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Climate Change in the North Bay-Algonquin Park Region of Ontario: Water Quality and Quantity

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"Climate has most effect on the natural systems of the landscape. No engineering can shield a forest or cover a watershed. Adapting to change in our terms has largely to do with how we manage our use of natural resources as they react to changing conditions – to temperature and rainfall, fire and insect pests, drought and flooding. Designing and redesigning with nature with as good an eye to the future as uncertain projections will allow, is the only sustainable approach. Adaptive management in the light of ongoing risk assessments means, first and foremost, understanding ecological and hydrological systems as best we can."

Pearson and Burton (2009)

Introduction

There is now broad international scientific agreement that human activities are primarily responsible for recently documented climate change (e.g., IPCC 2007). This has largely been attributed to the release of greenhouse gases (GHGs) into the atmosphere, which have caused warming temperatures, and have changed precipitation regimes and increased extreme weather events. Since the Intergovernmental Panel on Climate Change (IPCC) released its first report in 1990, average global temperature increases of about 0.2°C per decade have been observed, contributing to an average global temperature increase of 0.74°C during the period 1906-2005 (IPCC 2007).

Long-term changes to temperature and precipitation are expected because of climate change. Under low GHG emissions scenarios, the IPCC (2007) predicts a likely global temperature increase of 1.1°C to 2.9°C by 2100. In their worst case GHG emissions scenarios, however, the IPCC (2007) predicts that average global temperatures could increase as much as 6.4°C by 2100. Increases in temperature and the amount of precipitation are most likely to occur in high latitude regions (IPCC 2007). Furthermore, it is almost assured that hot extremes, heat waves, and heavy precipitation events will continue to become more frequent. Importantly, scientific observations are increasingly showing that many impacts of climate change are occurring faster and sooner than projected (Pearson and Burton 2009). In this sense, some current projections of climate change likely represent conservative estimates.

While these trends are expected to continue well into the future, the extent of climate change will largely depend on the level of GHG emissions mitigation around the world. Failure to reduce international GHG emissions will lead to more significant changes and increased risk of impacts. However, even if GHGs were dramatically reduced today, anthropogenic warming and sea level rise would continue for centuries due to the time scales associated with climate processes and feedbacks. For example, the IPCC (2007) has predicted that even with concentrations of all GHGs and aerosols kept at year 2000 levels, a further warming of about 0.1°C per decade is expected. These predictions point to the need for adaptation to climate change as well as for reducing sources of GHG emissions.

The objective of this report is to address the expected changes and potential effects of climate change on water quality and quantity in the North Bay-Algonquin (NBA) Region of Ontario (Figure 1). It is based on the results of other studies many of which have focussed on the Great Lakes Basin. Roughly half of the NBA Region falls within the eastern portion of the Great Lakes Basin. This report was adapted from Prno and Quinby (2010) and builds on Quinby and Prno (2010).

Expected Changes

In Ontario, climate change is expected to affect water quality (including drinking water), stream flow, lake levels, groundwater infiltration, and patterns of groundwater recharge to streams (de Loe and Berg 2006, Chiotti and Lavender 2008, Pearson and Burton 2009). For example, changes in seasonal and annual flow variability may alter the groundwater recharge, which is critical to the supply of drinking water. Increased water temperature, reduced stream flow, and changing lake levels may also influence the water quality of a surface water source (Ontario Ministry of Environment 2006).

Figure 1 – Core Area of the North Bay-Algonquin Park Region (adapted from Near North Ontario 2017)

Expected hydrological changes in the Great Lakes Basin because of climate change have been summarized by de Loe and Berg (2006), drawing on a number of previous studies (e.g., Lavender et al. 1998, Bruce et al. 2000, Mortsch et al. 2000, Kling et al. 2003, Great Lakes Water Quality Board 2003, Bruce et al. 2006). Expected impacts within the Great Lakes Basin are generally applicable to the NBA Region as the western part of the NBA Region is located within the Great Lakes Basin. Furthermore, some of the studies reviewed by de Loe and Berg (2006) have geographic boundaries extending into the Great Lakes-St. Lawrence system more broadly, thus completely encompassing the NBA Region (e.g., Lavender et al. 1998, Mortsch et al. 2000). Expected changes are summarized in Table 1.

Table 1 – Expected Hydrological Changes in the Great Lakes Basin Due to Climate Change
(from de Loe and Berg 2006)

Hydrologic Parameter	Expected Changes in the 21st Century, Great Lakes Basin
runoff	• decreased annual runoff, but increased winter runoff • earlier and lower spring freshet • summer and fall low flows are lower and last longer • increased frequency of high flows due to extreme precipitation events
lake levels	• lower net Basin supplies and declining levels due to increased evaporation and timing of precipitation • increased frequency of low water levels
groundwater recharge	• decreased groundwater recharge, with shallow aquifers being especially sensitive
groundwater discharge	• changes in amount and timing of baseflow to streams, lakes, and wetlands
ice cover	• ice cover season reduced or eliminated completely
snow cover	• reduced snow cover (depth, area, and duration)
water temperature	• increased water temperature in surface water bodies
soil moisture	• soil moisture may increase by as much as 80% during winter in the Basin, but decrease by as much as 30% in summer and autumn

Generally, annual runoff is expected to decrease, although increased winter runoff and high flows due to extreme precipitation events throughout the year are expected. Lake levels are expected to decline and groundwater recharge is expected to decrease. There will be changes to groundwater discharge in the amount and timing of baseflow to streams, lakes, and wetlands, and ice cover on lakes is expected to be reduced or eliminated completely over time. Snow cover will also be reduced and water temperature in surface water bodies will increase. Finally, it is expected that soil moisture will increase in the winter, but decrease in the summer and autumn.

It is important to note that these expected changes have been generalized for a large region (e.g., the Great Lakes Basin and/or Great Lakes-St. Lawrence system). Regional and local variables could affect the degree to which any of these (or other) changes are applicable to the NBA Region. Locally-based projections of climate change can be obtained through a downscaling process.

Potential Impacts

Potential impacts from climate change that may be pertinent to water resources planning in Ontario have been summarized by de Loe and Berg (2006). They draw on a number of previous studies (e.g., Lavender et al. 1998, Bruce et al. 2000, Great Lakes Water Quality Board 2003, Kling et al. 2003, Auld et al. 2004, Bruce et al. 2006) with a focus primarily on the Great Lakes Basin. These potential impacts are described in Table 2.

Table 2 – Potential Impacts of Climate Change on Water Resources in the Great Lakes Basin
(from de Loe and Berg 2006)

Type of Change	Potential Impacts of Change
frequency of extreme rainfall events	• greater frequency of waterborne diseases • increased transportation of contaminants from the land surface to water bodies
runoff	• increased stress on fish habitat due to reduced stream flows • reduced water quality because less water is available for dilution of sewage treatment plant effluents and runoff from agricultural and urban land • increased erosion from flashier stream flows • increased water treatment costs due to decreased water quality • increased competition and conflict over reduced water supplies during drought periods • increased frequency of flooding-related damage due to more high intensity storms
groundwater recharge and discharge	• changes to wetland form and function as discharge decreases • greater costs for groundwater-dependent communities, industries and rural residents associated with deepening wells • increased conflict because of additional competition for scarcer supplies • increased frequency of shallow wells drying up in rural areas • greater frequency of low flows in streams dependent on baseflow, causing increased competition and conflict, and increased stress on aquatic ecosystems
lake levels	• changes to coastal wetland form and function because of declining lake levels • decreased water quality resulting from lower water volume, increased non-point source pollution, and increased chemical reactions between water, sediments and pollutants • increased water treatment costs due to reduced lake water quality • increased costs associated with moving water supply intakes • greater costs to marina operators due to increased need for dredging of harbours and channels • increased costs to commercial navigation due to lighter cargos as a result of shallower water levels • reduced hydropower production due to lower flows between connecting channels
ice cover	• longer navigation season due to reduced ice thickness and shorter ice cover season • increased shore erosion and sedimentation • increased water temperatures due to decreased ice cover
water temperature	• increased stress on fish habitat due to increases in water temperature • reduced water quality resulting from greater biological activity (e.g., algae production) as water temperature increases • greater frequency of taste and odour problems in drinking water supplies
soil moisture	• increased stress on plants due to decreased summer soil moisture • increased demand for irrigation to supplement soil moisture on drought prone soils

Generally, increased frequency of waterborne diseases and the transportation of contaminants into water bodies are expected to occur due to more frequent extreme rainfall events. Projected changes in runoff will increase stress on fish habitat, reduce water quality, increase water treatment costs, increase conflict over reduced water supplies, increase erosion from flashier stream flows, and increase the frequency of flooding-related damage from high intensity storms. Projected changes in groundwater recharge and discharge will increase the frequency of shallow wells drying up and impose costs associated with deepening wells. These changes will also cause increased conflict due to scarcer water supplies, place increased stress on aquatic ecosystems, and cause changes to wetland structure and function.

Lower lake levels will increase costs associated with water treatment, with moving water supply intakes, with dredging harbours and channels, and for commercial shipping. Changes to coastal wetland form and function are also expected, as is a decrease in water quality and a reduction in hydropower production. Reductions in lake ice cover will increase shore erosion and sedimentation and increase water temperatures. Reduced ice cover will also enable a longer navigation season due to reduced thickness and a shorter ice cover season. Increases in water temperature are projected to cause stress on fish habitat and reduce water quality due to greater biological activity. Taste and odour problems in drinking water supplies are also expected to increase. Finally, projected changes to soil moisture are expected to increase stress on plants and increase the demand for irrigation.

The findings presented in Table 2 are also consistent with more recently published work on climate change and water resources in Ontario (e.g., Chiotti and Lavender 2008, Pearson and Burton 2009). However, in some cases, other studies provide additional context and information. For example, the Expert Panel on Climate Change Adaptation (Pearson and Burton 2009) notes that streams flowing in and out of some small lakes may also dry up for as long as several weeks in the summer. More frequent spring, summer, and fall rainstorms will increase the risk of flooding, and will increase the erosion of riverbanks and the turbidity of drinking water sources. Increased lake effect precipitation is also likely to occur in the lee of the Great Lakes because of more ice-free, open water in winter. Along with an earlier spring, this may in turn lead to a greater volume of spring run-off.

Although Chiotti and Lavender (2008) note that quantity of source water is not a present concern in central Ontario (which includes the NBA Region) and population growth is not projected to add additional stress, decreased water quality associated with climate change could increase treatment costs. Furthermore, the Expert Panel on Climate Change Adaptation (Pearson and Burton 2009) states that lakes affected by earlier spring warming and later cooling in the fall will stratify into a warm upper layer and lower cool water sooner in the year, increasing the risk of very low oxygen concentrations developing in cool, lower water. Low oxygen concentrations at intake pipe locations could also result in deteriorated water quality due to changes in chemical processes at the surface of lake bottom sediments.

Increased incidences of extreme weather events due to climate change will also pose additional local risks. Figure 2 shows that the number of hydro-meteorological disaster events in Canada has increased exponentially since around 1960 relative to geophysical disasters, which have remained relatively constant since 1900. The mean number of natural disasters in Canada in the 1990s increased more than 6-fold since the period 1900 to 1960 at an annual cost of $1,371 billion (Table 3). The number of people affected by these disasters also increased 31-fold during this time period.

Figure 2 - Number of Natural Disasters in Canada from 1900 to 2002 (data from Etkin et al. 2004; graphics from Séguin and Berry 2008)

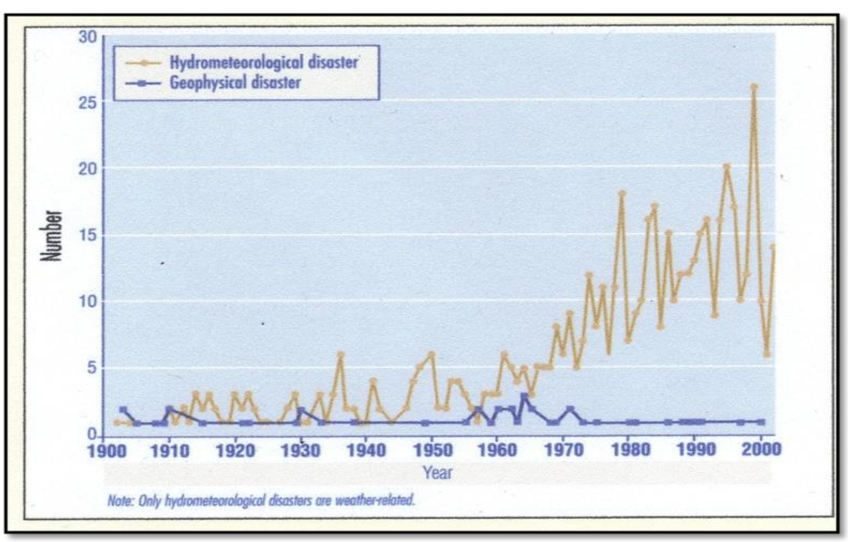


Table 3 - Natural Disasters in Canada from 1900 to the 1990s (from Séguin and Berry 2008)

Disaster Feature	1900-1960s (annual mean)	1970s (annual mean)	1980s (annual mean)	1990s (annual mean)
number of disasters	2.3	9.2	11.4	15.1
number of deaths	43	11	28	18
number affected	2,321	2,528	5,029	71,263
costs (direct damage; billions of dollars)	$69.7	$971.2	$1,762	$1,371

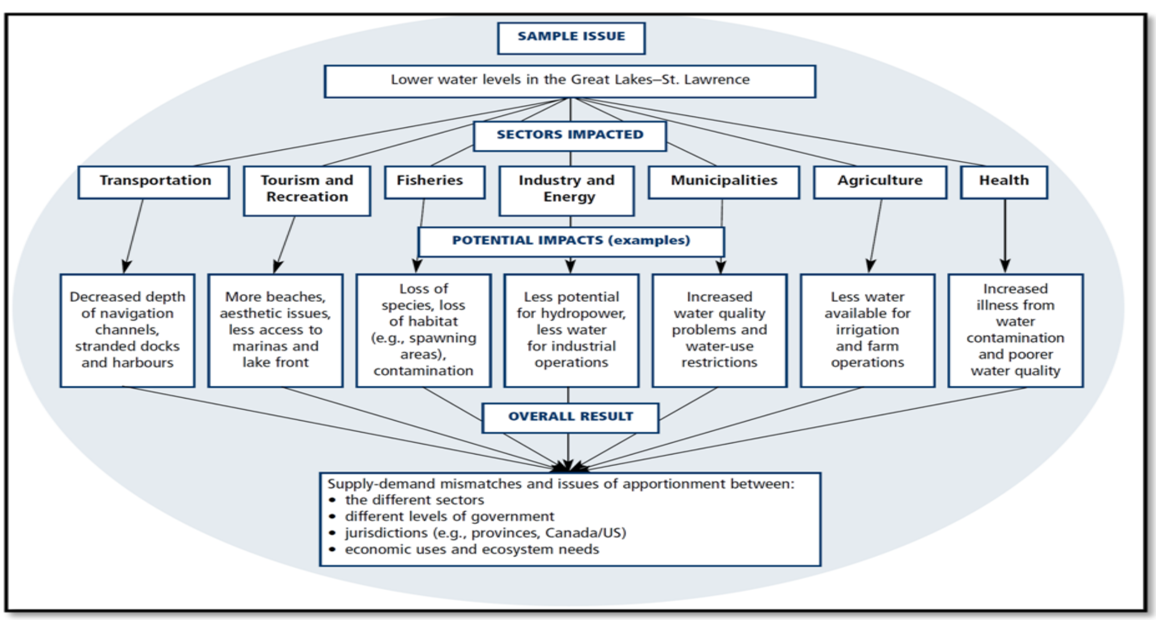
A number of major natural disasters that have occurred in central Ontario over the last 25 years are briefly described in Table 4. The most extreme event was the ice storm of 1998 that affected much of eastern Canada and parts of the northeastern U.S. The damage costs of this storm have been estimated at $5.4 billion. Three flooding events caused damages to city infrastructure and property ranging from $40 to $500 million, and a tornado in Barrie in 1985 caused $100 million in damages. In 2008, flooding in East Ferris and Bonfield Townships, within NBA Region, caused $2.4 million in damages. It is generally accepted by experts that extreme weather events resulting in costly natural disasters will become more frequent as climate continues to change in the future.

Table 4 - Some Extreme Weather Events in Central Ontario Since 1985

Location	Year	Extreme Event	Damage Costs
eastern Ontario (also occurred in Quebec and Atlantic provinces)	1998	ice storm	$5,400 million
Toronto	2005	flooding (local rainfall)	$500 million
Peterborough	2004	flooding (local rainfall)	$112 million
Barrie	1985	tornado	$100 million
Sudbury	2009	flooding (local rainfall)	$40 million
East Ferris & Bonfield Townships (SP Area)	2008	flooding (local rainfall)	$2.4 million

Water and climate change issues are interdisciplinary in nature and have the potential to affect numerous sectors. Figure 2 illustrates some of these cross-cutting issues as they relate to decreasing water levels in the Great Lakes-St. Lawrence Basin, and provides examples of potential impacts on sectors such as transportation, tourism and recreation, fisheries, industry and energy, municipalities, agriculture, and health. Due to their crosscutting nature, climate change and water issues can rarely be managed in isolation; their potential impacts on other sectors, levels of government, jurisdictions, economics, and ecosystem function must also be considered.

Figure 2 - Crosscutting Nature of Water Issues (from Lemmen and Warren 2004)



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