flow during irrigation season. The proponent has not demonstrated to the ministry's satisfaction that the requested taking can be accomplished without interfering with the natural function of the Jock River."[106] Although no similar measure is currently contemplated in Ontario, the general significance of such decisions is clear. In the context of potential or perceived water shortages, attention will focus on the question of priorities, however these may be defined.

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[103] This section was contributed by J. Benidickson.

[104] J. Meek (personal communication).

[105] "Officials resort to midnight patrols to stop lawn watering" *National Post* 6 July 2001.

[106] Patti Edgar, "Plug Pulled on Jock River Plan" *Ottawa Citizen* 22 November 2002). British Columbia introduced a Golf Course Development Moratorium Regulation (BC Reg 308/91) under the province's Environmental and Land Use Act (RSBC 1996, c. 117).

The suggestion has even been made that the re-use of wastewater in settings such as irrigation or at recreational facilities like golf courses and ski clubs will become more common..

11.5.1.3 Water Efficiency and Best Practices[107]

Water efficiency programs that are designed to reduce water use by 5 to 10 percent can be adopted by the municipalities. The target of water efficiency program may be average day, maximum day or seasonal demand or a mix of these. Water efficiency program comprises a choice of water efficiency measures that are being promoted to reduce demand and a mix of promotional and educational efforts that are the program's delivery mechanisms. Water efficiency measures include water saving practices, devices and appliances that can be used by residential and industrial, commercial and institutional customers and implementation of water saving initiatives (information programs, drought tolerant grasses, low-flow home devices, such as shower heads and toilets). Municipalities can use rebates and subsidies to encourage best management practices by the residents.

Other measures include:

- Implementation of water metering in locations lacking it;
- Implementation of a water pricing structure with increasing unit costs (see section 8.6.1).
- Demand management
- Conservation of peak season water
- Land use and development management to ensure sufficient water supplies
- Decrease in operating cost
- Increased water pumping/storage capacity
- Waste water recycling

11.5.1.3.1 Water Quality Related Adaptive Measures

Measures include:

- Enhancing capacity of waste water treatment (see section 11.3 above)
- Regular inspection of septic tanks
- Enhancing sewage treatment facility (see section 11.3 above)
- Increased maintenance of reservoirs
- Deepen wells
- Blockage of polluting sources
- Increased water testing facilities

[107] This section was contributed by V. Paris and R. Narbaitz

11.5.3.1.1 Extreme Events

11.5.3.1.1.1 Flood-related Adaptive Measures

Measures include:

- Rehabilitation/ construction of the various infrastructures like drainage system, water treatment facilities, dams, dykes etc.
- Flood pumping
- Better facilities for flood victims
- Stricter land use restrictions and planning
- Improved system for emergency management, new responsibilities, intra and inter departmental co-operation
- Improved management of outdoor recreation facilities

11.5.3.1.1.2 Drought-related Adaptive Measures

Measures include:

- Conservation of peak season water
- Supply management by decreasing system loss (see section 11.4.1 above)
- Land use and development management to ensure sufficient water supplies in extreme events
- Increased water pumping/storage capacity
- Waste water recycling (see section 11.4.1 above)
- Deepen wells

References

Dietz, T. and P. Stern (2002), *New Tools for Environmental Protection: Education, Information and Voluntary Measures*, National Research Council, Washington D.C.

Section 12 Conclusion: A Municipal Adaptation Strategy for Climate Change in Eastern Ontario[108]

It was said in section 1 that the adaptive capacity of a municipality is a function of various factors, which will be briefly discussed here in the Eastern Ontario context (see section 1.4 and Yohe *et al*., 2002). These factors were: the range of available technological options, the available resources and their distribution across the population, the structure of critical institutions and criteria for decision-making, human and social infrastructures, access to risk-spreading processes, ability of decision-makers to manage credible information and their own credibility, the public's perception of the source of the impact, and the significance of exposure to its local manifestations (Yohe *et al*., 2002).

Except for financial barriers, a municipality in Canada has access to all available technological options for climate change adaptation. However, it may not know which technology is most appropriate for relevant climate infrastructure impacts and there is little available expertise on these issues. Municipalities in Ontario, as they are elsewhere in Canada, are cash-strapped because of the mismatch between their responsibilities and their revenues. Income and, generally, resources distribution inequalities within the population, a determinant of vulnerability, is not a municipal responsibility but rather a provincial one. Some critical institutions for adaptation to climate change are under-funded and under-utilized. This is the case for CAs. Criteria for decision-making about water-related infrastructures seldom take the watershed as a unit. Expertise on climate change is available in local universities but little used. There seems to be a strong community spirit in Eastern Ontario, especially in the environmental area. Municipalities have access to reciprocal insurance, which, given the size and differentiated ecosystems of the province, are able to redistribute the climate risks. The ability of decision-makers to manage credible information in the area of climate change is unknown, except for EOHU, and the decision-makers' own credibility is unknown as well. The recent provincial and municipal elections offer a new window of opportunity for the introduction of climate change concerns at the municipal level. The public's perception of the source of the impact and the significance of exposure to its local manifestations is likely to be poor. While there are no generalized water quantity problems expected for our area of study, there are definitely localized problems and water quality ones, which result mainly from agricultural activities, over which municipalities and EOHU have nearly no jurisdiction. The projected installation of two hog farms in the area may have significant impacts on groundwater quality.[109] The human infrastructure offers vulnerabilities in terms of age-structure of the population in some areas. Lack of expertise as related to climate change and its impact on built infrastructure is also significant. The public, local governments and institutions perceive that climate change is occurring. Section 9.2.5 has indicated that both municipal and CAs' staff recognize that "climate change is a reality that we are going to adapt to", that "there is a consensus among scientists that climate change is a reality", and that "the impact of climate change will be significant in my watershed". However, except for extreme events, no exposure to climate change is expected to lead to significant harm in the area of study. No persistent drought is expected; agricultural productivity may actually increase for cash crops. There is no reason to believe that local

[108] This section was contributed by P. Crabbé.
[109] See section 2.3 *supra*

adaptive capacity to climate change would be lacking in Eastern Ontario. What is required now is to spread climate change awareness to the public at large and to translate this awareness into a climate adaptation strategy at the municipal and regional level. EOWRMS has provided recommendations with respect to some water infrastructures independently from climate change. Many of these recommendations go a long way towards adaptation to climate change. Therefore, our recommendations aim at synergy with EOWRMS'.

Since mitigation and adaptation cannot be dissociated, lessons learned from community mitigation initiatives are relevant for community adaptation. Key lessons from the implementation of FCM PCP program are adaptable to municipalities efforts towards climate change adaptation (FCM, Local Action Plans, 2002; http://www.fcm.ca/scep/case_studies/action_plans/action_plan_index.htm; Crabbé *et al*., 2002). Similarly, climate change adaptation experience by private firms is adaptable to municipalities (CERES 2002, 2003).

Lessons learned from these experiences and from our assessment of climate change vulnerability of Eastern Ontario municipalities lead to the following recommendations:

RECOMMENDATIONS

Recognizing that climate change is an additional stress on Eastern Ontario water-related infrastructures, on top of the increase in the number of households, agri-business, industrial and recreational changes, and existing pollution loadings, we offer the following recommendations to complement the Eastern Ontario Water Resources Management Study (EOWRMS) recommendations:

To Municipal Council

1. Embrace **climate change adaptation** as a **new municipal concern** and seek **cost - saving opportunities by acting early** upon it**.**

2. Continue to **support the activities of the Eastern Ontario Water Resources Committee (EOWRC)** on water-related infrastructures as it is the best venue for regional cooperation.

3. Ensure that the municipality has access to sufficient available **expertise** to deal with all aspects of **climate change** relevant to its community.

4. Continue to undertake, possibly within the municipality's official plan, a thorough **vulnerability assessment o**f the municipality's current and probable financial and environmental risk exposures to climate change.

   This requires each municipality to:

   a. Identify on a map the areas of the municipality, which are the most sensitive to climate change, for example, to drought (**Hazard mapping**);

   b. Continue to use a **Geographic Information System** (GIS), which is an indispensable tool to do the mapping and management of water and water-related infrastructures, starting with EOWRC recommendation 34;

   c. Continue to extend to climate change EOWRMS as done in this study, and implement EOWRC recommendation 2, 16, 18 and 26, in particular,

      i. Identify areas where there is a need for location specific groundwater and surface water quality/quantity protection resulting from historical or current land use;

      ii. Identify agricultural land in proximity to sensitive areas;

      iii. Assess risks of aquifer and well contamination.

5. Examine thoroughly in collaboration with NGOs and the public, possibly within the municipality's official plan, the **opportunities** which climate change may present for new and expanded business activity (for example, ethanol, tourism, etc.) and/or cost reduction from business. Emphasis should be on local economic benefits in order to gain community and municipal support.

6. Develop, announce and implement a **Strategy on Climate Change**, that is integrated into the municipality's overall planning and operations activities, within a watershed and agro-ecosystem perspective. It requires:

   a. Incorporation in the Strategy, at the earliest stages, of **best practice mechanisms for monitoring and evaluation** of climate change exposure;

   b. Formal levels of **accountability** to monitor and report to Council, constituents and the Province on the municipality's progress in addressing climate driven business-risks and opportunities;

   c. Review of the existing **regional governance structure** for water-related infrastructures from data collection and analysis to adoption of measures (see EOWRC recommendation 35);

   d. **Emergency response spill clean-up** plans for areas considered at high risk of water contamination (EOWRC recommendation 23).

7. Ensure that the Strategy is:

   a. Based on a clear **vision**

   b. Doable,

   c. Viable in the long-run

   d. High profile, and

   e. Has a **champion** from the local area, who keeps it moving at both **the political and staff** level

8. Ensure **Community ownership of the Strategy** for its long-run success**;** this requires:

   a. **Support from community leaders**

   b. Continuously **re-engaging support at the working level**

   c. **Community engagement** on any, even unrelated, issue

9. Take into consideration the size (number of inhabitants) of the municipality in determining the degree of formality for **the organizational structure for the Strategy.**

10. Since the Federation of Canadian Municipalities has programs (PCP, LAP) to assist municipalities for climate change **mitigation** and since adaptation measures are not independent of mitigation measures, as soon as municipal mitigation measures will be mandated by the Federal Government:

    a. Construct an **inventory** of the municipality's emissions (50 % of GHG emissions originate in municipalities territory (Municipalities Issue Paper, 1998));

    b. Establish an emissions **baseline,** against which to gauge the municipality's emission trends

    c. Make emissions **projections**

    d. Establish realistic **targets** for emission reductions, and

    e. Examine the practicality and affordability of **early mitigation measures**

    f. Calculate, verify through a third party auditor, and **register** GHG emissions savings or **offsets**.

11. Confer a **leading role on Conservation Authorities** in the risk-management of climate change adaptation, and adequate corresponding resources to manage climate change adaptation of **watershed infrastructures.**

12. Confer a **leading role on Municipal Committees** in the identification of needed expertise, data requirements, champions and organizational structure for the elaboration of the Climate Change Strategy.

13. Confer a **leading role to the Eastern Ontario Health Unit** (EOHU) in the risk-management of climate change adaptation because of:

    a. its **ability to communicate to the public** climate change-related messages through the environmental determinants of health

    b. its involvement with the municipalities in formulating **emergency plans** due at the end of the next calendar year

    c. its responsibilities towards **vulnerable populations**.

14. Determine infrastructure service standards and what constitutes **due diligence** at the infrastructure design stage.

15. Develop an adequate **combination of measures** (including the ones required for mitigation).

16. Require that the municipality adopts site-specific and regional **best practices** whenever available. Consider climate change and implement EOWRC recommendations 3, 11, 13, 14, 15, 18, 21 and 26, namely:

a. Identify existing groundwater and surface water resource and land use (including nutrient, pesticide, and sediment) **management programs** on a watershed and agro-ecosystem basis including sewage treatment and discharge, animal waste and its application, and review various non-point pollution source reduction program from a climate change adaptation perspective;

b. Assess broadly the **benefits and costs** of existing and proposed management programs to determine their effectiveness and equity among stakeholders;

c. Determine the need for **program changes**;

d. Develop **measures** to reduce the risks of contamination such as: reduction in nutrient loading through phosphorus credit system, development of vegetated riparian zones, wetland protection and creation, and limits on agricultural intensification (corn for ethanol, hog - farms, etc.).

e. **Mimimize impacts** of road salt and snow dumping practices.

17. Reaffirm EOWRC recommendation 9 and 31 in a climate change perspective, i.e. evaluate various **water efficiency** measures for major water consumer groups in a watershed, and implement the most cost-effective ones, such as metering Permits – To – Take - Water, and adopting increasing volumetric tariffs. These measures should be extended to all water consumers eventually.

18. **Identify and promptly adopt** adaptation and mitigation measures, whose early adoption will save the municipality money in the long-run.

19. Increase the level of **cooperation regionally** among the United-Counties of Prescott & Russell, and the United-Counties of Stormont, Dundas and Glengarry in mitigation, adaptation, and climate risk-bearing initiatives. The co-operation should be extended to the United Counties of Leeds - Grenville, the City of Cornwall, the City of Ottawa, the Rideau Conservation Auhority and Mississipi Valley Conservation, as well as with the Province, once its mitigation and adaptation commitments are established.

20. Increase the level of **cooperation with the insurance industry** to be able to demonstrate the efficacy of the municipality's climate strategy and of its vulnerability alleviation measures, to identify remaining "hot spots", and to agree about what constitutes residual risk.

21. Increase the size of some water and wastewater treatment plants and update some others to enable them to handle large and more frequent precipitation events while, at the same

time, applying **increasing volumetric** tariffs and other water conservation measures to help finance needed capital expenditures.

To the Eastern Ontario Water Resources Committee (EOWRC) and Conservation Authorities

22. Assess climate change risks to all **water-related infrastructures** and, especially, assess the effectiveness of **stormwater management** methods locally and regionally within a watershed context.

23. Take climate change into account and collaborate with the province whenever establishing and implementing programs for collecting **data,** and implementing EOWRC recommendation 1, namely data on:

a. Surface and groundwater **quantity and quality on a watershed basis**;

b. Human **water-taking and discharges on a watershed basis**,

c. Limitations on resource development

d. **Inter-relationships between upstream and downstream** communities on a watershed and sub-watershed basis (EOWRC recommendation 4 and 5).

24. Conduct a **regional projection of future water demand** assuming best practices on a subwatershed basis and develop corresponding **water supply** plan (EOWRC recommendation 28).

25. Recommend **early adaptation measures** to protect:

a. **groundwater**, wherever its available **quantity** is vulnerable to some climate scenarios; measures may include artificial recharge of groundwater in vulnerable areas;

b. both surface water and groundwater **quality from agricultural** pollution through adequate data gathering, adoption of computer models and decision-support systems.

26. Measure baseflow to determine the origin of flow in **dry-weather** periods (EOWRC Recommendation 8).

27. Install and **monitor**:

a. Multi-level piezometers (monitoring wells) at locations of high **groundwater sensitivity** and areas of regional groundwater recharge (areas of regional recharge are believed to be located along the divide between the South Nation and the Raisin River systems, and in the adjacent Rideau River basin); this will provide information of

utmost importance on the supply side of the equation, i.e. actual recharge values, instead of the educated guesses presently used in most groundwater studies.

b. Multi-level piezometers at surface-water gauging stations; this would provide extremely important information on **surface water – groundwater interactions** and on vertical groundwater movement at these locations. Other methods, such as electrical conductivity surveys, can also be used to provide additional information on the interaction.

28. **Sample periodically** the monitoring network, perhaps every year for **Major Constituent Chemistry and Water Quality** parameters; and perhaps, every few years, for isotopic composition. This will help monitor water quality and it may also provide important information on the natural evolution and origin of groundwater.

29. Reaffirm EOWRC recommendation 24 about carrying out **public education** and awareness to increase public understanding and action, through behavior understanding, around surface and groundwater management and protection under climate change including: well head protection, water testing, septic tank and tile field maintenance, water efficiency, nutrient management, as well as decontamination.

30. Offer **well and septic system inspection and remedial services** to the population concerned.

To the Eastern Ontario Health Unit (EOHU)

31. Emphasize the climate change dimension in **emergency plans** being currently developed.

32. Conduct **epidemiological surveillance and monitoring.**

33. Improve **communication** strategies with the public as to make the information valuable and practical.

To the Province

34. Revise, monitor and adopt a precautionary approach to the **Permit-to- Take - Water** (new ones as well as renewals) and transform it into a revenue - generating instrument.

35. List climate change as a **Provincial Interest** under Section 2 of the Planning Act and incorporate climate change into the Provincial Policy Statement.

36. Modify the regulatory environment defining **infrastructure standards** according to climate change requirements and allow them to be spatially differentiated according to climate change regional projected impact.

References

Alam, R. and P. Crabbé (2002), *Local Financing for Adaptation Measures to Climate Change*, Department of Economics, University of Ottawa, unpubl. Mnss.(Volume II of this Report).

CERES (2002), *Value at Risk: Climate Change and the Future of Governance*, Sustainable Governance Project Report prepared by Innovest Strategic Value Advisors.

CERES (2003), *Corporate Governance and Climate Change*, Sustainable Governance Project Report, prepared by D.G. Cogan.

EOWRMS (2001) *Recommendation Table*, mnss., updated by EOWRC 2003.

FCM, Local Action Plans, 2002, http://www.fcm.ca/scep/case_studies/action_plans/action_plan_index.htm;

Yohe, G. and R.S. J. Tol (2002), Indicators for Social and Economic Coping Capacity – Moving Toward a Working Definition of Adaptive Capacity, *Global Environmental Change*, 12, 25 – 40.

Appendix A References

Abouchar, J. (2001) "Implementation of the Precautionary Principle in Canada," in T. O'Riordan, J. Cameron and A. Jordon, eds. *Reinterpreting the Precautionary Principle*, London: Cameron May, 235-267.

Adams, J. (1995), *Risk*, University College London Press.

Adger, W.N., P.M. Kelly and N.H. Ninh (2001), *Living with Environmental Change; Social Vulnerability, Adaptation and Resilience in Vietnam*, Routledge.

Adger, W.N. and T. O'Riordan, Population, Adaptation and Resilience in O'Riordan, T. (2000), *Environmental Science for Environmental Management*, 2nd ed., Routledge, 149 – 170.

Adger, W.N. and P.M. Kelly (1999), Social Vulnerability to Climate Change and the Architecture of Entitlements, *Mitigation and Adaptation Strategies for Global Change*, vol. 4, p. 253 –266.

Adrangi, S. (2003), Signs of West Nile in Alberta Show Virus Extending its Range, *Globe and Mail*, July 14, A4.

AES (Alberta Environmental Service)(1999) *Surface Water Quality Guidelines for Use in Alberta: 1999*; Alberta Environment: Edmonton, AB.

Alam, R. and P. Crabbé (2002), Local *Financing for Adaptation Measures to Climate Change*, Department of Economics, University of Ottawa, unpubl. Mnss.

Alloway, C. (in prep.) *Factors Regulating Nitrogen Retention and Export in a Lowland River Drainage Network*. MSc, University of Ottawa.

Auerback, S. and A. James (2003), *The Annotated Municipal Act* , Carswell.

Aurelson, I., Burhoe, D.A., and R. D. Needham (2003), *Rural Municipalities and Climate Change Preparation: Bridging Mechanisms for Adaptation*, Department of Geography, University of Ottawa, unpubl. Mnss., March.

Baqi, M., K. Gamble, J.S. Keystone, and K.C. Kain (1998), Malaria: Probably Locally Acquired in Toronto, Ontario. *Canadian Journal of Infectious Diseases*, 9, 3, 183-184.

Basu, B. K. & F.R. Pick (1996), Factors Regulating Plankton Abundance in Large Temperate Rivers. *Limnol & Oceanogr.* 41: 1572-1577.

Basu, B. K. & F.R. Pick (1997), Phytoplankton and Zooplankton Development in a Lowland Temperate River. *J. of Plankton Research* 19: 237-253.

Beckett, W.S., 1991. Ozone, air pollution, and respiratory health. *Yale J Biol Med*. 64(2):167-75.

Beierle, Thomas C. and David M. Konisky (2001), "What Are We Gaining from Stakeholder Involvement? Observations from Environmental Planning in the Great Lakes." *Environment and Planning C: Government and Policy* 19(4):515 - 527.

Benest, F. (1998), "The Bottom Line." *Public Management* 80(4):10-13.

Benidickson, J. (2002) *Water Supply and Sewage Infrastructure in Ontario, 1880-1990s: Legal and Institutional Aspects of Public Health and Environmental History*, Issue Paper for the Walkerton Inquiry (Toronto)

Beshiri, R. (1999), How Farmers Weathered the Ice Storm '98' in *Canadian Agriculture at* a Glance/ Un coup d'oeil sur l'agriculture canadienne, Statistics Canada, Ottawa, December.

Binger, R.and F. Theurer (2001) *AnnAGNPS Technical Processes Documentation Version 2*; USDA-Agricultural Research Service: Oxford, Mississippi.

Blaikie, P., T. Cannon, I. Davis and B. Wisner (1994), *At Risk, Natural Hazards, People's Vulnerability, and Disasters*, Rutledge.

Bruce, James P. (2002), *Climate Change Effects on Regions of Canada*, prepared for Federation of Canadian Municipalities, Global Change Strategies International, January 30.

Bruce, J., I. Burton, I.D. M. Egner and J, Thelen (1999), *Municipal Risk assessment: Investigation of the Potential Municipal Impacts and Adaptation Measures Envisioned as a Result of Climate Change*, Global Change Strategies International.

Burnett, R, Cakmak, S and Brook J. 1998a. The Effect of the Urban Ambient Air Pollution Mix on Daily Mortality Rates in 11 Canadian Cities. *Canadian Journal of Public Health*, 89(3): 152-156.

Burnett, R, Cakmak, S, Raizenne, M, Stieb, D, Vincent, R, Krewski, D, Brook, J, Philips, O and Ozkaynak, H. 1998b. The Association between Ambient Carbon Monoxide Levels and Daily Mortality in Toronto, Canada. *Journal of the Air & Waste Management Association*, 48, 689-700.

Burnett, RT, Jessiman, B, Stieb, D, Krewski, D. 1997. Health effects of ambient particulate matter: A Canadian perspective. In: *Health Effects of Particulate Matter in Ambient Air*. Prague, Czech Republic. Ed Jaroslav J Vostal. April 23 25, 1997.

Burton, I. (2000), What are Adaptation Needs and How can they be Met?, *Proceedings of the Second IPCC Regional Meeting on DES*, Havana, Cuba, 23-25 February.

Burton, I., R.W. Kates and G.F. White (1993), *The Environment as Hazard*, The Guilford Press.

Byron, Ian and Allan Curtis (2002) "Maintaining Volunteer Commitment to Local Watershed Initiatives." *Environmental Management* 30(1):59–67.

Canadian Food Inspection Agency, 2002.

http://www.inspection.gc.ca/english/corpaffr/recarapp/2002/20020518e.shtml

Canadian Institute of Child Health (CICH), 2001, *Changing Habits, Changing Climate. A Foundation Analysis. Ottawa: CICH*

Canter, L.M. (1997), *Nitrates in Groundwater*. Lewis Publishers. Boca Raton, Forida.

Carpenter, S.R., W. Brock, and P. Hanson (1999), Ecological and Social Dynamics in Simple Models of Ecosystem Management, *Conservation Ecology*, 13(2):4, http://www.consecol.org/vol 13/iss2/art4

Carty, P., P.Crabbé, L.Craig, D. Krewski (2002), *Health Effects of Climate Change and Health Co-Benefits Resulting from Potential Kyoto - driven Policies: A Canadian Perspective*, Technical Report developed by the R. Samuel McLaughlin Centre for Population Health Risk Assessment, Institute of Population Health, University of Ottawa.

CERES (2002), *Value at Risk: Climate Change and the Future of Governance*, Sustainable Governance Project Report prepared by Innovest Strategic Value Advisors.

CERES (2003), *Corporate Governance and Climate Change*, Sustainable Governance Project Report, prepared by D.G. Cogan

Chambers P.A., M. Guy, E.S. Roberts, M.N. Charlton, R. Kent, C. Gagnon, G. Grove, and N. Foster (2001), *Nutrients and their impact on the Canadian Environment*, Agriculture and Agri-Food Canada, Environment Canada, Fisheries and Oceans Canada, Health Canada and Natural Resources Canada. Ottawa, Ont. 241 p.

Champlain District Health Council (HDHC), 2002, *Health System Monitoring Project Report*,

http://www.champlainhealth.ca/documents/cdhcmonitoringprojectreporteng.pdf

Chance, G.W. and E. Harmeson, 1998. Children are different: Environmental contaminants and

children's health., Canadian Journal of Public Health, 89. *Suppl. 1*.

Charron, D. F. (2003), Vulnerability of Waterborne Diseases to Climate Change in Canada: A Review. In S. E. Hrudey, Ed.,. Drinking Water Safety. A Total Quality Management Approach. Proceedings of the International Conference on Water and Health, Sept. 23-25, 2002 Ottawa, Ontario, Institute for Risk Research, University of Waterloo.

Chase, S. (2003), Kyoto Plan Offers Cash for Home Retrofits, *Globe and Mail*, June 11.

Chipman, J. (2002), *The Ontario Municipal Act: A Comprehensive Guide* (Canada Law Book);

Conservation Council of Ontario, http://www.greenontario.org/strategy/water.html

CH2M Gore & Storrie Limited (1999). *Final Report*. Phase 1A Eastern Ontario Water Resources Management Survey: United Counties of Prescott and Russell.

CH2M HILL, (2001), *Final Report*. Eastern Ontario Water Resources Management Study (EOWRMS): United Counties of Prescott & Russell, Stormont, Dundas, Glengarry, City of Ottawa

Climate Change and Health Office (CCHO) (2002), http://www.hc-sc.gc.ca/hecs-sesc/ccho/sitemap.htm

Crabbé, P. (2002), *Risk Analysis and Management for Climate Change*, Canadian Economics Association meeting, Calgary.

Crabbé, P., S. Findlay, R. Needham and S. Raman (1997), *Ecosystem Recovery on the St. Lawrence: Final Report*, Institute for Research on Environment and Economy, University of Ottawa, March 31.

Crabbé, P. and C. Mioc (2002), *Canadian Communities and Climate Change Impacts and Adaptation*, October, Unpubl. Mnss.

Creese, E.E., and J.E. Robinson (1996). « Urban water systems for sustainable development, » *Canadian Water Resources Journal*, 21(3), 209-220

Dales, R.E. , Cakmak, S., Burnett, R.T., Judek, Stan, Coates, Frances and Brook, J.R. 2000. Am. Influence of Ambient Fungal Spores on Emergency Visits for Asthma to a Regional Children's Hospital. *J. Respir. Crit. Care Med.* 162: 2087-2090.

Décoste, R. (2003), *Les changements climatiques au Québec*, Congrès de l'ACFAS, http://www.ouranos.ca

de Gruijl, F.R. and J.C. van der Leun (2000), Environment and Health: 3. Ozone Depletion and Ultraviolet Radiation. *Canadian Medical Association Journal*, 163, 7, 851-855.

Delfino, R.J., Becklake, M.R., and Hanley, J.A., 1994. The relationship of urgent hospital admissions for respiratory illnesses to photochemical air pollution levels in Montreal. *Environ Res*.67(1):1-19.

Delfino, R.J., Becklake, M.R., Hanley, J.A., and Singh, B., 1994. Estimation of unmeasured particulate air pollution data for an epidemiological study of daily respiratory morbidity. *Environ Res.* 67(1):20-38.

de Loe, Rob C., Sandra E. di Giantomasso, and Reid D. Kreutzwiser (2002), "Local Capacity for Groundwater Protection in Ontario." *Environmental Management* 29(2):217-233.

De Loë, R.C. and R.D. Kreutzwiser (2000). « Climate variability, climate change, and water resources management in the Great Lakes, » *Climate Change*, 45, 163-179

Dietz, T. and P.C. Stern (2002) *New Tools for Environmental Protection; Education, Information and Voluntary Measures*, National Research Council, Washington, D.C.

Drebot, M.A., H. Artsob and D. Werker (2000), Hantavirus Pulmonary Syndrome in Canada, 1989-1999. *Canada Communicable Disease Report*, 26

Droste R.L, (1997), *Theory and Practice of Water and Wastewater Treatment*, Wiley.

Duncan, K., T. Guidotti, W. Cheng, K. Naidoo, G. Gibson, L. Kalkstein, S. Sheridan, D. Waltner-Toews, S. MacEachern, and J. Last, (1998): Health Sector. In: *The Canada Country Study: Climate Impacts and Adaptation – National Sectoral Volume*, [Koshida, G. and W. Avis (eds)], Environment Canada, Downsview, pp. 501-590.

Eastern Ontario Health Unit (EOHU)(2000), *Statistical Report on Health*, http://www.eohu.on.ca/index_english.htm

Eastern Ontario Health Unit (EOHU)(2001), *Annual Report*, http://www.eohu.on.ca/EN/publications/annualreport_2001_e.pdf

Eastern Ontario Water Resources Management Study (EOWRMS) (2001) *Recommendation Table*, mnss.

FCM (Federation of Canadian Municipalities)(2001a), *Further Analysis on Water, Transportation and Housing Investment Needs*, FCM report submitted to the Federal Government, October 17, 2001.

FCM (Federation of Canadian Municipalities) (2001b), *Early Warning: Will Canadian Cities Compete?*, Report prepared for the National Roundtable on the Environment and the Economy, May.

FCM, Local Action Plans, 2002,

http://www.fcm.ca/scep/case_studies/action_plans/action_plan_index.htm

Fraser Institute (2001), *The Perfect Food in a Perfect Mess: The Cost of Milk in Canada*.

Frewer, L. (1999), "Risk Perception, Social Trust, and Public Participation in Strategic Decision Making: Implications for Emerging Technologies." *Ambio* 28(6):569-574.

GLSLB (Great Lakes-St. Lawrence Basin Project) Lavender, B., J.V. Smith, G. Koshida, and D. L. Morstch (1998), *Binational Great-Lakes-St. Lawrence Basin Climate Change and Hydrologic Scenarios Report*, Unpubl. Mnss.

Gomez, M.A., E. Hontoria, J. Gonzalez-Lopez (2002). Effect of Dissolved Oxygen Concentration on Nitrate Removal from Groundwater Using a Denitrifying Submerged Filter, *Journal of Hazardous Materials*, B90. 267-278.

Gore and Storie (1993) *Final Report for the Wastewater Allocation Study South Nation River*; South Nation River Conservation Authority: Berwick, ON.

Goss, M.J. and D. Goorahoo (1995), Nitrate Contamination of Groundwater: Measurement and Prediction. *Fertilizer Research*. 42: 331-338.

Government of Canada (2002), *Climate Change Plan for Canada*, http://www.climatechange.gc.ca/plan_for_canada/plan/index.html

Government of Ontario (2003), *Protecting Ontario's Drinking Water: Toward a Watershed-Based Source Protection Planning Framework*, Toronto: Queen's Printer.

Government of Ontario (municipal finances):
http://www.omeifa.on.ca
http://www.omex.org
http://www.omwa.org
http://www.smartgrowth.org
http://www.superbuild.gov.on.ca

Government of Ontario (stewardship councils):
http://www.ontariostewardship.org/
http://www.ontariostewardship.org/PRESCOTT/prescot.htm
http://www.ontariostewardship.org/SDG/splash.htm
http://www.modelforest.net/DOCS/windowwoodlots/SteveWilkins_e.pdf

Grenier, S. (2002), *La relation saisonnière chlorophylle a/phosphore et les facteurs de contrôle du phytoplankton dans le basin hydrographique de la Nation Sud.* BSc Honours thesis, Environmental Science Program, University of Ottawa.

Hamilton, P.B., Ley, L.M., Dean, S. and F.R. Pick (2003) *The Occurrence of*

Cylindrospermopsis raciborskii (Woloszynska) Seenay and Subba Raju, in Constance Lake, a New Invasive Cyanoprokaryote to Canada. Submitted.

Haque, E. *et al*. (2000), *Scoping of Issues Concerning Risk Reduction to All Hazards in Canadian Non-Urban Communities*, Final report, Emergency Preparedness Canada within the Canadian Framework for the International Decade for Natural Disaster Reduction, March 20.

Harvey, L. D. D. (2000), *Global Warming*; *The Hard Science*, Prentice-Hall 2000

Haughton, J. (2002), *A State of the Environment Report for the South Nation River Watershed.* BSc Honours thesis, Environmental Science Programme, University of Ottawa (Volume II of this Report). To be posted at www.nation.on.ca/English/wtrmgnt.htm

Health Canada (1998), *Well Water Contaminants: Results from PEAS. Farm Family Health,* Health Protection Branch. Ottawa. Health Canada website.

Health Canada (2002), *Water Quality Activities,* Health Canada website.

Health Canada (HC) (2002) *Making It Clear, Renewing the Federal Regulations on Bottled Water: A Discussion Paper, August.*

Health Canada (2003). *What's in Your Well? A Guide to Well Water Treatment and Maintenance. Fact Sheet,* Healthy Environments and Consumer Safety Branch,.Ottawa.

Health Canada, http://www.hc-sc.gc.ca/pphb-dgspsp/wnv-vwn/

Hewitson, B. (2003), Developing Perturbations for Climate Change Impact Assessments, *Transactions of the American Geophysical Society*, vol. 84, n0 35 (September), p. 337-41.

Hilborn, R., Living with Uncertainty in Resource Management, *North American Journal of Fisheries Management*, 7(1987), 1-5

Houghton, J., Y Ding, D Griggs, M Noguer, P van der Linden, X Dai, K Maskell and C Johnson, eds. (2001), *Climate Change 2001: the Scientific Basis*, Cambridge University Press.

IPCC (Intergovernmental Panel on Climate Change (2000), *Emissions Scenarios*, Cambridge University Press.

IPCC (Intergovernmental Panel on Climate Change) (2001), *Third Assessment Report, Working Group II, Adaptation, Impacts and Vulnerability, Summary for Policy-Makers*, Cambridge University Press and http://www.grida.no/climate/ipcc_tar/wg2/010.htm

Kane, S.M. and J.F. Shogren (2000), Linking Adaptation and Mitigation in Climate

Change Policy, in S.M. Kane and G.W. Yohe, *Societal Adaptation to Climate Variability and Change*, Kluwer (repr. from *Climate Change*, vol. 45, N^0 1, 2000).

Kellogg, Wendy A. (1999), "Community-based Organizations and Neighbourhood Environmental Problem Solving: A Framework for Adoption of Information Technologies." *Journal of Environmental Planning and Management* 42(4):445-465.

Kennedy, M. (2003), "West Nile Will Expand its Range", *Ottawa Citizen*, April 22, A3.

Kitchen, H. (2003), *Municipal Revenue and Expenditure Issues in Canada*, Canadian Tax Foundation, n^0 107.

Krewksi, D., Balbus, J., Butler-Jones, D., Haas, C., Isaac-Renton, J., Roberts, K. and Sinclair, M. 2002. *Managing the Health Risks of Drinking Water*. Walkerton Inquiry Commission Paper.

Kumar, A., I. Burton, and D. Etkin (2000), Managing Flood Hazard and Risk: Report of an Independent Expert Panel (Canada. Office of Critical Infrastructure Protection, Research Report 2000:DO10) http://www.ocipep-bpiepc.gc.ca/research/scie_tech/disMit/Man_Fld_Haz/ 2000-D010_e.asp

Laboratory Centre for Disease Control, 1999. *Adverse health events associated with the 1998 Ice Storm: Report of Hospital Surveillance of the Eastern Ontario Health Unit Region*. Canada Communicable Disease Report, 25-17.

Last and Chiotti, 2001, Climate change and Health, ISUMA, 2: 4: 62 - 69

Last, John and V. Sahni (2002), *Possible Effects of Climate Change in Canada and Eastern Ontario*, mnss. (Volume II of this Report)

Lawrence, Patrick L., J. Gordon Nelson, and Geoff Peach. 1993. "Great Lakes Shoreline Management Plan for the Saugeen Valley Conservation Authority." *The Operational Geographer* 11(2):26-33.

Leech, D. (2002), *Perceptions and Values of Local Decision-Makers; a Survey*, mnss.

Lemay, N. (2002), Eastern Ontario Climate: Variability and Trends during the 20th Century, M. Sc. Thesis, Department of Geography, University of Ottawa (Volume II of this Report).

Lowell, K. and Jaton, A., Ed. (1999), *Spatial Accuracy Assessment: Land Information Uncertainty in Natural Resources*, Laval University

Luk, G.K., W.C. Au-Yeung (2002), Experimental Investigation on the Chemical Reduction of Nitrate from Groundwater. *Advances in Environmental Research* 6: 441-453.

Lunman, K. (2003), West Nile Found in Crow in Ottawa, *Globe and Mail*, May 22, A8.

Margerum, Richard D. (1999), "Integrated Environmental Management: the Foundations for Successful Practice." *Environmental Management* 24(2):151-166.

Martens, P. 1998 Health and Climate change, : Modelling the Impacts of Global Warming and Ozone Depletion, Earthscan.

Mascarin, J. and C. J. Williams (2003), *Ontario Municipal Act, 2001 and Commentary,* Butterworths.

McDuff, M. D. (2001), "Building the Capacity of Grassroots Conservation Organizations to Conduct Participatory Evaluation." *Environmental Management* 27(5):715-727.

McGeehin MA, Mirabelli M., 2001. The potential impacts of climate variability and change on temperature-related morbidity and mortality in the United States. *Environ Health Perspect*. 109 Suppl 2:185-9.

Mc Kibbin, W. J. and P.J. Wilcoxen (2002), The Role of Economics in Climate Change Policy, *Journal of Economic Perspectives*, Spring, vol. 16, number 2, p.107-129.

McMichael, A.J., A.J. Haines, R. Sloof, and S. Kovats, (1996) Climate change and Human Health, WHO.

Meffe, G. *et al*. (2002), *Ecosystem Management : Adaptive Community-based Conservation.* Island Press. Washington, D.C. pp. 313.

Mimikou, M.A., E. Baltas, E. Varanou., and K. Pantazis (2000). « Regional impacts of climate change on water resources quantity and quality indicators, » *Journal of Hydrology*, 234, 95-109.

Naess, L.O., G. Bang and J. Vevatne (2003), *Understanding Institutional Adaptation to Climate Change: Comparative Studies of Responses to Floods at the Municipal Level in Norway*, Paper presented at the Montreal Open Meeting of the Human Dimensions of Global Environmental Change Research Community Conference.

Needham, R.D. (2002), *The Informed Opinion of Municipal Officials: Infrastructure Administration, Planning and Management in Eastern Ontario*, FCM, June 2001.

Needham, R.D. (2003), *Climate Change, Barriers to Learning within the Rural Municipal, Administrative- Managerial Domain*, Presentation at the SLRIES 10th Conference, Cornwall.

New-York State Department of Health:
http://www.health.state.ny.us/nysdoh/westnile/update/2003/wnv_map.gif

O'Connor, D.R.O (2002), *Report of the Walkerton Inquiry. The events of May 2000 and Related Issues*. Part One. Toronto: Ontario Ministry of the Attorney General., Queen's Printer for Ontario.

O'Connor, D.R.O (2002), *Report of the Walkerton Inquiry. A Strategy for Safe Drinking Water*. Part 2, Ontario Ministry of the Attorney General. Queen's Printer for Ontario.

OMMAH (Ontario Ministry of Municipal Affairs and Housing) (1999), *Local Services Realignment: A User's Guide*, Queen's Printer of Ontario.

O'Neil, M. (2002), *Adaptation Strategies/Response Options re Global Warming, unpubl. mnss.*

O'Neill, John. 2001, "Representing People, Representing Nature, Representing the World." *Environment and Planning C: Government and Policy* 19(4).

O'Neill J. and C.L. Spash (2000). "Conceptions of value in environmental decision-making" *Environmental Values*. Volume 9: 521 - 536.

Ontario Ministry of Health and Long-Term Care,
http://www.health.gov.on.ca/english/providers/program/pubhealth/westnile/wnv_03/wnv_surveillance.html

Ontario Health Protection and Promotion Act, 1990, amended 1997.

O'Riordan, T., C.L. Cooper, A. Jordan, S. Rayner, K.R. Richards, P. Runci and S. Yoffe (1998), Institutional Framework for Political Action, in S. Rayner and E.L. Malone, *Human Choice & Climate Change*, vol. 1, Battelle Press, p. 345 - 439.

Oxman, A. D. and Julian , A., 1993. The health impacts of ground-level ozone in Canada. Contract Report No. 3787. Ottawa: Environmental Health Directorate, Health Canada, 50 pp.

Patz J A et al., 2000. The potential health impacts of climate variability and change for the United States; Executive summary of the report of the health sector of the U.S. National Assessment. *Environ Health Perspect*, 108:367-376.

Pelling, M. (1998), Participation, Social Capital and Vulnerability to Urban Flooding in Guyana, *Journal of International Development*, vol. 10, 469-486.

Philippi, Nancy. 1997. *Flood Plain Management: Ecological and Economic Perspectives*. Austin, Texas: Environmental Intelligence Unit, R.G. Landes Company.

Pielke, R.A.Jr. and M.W. Downton (2000). « Precipitation and Damaging Floods: Trends in the

United States, 1932-97, » *Journal of Climate,* American Meteorological Society, 13(15)

Pollution Probe Foundation, 2002. *Adapting Health Infrastructures to cope with Health Effects of Climate Change: A Case Study of the Toronto-Niagara Region.* Pollution Probe Foundation.

Pope III, C.A, Thun, M., Namboodiri, M., Dockery, D., Evans, J., Speizer, F. and Heath, Jr., C., 1995, Particulate Air Pollution as a Predictor of Mortality in a Prospective Study of U.S. Adults, *American Journal of Respiratory Critical Care Medicine*, 151: 669 - 674.

Primeau, S., 1999. Le bassin de la rivière Yamaska: qualité des eaux de 1979 a 1997, section2, dans ministère de l'Environnement (ed.), Le bassin de la rivière Yamaska : état de l'écosysteme aquatique, Québec, Direction des écosystemes aquatiques, envirodoq n°EN990224, rapport n°Ea-14.

Raizenne, M. et al. 1998 Air Pollution exposures and Children 's Health, Canadian Journal of Public Health 85. suppl. 1.

Rideau River Round Table (2001) *State of the River Report: a Report on the Environmental Health of the Rideau River.* www. rideauvalley.on.ca/programs/rrr/rrr.html

Robinson Consultants, (2003), Draft Final Report. *Municipal Groundwater Study; The Nation Municipality.* Draft Report Prepared for the Eastern Ontario Water Resources Committee, October 2003.

Robinson Consultants, (2003), Draft Final Report. *Municipal Groundwater Study; Township of North Dundas*. Draft Report Prepared for the Eastern Ontario Water Resources Committee, October 2003.

Robinson Consultants, (2003), Draft Final Report. *Municipal Groundwater Study; Township of South Storemeont*. Draft Report Prepared for the Eastern Ontario Water Resources Committee, October 2003.

Robinson Consultants, (2003), Draft Final Report. *Municipal Groundwater Study; Township of North Storemont*. Draft Report Prepared for the Eastern Ontario Water Resources Committee, October 2003.

Robinson Consultants, (2003), Draft Final Report. *Municipal Groundwater Study; Township of Russell*. Draft Report Prepared for the Eastern Ontario Water Resources Committee, October 2003.

Robinson Consultants, (2003), Draft Final Report. *Municipal Groundwater Study; City of Ottawa*. Draft Report Prepared for the Eastern Ontario Water Resources Committee, October 2003.

Robinson Consultants, (2003, Draft Final Report. *Municipal Groundwater Study; Township of North Glengarry*. Draft Report Prepared for the Eastern Ontario Water Resources Committee, October 2003.

Ross, Angus, *Climate Change and Its Impact on the Insurance Industry*, Institute of Catastrophic Loss Reduction (ICLR) Research Paper No. 8, June, 2000.

Rounds, Richard C. (1997), *Changing Rural Institutions: A Canadian Perspective.* Pp. 248: Canadian Rural Reconstruction Foundation in cooperation with the Rural Development Institute.

Russell, W.D.R., *Russell on Roads,* forthcoming.

Schwartz J. 1994. What are people dying of on high air pollution days? *Environ Res* 64:26-35.

Schwartz J, Dockery DW, Neas LM. 1996. Is daily mortality associated specifically with fine particles? *J Air Waste Manage Assoc* 46:927 939.

Slaper, H., G.J.M. Velders, J.S. Daniels, F.R. de Gruijl and J.C. Van der Leun (1996) Estimates of Ozone Depletion and Skin Cancer Incidence to Examine the Vienna Convention Achievements. *Nature,* 384, 256-258.

Smit, B. (2003), *Impact and Adaptation Research Methodologies*, C-CIARN Technical Workshop, Montreal., May 12.

Smit, B., I.Burton, R.J.T. Klein, and R. Street (1999), The Science of Adaptation: A Framework for Assessment, *Mitigation and Adaptation Strategies for Global Change*, 4, 199 – 213.

Smit, B., I. Burton, R.J.T. Klein and J. Wandel (2000), An Anatomy of Adaptation to Climate Change and Variability, in S.M. Kane and G.W. Yohe, *Societal Adaptation to Climate Variability and Change,* Kluwer (repr. from *Climate Change,* vol. 45 , N^{0} 1, 2000), 223-51.

Smit, B. and M. W. Skinner (2002), Adaptation Options to Climate Change: A Typology, *Mitigation and Adaptation Strategies for Global Change*, 7, 85 -114.

Smith, G.R. (1998), Are We Leaving the Community Out of Rural Community Sustainability? An Examination of Approaches to Development and Implementation of Indicators of Rural Community Sustainability and Related Public Participation, *International Journal of Sustainable Development and World Ecology* 5(2):82-98.

Soares, M.J.M (2000). Biological Denitrification of Groundwater, *Water, Air, and Soil Pollution,* 123: 183-193.

South Nation Conservation (1997), *Annual Report*.

Spix C., Anderson, H.R., Schwartz, J., Vigotti, M.A., LeTertre, A., Vonk, J.M., Touloumi, G., Balducci, F., Piekarski, T., Bacharova, L., Tobias, A., Ponka, A., and Katsouyanni, K., 1998. Short-term effects of air pollution on hospital admissions of respiratory diseases in Europe: a quantitative summary of APHEA study results. Air Pollution and Health: a European Approach. *Arch Environ Health.* 53(1):54-64.

Sweeney, Michael W. (2001), "Broadening Democracy in Environmental Policy Processes." *Environment and Planning C: Government and Policy* 19:475-481.

Thurston G.D., Ito, K., Hayes, C.G., Bates, D.V., and Lippmann, M., 1994. Respiratory hospital admissions and summertime haze air pollution in Toronto, Ontario: consideration of the role of acid aerosols. *Environ Res.* 65(2):271-90.

Tindall, C.R. and S.N., Tindall (2000), *Local Government in Canada*, 5th ed., Nelson.

UCS-ESA (Union of Concerned Scientists and Ecological Society of America) (2003), *Confronting Climate Change in the Great Lakes Region*, http://www.ucsusa.org/greatlakes/

USGCRP (United-States Global Climate Research Program), Sousounis, P. J. and J.M. Bisanz (2000), *Preparing for a Changing Climate. The Potential Consequences of Climate Variability and Change, Great Lakes* A Summary by the Great Lakes Regional Assessment Group for the U.S. Global Change Research Program, October, http://www.geo.msu.edu/glra/assessment/assessment.html

U.S. Army Engineers Waterways Experiment Station (1995) *CE-QUAL-RIV1: A Dynamic, One Dimensional (Longitudinal) Water Quality Model for Streams: Users Manual*; Report EL-95-2, U.S. Army Engineers Waterways Experiment Station: Vicksburg, MS.

Van Ert, G. (2001) The Problems and Promise of Spraytech v Hudson, xxxix, *Canadian Yearbook of International Law*, 371-385.

Weart, S. (2003), The Discovery of Rapid Climate Change, *Physics Today*, 56, iss. 8 (August), p. (http://www.physicstoday.org/vol-56/iss-8/p30.html , August 28, 2003)

Whipple, William Jr. (2001), "Coordination Between Water Resources Development and Environmental Needs." *Journal of Water Resources Planning and Management* (January/February):1-3.

Wigle, 2001, Sectoral Impacts of Kyoto Compliance, W.P. industry Canada, # 34.

Wilson, D.J. (2000), *Systems Analysis of Decision Support Systems for Water Resource Users and Planners in Eastern Ontario*; Thesis, University of Ottawa: Ottawa, ON.

Woodrow, M. (2002), *Climate Change and Health: A Local Perspective Focusing on Eastern Ontario,* Unpubl. Mnss., Institute of the Environment, University of Ottawa, 2002 (Volume II of this Report).

Yohe, G. and R.S. J. Tol (2002), Indicators for Social and Economic Coping Capacity – Moving Toward a Working Definition of Adaptive Capacity, *Global Environmental Change*, 12, 25 – 40.

Yohe and F. L. Toth (2000), Adaptation and the Guardrail Approach to Tolerable Climate Change, in S.M. Kane and G.W. Yohe, *Societal Adaptation to Climate Variability and Change*, Kluwer (repr. from *Climate Change*, vol. 45 , N^0 1, 2000), 103-128.

Appendix B Project Participants and Education and Training

Faculty

Andrew, Caroline, Professor of Political Science, specializes in municipal governance and sustainability at the local level

Benidickson, Jamie, Professor of Common Law, specializes in municipal governance and environmental law

Carty, Paula, Research Associate**,** McLaughlin Center for Population Health Risk Assessment

Crabbé, **Philippe,** CURA Director, Professor Emeritus of Environmental and Natural Resources Economics, specializes in climate change and sustainability

Droste, **Ronald,** Professor of Civil Engineering, specializes in Wastewater treatment and Watershed Management

Krewski, Daniel, Professor of Epidemiology, specializes in risk management and air quality

Lagarec, **Daniel**, Professor of Geography, member of the CURA Management Committee, specializes in climate change and sustainability

Last, John, Professor Emeritus Epidemiology, health effects of climate change

Lean, **David,** Professor of Biology, specializes in Ecotoxicology

Narbaitz, **Roberto,** Professor of Civil Engineering, specializes in wastewater treatment

Needham, **Roger D**., Associate Professor of Geography, member of the CURA Management Committee, specializes in Natural Resources Management and Institutions

Pick, **Frances,** Professor of Biology, specializes in river ecology

Robin, **Michel,** Associate Professor of Earth Sciences, member of the CURA Management Committee, specializes in Hydrogeology

Woodrow, Maureen, Research Associate, Institute of the Environment

Students and Post-doc

Alam, Rafat, Doctoral candidate (Economics), assists Philippe Crabbé

Aurelson, **Izabella,** B.A. (Geography), assists Roger Needham

Ait - Ouyahia, Meriem, Doctoral candidate (Economics), assists Philippe Crabbé

Berke, Jordana, LL.B., assists Jamie Benidickson

Boisvert, Andreanne, M.A. (Geography), assists Roger Needham

Brescacin, Nadia, B. A. (Geography), assists Roger Needham (undergraduate thesis: **"**Municipal Ability to Protect Wetlands under Climate Change Stress**"** Director: R. Needham)

Burhoe, **David,** M.A. (Geography), assists Roger Needham and Philippe Crabbé (Master's Thesis: "Municipal Capacity to Implement an Ecosystem Approach in Coastal Zone Management, St. Lawrence River", Director: R. Needham)

Carberry, **Dasha,** Master's candidate in Ecotoxicology, assists David Lean

Daneshfar, **Bahram,** Post-doctoral Fellow, assists Michel Robin

Deslauriers, Rachel, M.A. (Geography), assists Daniel Lagarec (Master's thesis: "Le défi de l'Est Ontarien: la gestion de l'eau dans un contexte de changement", Director: D. Lagarec)

Godin, Claire B. A. (Geography), assists Daniel Lagarec

Leech, **David** Doctoral candidate (Political Science), assists Caroline Andrew

Lemay, Nancy, M. Sc. (Geography), assists Konrad Gajewski (Master's thesis: "Eastern Ontario Climate: Variability and Trends during the 20th Century, 2003"; Director: K. Gajewski)

Lyon, **Vanessa**, Master's candidate (Biology), assists Frances Pick

Nicholson, Chantal, B. A. (Geography)**,** assists Roger Needham

Normand, Vanessa, M.A. (Geography)**,** Assists Daniel lagarec

Nott, Adam, LL.B., assists Jamie Benidickson

O'Neill, Michael, LL.M., assists Jamie Benidickson

Paris, **Véronique,** Master's candidate (Civil Engineering), assists Roberto Narbaitz

Parker, **Geoffrey,** Master's candidate (Civil Engineering), assists Ronald Droste

Richard, François**,** Ph.D**.** (Earth Sciences), assists Michel Robin

Roch, Marie, assists Daniel Lagarec

Watelet, **Anne**, Ph**.** D. (Geography), assists Daniel Lagarec

Yang, Yiqun, M.A. (Economics), assists Daniel Krewski

Administrative support

Jones Hurd, Robert,data collection**,** assists Francis Pick

Makunan, Masidi, data collection, assists Maureen Woodrow

Marvin, Kristin, data collection, assists Maureen Woodrow

Renaud, Russell, Project Administrator

Appendix C: Press Releases

PRESS RELEASE

November 21 2003

Preparing Eastern Ontario Water-related Institutions for Climate Change

Climate projections tell us that Eastern Ontario can expect a climate moving to the one currently experienced in Northern Virginia during the course of this century.

A multidisciplinary group of researchers at the University of Ottawa has been investigating the institutional implications of such changes on water – related infrastructures for small municipalities in Eastern Ontario. This work has been carried out during the last four years in collaboration with the Eastern Ontario Water Resources Committee (EOWRC), the Federation of Canadian Municipalities (FCM), and the St. Lawrence River Institute of Environmental Sciences with funding from the Social Sciences and Humanities Research Council of Canada.

Results:

- ✓ Climate change is not all doom and gloom for Eastern Ontario, far from there.
- ✓ It does, however, require that attention be given to some potentially nasty localized problems.

What Does Climate Change Mean for Eastern Ontario And What Can We Do About It?

- ✓ Climate change projections tell us that we can expect:
  - o with considerable uncertainty,
  - o a climate changing progressively over a century
  - o but not necessarily smoothly
  - o towards the one currently experienced in Northern Virginia
- ✓ This is not bad news for agriculture and agricultural property taxes (more corn, more soybeans, less hay!).

- ✓ Climate change comes on top of
  - o demographic pressures around Ottawa,
  - o economic pressures (hog – farms, ethanol production, large increase in assessed agricultural land value), and

- heavy agricultural pollution on the South-Nation River
- provincial reorganization of municipal and drinking water responsibilities, and on
- cash - strapped institutions such as municipalities and Conservation Authorities.
- aging and sometimes inadequate water-related infrastructures.

✓ Best Management Practices such as
- wetland protection and creation,
- development of buffer zones along watercourses,
- mandated reductions of agricultural pollution by municipalities and Conservation Authorities

are measures which could go a long way in adapting to climate change.

✓ We can expect:
- lower water levels, and earlier peak flows in rivers.
- more rain (including ice storms) in the winter than in the summer, during which droughts, like those of 2001 and 2002, are likely to become more frequent.
- No general drinking water scarcity problem is expected for the region on a yearly basis even under unusually dry weather scenarios.
- Localized quantity and quality problems during wet periods following dry summer months are likely to occur especially in groundwater recharge areas.
  - These require the immediate attention of local municipalities and Conservation Authorities in terms of well protection, groundwater recharge and animal waste applications over which municipalities and Conservation Authorities have little control.

✓ The current high level of coliform bacteria found in groundwater is a concern, especially in agriculture-intensive areas and dug wells.
- Nitrate does not seem to constitute a current problem.

✓ Water-treatment and wastewater treatment plant capacity is generally adequate in the region even when handling the larger volume of rainwater expected during the winter;
- wastewater quality fluctuations and rainwater infiltration into sewers are likely to occur, however, and require municipal attention.

✓ Required measures:
- Consumers will have to pay for water according to their consumption – more per liter as they consume more; this will increase water conservation and yield revenues to invest in water infrastructures.
- Provincial regulations governing large water consumers will have to be overhauled to insure better monitoring of water consumption, more municipal responsibility in its management, and more revenue generation.

What Existing Institutional Barriers Need to Be Removed for Climate Change Adaptation to Become a Local Government Concern?

- ✓ Many barriers lay in the way of institutional adaptation to climate change:
  - o location of infrastructures in conflict with current development pressures;
  - o insufficient municipal autonomy on water and agricultural pollution management;
  - o absence of management planning over the life of infrastructures;
  - o inadequate long-term municipal financing;
  - o lack of information on climate change impacts on infrastructure design;
  - o overdependence on engineering consultants.
  - o insufficient cooperation at the regional level:
    - on infrastructure data-bases
    - on regional water supply and demand projections, and
    - with stakeholders such as the insurance industry.

Planned adaptation is likely to reveal new economic opportunities and cost less money to taxpayers (especially in terms of environmental services) than adaptation by crisis such as the response to the 1998 ice storm.

- ✓ Some bridges which could help overcome these barriers are:
  - o recognition of climate change as a "Provincial Interest" in the Provincial Planning Act;
  - o reform of municipal finances on both the revenue and capital expenditure side;
  - o improved access to provincial funding sources.
  - o Recognition by the Province of
    - the benefit of assessments conducted by municipalities to determine which of their assets are the most vulnerable to climate change and
    - which adaptation measures are the most appropriate.

Four existing institutions and windows of opportunity can be relied on by municipalities to build an effective Climate Change Strategy on the tripod of a watershed/region perspective, credibility, and expertise:

- ✓ Conservation Authorities which offer
  - o their science-based watershed perspective
  - o strong involvement in local knowledge networks.

- ✓ EOWRC,
  - o which holds strong ties with Conservation Authorities, municipalities, and agricultural stakeholders, and
  - o offers a regional perspective.

- ✓ The Eastern Ontario Health Unit
  - o which has responsibilities towards vulnerable populations during intense heat periods such as
    - the very young (indoors and outdoors allergies),
    - the very old (heat strokes, respiratory ailments) and
    - those with pre-existing heart conditions.

- Its messages about health impacts of climate change (e.g. West Nile virus) are credible and carefully monitored by the population.

✓ Citizens' committees, used by many municipalities and Conservation Authorities, allow the voluntary recruitment of climate experts available in local universities and colleges.
  - These experts will have to insure that the climate information they provide is
    - consistent,
    - credible,
    - downscaled at the local level,
    - pertinent to specific municipal infrastructures and professional groups,
    - communicable to the laymen and the media, and
    - highlights the benefits of early planned adaptation.

✓ Windows of Opportunity
  - Emergency Planning currently required from municipalities by the Province to address climate change adaptation.
  - voluntary climate change programs of FCM and
  - the soon to be mandated ones from the Federal Government.

Contact: Professor P. Crabbé
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COMMUNIQUÉ DE PRESSE
2003-11-24

Préparer aux changements climatiques les institutions reliées à l'eau dans l'Est de l'Ontario

Les projections climatiques nous disent que l'Est de l'Ontario peut s'attendre à un climat évoluant sur l'espace d'un siècle, de son état actuel vers celui présentement vécu en Virginie septentrionale.

Un groupe multidisciplinaire de chercheurs de l'Université d'Ottawa a investigué les implications institutionnelles d'un tel changement sur les infrastructures reliées à l'eau appartenant aux petites municipalités dans l'Est de l'Ontario. Cette recherche a été menée durant les quatre dernières années en collaboration avec le Comité des Ressources en Eau de l'Est de l'Ontario (CREEO), la Fédération Canadienne des Municipalités (FCM) et l'Institut des Sciences Environnementales du Fleuve St- Laurent (ISEFSL) grâce au financement obtenu du Conseil de Recherche en Sciences Sociales et Humaines du Canada.

Résultats

- ✓ Le changement climatique ne sera nullement un désastre pour l'Est de l'Ontario, loin de là.
- ✓ Il doit cependant retenir l'attention en rapport avec certains problèmes locaux potentiellement méchants.

Qu'est-ce que le changement climatique signifie pour l'Est de l'Ontario et que pouvons - nous faire à son sujet?

- ✓ Les projections du changement climatique nous disent de nous attendre:
  - o Avec beaucoup d'incertitude
  - o À un climat changeant progressivement au cours d'un siècle
  - o Mais pas nécessairement sans heurt
  - o Vers le climat actuel de la Virginie du Nord
- ✓ Ceci n'est pas une mauvaise nouvelle pour l'agriculture et les taxes foncières agricoles (plus de ma?s, plus de soja, moins de foin!)

- ✓ Le changement climatique vient en sus de
  - o Pressions démographiques aux environs d'Ottawa
  - o Pressions économiques (fermes porcines, production d'éthanol, forte augmentation de l'évaluation foncière agricole) et
  - o Forte pollution agricole le long de la rivière Nation - Sud
  - o Réorganisation provinciale des responsabilités municipales et en matière d'eau potable

- Institutions sous - financées telles que les municipalités et les Agences de Conservation
- Infrastructures vieillissantes et parfois inadéquates reliées à l'eau

✓ Meilleures Pratiques de Gestion telles que :
- La protection et création de milieux humides
- Le développement de zone - tampons le long des cours d'eau
- Les réductions obligatoires de pollution agricole exigées par les municipalités et Agences de Conservation

Sont des mesures qui peuvent aller loin dans l'adaptation au changement climatique.

✓ Nous pouvons nous attendre à
- Des niveaux d'eau plus bas et des crûes plus avancées dans la saison pour les rivières
- Plus de pluie (incluant des pluies verglaçantes) en hiver qu'en été, pendant lequel des sécheresses, comme celles de 2001 et 2002, seront vraissemblablement plus fréquentes
- Aucune rareté généralisée de l'eau potable pour la région sur une base annuelle même pour des scénarios de temps sec peu commun
- Des problèmes localisés de quantité et de qualité d'eau pendant des périodes humides suivant des mois secs pendant l'été, spécialement dans les aires de recharge des eaux souterraines
  - Celles-ci requièrent l'attention immédiate des municipalités locales et des Agences de Conservation en terme de protection des têtes de puits, de recharge des eaux souterraines et des applications de purin animal sur lesquelles les municipalités et Agences de Conservation ont peu de contrôle.

✓ Le haut niveau actuel de bactéries coliformes trouvées dans les eaux souterraines est une préoccupation, surtout dans les aires d'agriculture intensives et dans les puits creusés
- Le nitrate ne paraît pas être un problème sérieux.

✓ La capacité des usines de traitement d'eau potable et des eaux usées est généralement adéquate dans la région même pour traiter une plus grande quantité d'eau de pluie attendue pendant l'hiver
- Des fluctuations de qualité des eaux usées et infiltrations d'eau de pluie dans les égouts sont cependant probables et requièrent l'attention des municipalités.

✓ Mesures requises :
- Les consommateurs devront payer pour l'eau selon leur consommation – davantage par litre consommé; cette mesure augmentera la conservation de l'eau et générera des revenus à investir dans les infrastructures reliées à l'eau.
- Les règlements provinciaux gouvernant les gros consommateurs d'eau devront être révisés pour assurer un meilleur contrôle de la consommation d'eau, plus de responsabilité municipale dans sa gestion, et plus de génération de revenu.

Quelles barrières institutionnelles doivent être démontées pour que l'adaptation au changement climatique devienne une préoccupation des gouvernements locaux?

- ✓ De nombreuses barrières entravent l'adaptation institutionnelle au changement climatique :
    - o Localisation d'infrastructures en conflit avec les pressions de développement actuel
    - o Insuffisante autonomie municipale sur l'eau et la gestion de la pollution agricole
    - o Absence de gestion planifiée sur l'ensemble de la vie des infrastructures
    - o Financement municipal à long - terme inadéquat
    - o Manque d'information sur les impacts du changement climatique sur le design des infrastructures
    - o Sur - dépendance vis-à-vis des consultants en ingénierie
    - o Coopération insuffisante au niveau régional :
        - ▪ Sur les bases de données concernant les infrastructures
        - ▪ Sur les projections régionales d'offre et de demande d'eau et
        - ▪ Avec les parties prenantes telles l'industrie de l'assurance

L'adaptation planifiée révélera probablement des opportunités économiques nouvelles et coûtera mains d'argent aux payeurs de taxes (surtout en services environnementaux) que l'adaptation par crise telle que la réponse à la pluie verglaçante de 1998.

- ✓ Quelques ponts, qui pourraient surmonter ces obstacles, seraient :
    - o La reconnaissance du changement climatique comme « Intérêt provincial » dans la loi provinciale sur la planification
    - o Réformes aux finances municipales tant du côté revenus que des dépenses en capital
    - o Accès plus facile aux sources de financement provincial
    - o Reconnaissance par la Province :
        - ▪ Du bénéfice des évaluations menées par les municipalités pour déterminer lesquels de leurs avoirs sont les plus vulnérables aux changements climatiques et
        - ▪ Quelles mesures d'adaptation sont les plus appropriées

Quatre institutions existantes et fenêtres d'opportunité peuvent servir aux municipalités pour bâtir une Stratégie de Changement Climatique efficace sur le tripode d'une perspective de bassin versant/régionale, de crédibilité et d'expertise :

- ✓ Les Agences de Conservation qui offrent;
    - o Une perspective de bassin versant fondée sur une assise scientifique
    - o Une forte implication dans les réseaux locaux d'information

- ✓ CREEO
    - o Qui maintient de forts liens avec les Agences de Conservation, les municipalités, et les parties prenantes agricoles, et
    - o Offrent une perspective régionale
- ✓ L'Unité de Santé de l'Est de l'Ontario

- Qui a des responsabilités vis-à-vis des populations vulnérables, surtout en périodes de grosse chaleur, telles que
  - Les très jeunes (allergies à l'intérieur et l'extérieur)
  - Les très âgés (attaques cardiaques, maladies respiratoires) et
  - Ceux affectés par une condition cardiaque pré - existante
- Ses messages sur les impacts sanitaires du changement climatique (par exemple, Virus du Nil Occidental) sont crédibles et soigneusement suivis par la population

✓ Les Comités de citoyens, utilisés par de nombreuses municipalités et Agences de Conservation. Ils permettent le recrutement d'experts climatiques bénévoles disponibles dans les université et collèges locaux.
- Ces experts devront s'assurer que l'information climatique qu'ils offrent est
  - Cohérente
  - Crédible
  - Réduite à l'échelle locale
  - Pertinente à des infrastructure municipales spécifiques et aux groupes professionnels
  - Communicable aux non-spécialistes et aux médias et
  - mettent en vedette les bénéfices d'une adaptation planifiée anticipée

✓ Les fenêtres d'opportunité
- Insertion de l'adaptation au changement climatique dans la Planification d'urgence présentement requise des municipalités par la Province
- Programmes optionnels de protection contre le changement climatique de FCM et
- Les mesures obligatoires requises bientôt par le gouvernement fédéral.

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