Changing Climate – a Challenge and an Opportunity

Background Paper

June 2015

KAWARTHA CONSERVATION

Discover · Protect · Restore

About Kawartha Conservation

Who we are

We are a watershed-based organization that uses planning, stewardship, science, and conservation lands management to protect and sustain outstanding water quality and quantity supported by healthy landscapes.

Why is watershed management important?

Abundant, clean water is the lifeblood of the Kawarthas. It is essential for our quality of life, health, and continued prosperity. It supplies our drinking water, maintains property values, sustains an agricultural industry, and contributes to a tourism-based economy that relies on recreational boating, fishing, and swimming. Our programs and services promote an integrated watershed approach that balances human, environmental, and economic needs.

The community we support

We focus our programs and services within the natural boundaries of the Kawartha watershed, which extend from Lake Scugog in the southwest and Pigeon Lake in the east, to Balsam Lake in the northwest and Crystal Lake in the northeast – a total of 2,563 square kilometres.

Our history and governance

In 1979, we were established by our municipal partners under the Ontario *Conservation Authorities Act*.

The natural boundaries of our watershed overlap the six municipalities that govern Kawartha Conservation by representation on our Board of Directors. Our municipal partners include the City of Kawartha Lakes, Region of Durham, Township of Scugog, Township of Brock, Municipality of Clarington, Municipality of Trent Lakes, and Township of Cavan Monaghan.

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Executive Summary

Kawartha Conservation is the watershed management agency delivering local services and programs that protect and manage our water and other natural resources. Our vision for the future is "***a sustainable watershed with clean and abundant water and natural resources assured for future generations.***" As changing climate puts this vision at risk, we recognize that the response to this challenge must become part of our core business.

As a leader in watershed management, Kawartha Conservation collaborates with our member municipalities and partner agencies in developing and implementing a wide range of programs, and also proposes the development of management programming to mitigate and adapt to climate changes. This background paper presents a framework for a Kawartha Conservation Climate Change Strategy and is based on extensive literature research.

Key Topics

- Analysis of observed changes in weather and climate and their future projections;
- Impacts of changing climate on the natural environment and society;
- National and provincial frameworks and actions on climate change;
- Response to climate change by Ontario municipalities, Conservation Authorities, and NGOs;
- Mitigation and adaptation: planning for the future; and
- Framework for a climate strategy for Kawartha Conservation.

It is globally recognized that changing climate is one of the most urgent challenges of our time. The Intergovernmental Panel on Climate Change, in its Fifth Assessment Report, released in 2013, states that "Warming of our climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, the sea level has risen, and the concentrations of greenhouse gases have increased." Furthermore, the World Meteorological Organization confirmed that the that fourteen of the fifteen warmest years on record have all occurred in the 21st century, with 2014 being the hottest ever observed.

The climate in our watershed is becoming warmer, especially in winter and spring. Winters are getting milder, and the coldest days are not as cold as they used to be. The amount of snowfall is decreasing but, at the same time, rain events during the winter months are becoming more frequent and abundant. In summer months, the hottest days are hotter and heat waves last longer. As warmer air can hold more moisture, precipitation events become less frequent but more intense.

These changes are already affecting components of the hydrological cycle (precipitation, runoff, and evapotranspiration). We must become much more prepared to manage significant changes in water availability and distribution.

Relevant Changes

- Changes in precipitation patterns increase winter and yearly spring runoff, bringing greater threats of mid-winter and spring flooding, similar to events observed on the Burnt and Gull rivers in 2013 and 2014.

- The spring freshet occurs earlier and is generally lower.
- Summer and fall low flows are lower and last longer. Over the last 15 years, our watershed has experienced low water conditions in 1999, 2000, 2001, 2005, 2007, and 2012.
- More intense precipitation increases the occurrence of flooding events, especially in urban areas, with the most significant including Peterborough in 2002 and 2004; Toronto in 2005, 2013, and 2014; Burlington in 2012; and Hamilton in 2014.

As more pollutants enter watercourses and water bodies with increased precipitation runoff, water quality parameters and water temperature are changing. This allows harmful bacteria and algae, such as blue-green algae, to thrive.

Changes in weather and climate affect our economy and society. The agriculture industry must adapt to the new conditions, adopting new crop varieties that are resistant to more frequent droughts and higher temperatures during the growing season, as well as soil conservation practices geared to minimizing erosion during sudden high precipitation events. As the local tourism industry relies heavily on stable water levels and clean water, there will be increasing problems as summer water levels are more difficult to maintain. The period of ice cover for lakes and other water bodies is progressively reduced, water quality is impacted, and fish communities are affected by increased water temperatures and a longer growing season for aquatic vegetation.

The future climate will place new stresses on the health of watershed residents. Both benefits and challenges come from climate changes, however, negative impacts prevail. Factors affecting human health include heat waves, smog episodes, an increased number of severe weather events, and a greater opportunity for insect-borne diseases as West Nile virus, Lyme disease, and other disorders spread north.

The changing climate brings changes to the aquatic and terrestrial components of the ecosystem. Observations of fish populations in southern Ontario, including the Kawartha Conservation watershed, are indicating a shift from cold and coolwater species to more warmwater species. Lower water levels in the lakes and lower groundwater levels are damaging wetlands. Invasive species are benefiting from climate change and expanding their presence in the ecosystem, putting pressure on native plants and animals.

Responding to this global challenge, the Canadian government, provincial and local governments, and communities are taking steps to better understand the climate change process and its consequences, while developing and implementing an array of mitigation and adaptation measures.

Some measures have been implemented by the federal government to regulate and reduce greenhouse gas emissions, specifically in the electricity and transportation sectors. Government investments support planning for adaptation initiatives. Funding, made available to the scientific community, supports climate change research. Canada participates in international climate change community.

Ontario's policies and measures to address climate change mitigation and adaptation are focused on reducing greenhouse gas emissions and working toward a low-carbon economy. These measures promote energy efficiency, conservation, and planning for future change. Phasing out coal-fired electricity generation in the electricity sector is one step forward for Ontario in achieving greenhouse gases emissions reductions. A legislative foundation has been introduced, with significant efforts to protect Ontario's natural features and build ecosystem resilience.

Municipalities share the responsibilities for managing risks that stem from a changing climate. Municipal governments are in a position to significantly influence many factors that determine its residents' vulnerabilities to climate-related risks. Municipal governments, through their own operations and decision-making powers, can have a major impact on the pattern of urban and rural development, transportation, economic activity, consumption of energy resources, and protecting natural features that mitigate climate change impacts.

Municipal government is also the level of government closest to citizens; it can most easily engage and influence households and businesses to implement local actions on climate change mitigation and adaptation. Municipal governments can act as regulator, facilitator, partner, program deliverer, and educator. A number of municipalities in Ontario have already stepped up to the challenge and are developing and implementing local action plans and strategies.

The Kawartha Conservation Climate Change Strategy will outline strategic directions for climate change actions and provide recommendations on how to adapt to and mitigate climate change locally. The overall goal of the Strategy is "***to increase the resiliency of our watershed and communities in order to adapt to and evolve with changing climate*.**" The actions will be based on the principles of Integrated Watershed Management and on collaboration with watershed partners. They will be developed on the basis of local knowledge and integrated into the core Kawartha Conservation operations.

Guiding Principles of the Climate Change Strategy

- Proposed actions will fall under the general direction of the *Kawartha Conservation Strategic Plan 2012 – 2016.*
- Integrated Watershed Management is our guiding approach.
- Collaboration with many stakeholders such as municipal partners, governmental agencies, business and agricultural communities, non-governmental organizations, and landowners is fundamental to planning and implementing actions to deal with climate change.
- Integration of the proposed actions into existing Kawartha Conservation operations is a priority.
- Where possible, proposed actions will address both adaptation and mitigation of climate change and focus on improving the resilience of natural systems and public areas.
- The actions are to be developed based on relevant knowledge, monitoring, and data.
- Adaptive management will provide flexibility in delivering programs and services.

As climate change becomes a major consideration in decision making and management planning, Kawartha Conservation will continue to provide leadership and support for watershed communities and partners. The Climate Change Strategy will complement watershed management and monitoring programs through an adaptive process, thereby strengthening conservation and the health of local watersheds.

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Acronyms

CA	Conservation Authority
CCAC	Climate and Clean Air Coalition
CH_4	Methane
CO_2	Carbon dioxide
FCM	Federation of Canadian Municipalities
GHG	Greenhouse gases
IPCC	Intergovernmental Panel on Climate Change
ICSP	Integrated Community Sustainability Plan
IWM	Integrated Watershed Management
MNRF	Ministry of Natural Resources and Forestry
MOECC	Ministry of the Environment and Climate Change
NGO	Non-governmental organization
N_2O	Nitrous oxide
ORMCP	Oak Ridge Moraine Conservation Plan
PCP	Partners for Climate Protection
ppm	Parts per million
PPS	Provincial Policy Statement
RCM	Regional Climate Model
SRES	Special Report on Emissions Scenarios
TSW	Trent-Severn Waterway
UNFCCC	United Nations Framework Convention on Climate Change

1.0 Introduction

Climate and weather is different. Weather is constantly changing. Next year's weather will not be exactly the same as this year's, and this year is different from the last. The long term average becomes our regional climate. It can be said that climate is what we expect – weather is what we get. **Climate change** therefore is defined as a shift in long-term average weather patterns (with respect to a baseline or a reference period), which can include changes in temperature and precipitation amounts (*Canada's Action on Climate Change*, 2013). Climate change may be due to both natural (internal or external processes of the climate system) and anthropogenic forces (for example, an increase in concentrations of greenhouse gases (GHGs)).

> **Climate Change** - refers to any change in climate over time whether due to natural variability or as a result of human activity
>
> Source: (Solomon et al., 2007)

Climate variability is defined as a deviation from the overall trend or from a stationary state, and refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) on climate on all temporal and spatial scales (Intergovernmental Panel on Climate Change (IPCC), 2015). Climate variability can be thought of as a short-term fluctuation superimposed on a long-term climate change or trend. Cycles of high and low values of weather events (such as droughts and floods) are not climate change unless they are prolonged over many decades. Low frequency variability refers to phenomena such as the North Atlantic Oscillation or El Niño which occur at a decadal scale or longer. High frequency variability refers to meteorological events and their distribution (for example, frequency, duration, and intensity) at yearly, seasonal, or monthly time-scales.

As science shows, the planet has seen dramatic changes in climate and weather conditions, both warmer and colder periods, during its history. Twelve thousand years ago, the Oak Ridges Moraine was formed as a result of the melting of the giant glacier that covered all of Canada (EcoSpark and Save The Oak Ridges Moraine (STORM) Coalition, 2010). Warmer weather during the medieval warm period (AD 900 to 1300) allowed the colonization of Greenland and the Canadian east coast by the Vikings.

Observations demonstrate that atmospheric temperature has been following a strong rising trend recently, especially during the last century. This climate changing process is known as global warming. Increased concentration of the greenhouse gases in the atmosphere caused by human activities has been clearly identified as an accelerating factor of that phenomenon. It is expected that global warming will bring significant changes to weather and climate conditions, including variability and magnitude, in the near future.

> **Global Warming** – refers to an increase in a planet's surface temperature caused by the absorption of infrared radiation by gases in the atmosphere, including carbon dioxide, methane, and water vapour
>
> Source: (Global Warming, 2014)

There is a strong consensus in the international scientific community that the impacts of climate change are already being felt. Warmer winters, less snow, hotter summers, and increasing numbers of damaging precipitation events and wind storms are being observed during recent decades. The World Meteorological

Organization has recently confirmed that the first 15 years of the 21st century have been the warmest on record, with 2014 being the hottest ever observed (World Meteorological Organization, 2015).

The Institute for Catastrophic Loss Reduction reports that the number of extreme weather-related events, such as flooding, tornados, and droughts, has been increasing steadily over the last 50 years both in Canada and around the globe, while geological events, such as earthquakes and landslides, remained at the same level. As a result, insurance payouts have Cap grown dramatically. More than $2 billion in insured losses were paid in 2013 for the first time in history as a result of two flooding events that occurred in the Greater Toronto Area and in southern Alberta. It was the fifth year in a row when insured damages exceeded $1 billion (McGillivray, 2015).

An increase in atmospheric greenhouse gas concentrations is expected to occur even if the worldwide commitments to reduce GHG emissions are fully met by all participating countries. While the absolute magnitude of predicted changes is uncertain, there is a high degree of confidence in the direction of changes and in the recognition that climate change effects will persist for many centuries.

Because Kawartha Conservation is committed to protecting and sustaining outstanding water quality and quantity supported by healthy landscapes, we believe that climate change is part of our business. We commit to taking immediate action and demonstrating leadership in our communities and partnerships on climate change programs.

This background paper sets a framework for the Kawartha Conservation Climate Change Strategy and is based on extensive literature research.

Key Topics

- Analysis of observed changes in weather and climate and their future projections;
- Impacts of changing climate on the natural environment and society;
- National and provincial frameworks and actions on climate change;
- Response to climate change by Ontario municipalities, Conservation Authorities, and NGOs;
- Mitigation and adaptation: planning for the future; and
- Framework for a climate strategy for Kawartha Conservation.

2.0 Climate Trends and Variability

The Intergovernmental Panel on Climate Change, the leading international body charged with deciphering what climate change holds for our future, released *The Physical Science Basis Summary for Policymakers. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* in September 2013 (IPCC, 2013). This document "...considers new evidence of climate change based on many independent scientific analyses from observations of the climate system, paleoclimate archives, theoretical studies of climate processes and simulations using climate models." Nineteen conclusions have been made regarding the state of global climate conditions, providing evidence of a changing climate. Some of the conclusions are as follows:

- Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased.
- Each of the last three decades has been successively warmer than any preceding decade since 1850.
- The atmospheric concentrations of carbon dioxide (CO_2), methane, and nitrous oxide have increased to levels unprecedented in at least the last 800,000 years. CO_2 concentrations have increased by 40% since pre-industrial times, primarily from fossil fuel emissions and secondarily from land use change emissions.
- Human influence on the climate system is clear. This is evident from the increasing greenhouse gas concentrations in the atmosphere, positive radiative forcing, observed warming, and understanding of the climate system.
- The evidence for human influence has grown since the Fourth Assessment Report. It is *extremely likely* that human influence has been the dominant cause of the observed warming since the mid-20th century.
- Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions.

2.1 The Greenhouse Effect and Climate Change

The greenhouse effect concept is the atmosphere's natural ability to store the heat radiated from the earth on its way to space. The natural greenhouse effect keeps the earth warm enough to support life, but excess greenhouse gas from human activities is causing an increase in global temperature (Figure 2.1).

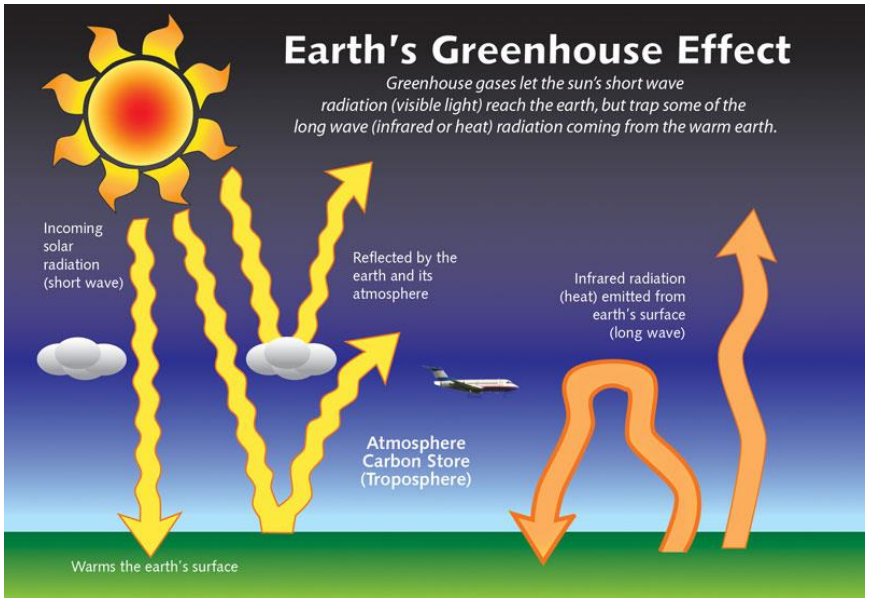

Figure 2.1: The Greenhouse Effect
Source*:* (New York State Department of Environmental Conservation, 2014)

Though GHGs such as carbon dioxide, methane, and nitrous oxide occur naturally, they are increasing in the atmosphere due to human activity, for example, burning fossil fuels and deforestation. In addition, humans have also invented and released to the atmosphere a number of powerful GHGs such as chlorofluorocarbons, hydrofluorocarbons, perfluorocarbons, and sulphur hexafluoride (Table 2.1).

Table 2.1: Key Greenhouse Gases and their Sources. (Adapted from Annenberg Learner, 2014)

Symbol	Name	Sources
CO_2	Carbon Dioxide	Fossil fuel combustion, forest clearing, cement production, etc.
CH_4	Methane	Landfills, production and distribution of natural gas & petroleum, fermentation from livestock, sewage waste treatment, fossil fuel combustion, etc.
N_2O	Nitrous Oxide	Fossil fuel combustion, fertilizers, nylon production, manure, etc.
HFCs	Hydrofluorocarbons	Refrigeration gases, aluminum smelting, semiconductor manufacturing, etc.
PFCs	Perfluorocarbons	Aluminum production, semiconductor industry, etc.
SF_6	Sulphur Hexafluoride	Electrical transmission and distribution systems, circuit breakers, magnesium production, etc.

Although all greenhouse gases contribute to the greenhouse effect, some have greater implications for long-term temperature change than others.

- **Carbon dioxide (CO_2)** is the fifth most common substance found in the atmosphere though it makes up only 0.036% of atmospheric gases. It has a lengthy lifecycle, remaining in the atmosphere for between 50 and 200 years. According to the IPCC Fifth Assessment Report, CO_2 levels are higher than any time in the last 800,000 years; it is estimated that increases in carbon dioxide levels account for approximately 63% of the recent rise in global temperatures (IPCC, 2013).

- **Methane (CH_4)** has a shorter lifecycle than carbon dioxide (10 to 12 years), and there is less of it in the atmosphere. However, methane is a major greenhouse gas because it can absorb solar radiation much more efficiently than carbon dioxide. Methane levels in the atmosphere have increased 150% since the 1750's due to increases in human population and activities such as livestock farming, as well as increased gas leakage from landfills.

- **Nitrous Oxide (N_2O)** has an atmospheric lifetime of more than 100 years. Though emitted in much smaller amounts than carbon dioxide or methane, its long lifecycle ensures a build-up in the atmosphere. In 2005, nitrous oxide accounted for approximately 10% of the greenhouse effect.

Other greenhouse gases do not significantly contribute to the greenhouse effect for various reasons. Chlorofluorocarbons are very strong greenhouse gases but they are emitted in much smaller volumes, in part because of controls placed on their use to reduce ozone depletion.

Scientists have studied fluctuations in CO_2 historically by measuring concentrations of the gas trapped in ice core samples taken from the polar regions. Temperature changes have been estimated by analyzing tree rings, pollen remains, glaciers, and ocean sediments, among other things. As a result of these analyses, climate scientists have been able to show a clear relationship between CO_2 concentrations and temperature over more than 800,000 years.

Observations confirm that concentrations of CO_2, CH_4, and N_2O now substantially exceed the highest concentrations recorded in ice cores during the past 800,000 years. The mean rates of increase in atmospheric concentrations over the past century are, with very high confidence, unprecedented in the last 22,000 years (IPCC, 2013).

In its reports, the IPCC has tended to focus on climate projections based on mid-range emissions scenarios. However, actual emissions – more than 30 billion tons of CO_2 annually – suggest that more attention should be paid to the potential for more extreme warming and associated impacts. The warming of the oceans and melting of ice sheets lag many years behind the warming of the atmosphere. It is abundantly clear that the effects of climate change will continue to be felt for decades after effective mitigation strategies are in place. In the worst-case scenarios modeled by the IPCC, the average global temperature could rise by as much as 6.4 °C by the end of the century, that is only 85 years away and is within the life span of children being born today. The potential consequences of such an increase would be catastrophic. Global GHG emissions are currently increasing at a faster rate than that in the IPCC's worst-case scenario; these emissions rose 3.3% per year between 2000 and 2006.

2.2 Modeling the Future Climate

Climate models are mathematical representations of the climate system. Models show many important mean climate features, such as the large-scale distributions of atmospheric temperature, precipitation, radiation, and wind, and also of oceanic temperatures, currents, and sea-ice cover.

Simulating climate change at the regional and national levels is essential for local policy making. Only by assessing the real impact on local climate is it possible to justify difficult social and economic policies to prevent a dangerous deterioration in the global climate.

Assumptions that describe future releases into the atmosphere of greenhouse gases, aerosols, and other pollutants are called emissions scenarios. They are based on expectations of driving forces, such as patterns of economic and population growth, technology development, and other factors. Levels of future emissions are highly uncertain, and different scenarios provide alternative images of how the future might develop. They assist in climate change analysis, including climate modeling and the assessment of impacts, adaptation, and mitigation.

The degree of certainty in key findings on weather and climate change is assessed by researchers using special protocol set up by the IPCC. Each key finding is assessed based on the evaluation of associated evidence and agreement. The following terms are used to indicate the assessed likelihood:

Virtually certain	99–100% probability	Unlikely	0–33% probability
Very likely	90–100% probability	Very unlikely	0–10% probability
Likely	66–100% probability	Exceptionally unlikely	0–1% probability.
About as likely as not	33–66% probability		

The assessment of the likelihood of the key observed changes in weather and climate, as stated in the IPCC Fifth Assessment Report, is shown in Table 2.2. Researchers are very confident that the global climate has changed and that humans contribute to this change. By the end of this century, the air temperature will increase, which will result in warmer winters and hotter summers. Precipitation events will become more frequent, more intense, and heavier.

Appendix A lists the observed changes in climate and weather in Canada, and Appendix B lists the projected changes in the climate system for Canada, derived from combination of global climate models.

Table 2.2: Global Scale Assessment and Likelihood of Changes in Weather and Climate. (Adapted from IPCC, 2013)

Weather/climate phenomena	**Likelihood of further changes**	
	Early 21st century 2016–2035	Past 21st century 2081–2100
Warmer and fewer cold days and nights	Likely (66–100%)	Virtually certain (99–100%)
Warmer and more frequent hot days and nights	Likely (66–100%)	Virtually certain (99–100%)
More frequent and longer warm spells and heat waves	Not assessed	Very likely (90–100%)
More frequent heavy precipitation events. Increase in the intensity and amount of heavy precipitation	Likely over many land areas (66–100%)	**Very likely** over most of the mid-latitude lands (90–100%)
Increase in intensity and duration of drought	Low confidence	Likely on a regional to global scale (66–100%)

2.3 Changes Observed

The following changes in climate and weather in Ontario, including the Kawartha Conservation watershed, have been observed and are expected to intensify:

- A warming trend in air temperature, especially noticeable in winter;
- An increased number of intense precipitation events; and
- An increased number of extreme weather events, including precipitation events.

These changes will impact society and the ecosystem. Some are discussed in the next sections.

2.3.1 Temperature

According to the latest IPCC Report (IPCC, 2013), over the last 30 years, the mean temperature in each succeeding decade has been warmer than the previous decade; within the Northern Hemisphere, this is likely to have been the warmest period during the last 1,400 years. Since 1880, global mean surface temperatures have risen a seemingly insignificant 0.85 °C, however, considering that a 4 °C increase is the difference between today's temperatures and those of the last ice age, it becomes clear that seemingly small changes have a profound impact (Miller, 2014).

The annual average air temperature in Canada has warmed by 1.5 °C over the period 1950 to 2010 (Bush, Loder, James, Mortsch, & Cohen, 2014). Recent analysis shows that 2011 and 2012 were 1.5 °C and 1.9 °C warmer than the reference period (the 1961 to 1990 average), and 2010 still stands as the warmest year on record in Canada, at 3.0 °C above normal (Environment Canada, 2011). Daily minimum temperatures have been rising slightly faster than daily maximum temperatures over the period 1950 to 2010. Warming in Canada is generally observed in all seasons, with the greatest warming occurring in winter and spring. Warming trends are generally much weaker in the summer and fall. In Ontario, the increase in average temperature during the last 60 years has varied from about 1.3 °C in the west to very little increase in the southeast near Lake Ontario (Environment Canada, 2011).

Local data confirms the above-mentioned findings. The long-term daily minimum, daily maximum, and yearly average temperatures recorded by the Lindsay Frost climate station (Environment Canada) from 1975 to 2006 were studied. It was determined that all three datasets exhibit the rising trends, while the most obvious increase is detected for the daily minimum temperatures (Figure 2.2).

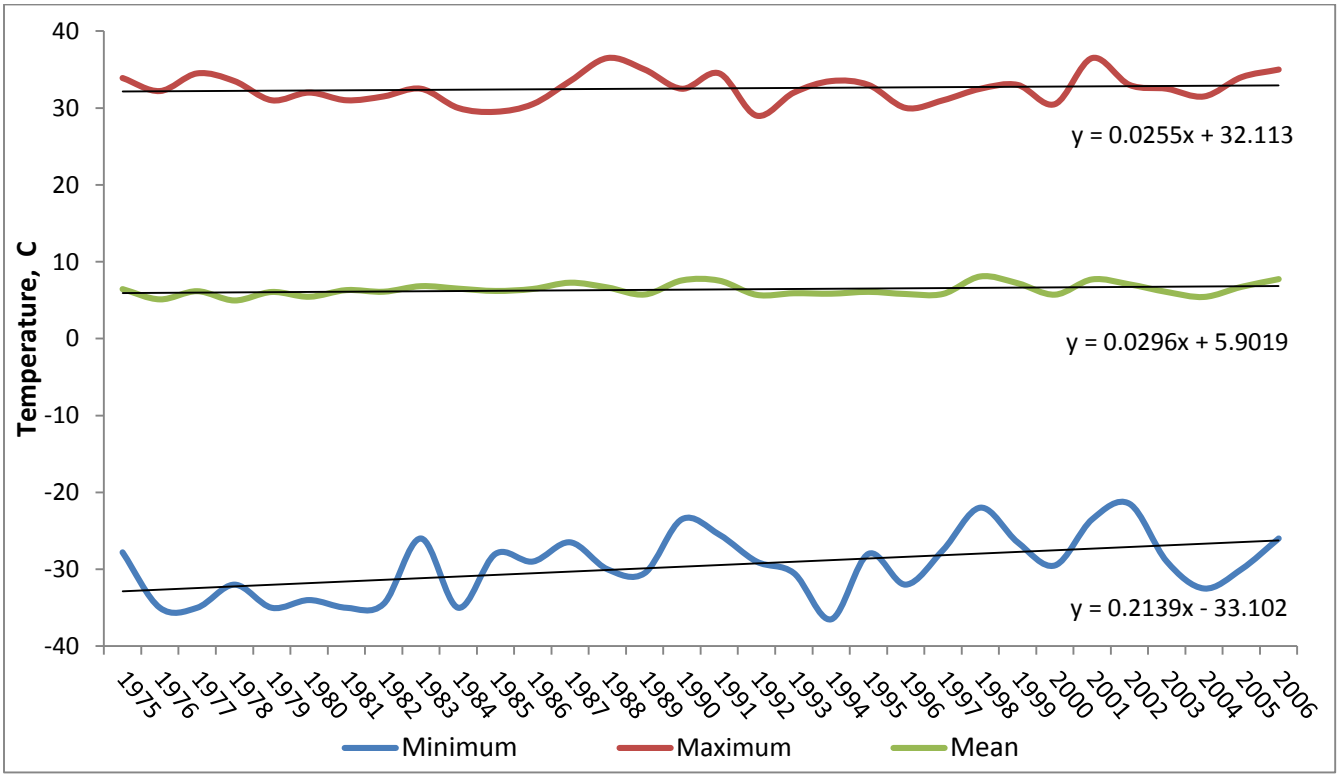

Figure 2.2: Long-term Yearly Minimum, Maximum, and Average Temperatures and their Trends for the Lindsay Frost Climate Station (Environment Canada), 1975–2006

2.3.2 Precipitation

Warming of the Earth's surface and atmosphere results in changes in evaporation and precipitation, as well as in atmospheric circulation patterns that influence the geographical distribution of rain. Warmer temperatures lead to greater potential evaporation of surface water, thus increasing the potential for surface drying and increasing the amount of moisture in the air. Because warmer air can hold more moisture, more intense precipitation events are expected.

As research demonstrates, precipitation trends are more difficult to detect than temperature trends (Bush, Loder, James, Mortsch, & Cohen, 2014). Using adjusted daily precipitation data, it has been determined that Canada has generally become wetter in recent decades; an increase in annual precipitation of about 16% over the period 1950 to 2010 has been detected (Mekis & Vincent, 2011). At most stations, total seasonal precipitation has increased in spring and fall, while many sites show declining winter precipitation. The observed decrease in total winter precipitation is mainly due to the decrease in winter snowfall, while winter rainfall has changed little (Mekis & Vincent, 2011). In several regions of Southern Canada, there has been a shift in precipitation type, with decreasing snowfall and increasing rainfall, as would be expected with warming temperatures.

Undertaken analysis of precipitation data for the Lindsay Frost climate station has yielded similar results. As Figure 2.3 confirms, an increasing trend in yearly precipitation amounts over the period 1975 to 2006 has been detected.

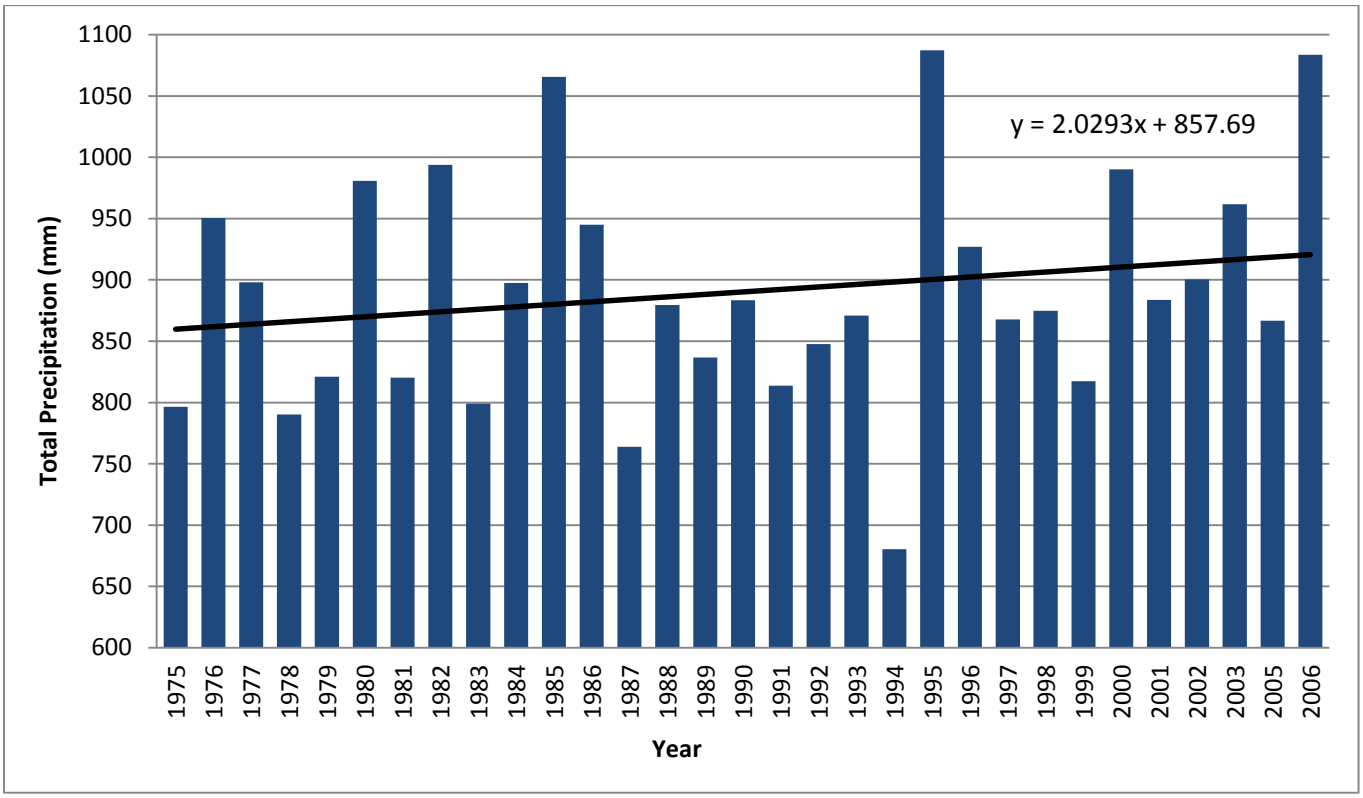

Figure 2.3: Long-term Yearly Total Precipitation and its Trend from the Lindsay Frost Climate Station (Environment Canada), 1975–2006.

2.3.3 Weather Extremes

In a changing climate, extreme temperatures and precipitation will also change as a result of shifts in mean conditions and/or as a result of changes in variability. For example, warming is expected to be accompanied by a decrease in cold extremes and an increase in hot extremes. It is also expected that the global hydrological cycle will intensify with continued global warming, leading to an increasing intensity of both wet and dry extremes and associated hazards such as floods and droughts (Bush, Loder, James, Mortsch, & Cohen, 2014). An extreme event, by definition, is rare – making analysis of changes in extreme events challenging.

In Canada, temperature trends indicate that cold weather events continue to decrease while warm weather events continue to increase (Bush, Loder, James, Mortsch, & Cohen, 2014). This observation is in agreement with an assessment of trends across North America.

Based on this information, an increase in severe weather events in the future is expected. For example, one study projected that the number of days with a maximum temperature above 30 °C in the summer at Toronto Pearson Airport will increase from about 15 days in 2005 to about 28 in 2050 (*Telling the Weather Story*, 2012).

A study of April to November rainfall extremes in four selected river basins in southern Ontario – the Grand, Humber, Rideau, and Upper Thames – projected large percentage increases in future three-day accumulated rainfall extremes with a warming climate (Cheng, Li, & Auld, 2011). The 20-year return values of annual maximum three-day accumulated rainfall totals are projected to increase by 30% to 55% for the period 2026 to 2075. Despite some level of uncertainty in all these projections, increases in the intensity of extreme precipitation events are very likely.

With warming winters and increasing precipitation, some studies project more freezing rain events for Ontario (Cheng, Li, & Auld, 2011). The increase in the number of freezing rain events could be progressively greater from south to north, or from southwest to northeast, across Eastern Canada. For example, the percentage increase for severe freezing rain events (lasting six hours per day or longer) is projected to be about 35% in southwestern Ontario and around the lower Great Lakes, and about 80% in eastern Ontario around the Ottawa Valley and extending to Sudbury by the period 2081 to 2100.

2.4 Climate Projections for Southern Ontario

Climate projections for southern Ontario, presented in this section, are obtained from the report, *Climate Change Projections for Ontario: Practical Information for Policymakers and Planners*, prepared by the Ontario Ministry of Natural Resources (Science and Information Resources Division) and the Canadian Forest Service (Colombo, 2007). Details on the climate model and emission scenario, used to develop the maps are available in the report.

Figures 2.4 to 2.7 illustrate Ontario's future climate by showing the differences in temperature (summer and winter) and precipitation (warm and cold season) for the time period 2071 to 2100, compared to 1971 to 2000.

Summer climate

Southern Ontario summer temperatures have historically been warmest in the Niagara Peninsula, the western shore of Lake Ontario from Oshawa to Hamilton, and the southwestern part of the region that includes Windsor and the north shore of Lake Erie. Under future climate conditions, it is projected that most of southern Ontario

will have summers that are 2 to 3 °C warmer by mid-century and 4 to 5 °C warmer by 2071. These changes mean that by 2071, residents of much of southern Ontario, including the Kawartha Conservation watershed, will experience the types of hot summers that presently occur only in southwestern Ontario, near Windsor and Essex County. For people living in the area from Windsor and Sarnia east to Niagara and the Greater Toronto Area, the 5 to 6 °C increase in average summer temperature will make it about as hot as summers in present-day Virginia.

Across southern Ontario, precipitation from April to September has historically been 400 to 600 millimetres (mm), with the Parry Sound District and the area east of Ottawa-Brockville being the wettest. In the period 2011 to 2040, almost all of southern Ontario – south of the line from Owen Sound to Pembroke – is expected to receive up to 10% less rainfall; north of that line, rainfall will increase by up to 10%. By 2071 to 2100, a substantial part of Ontario's prime agricultural land, including the Kawartha Lakes region, will receive 10 to 20% less precipitation from April to September.

Winter climate

People who live in the area encompassed by Toronto-Niagara-Windsor-Sarnia enjoy the warmest winters in Ontario, with average temperatures just below freezing from December through February. In contrast, people in the Algonquin Park area experience the coldest winters in southern Ontario, averaging -10 to -15 °C. Mean winter temperatures in the Kawartha Conservation watershed, calculated for the period 1981 to 2010, vary from -5.8 °C in Blackstock to -6.5 °C in Lindsay, that is, in line with the rest of southern Ontario, including Ottawa, Kitchener, and Owen Sound.

As it is predicted, between 2011 and 2040, winter temperatures in most of southern Ontario will warm by 1 to 2 °C. By mid-century, average winter temperatures in most of the south could increase by 3 to 4 °C. By 2071, winter temperatures will increase by 4 to 5 °C in southwestern Ontario and possibly up to 5 to 6 °C in other parts of southern Ontario, including the Kawartha Conservation watershed. As a result, in 2071 to 2100, people living in Barrie, Brockville, and Parry Sound will have winters like those currently experienced in Niagara and Windsor. The already mild winters of the Golden Horseshoe, Sarnia, and Chatham will be even milder in 2071, with average winter temperatures more like the current winter temperatures in southern Ohio and Indiana.

Overall, it is expected that warming will be greater in winter than summer, and greater in the north than the south.

Overall, it is expected that warming will be greater in winter than summer, and greater in the north than the south.

Cold season precipitation has historically been heaviest in the snow belts on the shores of Lake Huron and Georgian Bay, with most precipitation falling near Owen Sound and Parry Sound. In the future, from 2011 to 2040 and onwards, most of southern Ontario is predicted to receive 20 to 30% more cold season precipitation. People living in the Kawartha Conservation watershed can expect to get up to 30% more cold season precipitation. It is important to remember that with increased winter temperatures, precipitation will most likely change from snow to rain.

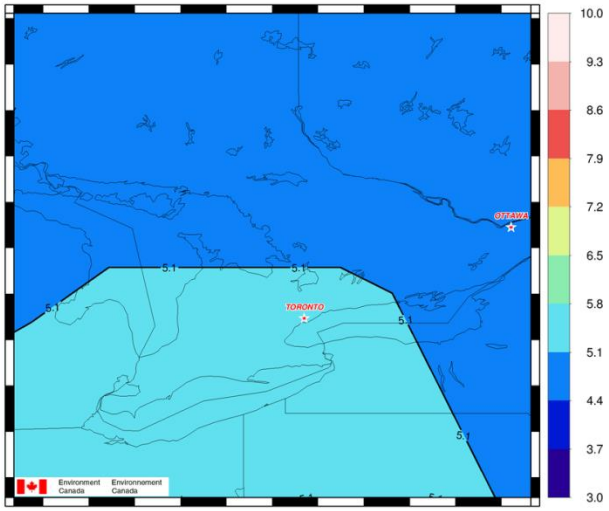

Figure 2.4: Differences (°C) in Mean Summer Temperature in 2071-2100 compared to 1971-2000 Baseline, Southern Ontario. Source: (Canadian Climate Change Scenarios Network, 2014)

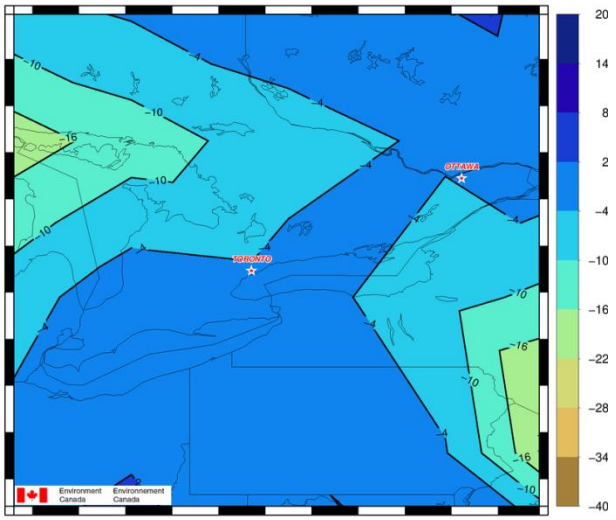

Figure 2.5: Differences (%) in Total Summer Precipitation in 2071-2100 compared to 1971-2000 Baseline, Southern Ontario. Source: (Canadian Climate Change Scenarios Network, 2014)

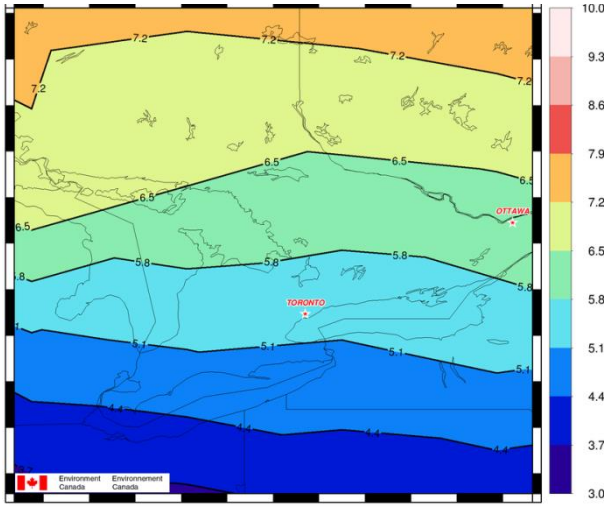

Figure 2.6: Differences (°C) in Mean Winter Temperature in 2071-2100 compared to 1971-2000 Baseline, Southern Ontario. Source: (Canadian Climate Change Scenarios Network, 2014)

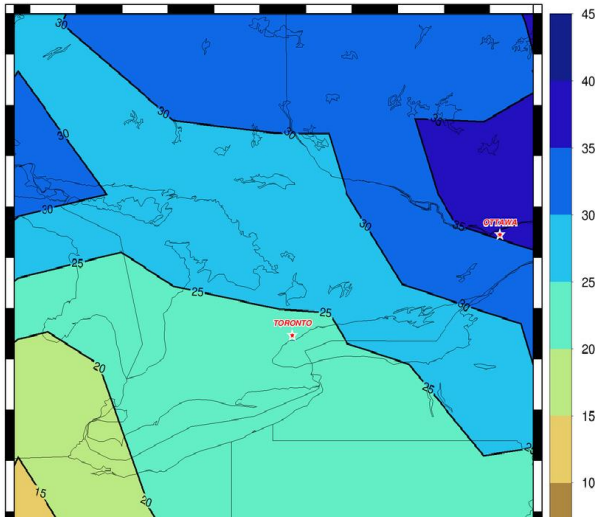

Figure 2.7: Differences (%) in Total Winter Season Precipitation in 2071-2100 compared to 1971-2000 Baseline, Southern Ontario. Source: (Canadian Climate Change Scenarios Network, 2014)

The *Durham Region's Future Climate (2040 – 2049)* study, undertaken by the SENES Consultants for the Durham Region Roundtable on Climate Change, provides better insights on the weather and climate of the Regional Municipality of Durham in the decade 2040 to 2049 (SENES, 2013). The study provides projections of both climate averages and weather extremes for the future period compared to the past decade (2000 to 2009) at a high level of geographic resolution. Eight locations were selected for the study including Port Perry. Therefore, the changes in weather in **Port Perry** in the decade 2040 to 2049 will include the following:

- **Considerably warmer summers and winters**
    - Average annual temperatures will increase by ~4.0 ˚C.
    - Extreme daily maximum temperature *becomes warmer* by 9 °C.
    - 56 more days with temperatures above zero is expected.
    - 22 more days with temperatures above 30 °C will be observed.
    - Extreme daily minimum temperature *becomes less cold* by 13 °C.
    - There will be 52 fewer days with temperatures below zero.
    - There will be 34 fewer days with temperatures below -10 °C.
- **Less snow and more rain in winter**
    - There will be an 80% reduction in the number of days with snow events involving more than 5 cm of snow.
    - There will be 31 more days with rain.
- **More frequent and intense summer rain events**
    - There will be much more summer storm precipitation during July (57% on average) and August (94% on average).
- **About 16% more precipitation (snow and rainfall) overall**
    - The one day maximum will increase by almost 50%.
    - The one day maximum of snow will drop about 40%.
    - The number of days of rain greater than 25 mm will increase by 100%.
- **Extreme rainstorm events will be more extreme**
    - There will be a 15% increase in the potential for violent storms.
    - There will be a 53% increase in the potential for tornadoes.
    - July will have 74% more rain.
    - August will have 79% more rain.
- **Average annual temperatures will increase by 4.0 ˚C**
    - Average winter temperatures will increase by 5.8 ˚C.
    - Average summer temperatures will increase by 2.6 ˚C.
    - Extreme daily minimum temperature *becomes less cold* by 12 ˚C.
    - Extreme daily maximum temperature *becomes warmer* by 7.1 ˚C.

All of the projected climate changes bring significant consequences in the hydrological cycle, availability and distribution of water resources, flora, fauna and the aquatic ecosystem. Chapter 3 will discuss those components in greater detail.

2.5 Greenhouse Gas Reduction

As greenhouse gases play a key role in climate change, it is recognized that future changes will depend on the amount of GHGs emitted. A major step in combatting global warming is to reduce those emissions. A number of nations, have come together and agreed on GHG reduction targets.

2.5.1 National Projections

Canada is the only country in the world to have ratified, and then has chosen to withdraw from, the Kyoto Protocol (*National Post*, 2011). The current government of Canada has committed to reducing its emissions by 17% from 2005 levels, by the year 2020. As economy-wide emissions in 2005 were 736 megatonnes (Mt), Canada's implied Copenhagen target is 611 Mt in 2020 (Environment Canada, 2014).

A number of factors influence greenhouse gas emissions in Canada. Economic and population growth, as well as the mix of energy supply, are examples of drivers of emissions. Projections of future emissions are greatly influenced by the underlying assumptions about the expected development of economic drivers over time. As the economy grows, total emissions are projected to increase. The analysis indicates that if Canadians continue with business as usual, emissions in 2020 would rise to 857 Mt (Figure 2.8) (Environment Canada, 2014). With measures already introduced by government and supported by industry and population, Canada's GHG emissions in 2020 are projected to be 727 Mt, a total of 130 Mt less than under a "business as usual" scenario. This highlights the significant expected impacts of actions already established, but also indicates the need for further efforts, as additional reductions of 116 Mt will be required to meet Canada's Copenhagen commitment.

Figure 2.8: Scenarios of Canadian Emissions to 2020**.** Source: (Environment Canada, 2014)

Total GHG emissions per capita have decreased significantly since 2005, when they were 22.8 tons per person. In 2012, emissions per capita were only 20.1 tons per person, which is the lowest level recorded since records began in 1990. Projections show this trend continuing through 2020, with per capita emissions expected to be 19.7 tons per person in 2020 (Environment Canada, 2014).

2.5.2 Provincial Projections

Ontario's province-wide emission reduction targets are set in the Climate Change Action Plan (*Go Green: Ontario's Action Plan on Climate Change*, 2007). It includes a set of short-term (6% below 1990 levels by 2014), medium-term (15% below 1990 levels by 2020), and long-term (80% below 1990 levels by 2050) targets for reducing Ontario's GHG emissions.

According to the *National Inventory Report 1990–2012: Greenhouse Gas Sources and Sinks in Canada*, 2014), Ontario's GHG emissions in 2012 were 167 Mt. This is the lowest annual level of emissions since the baseline year of 1990. As shown in the latest report on climate change by the Environmental Commissioner of Ontario (Miller, 2014), the last several years have witnessed a significant decline from the peaks experienced between 2000 and 2005, when emissions from coal-fired electricity generation were at their highest (Figure 2.9).

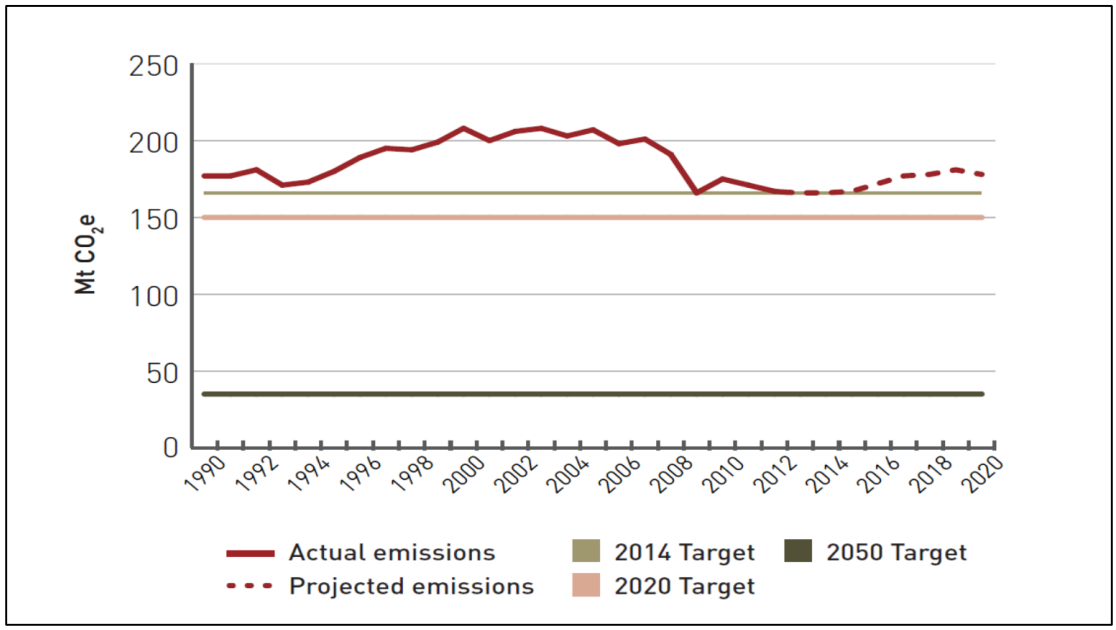

Figure 2.9: Ontario Greenhouse Gas Emissions, Trends and Targets. Source: (Miller, 2014)

The 2012 emissions total suggests that Ontario does meet its 2014 target. Unfortunately, the future projections indicate an upward trend in emissions after 2014. This means Ontario will exceed its target for 2020. According to the last climate change progress report, released in November 2012 (*Climate Vision. Climate Change Progress Report*, 2012), the GHG emissions will exceed the target in 2020. To change that projection and to meet the 2020 target, more work needs to be done on emissions.

3.0 Impact and Vulnerability

As weather and climate play a very important role in all aspects of the ecosystem and society, there will be noticeable consequences from the expected changes. The list of changes is lengthy, and many aspects of the local economy, community, and ecosystem will be affected. The following section discusses the possible impacts of climate change and their outcomes in the Kawartha Conservation watershed.

3.1 Water Resources

Water is the key resource for a thriving community, a successful economy, and a healthy ecosystem. As climate change affects all components of the hydrological cycle (precipitation, runoff, and evapotranspiration), we should be prepared to face significant changes in water availability and distribution.

Table 3.1 outlines the expected changes to water resources and their components.

Projected changes in components of the hydrological cycle may result in the following outcomes.
More frequent and intense extreme rainfall events may lead to:

- Increased occurrence of flooding events, both major events and nuisance flooding such as road overtopping, and basement and shoreline flooding;
- Increase in magnitude and number of major flooding events in historical flood-prone areas (Little Britain and Burnt River);
- Development of new, unknown flood-prone areas; and
- Increased transportation of contaminants from the land surface to lakes that will increase loads of pollutants and further affect lake ecosystem health.

More frequent flood events will result in increased frequency and costs of flood-related damages and also increased stress on the stormwater management/wastewater treatment infrastructure, especially in urban areas such as Lindsay, Port Perry, Bobcaygeon, and Fenelon Falls. Costs for the maintenance of existing stormwater infrastructure and the construction of new infrastructure will be higher.

Increased winter runoff will cause more winter flooding events as a result of precipitation-on-snow events.

Increased bank and channel erosion should be anticipated from “flashier” streamflows.

Decreased summer runoff will result in low flow conditions that, in turn, will stress fish habitat and lead to degraded water quality because less water is available for the dilution of contaminants such as sewage treatment plant effluents and runoff from agricultural and urban lands.

As our water supply and distribution systems are already aged and stressed, an **increasing incidence of low water or drought conditions** will require greater effort to maintain or replace the systems. Intensification of water monitoring and conservation programs will also be required. A study examining the sensitivity to drought of urban municipal water systems in southern Ontario has identified several features that put communities at risk, including dependence on groundwater or river water, aging or poorly maintained distribution networks, and systems with limited storage capacity relative to demand (Kreutwiser, Moraru, de Loë, Mills, & Schaefer, 2003). Where **drinking water supply** depends on a surface water source (e.g., Lindsay, Bobcaygeon, Fenelon

Falls, and others), its costs may increase due to degraded water quality and lower water levels. Low flow conditions may cause increased competition and conflict over reduced water supplies among water users during drought periods.

Table 3.1: Expected Changes in Water Resources (in the Near Future) for Southern Ontario including the Kawartha Conservation Watershed. (Adapted from de Loë, 2006).

FEATURE	EXPECTED CHANGES
Runoff	• Decreased total annual runoff, but increased winter runoff • Earlier and lower spring freshet • Increased frequency of rain events in winter, which can cause extra high runoff and water levels in watercourses • Summer and fall low flows are lower and last longer • Increased frequency and magnitude of high flows following extreme precipitation events in summer
Water levels	• Short-term increased water levels as a result of flash floods; higher stream velocities and increased capacity for erosion/destruction • Longer lower water levels as a result of decreased runoff • Increased loss of water due to increased evaporation • Increased frequency of low water/drought conditions
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 – in depth, area, and duration
Water temperature	• Increased water temperature in rivers and lakes
Water quality	• Deteriorated water quality • Higher concentration of nutrients and contaminants
Soil moisture	• Soil moisture may increase by as much as 80% during winter, but decrease by as much as 30% in summer and autumn

Groundwater recharge will most likely decrease, consequently decreasing the groundwater levels and rates of groundwater discharge to local streams, lakes, and wetlands. As a result, streams dependent on baseflow during low precipitation periods will experience lower levels and flows, adding stress on aquatic ecosystems. Instances when watercourses become dry will be more common. The central portion of the Kawartha Conservation watershed, including Mariposa Brook, Emily Creek, Stoney Creek, Scugog River, and other small subwatersheds, is especially vulnerable.

Decreased groundwater levels and discharges may change the forms and functions of wetlands. Some wetlands may become dry.

Decreased groundwater levels will also put additional strain on the water supply systems – municipal and domestic – that rely on groundwater sources. This has the potential to become a very significant problem for local municipalities, since over 60% of residents rely on groundwater as a source of potable water. Risk of water shortages and additional competition for scarcer supply will increase. More private wells may dry up, and water shortages may develop in areas that have never experienced them before.

As a result of decreased annual runoff and groundwater discharge, water levels of the Kawartha Lakes may decline. It will become more challenging for the Trent-Seven Waterway to maintain the navigation system according to current water level management practices, impacting tourism in the region. Lake Scugog, having no headwaters storage, is the most vulnerable. This will severely impact recreational and tourism opportunities in our watershed and cause economic losses to some sectors. Values of shoreline properties may decrease.

In addition, lower lake water levels will cause **negative changes to shorelines and shoreline ecosystems and also degradation of water quality**. The water quality issues will arise from lower water volume, increased water temperature, non-point source pollution, and increased chemical reactions among water, sediments, and pollutants. As previously noted, municipal water supply systems that draw water from lakes may face higher water treatment costs due to reduced lake water quality, or they may need to relocate the water supply intakes.

An increase in water temperature will stress fish habitat and create favourable conditions for warmwater fish species; it will promote greater biological activity (e.g., algae production and growth of aquatic vegetation); and it may cause taste and odour problems in drinking water supplies.

As winters become warmer and shorter, ice-cover season is expected to decrease, reducing the respective recreational and tourism opportunities (such as ice snowmobiling and ice fishing) and causing losses to the local economy.

3.2 Infrastructure and Transportation System

As severe rainfall events are projected to happen more often, there will be increased potential for disruptions to critical community infrastructure, including water treatment and distribution systems, energy generation and transmission, transportation, and residential damage. The risk of such impacts is elevated in urban areas since those areas will experience greater increase in runoff over impermeable surfaces.

Existing infrastructure, including stormwater drainage, water supply and treatment systems, culverts, snow load capacity, power transmission towers, and many other components, has all been designed based on past climate, that is, the *stationarity* concept. *Stationarity* assumes that the statistical characteristics of a series (e.g., annual

streamflow and annual flood peak) are constant over time. Thus, a 100-year return period design standard applied to infrastructure remains invariable over time. As weather extremes change, this fundamental concept of the water resources structural design is failing (Milly et al., 2008). Changes in precipitation amounts and patterns under climate change suggest that standards currently used may no longer be valid for design assumptions. What was once a 100-year return period standard may (and most likely will, under the climate change scenario) become a 50- or 25-year standard. Under those changes, the previously designed drainage infrastructure becomes inadequate and increases the risk to the public.

Furthermore, premature deterioration of infrastructure may be caused by climate factors such as freeze-thaw cycles, ground frost penetration, wind and water actions, ultraviolet radiation, and pollution. One of the salient and expensive issues of the future will be how to retrofit substandard buildings and other structures to the latest building code and standards requirements reflecting the changed climate.

Impacts of warmer winter temperatures

As previously noted, the most significant future temperature increases in southern Ontario, including the Kawartha Conservation watershed, are expected over the winter period. This will affect the frequency of freeze-thaw cycles. In months like January and February, when mean temperatures are at their lowest, this will be less significant, as temperature increases are less likely to raise mean temperatures above 0 °C into the thaw zone. It is more probable that climate change will alter the frequency of freeze-thaw events at each end of the winter season, in late fall and early spring.

Freeze-thaw cycles put a significant strain on infrastructure, wearing it out more quickly and leading to costly repairs and replacements. Natural Resources Canada notes that environmental factors account for the greatest portion of pavement deterioration, and that freeze-thaw cycles are vastly more destructive than damage due to extreme summer heat (Natural Resources Canada, 2013). Up to 50% of deterioration on high-volume roads and as much as 80% on low-volume roads can be attributed to weather effects. Much like pavements, buildings are also susceptible to winter freeze-thaw cycles, where building surfaces are degraded as a result of repeated ice expansion and melting.

3.3 Agriculture and Farming

Agriculture is a vital component of the local economy. Nearly 1,500 farms are located in the Kawartha Conservation watershed, with agriculture utilizing up to 44% of the watershed's land.

By its nature, agriculture is extremely sensitive to climate variations. Even small to moderate variations in temperature, precipitation, and soil moisture may cause huge differences in crop production.

Both negative and positive outcomes are expected to arise from climate change (Figure 3.1). On one hand, projected changes could lead to more extreme weather conditions, increases in pest problems, and severe water shortages. On the other hand, a warmer climate and a longer growing season could benefit many aspects of local agriculture. It is projected that the growing season and the number of frost free days will increase by more than 60 days by the year 2100. This may provide local farmers with added opportunities to expand the range of crops cultivated.

However, in many cases, the positive and negative impacts of climate change may tend to offset each other. For instance, the positive impacts of warmer temperatures and enhanced CO_2 on crop growth are expected to largely offset the negative impacts of increased moisture stress and accelerated crop maturation time.

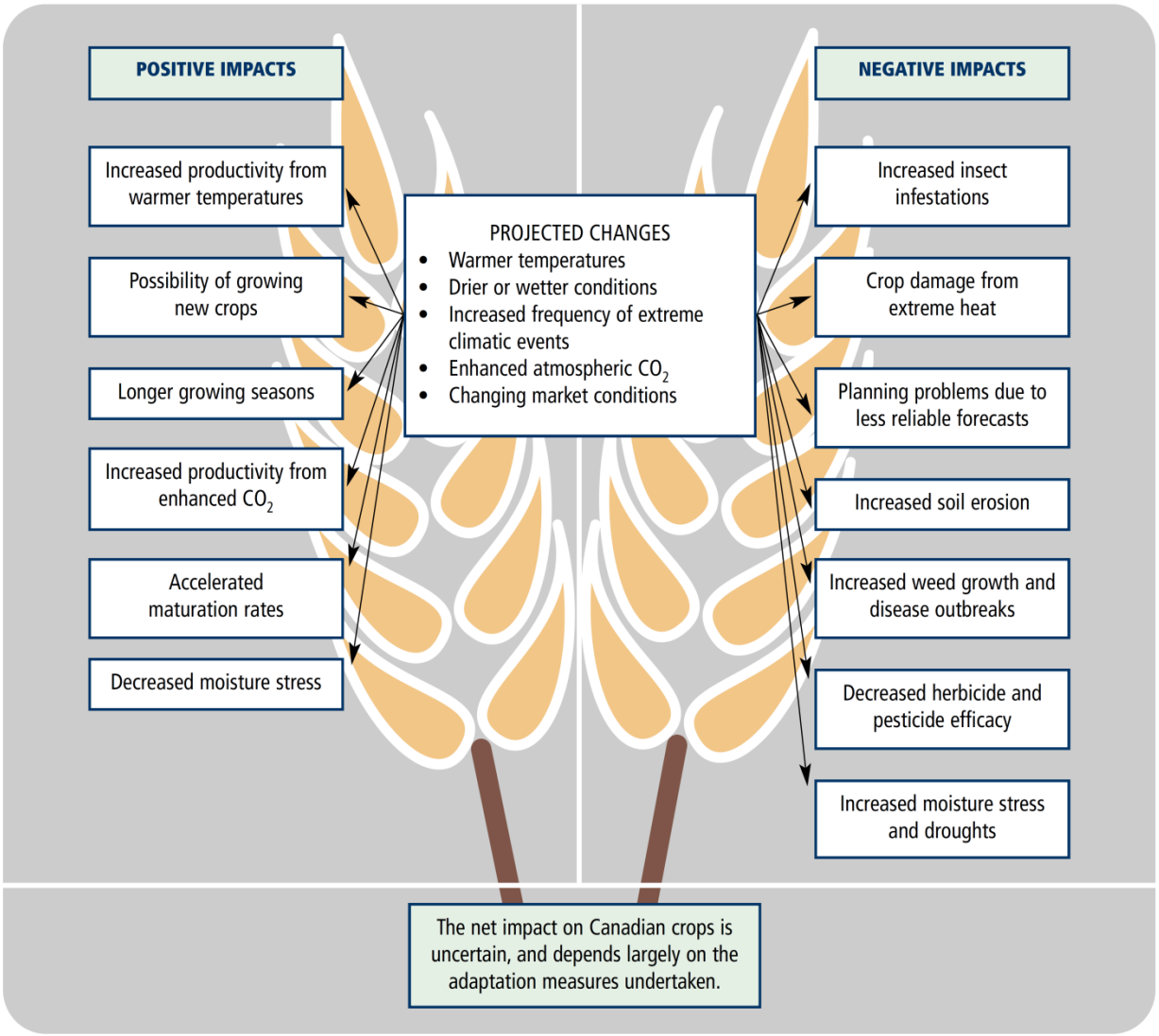

Figure 3.1: Potential Impacts of Climate Change on Agricultural Crops. Source: (Warren, 2014)

Farmers have a long history of adapting to and meeting climate challenges. A key factor in determining the magnitude of climate change impacts on agriculture is adaptation that is proactive rather than reactive. Appropriate adaptation measures would allow agriculture to minimize losses by reducing the negative impacts and maximize profits by capitalizing on the benefits. There are many different adaptation options available to the agricultural sector, which vary greatly in their application and approach. Selecting and implementing adaptation strategies will require consideration of the physical, socio-economic, and political influences on agriculture, as well as the contributing roles of producers, industry, and government. It is important to recognize that climate change is just one of many challenges facing the agricultural sector, and that it should not be considered a short-term priority in decision making. With successful proactive adaptation in the agricultural sector, farmers may enjoy competitive advantages and strengthen their long-term economic stability.

3.4 Tourism and Recreation

Water provides a means for the enjoyment of many recreational activities. The Kawartha Lakes system (Balsam Lake, Cameron Lake, Sturgeon Lake, Pigeon Lake, and Lake Scugog) forms a key section of the Trent-Severn Waterway (TSW), a landmark in the Kawartha Conservation watershed. Boating, canoeing, kayaking, fishing, and swimming are very popular activities in local lakes and rivers.

Tourism is a rapidly developing sector in the Kawartha Conservation watershed. It is estimated that the City of Kawartha Lakes receives 1.05 million visits each year, which amounts to $66.9 million and results in over $1 million in municipal tax revenue (The Tourism Company, 2008).

In *A Strategic Tourism Plan for City of Kawartha Lakes* (The Tourism Company, 2008), four main tourism attractors were identified for the region including:

- Navigable waterways, predominately the Trent-Severn Waterway (waterway, lock stations, and land-based features) as well as lakes and rivers linked to the TSW system;
- Long standing agricultural fairs;
- Seasonal recreational properties/urban escapes such as private cottages, seasonal campsites, and provincial parks to access outdoor pursuits and nature; and
- Organized special interest recreational pursuits including fishing tournaments.

With the exception of agricultural fairs, the main attractors are all water-based and would be affected socially and economically by changes in water levels and flow.

The decline of water levels in summer, as a result of climate change, will negatively affect tourism and recreation the most. As local tourism is mainly seasonal in nature, with the core focus on summer water activities, it will be impacted by the low water conditions in a number of ways. Numbers of visitors to the region are expected to drop, impacting both businesses and directly relating to water activities as well as associated businesses, such as the retail and food industry. Coldwater and sport fishing will be significantly affected.

At the same time, shorter and warmer winters will affect the duration and reliability of the winter recreation season. It will put in jeopardy activities such as snowmobiling, ice fishing, and skiing. Projections indicate a reduction in the snowmobiling season of between 30 and 50% by the 2020s (Lemmen, Warren, Lacroix, & Bush, 2008). The maintenance costs of ski resorts and ski hills will increase considerably, while visitor numbers will decrease. Eventually, the ski industry, if left unchanged, may collapse.

Only careful adaptation will allow a gradual transition, rather than disruption, in this very important sector of the local economy.

3.5 Human Health and Well-being

Although human health is influenced by a range of social and economic factors, variable climatic conditions also play a role. It is expected that climate change will place new stresses and emphases on the health of watershed residents and the healthcare sector. Similar to other areas, both benefits and challenges are expected to result

from future climate change. However, the general consensus is that negative impacts will likely prevail for all but the most modest warming scenarios.

Factors that will affect human health include heat waves and smog episodes, increased numbers of severe weather events, and more contaminated water and air. It is estimated that heat-related mortality could double in southern and central Ontario by the 2050s, while air pollution mortality, compounded by warmer summer temperatures, could increase by about 15 to 25% during the same interval (Expert Panel on Climate Change Adaptation, 2009).

Potential health impacts from climate change and variability are summarized below and listed in Table 3.2.

Table 3.2: Potential Health Impacts from Climate Change and Variability. (Adapted from Natural Resources Canada, 2013)

HEALTH CONCERNS	AREAS OF HEALTH VULNERABILITIES
Temperature-related vulnerability	• Heat- and cold-related illnesses/mortality • Respiratory and cardiovascular illnesses • Increased occupational health risks
Health effects of extreme weather events	• Injuries and illnesses resulting from the event • Social and mental health stress due to disasters • Damaged public health facilities and infrastructure • Occupational health hazards • Population displacement
Health problems related to air pollution	• Increased concentration of outdoor and indoor air pollutants and allergens • Asthma and other respiratory diseases • Heart attacks, strokes, and other cardiovascular diseases • Cancer
Health effects of water- and food-borne contamination	• Enteric diseases and poisoning caused by chemical and biological contaminants
Diseases distributed by insects	• Changed distribution patterns of diseases caused by bacteria, viruses, and other pathogens distributed by mosquitoes, ticks, and other insects
Health effects of exposure to ultraviolet rays	• Skin damage and skin cancer

	• Cataracts • Disturbed immune function
Most vulnerable population	• Seniors • Children • Chronically ill people • Low income and homeless people • Disabled people • People living off the land
Socio-economic impacts on community health and well-being	• Loss of income and productivity • Social disruption • Diminished quality of life • Increased costs to health care • Health effects of mitigation technologies • Lack of institutional capacity to deal with disasters

Heat, Smog, and Air Quality

As mentioned, climate change is expected to bring more prolonged and intense heat waves and periods of drought (*Telling the Weather Story*, 2012). By 2050, the number of days per year with maximum temperatures greater than 30 ˚C is expected to double. Increases in both the average temperature and the intensity and duration of extreme heat events have been identified as key climate change risks for human health. The elderly are at greatest risk, which is of concern, given the demographics in the Kawartha Conservation watershed.

Extreme heat presents numerous public health risks, especially to vulnerable populations. Vulnerable populations include the elderly, infants, individuals with pre-existing health conditions, low income individuals, individuals living alone or in crowded conditions, and those without air conditioning. A heat wave that hit Chicago in 1995 killed an estimated 550 to 800 people (Klinenberg, 2002), and in Europe, more than 70,000 people died from a succession of heat waves that struck in 2003 (De Bono, Peduzzi, Kluser, & Giuliani, 2004). In both cases, the vast majority of those killed were seniors. In Toronto during the summer of 2005, six deaths occurred in rooming houses and shelters, where a lack of air conditioning, combined with fire codes that required doors to remain shut, raised internal air temperatures to critical levels (Wieditz & Penney, 2007).

Healthy individuals, while less likely to die from extreme heat, can suffer from fainting, dehydration, heatstroke, heat cramps, and heat exhaustion.

Smog and air pollution levels are a function of atmospheric conditions. Higher air temperatures speed up the chemical reaction between nitrogen oxides (NO_X) and volatile organic compounds (VOCs) to form ground-level ozone (O_3), the primary ingredient in smog. Smog is especially problematic during periods of extended warm weather. As temperatures have increased and continue to increase, mean ozone levels are increasing as well.

Vector-borne and Food-borne Illnesses

Projected ecological change is expected to support the higher survival rates and spread of many insects, including mosquitoes and ticks (Figure 3.2). As a result, insect borne-diseases such as West Nile virus, Lyme disease, and even malaria are expected to become more prevalent. The impacts on the more vulnerable groups of the population, including the elderly, the young, the infirm, and the poor are of particular concern.

Figure 3.2: Expected Range of the Blacklegged Tick under Climate Change. Source: (Charron & Socket, 2005)

Food-borne illnesses tend to peak in the summer when warm temperatures promote pathogen growth in food. Research by Health Canada has demonstrated the relationship between temperature and food-borne disease: as air temperatures increase, so do the number of food-borne disease outbreaks (Uyttendaele, Liu, & Hofstra, 2015). With the onset of hotter summers and more frequent heat waves, like those in 2005 and 2010, we can expect to see a rise in the incidence of food poisoning.

3.6 Ecosystem and Biodiversity

Projected climate change will bring significant changes to the ecosystem, both to aquatic and terrestrial components. Observations in the relative abundance of fish species in southern Ontario, including the Kawartha Conservation watershed, are already showing a shift from cold and coolwater species to more warmwater species (Expert Panel on Climate Change Adaptation, 2009). Lower water levels in the lakes, projected for the future, will damage the wetlands that presently maintain shoreline integrity, reduce erosion, filter contaminants, absorb excess stormwater, and provide important habitat for fish and wildlife. Invasive species will likely benefit from climate change and increase their presence in the ecosystem, adding pressure on native plants and animals.

Climate change will represent yet another stressor on the terrestrial ecosystem, adding to the loss of natural habitat associated with agricultural development and urbanization that has been a major factor in biodiversity loss for a long time.

3.6.1 Flora and Fauna Communities

A review of various studies on flora and fauna communities indicates that climate change impacts to ecosystems in southern Ontario are subject to key drivers, and that some mitigation may lessen the impacts and assist local

ecosystems to adapt partially to the changes that climate change will bring. “The effects of climate change on communities and ecosystems are difficult to predict because of complexities and uncertainties associated with biotic interactions” (Nituch & Bowman, 2013).

Range expansions and contractions will likely occur for many species, and they will likely have the greatest negative impact on species that are habitat and climate specific, with little ability to adapt to changing conditions over a short period of time. The gray jay (*Perisoreus canadensis*) is a species that has exhibited evidence of range contraction due to the loss of cold-dependent food caches during breeding periods, negatively impacting breeding success. More adaptable generalist species that are found in wider habitat and climate types will likely continue to expand their ranges.

Habitat fragmentation will negatively impact biological diversity, particularly in southern Ontario including the Kawartha Conservation watershed, where habitat is extensively fragmented by agricultural and other development. Fragmentation inhibits the movement of species (e.g., those with limited mobility such as amphibians) during the process of climate change and therefore, as conditions become more inhospitable, species cannot move to more suitable locations for their survival. For example, a rapid population decline of the green salamander (*Aneides aeneus*) within a highly fragmented habitat has been linked to an increase in temperatures over the last 50 years (as cited in Nituch & Bowman, 2013).

The growth rate of some tree species is expected to increase where other conditions, such as soil moisture and absence of fire, are favourable. However, higher temperatures reduce the growth rate of black spruce and white spruce. Combinations of impacts may result, for example, in black spruce and balsam fir being replaced by more drought-tolerant jack pine and aspen in increasingly dry areas, but the spread of mountain pine beetle from the west may, in turn, threaten jack pine in those same locations. Wild fires and tornados are likely to become greater threats to ecosystems.

Climate change will also facilitate the movement and survival of diseases and parasites that are not currently found in the Kawartha region, and therefore they will negatively impact species that are not currently exposed to them. Disease will become more prevalent in all species locally, and due to climate extremes, the ability to adapt and develop resistance will further compromise species diversity and abundance.

Climate change will likely facilitate an unprecedented era of invasive species arriving and surviving in the Kawartha region. As climatic conditions change, competition from new species, whether introduced through human activities or moving into the area on their own, will displace local species that are less adaptable to new conditions. The new species will prey on local species causing decline or extinction, or causing hybridization of species that are at the edge of their ranges. For example, a strong association between patterns of climatic suitability and the emergence of the invasive gypsy moth (*Lymantria dispar*) is evident in Ontario. Régnière notes that records indicate a significant increase in the distribution of the invasive moth since 1980, during which time the climate has warmed (as cited in Nituch & Bowman, 2013).

There is mounting evidence that climate change is causing negative impacts on local ecosystems, such as range contractions for native species. Hughes notes that the ranges of some Arctic and alpine plants have contracted northwards (as cited in Varrin, Bowman, & Gray, 2007). Butler notes that migratory birds have also begun to show evidence that climate change is negatively impacting neotropical migrants; they are at a disadvantage to short distance migrants that arrive on their breeding grounds earlier (as cited in Varrin, Bowman, & Gray, 2007). Hitch and Leberg note that hybridization in species with range overlap has demonstrated a negative impact on

black-capped chickadees (*Poecile atricapillus*), as Carolina chickadees (*Poecile carolinensis*) expand their range at a rate of 2 kilometres (km) per year, and will soon be displaced in southern Ontario (as cited in Varrin, Bowman, & Gray, 2007).

3.6.2 Aquatic Habitat

Based on the predictions of future weather and climate, two broad-based changes for freshwater aquatic ecosystems are likely to be expected: the availability and distribution of aquatic habitat types and reduced quality of aquatic habitat (Dove-Thompson, Lewis, Gray, Chu, & Dunlop, 2011). The anticipated changes may include the following.

Reduced coldwater habitat. Coldwater stream habitat is limited within Kawartha Conservation's jurisdiction; only 20% of the approximately 2,800 km of streams are considered coldwater. Most of these still support native brook trout, a sensitive and locally rare indicator species. Coldwater stream habitat in Kawartha Conservation's jurisdiction is particularly vulnerable because of low to moderate groundwater inputs.

Expected increases in water temperature in lakes, streams, and wetlands associated with climate change will reduce the availability of coldwater habitat. Although most of the Kawartha Lakes are considered warmwater lakes, many of the deep basins within the lakes (e.g., Balsam Lake, Cameron Lake, Sturgeon Lake, and Pigeon Lake) thermally stratify for brief periods that sustain coldwater habitat during the summer months. These relatively small areas support locally rare populations of several coldwater aquatic communities including fishes and zooplankton. Increasing water temperature will likely decrease the available volume of coldwater habitat for these species during the summer. Crystal Lake, the only coldwater lake within Kawartha Conservation's jurisdiction, will likely also exhibit a reduction in coldwater volume impacting several coldwater communities supported by the lake.

Increased warmwater habitat. Warmer water temperatures will correspond to a shift in the thermal regimes to warmer habitat regimes. Increased water temperatures, along with lower phosphorus levels and increased water clarity, have already been demonstrated as a key driver of observed changes in fish communities in the Kawartha Lakes over the last 30 years (Robillard & Fox, 2006). A shift to a warmer thermal regime will give fishes that prefer warmer temperatures a competitive advantage over those that prefer cooler temperatures. Since the majority of watercourses in the Kawartha Lakes are already considered warmwater habitat, shifts in thermal regimes will not be as dramatic as in coldwater lakes and streams.

Decreased base flows and groundwater inputs. As previously noted, the groundwater recharge is expected to decline as a result of changes in precipitation patterns and increased air temperature. A steady supply of cold groundwater is necessary to maintain viable coldwater aquatic habitat that supports locally rare species such as brook trout and mottled sculpin. Reductions in groundwater input will result in watercourses becoming more dominated by surface water runoff, which will restrict the capacity to support these rare coldwater communities. Small streams that traditionally flow year-round will likely become more intermittent in their flow regime, which will decrease the amount of year-round aquatic habitat available.

Blocked migration routes. In areas where changes in precipitation and evaporation lead to reductions in water levels, the movement of fish, access to spawning and nursery habitats, and migration may be impaired. This may be particularly evident in the Kawartha Lakes where shallow, gently sloping nearshore habitats are relatively abundant compared to deep open water areas. These littoral areas provide significant habitat for most aquatic

species in the lakes. A reduction in surface area would likely impact aquatic communities. With respect to streams and rivers, reductions in water levels and baseflow could limit continuous access to upstream-downstream habitat due to blockages from perched culverts and other obstructions, limiting habitat access during low flow conditions.

Increased or decreased wetland areas affecting fish production. Wetlands are expected to be impacted by changes in water levels and groundwater inflow. Wetlands are particularly important for providing spawning and nursery habitat for fishes and year-round habitat for other aquatic species. Reductions in wetland areas may be particularly observable in wetlands influenced by rivers and in inland, isolated wetlands. However, impacts on wetlands associated with shallow nearshore areas of lakes are more difficult to predict. Aquatic habitat may actually expand from an increase in vegetative growth caused by warmer water temperatures, a longer growing season, and reduced lake-ice coverage. This could give a competitive advantage to aquatic communities that prefer habitats dominated by macrophytes (aquatic plants), such as yellow perch and largemouth bass. On the other hand, gently sloping nearshore wetland areas of certain lakes (e.g., Lake Scugog, southern Pigeon Lake, etc.) may diminish due to reductions in water levels.

Increased shoreline erosion and runoff resulting in loss of spawning habitat. Extremely high and fast flows from severe precipitation events will likely increase the erosion of soils and contribute to additional sedimentation of the nearshore areas of lakes and streams. This can result in loss of spawning habitat for species that prefer coarse substrates such as gravel and cobble. High water levels in the spring of 2013 and 2014 caused erosion that was observed along many waterfront properties in the Kawartha Lakes.

Warmer water and lower dissolved oxygen resulting in increased algal and bacterial growth and fish kills Warmer water holds less dissolved oxygen than cold water. Therefore, higher water temperatures will likely reduce habitat suitability for sensitive coldwater aquatic communities that rely on oxygen-rich waters. The majority of the Kawartha Lakes support warmwater species that are relatively tolerant to lower oxygen levels, so this probably will not limit their capacity for habitat. Warmer waters will likely lead to increases in algal and bacterial growth. The spread of bacteria was one of the key drivers (along with the Koi herpes virus) of the carp die-off in the Kawartha Lakes in 2007 and 2008 (Ministry of Natural Resources, 2008).

4.0 Responding to the Challenge

As our understanding of climate change has increased, the following are the main points to consider in planning our response (Warren, 2014):

- Canada's climate is changing, with observed changes in air temperature, precipitation, snow and ice cover, and other indicators. Further changes in climate are inevitable.
- Changes in climate are increasingly affecting Canada's natural environment, economic sectors, and the health of Canadians.
- Extreme weather events are a key concern for Canada and there is growing confidence that some types of extreme events will increase in frequency and/or intensity as the climate continues to warm.
- Adaptation is accepted as a necessary response to climate change, complementing global measures to reduce greenhouse gas emissions. Adaptation enhances the social and economic resilience of Canadians to climate change impacts.
- Adaptation is occurring with increasing frequency and enhanced engagement. Continued action will help to build capacity, address information needs, and overcome challenges.
- Adaptation can sometimes turn risks into opportunities, and opportunities into benefits.
- Collaboration and adaptive management are approaches that governments and industry are increasingly pursuing to advance adaptation.

The impacts of climate change will create negative and positive effects everywhere: in our watershed and communities, in our province, in our country, and around the world.

The Government of Canada, provincial and local governments, and communities are undertaking a better understanding of the climate change process and its consequences, as well as development of mitigation and adaptation measures.

Sections 4.1 and 4.2 present a summary of programs and initiatives which have been initiated or contemplated by the Government of Canada and the Province of Ontario. We are not making any assessment as the level of implementation.

4.1 National Perspective

Recognizing the current change in climate and the importance of mitigation and adaptation to it, the federal government reports that a climate change plan has been developed and is being implemented (Government of Canada, 2014). The plan is based on a scientific foundation and includes actions on, and investments in mitigation and adaptation, as well as international engagement through a number of partnerships.

The Minister of the Environment is the lead minister for climate change policies and measures. Natural Resources Canada, Transport Canada, and other federal departments are also involved in the development and implementation of climate change policies and measures.

The federal actions are focused on:

- **Regulations to reduce GHG emissions,**
- **Strategic investments in areas such as clean energy technology and climate change adaptation,**
- **Scientific research to support policy development and decision-making, and**
- **Participating in international climate change efforts.**

4.1.1 Regulating Emissions

According to federal government reports, since 2005 Canadian GHG emissions have decreased by 5.1% while the economy has grown by 10.6% (*Canada's Action on Climate Change*, 2014). Regulation of greenhouse gas emissions is taking place on a sector-by-sector basis. The two largest sources of GHG emissions – the transportation and electricity sectors – were targeted first, and work continues on developing regulations for other major sources of GHG emissions, including the oil and gas sector. It is believed that this approach allows maximum progress on reducing emissions while maintaining economic competitiveness.

Federal legislative tools used to regulate emissions include:

- The *Canadian Environmental Protection Act,* 1999*;*
- The *Energy Efficiency Act;*
- The *Canada Shipping Act,* 2001*;*
- The *Aeronautics Act;* and
- The *Railway Safety Act.*

The following regulations in the transportation and electricity sectors were developed to reduce GHG emissions:

- The *Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations* (2010) imposes GHG emissions standards on passenger automobiles and light trucks.
- The *Heavy-duty Vehicle and Engine Greenhouse Gas Emission Regulations* (2013) applies emissions standards to new on-road heavy-duty vehicles and engines.
- The *Vessel Pollution and Dangerous Chemicals Regulations* (2012) implements the energy efficiency requirements for ships in accordance with international agreements.
- The *Reduction of Carbon Dioxide Emissions from Coal-fired Generation of Electricity Regulations* (2012) applies emissions limits to new and rebuilt coal-fired electricity generation units.
- The *Energy Efficiency Regulations* directs the EnerGuide program for household appliances and products.

4.1.2 Strategic Investments

The Government of Canada recognizes the importance of clean technologies for achieving sustainable economic prosperity, while creating a healthier environment (Government of Canada, 2014). Since 2006, the federal government reports their investment of over $10 billion towards green infrastructure, energy efficiency, the development of clean energy technologies, and the production of cleaner energy and fuels, including:

- The ecoENERGY for Renewable Power program has supported more than 100 projects focused on the generation of electricity from renewable energy sources.

- Over $500 million has been committed to the carbon capture and storage initiative**.**
- More than 245 clean technology projects have been supported through Sustainable Development Technology Canada (SDTC). Recent examples of projects funded through the SDTC include an electrical vehicle charging station, a system to convert municipal solid waste into energy-rich gas to produce heat and electricity in remote and rural areas, and a wind hybrid power plant.

In addition, over $235 million has been invested into adaptation initiatives to improve the understanding of climate change and the planning for climate impacts.

4.1.3 Development of Science

Climate change research is a joint effort implemented through core government programs, academic institutions, and collaborative research networks. Research and monitoring provide the scientific foundation to guide Canadian decisions on climate change mitigation and adaptation (Government of Canada, 2014). Research findings contribute to domestic climate change policies and decisions; inform international bodies such as the Intergovernmental Panel on Climate Change, the Arctic Council, and the Global Methane Initiative; and support Canada's reporting obligations under the United Nations Framework Convention on Climate Change (UNFCCC). Over $61 million over five years is allocated for initiatives focused on climate change and atmospheric research.

4.1.4 International Actions

On the international stage, Canada is an active participant in international climate change activities (Government of Canada, 2014). Canada continues to play an active role in the United Nations Framework Convention on Climate Change and is committed to establishing a fair and effective climate change agreement that includes all major emitters. Canada’s leadership was instrumental in achieving a breakthrough on an important initiative to help developing countries reduce deforestation and forest degradation, which accounts for nearly 15% of global GHG emissions (Government of Canada, 2014).

Canada extends its efforts beyond the UNFCCC by working with other countries through complementary forums such as the Arctic Council, the Montreal Protocol, and the Climate and Clean Air Coalition (CCAC) to develop practical and collaborative initiatives to reduce GHG emissions and short-lived climate pollutants.

4.2 Ontario Approach

In February 2015, the province, represented by the Ministry of the Environment and Climate Change (MOECC), released *Ontario’s Climate Change Discussion Paper 2015* (Ministry of the Environment and Climate Change, 2015). It is one step in a sequence of provincial documents focused on climate change.

The Expert Panel on Climate Change Adaptation was established in 2007 and produced a report that included 59 recommendations on how to minimize the negative impacts of a changing climate in 2009 (Expert Panel on Climate Change Adaptation, 2009). In response to the Expert Panel recommendations, the *Climate Ready: Adaptation Strategy and Action Plan, 2011-2014* was released in 2011. According to the strategy, the province should prepare for “the impacts of a changing climate through implementation of policies and programs that minimize risks to our health and safety, the environment and the economy, and maximizes the benefits from opportunities which may arise” (Government of Ontario, 2011)**.**

Ontario's Climate Change Discussion Paper 2015 reinforces Ontario's climate change vision for the long term, as follows:

- Redesign and build a strong, carbon-neutral economy, community, infrastructure, and energy system;
- Protect ecosystems, including air, land, and water;
- Establish Ontario as a leader in climate change mitigation and science; and
- Leave a legacy of a healthy world for our children and future generations.

The document lays out guiding principles for achieving a low-carbon economy. It sets a long-term goal of transforming Ontario into a low-carbon economy and a society with resilience to change, and it emphasizes the need for short-term critical actions to achieve those goals.

Through this Discussion Paper, the province is seeking institutional and public input and ideas to develop further long-term climate change strategy that "will allow us to achieve our goal of a healthy, prosperous province recognized as a world leader in climate change solutions" (Government of Ontario, 2011).

Climate change mitigation and adaptation actions currently being undertaken by the Province of Ontario are focused on the following:

- **Reducing greenhouse gas emissions and working toward a low-carbon economy**,
- **Promoting energy efficiency and conservation, and**
- **Preparing for future change and planning ahead.**

4.2.1 Reducing Greenhouse Gases

The following legislative tools allow for the reduction of greenhouse gases:

- The *Environmental Protection Act.* The act was amended in 2009 to provide for a greenhouse gas emissions reduction program to link with other systems. Also in 2009, Ontario introduced a regulation requiring large emitters to report their greenhouse gas emissions.
- The *Green Energy and Green Economy Act,* 2009 provides the means for transition to a low-carbon, clean-energy economy.
- *Ontario's Long-Term Energy Plan* (2010) encourages change in Ontario's energy sector.

Similar to the federal government, Ontario approached the reduction of greenhouse gases on a sector-by-sector basis. In the electricity sector, phasing out coal-fired electricity generation allowed Ontario to achieve significant emissions reductions. By April 2014, all coal-power generating units were shut down, which made Ontario the first in North America to end coal-fired electricity generation.

Provincial investments in public transit, such as the Metrolinx project in Toronto, GO Transit, the Region of Waterloo's Rapid Transit, and Ottawa Light Rail Transit, support positive changes in the transportation sector. The 25-year Regional Transportation Plan, *The Big Move: Transforming Transportation in the Greater Toronto and Hamilton Area* (2008), is expected to improve regional transportation, protect the environment, and enhance the quality of life in the Greater Toronto and Hamilton Area.

Ontario supports an electric vehicle program, providing incentives on plug-in electric vehicles and supporting a vision of one in 20 vehicles driven in Ontario being electric by 2020.

To reduce GHG emissions in the agriculture and waste sectors, Ontario implements programs such as:

- The Environmental Farm Plan that supports the reduction of greenhouse gas emissions through manure management, nutrient management planning, precision agriculture, farm energy audits, and farm energy and water conservation measures.
- The Ontario Biogas Systems Financial Assistance Program led to more than 11 megawatts of installed electrical capacity, enough power for 10,000 homes. The program supported greenhouse gas emission reductions by a direct avoidance of emissions from manure storage and through offsetting emissions by replacing fossil fuel-generated electricity.
- The Ontario Ethanol Growth Fund has helped to create seven ethanol facilities. The fund has generated over $635 million in capital investment, and it continues to assist in reducing GHG emissions in Ontario.
- Reducing the amount of waste helps decrease GHG emissions and supports a greener economy. Successful waste diversion programs such as Blue Box, Municipal Hazardous or Special Waste, and the Waste Electrical and Electronic Equipment Program promote waste reduction and help to cut greenhouse gases.

Projects under the Green Energy and Green Economy Act and the Long-Term Energy Plan are currently exempt from the requirement for Full Environmental Assessments. The failure to require Full Environmental Assessments in accordance with Ministry's Statements of Environmental Values, compromises the environmental protection that currently exists and fails to consider social and economic impacts of projects. Public support depends on proper consideration of environmental, social and economic impacts of any and all proposed large scale energy projects. To this end, Kawartha Conservation passed a resolution (#129/12) on October 9, 2012 calling for Full Environmental Assessments for industrial wind turbine and other renewable energy projects as a condition of the Renewable Energy Approval.

Recently, Ontario announced a Cap and Trade system for the province. According to the Province's press release (Ontario, April 13, 2015), "a cap and trade program is intended to reduce the amount of greenhouse gas pollution by setting a limit on emissions allowed in each sector of the economy, rewarding innovative companies, providing certainty for industries, and creating more opportunities for investment." It is emphasised in the press release that "the province will work with communities and industry on the system's design to ensure that it works best for Ontario". Details of the program have yet to be provided.

4.2.2 Energy Conservation and Efficiency

To improve energy conservation and efficiency, and to develop cleaner energy, the following actions have been undertaken by the Province of Ontario:

- The Ontario Building Code was updated, so that houses and buildings are more energy efficient. An average house built in 2012 is approximately 40% more energy efficient than a house built according to previous standards.
- The Ontario Broader Public Sector including municipalities, universities, colleges, schools, and hospitals is required to develop energy conservation plans and report on energy use and GHG emissions.
- Programs such as the Fridge & Freezer Pickup, Smart Meters, and peaksaver PLUS® encourage general energy efficiency and conservation practices by businesses and members of the public.

4.2.3 Preparing for Changes Ahead: Land Use and Stewardship

The following provincial legislative documents have been introduced or recently updated; they address climate change while supporting efficient land use and protecting the ecosystem.

The *Provincial Policy Statement* (PPS) was updated in 2014 to respond to the need for reducing GHG emissions through policies that promote efficient use and management of land and infrastructure, protection of the environment, and efficient use of resources. This includes the promotion of compact development, increased use of public transit and non-motorized methods of transport, and encouragement of land use patterns and forms of settlement based on higher densities and mixed uses.

The *Oak Ridges Moraine Conservation Plan* (2002) protects, improves and restores the ecological and hydrological integrity of the Oak Ridges Moraine, one of Ontario's most significant landforms. The plan sets out four land use designations and the permitted uses for each, with fewer activities allowed in each more protective designation.

The *Greenbelt Plan* (2005) controls urban sprawl and provides permanent protection to the agricultural lands and environmentally sensitive areas in southern Ontario.

The *Places to Grow Act* (2005) plans for growth and development in a way that supports economic prosperity, protects the environment, and helps communities achieve a high quality of life across the province. It calls for the creation of more compact, complete, and sustainable communities, with adequate combinations of housing, jobs, and community services.

Building Ecosystem Resilience

To protect Ontario's environment and increase its resilience, a number of tools for natural resource managers and programs have been developed, as follows:

- The *Biodiversity: It's in Our Nature* (2012) document sets out the actions that will contribute to the vision and goals outlined in *Ontario's Biodiversity Strategy, 2011*. This plan coordinates efforts of the province and its partners in sustaining ecosystem biodiversity. An important action in the strategy is enhancing the resilience of ecosystems by doing climate change vulnerability assessments and providing tools to support adaptation planning.
- The *Ontario Invasive Species Strategic Plan 2012* aims to prevent new invaders from settling in Ontario, to slow and, where possible, reverse the spread of existing invasive species, and to reduce the harmful impacts of existing invasive species.
- *A Practitioners Guide to Climate Change Adaptation in Ontario's Ecosystems* assists organizations such as Conservation Authorities and stewardship groups to prepare for climate change.
- In the 50 Million Tree Program, the province has set a goal of planting 50 million trees by 2025 in Ontario. The objectives of the program are to sequester carbon, increase the adaptive capacity to withstand climate change, increase wildlife habitat, and increase soil and water conservation. More than 11.3 million trees have been planted to date (*Climate Vision. Climate Change Progress Report*, 2012).
- The Province of Ontario has committed to protect at least 225,000 square kilometres (almost 21% of Ontario's total area) of the Far North Boreal region from development in the *Far North Act* (2010). Once

established, it will be one of the largest protected areas in the world, recognized as a globally significant carbon sink.

- Ontario's proposed Great Lakes Protection Act includes actions to understand and adapt to the impacts of climate change on the Great Lakes.

4.3 Local Response

4.3.1 Policy Framework

Municipalities have their share in many of the responsibilities for managing risks from a changing climate perspective. Municipal governments have primary responsibility for, or can significantly influence, many of the factors that determine its residents' vulnerabilities to climate-related risks.

A strong policy foundation allows for managing risks associated with climate change. The Ontario *Municipal Act,* 2001; the *Provincial Policy Statement, 2014*; *The Emergency Management and Civil Protection Act,* 2003; and the *Conservation Authorities Act* all require that municipalities take action to prevent, mitigate, or respond to threats to human health and safety, public property, and the environment.

The Ontario *Municipal Act* assigns broad authority and accountability to municipalities in 10 spheres of local jurisdiction, including four that are directly affected by and related to climate change:

- Public utilities;
- Culture, parks, recreation, and heritage;
- Structures; and
- Economic development services.

The Emergency Management and Civil Protection Act requires municipalities to develop comprehensive, risk-based emergency management programs based on prevention, preparedness, response, and recovery. Municipalities are required to establish their *enhanced-level* program, identifying specific areas that must include vulnerabilities to climate change.

The *Provincial Policy Statement* (PPS) provides direction to respond to climate change impacts to reduce economic costs and potential environmental, social, and health risks (Ministry of Municipal Affairs and Housing, 2014) by

- Considering the potential impacts of climate change that may increase the risks of natural hazards, and
- Directing development away from areas of high to extreme risk of wildland fire, unless the risk is mitigated.

Policies on climate change, as defined in the PPS 2014, are broader than those related to natural hazards (Ministry of Municipal Affairs and Housing, 2014). There is enhanced policy direction to ensure that communities are resilient to the impacts of climate change by

- Supporting land use and development patterns that reduce greenhouse gas emissions and promote adaptation to climate change,
- Encouraging green infrastructure, and
- Strengthening stormwater management requirements as important components of broader infrastructure planning.

The PPS 2014 recognizes that mitigation and adaptation strategies must be incorporated into development plans, as the potential for municipal liability associated with extreme weather is a major and growing concern (Vaianisi, 2014).

4.3.2 Municipal Actions

Municipalities have an opportunity to play a key role in fighting climate change. It has been estimated that municipal governments currently have direct or indirect control over approximately 44% of GHG emissions in Canada (EnviroEconomics, 2009). Many municipalities in Ontario and throughout Canada have already begun to address excessive GHG emissions and climate change. They are proceeding with sustainable policies and approaches to manage water supplies, reduce energy consumption, optimize transportation, and examine land use policies. These actions yield two benefits: they increase economic efficiencies and reduce GHG emissions.

Municipal governments, through their own operations and decision-making powers, have a major impact on the pattern of urban and rural development, transportation, economic activity, and consumption of energy resources. As a result, municipalities have direct and indirect control over how, where, and what volume of GHG emissions are produced.

- GHG emissions under the *direct* control of municipalities include those arising directly from providing municipal services and operating municipal buildings, fleets, and facilities.
- GHG emissions under *indirect* control include those in which municipalities play a significant role in determining the level of emissions through municipal planning, public transit access, and policy mechanisms, such as building codes, landscape design and land use regulations. Examples are development charges and zoning requirements.

In this respect, municipalities shape how GHG emissions are generated through land use practices, spatial distribution of the economy, transportation systems, and the energy efficiency of the community building stock.

Municipal governments are also the level of government closest to citizens; they can most easily engage households and businesses to implement local projects to reduce GHG emissions. Municipal governments can influence GHG emissions as a regulator, facilitator, partner, program deliverer, and educator.

Municipalities can take many actions to combat climate change by reducing GHG emissions. Some of them are listed in Table 4.1. In general, these measures can be divided into the following categories, with the first two falling directly within municipal control, and the remainder under indirect municipal control:

1. **Municipal Operations.** Emissions reductions may be achieved from improvement in the energy efficiency of buildings, fleets, and facilities operated by a municipality.

2. **Solid Waste.** Emissions reductions may be attained from the capture of landfill gas at landfill sites, and from the use and recycling of materials that would otherwise remain in the landfill.

3. **Buildings.** Emissions reductions may be attained through construction and retrofit of energy-efficient private buildings, and implemented through federal, provincial/territorial and/or municipal guidelines, zoning by-laws, energy codes, or incentives.

4. **Transportation and Land Use.** Emissions reductions may be achieved by reducing private and commercial vehicle trips or vehicle kilometres travelled through urban design and planning initiatives, as well as supportive federal, provincial/territorial and/or municipal regulations such as changes to tax codes or implementation of user fees.

Table 4.1: Municipal Climate Change Actions. (*Partners for Climate Protection*, 2012)

IN THE CORPORATE SECTOR	IN THE COMMUNITY SECTOR
• Retrofit buildings and adopt green building standards for new buildings and sites	• Start a community-wide composting program
• Change traffic lights to energy saving light-emitting diodes (LEDs)	• Sell rain barrels at a reduced cost and launch an awareness program on water conservation
• Replace streetlights with more efficient bulbs	• Use financial incentives to help residents reduce waste
• Start a water conservation program	• Promote energy efficiency in the industrial sector
• Plant trees to improve air quality	• Create incentives for using public transit
• Start an anti-idling program for municipal vehicles	• Use by-laws and development approval incentives to increase building standards and land use mix
• Create staff incentives for carpooling and the use of public transit	• Support and encourage energy efficiency initiatives in the residential and private sectors
• Promote green fleet management practices such as right sizing, low carbon fuels, and hybrid/electric vehicles	• Develop and maintain infrastructure friendly to pedestrians and bicycles
• Purchase renewable energy or develop local sources for generation (such as wind, solar, or district energy)	• Initiate commuter challenges to reduce vehicle use
• Implement comprehensive landfill gas recovery systems at municipal landfill sites	• Support community garden initiatives or urban agriculture using surplus land or by developing green roofs

Municipalities have an opportunity to develop and implement landscape design policies that would increase resiliency of the landscape and improve its capacity to absorb and store water, act as carbon sinks, maintain current carbon sinks and lower surface and water temperatures.

The Federation of Canadian Municipalities (FCM), through the Partners for Climate Protection (PCP) program, provides assistance to municipal governments in environmental protection, including climate change. The Partners for Climate Protection program is a network of Canadian municipal governments that has committed to reducing greenhouse gases and acting on climate change. The PCP is the Canadian component of the International Council for Local Environmental Initiatives (ICLEI) - Cities for Climate Protection partnership, which involves more than 1,100 communities worldwide. The program empowers municipalities to take action against climate change through a five-milestone process that guides members in creating GHG inventories, setting realistic and achievable GHG reduction targets, developing local action plans, and implementing plans using specific, measurable actions to reduce emissions. Since the program's inception in 1994, over 250 municipalities from across Canada have joined PCP, making a public commitment to act on climate change. PCP membership covers all provinces and territories and accounts for more than 80% of the Canadian population. More than 60 Ontario municipalities, including the Regional Municipality of Durham, the Township of Brock, and the Township of Scugog, are members of the *Partners for Climate Protection* community. PCP receives financial support from FCM's Green Municipal Fund, and it provides funding (grants and loans) for all levels of local government and their partners for environmental initiatives such as:

- **Plans**, including sustainable neighbourhood action plans, community brownfield action plans, and greenhouse gas reduction plans;
- **Feasibility studies and field tests** aligned with our capital project criteria in the brownfields, energy, transportation, waste, and water sectors; and
- **Capital projects in the brownfields**, energy, transportation, waste, and water sectors.

Becoming a member of the PCP is a good starting point for municipalities who want to act on environmental protection. This program helps empower the community to decide where, when, and how it will take action on climate change. It is up to local governments to develop and evaluate their reasons for taking this action. The PCP milestone framework and toolkit can provide a platform for the municipality to

- Build the business case for climate protection,
- Foster collaborative approaches with the wider community, and
- Engage the public on issues surrounding climate change and local sustainability.

Appendix C contains examples of the municipal climate change planning documents and lists of the actions taken. Both upper- and lower-tier municipalities are represented.

The Region of Durham has created a vision for the municipality as “a carbon-neutral, sustainable, prosperous and resilient community with a high quality of life” (Region of Durham, 2013). This vision statement establishes carbon neutrality as an aggressive, long-term goal. This goal is balanced by the simultaneous objectives of making Durham Region sustainable, prosperous, and resilient to future pressures and shocks, while maintaining a high quality of life for its residents. The Durham Region Roundtable on Climate Change (DRRCC) was

established and the *Region of Durham Community Climate Change Local Action Plan* (LAP) was developed and approved in 2012. The plan is focused on mitigation measures and identifies 18 potential programs that are strategic, effective in reducing GHG emissions, and attractive to the community by producing environmental, economic, and social co-benefits (Region of Durham, 2013).

In October 2013, the DRRCC began working on a Community Climate Adaptation Plan (CCAP). The Plan's objectives are

- To identify future climate conditions within eight area municipalities;
- To consider the likely impacts of extreme weather;
- To make recommendations that will prepare, protect, and safeguard infrastructure and citizens; and
- To increase community resiliency to extreme weather conditions.

Next steps in the plan development will identify the actions and programs to increase the resilience of the Durham community (Climate Adaptation Subcommittee. Durham Region Roundtable on Climate Change, 2014).

The Township of Scugog, the Township of Uxbridge, and the Township of Brock developed the North Durham Integrated Community Sustainability Plan in 2012. The Plan, supported by the PCP and the Region of Durham, is an over-arching plan that links separate programs and initiatives in the community through the four pillars of economic, environmental, social, and cultural sustainability and envisions a longer-term perspective. It is not specifically targeted toward climate change response, but, among other actions, it establishes community and municipal corporate emissions reduction targets.

Our Kawartha Lakes Integrated Community Sustainability Plan (ICSP) for the City of Kawartha Lakes is a collection of goals and actions to improve the environmental, economic, social, and cultural sustainability in the community of Kawartha Lakes. The ICSP includes a vision for the future of the city, a list of accomplishments, and a report on unique aspects of community sustainability. Climate change is not a separate topic in the plan, but the following themes: energy and resource conservation, reduction of the carbon footprint, and employment of responsible environmental practices are embedded in the ICSP.

4.4 Conservation Authorities: Leaders in Watershed Management

Conservation Authorities (CAs) are local watershed management agencies delivering services and programs that protect and manage water and other natural resources within the watersheds of their jurisdiction. Conservation Authorities have a long history of successful collaboration with provincial and municipal governments, partner agencies, non-governmental organizations, and community members in a variety of programs. They promote an Integrated Watershed Management approach, balancing human, environmental, and economic needs. Under the *Planning Act,* Conservation Authorities are delegated the responsibility to comment on municipal planning documents and applications to determine consistency with the natural hazards policies of the *Provincial Policy Statement*. Through regulations in the *Conservation Authorities Act*, CAs regulate development, as defined under the Act, in areas prone to water-related hazards (such as shorelines, floodplains, wetlands, and hazardous lands) for impacts to control of the hazards (e.g., flooding, erosion, dynamic beaches, pollution, and conservation of land) and for interference with a watercourse or wetland. Also, Conservation Authorities are responsible for flood warning systems, flood plain mapping, and drinking water source protection.

Building on their mandate, their responsibilities, and their experience, Conservation Authorities have embraced climate change as another challenge to be addressed in watershed management. They recognize that it is critical to incorporate climate change adaptation into existing policies and programs, prioritizing actions that have co-benefits for mitigation and adaptation.

Conservation Authority Roles in Climate Change Adaptation

As leaders in environmental protection in Ontario, Conservation Authorities support measures to conserve, preserve, restore, mitigate and adapt to climate change. Many Conservation Authorities are already recognizing the potential impacts of a changing climate on water and land resources, and they are developing strategies to address those impacts.

Conservation Authorities support a wide array of climate change actions that relate to their mandate and responsibilities, such as the following:

- Promote greater collaboration for climate change adaptation through an Integrated Watershed Management approach.
- Enhance science and monitoring to track local impacts of climate change and support local watershed adaptation strategies.
- Improve the ability to protect Ontario from flood hazards through updated mapping and reviewing of flood forecasting systems and flood control infrastructure.
- Review the natural hazard technical guidelines in support of CA land use planning responsibilities and associated regulatory tools under the *Conservation Authorities Act*.
- Lead the Ontario Low Water Response Program within the jurisdiction.
- Build local ecosystem resilience through continued investments and partnerships targeting biodiversity, preservation, restoration, enhancement of green infrastructure and the Great Lakes shoreline.
- Maintain collaboration between Conservation Ontario and the province on climate change issues.

A Watershed Management Approach to Climate Change Adaptation

An Integrated Watershed Management (IWM) approach is the process of managing human activities and natural resources in an area defined by watershed boundaries. This approach allows multiple issues and objectives to be addressed and enables planning in a very complex and uncertain environment.

The IWM approach allows the organization and coordination of the work of various agencies involved in adapting to changing climate. Conservation Authorities have a successful history of working in partnership with provincial ministries, municipalities, and many other stakeholders to manage Ontario's water resources. This includes initiatives such as long-standing roles in watershed monitoring, protecting the public from flood hazards, mitigating the impacts of drought, and implementing the *Clean Water Act* to protect Ontario's sources of drinking water. As watershed management agencies, Conservation Authorities have been leading the development and implementation of watershed plans for many years.

The following are areas where Conservation Authorities can provide their expertise and employ their experience.

Science and Monitoring

Additional monitoring and modeling are required for beneficial adaptation initiatives. Conservation Authorities fulfill that role and are partners with the province in water and environmental data collection. The uncertainties of the response of Ontario's natural systems to a changing climate require a highly adaptive approach to future programming. Robust environmental monitoring as well as local understanding and modeling of the changing climate and the environmental response are critical to an adaptive approach.

Through watershed studies and data collection done in a variety of federal, provincial, and municipal partnerships, Conservation Authorities have accumulated a wide range of scientific information and local knowledge that can support climate change decisions. Conservation Authorities are key partners with the Ministry of the Environment and Climate Change (MOECC) and the Ministry of Natural Resources and Forestry (MNRF) in the ongoing collection of the water and environmental monitoring data that will support climate change detection and adaptation. One of the latest partnership initiatives is a network of seven monitoring locations established in southern Ontario to monitor climate, water quality, and water quantity parameters to detect climate change and its consequences.

Flood Management

Ontario's flood management system, provided by Conservation Authorities, has been recognized as one of the most efficient in the world. With continuing development, enhancement, and added investments, it has the capacity to cope with the changes in flood patterns.

As the lead agencies for flood hazards, Conservation Authorities are already adapting or investigating how to adapt their programs to account for climate change. For example, a group of the Conservation Authorities situated in the Greater Toronto Area (including Kawartha Conservation) has partnered with Environment Canada in developing regional intensity-duration-frequency (IDF) curves that provide better information for locations where IDF curves are outdated.

Climate change, together with growing populations and aging infrastructure, has reduced the capacity of watersheds to cope with storm runoff, exposing growing populations to increased flood risk and damage from flooding. The Conservation Ontario 2009 report, *Protecting People and Property: A Business Case for Investing in Flood Prevention and Control* (Conservation Ontario, 2009), shows that Ontario's flood management programs need to significantly improve in order to adequately protect life and property, and to ensure that flood emergencies are managed effectively now and in the future.

Conservation Authorities are facing specific adaptation challenges with respect to flooding.

- Floodplain mapping is the basis of all flood prevention programs. As documented in the Conservation Ontario 2009 report, there is a significant need to update flood risk assessments and floodplain maps. Conservation Authorities promote the incorporation of climate change into floodplain criteria, as well as the extension and updating of floodplain mapping coverage.

- Conservation Authorities, in partnership with MNRF, operate Ontario's flood forecasting and emergency response system. A number of Conservation Authorities are already reviewing and upgrading their systems in response to changing storm conditions.

- Through their role in development review and permitting, Conservation Authorities are actively involved in urban stormwater management. For example, in the Greater Toronto Area, they have developed a technical guideline and are working with their municipal partners in implementing Low Impact Development (LID) measures.

Land Use Planning

Conservation Authorities currently represent provincial interests regarding natural hazards through the *Provincial Policy Statement*, and they will have significant responsibility for ensuring that planning decisions adapt to climate change. These policies are critical to the delivery of an effective flood prevention program in Ontario. The policies must keep vulnerable development out of natural hazards in the watersheds and along the Great Lakes shorelines. At the same time land use planning ensures that natural heritage and green infrastructure components are protected.

Natural Heritage and Stewardship

Conservation Authorities contribute significantly to the protection of natural heritage in Ontario and are major landowners, collectively owning 143,000 hectares, including forests, wetlands, areas of natural & scientific interest, and significant natural habitat. Conservation Authorities, including Kawartha Conservation, continue to acquire and manage lands of conservation significance, enhancing ecosystem resilience to climate change. In addition, Conservation Authorities also work with local and regional municipal governments to increase natural heritage and biodiversity. As a local example, the currently developed Kawarthas Naturally Connected natural heritage system links natural heritage features and areas by natural corridors, which is essential to protecting healthy biodiversity and ecosystem resiliency from impacts related to climate change.

Conservation Authorities also deliver programs that support afforestation and private land stewardship. Kawartha Conservation offers a Tree Seedlings distribution program that provides low-cost tree seedlings to watershed landowners. Also, Conservation Authorities are leading partners with Trees Ontario in the 50 Million Tree Program, accounting for 70% of the trees planted under this initiative. In 2009 and 2010, Conservation Authorities led the planting of over three million trees (Conservation Ontario, 2011).

Conservation Authorities also deliver a variety of other private land stewardship programs that support climate change adaptation. These programs include rural water quality improvement; agricultural beneficial management practices; as well as stream, shoreline and habitat rehabilitation, restoration, and enhancement.

Low Water Response

Conservation Authorities partner with the province in the delivery of the Ontario Low Water Response Program. Increasing demand for water coupled with the potential for reduced supplies in the summer months creates the potential for more significant drought events in the province. The incorporation of new science and the enhancement of the decision-making process support the further implementation of the program.

4.5 NGOs and Climate Change

Non-governmental organizations (NGOs) who are focused on environmental issues play a wide range of roles in addressing climate change problems (Krajnc, 2004).

Some, such as the Ontario Centre for Climate Impacts and Adaptation Resources (OCCIAR) and the Climate Action Network Canada analyze and popularize the science and impacts of climate change in background reports and public appearances. Other challenge industry through direct actions and shareholder meetings. Many target governments through electoral or legislative lobbying strategies. Others are focused on long-term public education campaigns, developing curriculum materials for teachers, organizing grassroots initiatives such as community workshops and presentations, and building the movement. The following section outlines the activities of the more noteworthy NGOs focused on climate change.

The Ontario Climate Consortium (OCC), the *Consortium*, represents scientists, researchers and practitioners from across Ontario with a focus on addressing climate change issues pertinent to Ontario and beyond (Ontario Climate Consortium, 2015). The *Consortium* builds upon the well-established climate science expertise located within partner universities but also the practical experience of end-users such as large urban municipalities in the Greater Toronto Area (GTA) and Conservation Authorities across the province. Toronto and Region Conservation Authority provides secretarial services and coordination for the *Consortium* in partnership with York University, McMaster University, and Western University.

The *Consortium* was developed as a direct response to federal and provincial calls for informed, pro-active response to climate change and climate risk. The *Consortium's* objective is to facilitate Ontario's transition to a climate-resilient, climate-ready province by building local capacity for state of the art climate science and associated research while supporting a wide range of end users and their needs.

The Ontario Centre for Climate Impacts and Adaptation Resources (OCCIAR) is a university-based resource hub for researchers and stakeholders searching for information on climate change impacts and adaptation (Ontario Centre for Climate Impacts and Adaptation Resources, 2015). The centre communicates the latest research on climate change impacts and adaptation, liaises with partners across Canada to encourage adaptation to climate change, and aids in the development of tools to assist with municipal adaptation.

The Clean Air Partnership (CAP) is a Toronto-based group that works with partners to achieve clean air, facilitate the exchange of ideas, advance change, and promote and coordinate implementation of actions that improve local air quality (Clean Air Partnership, 2015). Its mission is to transform cities into sustainable, vibrant, resilient communities, where the air is clean to breathe and greenhouse gas emissions are minimized. CAP's actions are directed at addressing the greening of cities through cleaning the air, stabilizing climate, and protecting people from air pollution and the impacts of climate change through research, mapping, policy initiatives, market solutions, and public education. CAP works closely with local communities and others who share the common goal of healthy sustainable cities.

The Toronto Climate Campaign is a coalition of representatives from unions, environmental and social justice organizations, students, and citizens whose key initiative is to educate, motivate and mobilize a collective mass-movement to demand solutions to climate change. Its goal is to push an urgent shift by governments, businesses and institutions toward policies that aggressively promote sustainable living. Their strategy is to organize events

such as rallies, public meetings with speakers, and support for other environmental groups (Climate Action Campaign International, 2015).

The Climate Action Network Canada acts as a clearinghouse and network for more than 100 Canadian groups working on climate change including local groups, such as the Algonquin Park Wildlands League and Climate Action Niagara, and international organizations, such as the Citizens Environmental Alliance and Citizens Climate Lobby. The Climate Action Network provides a forum for communication on policy developments and devises cooperative strategies (Climate Action Network Canada, 2015). Their key strategy is to use information effectively. The network is able to pool scarce NGO resources and produce significant reports, such as *Kyoto and Beyond: The low-emission path to innovation and efficiency (Torrie, Parfett & Steenhof, 2002)*, published with the David Suzuki Foundation.

The David Suzuki Foundation (DSF) activities at the national level are focused on developing a clean, renewable energy plan for Canada (David Suzuki Foundation, 2015). At the provincial level, they are encouraging friendly competition to see which province can adopt the best climate policies through the Race to the Top campaign. For individuals, the DSF offers resources on how to reduce an individual carbon footprint at home and at work.

The Sierra Club Canada is a grassroots volunteer-driven organization that has a long, successful history of campaigning in the field of environmental protection (Sierra Club Ontario, 2015). While its national office is focused on national and international campaigns such as Climate Change and Nuclear-Free Canada, the regional chapters focus on regional issues that are of high priority. The Coal Plant Phase Out campaign was an example of the organization's success in Ontario. Currently, the Sierra Club Ontario work is focused on the Great Lakes ecosystem, the Greenbelt, and Green Energy. Sierra Club Ontario also works on very local issues, in coordination with smaller communities in Ontario. For example, the Sierra Club Peel Group is working on removing all heavy industrial facilities out of the Credit River Valley.

The Pembina Institute advances clean energy solutions through innovative research, education, consulting and advocacy. The institute works to develop comprehensive climate policy packages for Canada and the Canadian provinces and territories that include pricing carbon, reducing emissions and improving energy efficiency (Pembina Institute, 2015). It also promotes climate change awareness and monitors policy and business developments that have real implications for climate change. The Pembina Institute was originally founded by high school teachers and it also runs workshops for teachers and develops curriculum material.

There are many other non-government organizations whose activities, although not focussed on climate change adaptation support positive climate change actions by working on local issues or implementing small, hands-on projects. Only a few of them are listed below.

Save The Oak Ridges Moraine (STORM) Coalition is focused on protecting the ecological integrity of the Oak Ridges Moraine. The STORM is working at the local and regional levels to ensure that municipalities make good planning decisions that respect the environmental significance of the moraine and that take into account its ecological and hydrological functions.

The Ontario Land Trust Alliance represents 32 community-based land trusts across Ontario and promotes voluntary land conservation to benefit communities and natural heritage systems. Over 90,000 acres across the Province are protected by the OLTA.

Trees Canada engages communities, governments, corporations and individuals and provides education, technical expertise, and resources to plant and care for urban and rural trees. Nearly 80 million trees have been planted and more than 550 schoolyards have been greened across the country.

EcoSpark works with communities and schools, providing them with the knowledge and tools to monitor their environment and take action for positive environmental change.

Ducks Unlimited Canada's is committed to preserve wetlands to benefit of wildlife, people and ecosystem overall by undertaking conservation projects.

5.0 Looking into Problems and Seeing Opportunities: Mitigation and Adaptation

As climate is changing, it affects many aspects of life. These changes are beginning to have severe impacts, from more frequent and severe climate events with direct effects on people and property to fundamental changes to ecosystems; these changes may undermine local economies, increase human health risks from infectious and noninfectious diseases, and affect the availability and quality of water. Climate change is, without a doubt, a serious threat to sustainability and quality of life.

It will take a considerable effort from society to adapt to and manage climate-related risks and to keep pace with the challenges. Even now we are becoming more vulnerable to impacts related to climate variability and change, due in part to increasing urbanization, a growing and aging population, and deteriorating public infrastructures. These changes put more people and property at risk; in addition, the climate will almost certainly continue to warm and become increasingly variable over the coming decades.

Mitigation - in the context of climate change, mitigation is an intervention intended to reduce adverse human influence on the climate system; it includes strategies to reduce greenhouse gas sources and emissions, and enhance greenhouse gas sinks
Source: (Canadian Geographic, 2012)

It is possible to reduce vulnerability to climate change. An effective response to climate change will involve activities that develop simultaneously in two directions: mitigation and adaptation. Mitigation is avoiding what we cannot manage. The aim of mitigation is to stabilize or reduce greenhouse gas emissions, decreasing both the degree of climate change and the rate of change, so that effective adaptation can occur. Mitigation measures are global actions while adaptation measures are local and represent the most tangible ways for CAs to engage their constituents in meaningful ways.

Adaptation is not a new concept, it is managing what we cannot avoid. Humans have always adapted to change and will continue to do so in the future. Highway snow removal, management of water levels along the Trent-Severn Waterway, and the construction of floodways, breakwaters, and irrigation systems are all examples of modern adaptations to the naturally variable climate.

Adaptive measures range from actions by individuals or companies to policies for planning and infrastructure development. Measures may be implemented on a local, national, or global scale, and they may involve technological, institutional, or behavioural changes.

Adaptation - Adjustment in natural or human systems in response to actual or expected climate changes and their effects, which moderates harm or exploits beneficial opportunities

Source: (Glossary of climate change acronyms, 2014)

Adaptation is aimed at adjusting resource use and economic activities to minimize the negative impacts of climate change, as well as taking advantage of new opportunities that may arise. Effective adaptation strategies should consider current and future vulnerabilities, and they should incorporate climate change into existing risk management frameworks.

Early actions and targeted investment are more effective and cheaper than post-disaster efforts (Government of Ontario, 2011). Well-targeted, initial investments designed to improve climate resilience are less expensive and more valuable than complex disaster response efforts. The National Round Table on the Environment and the Economy estimated that every dollar spent now on adaptation will yield $9 to $38 worth of avoided damages in the future (National Round Table on the Environment and the Economy, 2011). Adaptation measures will bring some economic opportunities, for example, the implementation of new crops in agriculture, and new energy and water conservation technologies.

As mentioned in this report, a number of municipalities and other agencies have already stepped up to the challenge and developed local action plans and strategies. As our research indicates, there are resources (such as guidelines and workbooks for municipalities) and potential funding available to begin work on mitigation and adaptation strategies.

6.0 Working Toward Climate Change Strategy

The changing climate is bringing a number of transitions to local weather and subsequent impacts on local ecosystems and communities. The expected changes to weather in the Kawartha Conservation watershed include:

- Higher temperatures in all seasons, but especially in winter;
- More variable precipitation, with increases in both the incidence of drought and intense precipitation; and
- More storms and higher wind speeds.

These changes in weather patterns will result in a number of impacts influencing all of society, including, but not limited to:

- Increased vulnerability of infrastructure as a result of excess heat, intense rain or heavy snow, high winds, and freeze-thaw cycles;
- Economic impacts resulting from both negative outcomes and new business opportunities;
- Higher financial impact from weather-related events;
- Increased number and length of heat waves;
- More smog and poor air quality;
- More flooding; and
- Increases in some vector-borne, food-borne, and water-borne diseases.

Often, the impacts will pose significant social and economic hardships for entire communities. Natural disasters such as the 2004 flood in Peterborough and the 2011 tornado in Goderich are relevant examples. However, these climate change outcomes may be difficult to predict: when and where specific weather events will occur and to what level they will impact communities. For this reason, local municipalities and organizations, including Kawartha Conservation, will need to identify vulnerabilities, assess preparedness, and take steps to address these climate change impacts through plans and programs that are adaptive to climate change.

As stated in the *Kawartha Conservation Strategic Plan 2012-2016* (Kawartha Conservation, 2012), our vision for the future is “a sustainable watershed with clean and abundant water and natural resources assured for future generations.” As changing climate puts this statement at risk, we recognize that the response to this challenge becomes part of our business and commit to taking immediate action, and demonstrating leadership, and supporting our communities and partners in dealing with climate change mitigation and adaptation.

The Kawartha Conservation Climate Change Strategy will be built on our strengths in adaptive watershed management and leadership in applying sustainability at the local level. It will outline proactive strategic directions to address the impacts of climate change and provide a planning framework for local climate change adaption and mitigation. The goal of the Strategy is “to increase the resiliency of our watershed and communities in order to adapt to and evolve with changing climate.” The actions will be based on the principles of Integrated Watershed Management and collaboration with watershed partners. They will be developed on the basis of local knowledge and integrated into the core Kawartha Conservation operations.

The following principles will guide development of the Climate Change Strategy:

- Proposed actions will build upon strategic action of the *Kawartha Conservation Strategic Plan 2012-2016* and other documents.
- Integrated Watershed Management is our guiding approach.
- Collaboration with many stakeholders such as municipal partners, government agencies, business and agricultural communities, non-governmental organizations, and landowners is fundamental to planning and implementing actions to deal with climate change.
- Integration of the proposed actions into existing Kawartha Conservation operations is a priority.
- Where possible, proposed actions are to address both adaptation and mitigation of climate change.
- "No-regrets" actions, focused on improving the resilience of natural systems and public safety, regardless of the eventual climate change outcomes, are a priority.
- The actions are to be developed based on science, knowledge, and data.
- Adaptive management will be used to allow for flexibility in delivering programs and services, in light of climate change.

The climate change actions will fall under Kawartha Conservation's goals as outlined in the *Kawartha Conservation Strategic Plan 2012-2016* and will echo a number of strategic actions. Additional actions will be needed to enhance our mitigation and adaptation activities. A list of proposed actions (from our current perspective) is outlined in Table 6.1.

Next Steps in the development of the Climate Change Strategy include the following (also see Figure 6.1):

- Present the Climate Change Background Paper to the Kawartha Conservation Board of Directors and seek its approval to move ahead with development of the Climate Change Strategy: May 2015.
- Form the internal working group and develop a draft of the Strategy document: May to July 2015.
- Hold the public and partner consultations, and peer review process: August 2015.
- Refine the Strategy document based on feedback: September 2015.
- Bring the Kawartha Conservation Climate Change Strategy to the Kawartha Conservation Board of Directors for endorsement: October 2015.

Table 6.1: List of Actions for Consideration for the Climate Change Strategy

Strategic Actions	Added Actions
PROTECTING: ***Safeguard people, property, and communities from natural hazards such as flooding and erosion***	
• Develop and update floodplain mapping for priority flood damage centres. • Proactively administer and enforce regulations under the *Conservation Authority Act.* • Support the development of Municipal Emergency Response Plans. • Improve the current monitoring network for high and low water response.	• Support municipalities in improving their emergency planning by incorporating floodplain mapping into it. • Integrate Low Impact Development practices and stormwater management Best Management Practices into the planning process to mitigate increased runoff and diminished water quality in urbanized areas. • Encourage and assist member municipalities in updating design standards for infrastructure, stormwater facilities, and major and minor drainage systems to address more frequent, high intensity flow events. • Promote retrofitting of existing stormwater systems. • Enhance emergency warning and response. • Review and enhance flood forecasting and warning services, including the development of forecasting models. • Further develop the low water/drought conditions process, as well as the identification and notification indicators. Encourage member municipalities to develop strategies and plans for low water response adaptation.

CONSERVING AND RESTORING: ***Conserve and restore a healthy, resilient environment***	
• Develop and implement a Natural Heritage Strategy for the watershed. • Reinstitute a watershed-wide reforestation program. • Support partnerships that preserve and improve the health of the watershed and our communities. • Protect natural features through the planning and regulation process. • Anticipate and address environmental issues. • Enhance shoreline stewardship programs. • Monitor changes in climate for resource-related impacts and develop adaptation strategies.	• Support further land securement. • While enhancing natural heritage systems, focus on connecting green spaces, and riparian and shoreline areas. Use native species for reforestation projects. • Continue to be a leader in watershed stewardship through education, outreach, and increased awareness. • Support and assist municipalities in the development and implementation of tree conservation by-laws. • Continue managing and enhancing our conservation lands. • Support healthy lifestyle choices and help offset the negative effects of climate change on human health by offering watershed residents high-quality recreational opportunities in our conservation areas. • Develop educational programs for children to increase environmental awareness, including climate change challenges. This will help to foster a generation willing to accept the adjustments for mitigation and adaption. • Audit, evaluate, and improve our corporate performance to minimize the footprint in energy, water use, and waste production.

DISCOVERING: ***Develop greater scientific knowledge of the watershed that advances decision making***	
• Identify and address critical science-based information and knowledge gaps. • Create a baseline of standardized watershed information. • Work with municipal partners to identify and implement innovative approaches to stormwater management and Low Impact Development. • Work with agricultural and development industries to profile the Best Management Practices.	• Develop a Watershed Monitoring Strategy that addresses climate change monitoring. • Collect long-term monitoring data on key watershed end ecosystem characteristics, which will provide better understanding of baseline conditions and earlier identification of stressors. Involve local agencies and government partners as well as members of the public, where possible. • Report monitoring results to the public regularly to maintain environmental awareness and consciousness. Use the Watershed Report Card and other options as reporting tools.

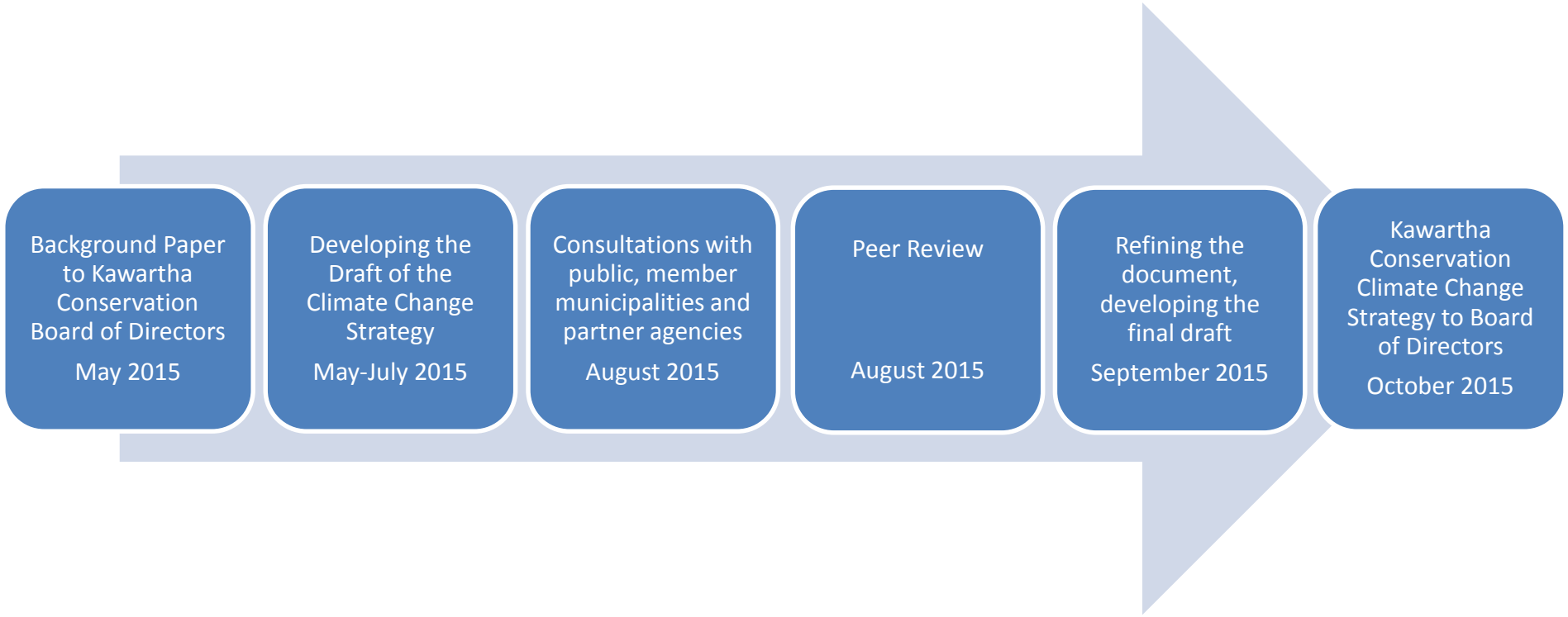

Figure 6.1: Kawartha Conservation Climate Change Strategy Project Timeline

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8.0 Glossary

Adaptation:	Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.
Afforestation:	Planting of new forests on lands that historically have not contained forests
Anthropogenic greenhouse emissions:	Greenhouse gas emissions resulting from human activities
Biofuels or Biomass fuels:	A fuel produced from dry organic matter or combustible oils produced by plants. These fuels are considered renewable as long as the vegetation producing them is maintained or replanted, such as firewood, alcohol fermented from sugar, and combustible oils extracted from soy beans. Their use in place of fossil fuels cuts greenhouse gas emissions because the plants that are the fuel sources capture carbon dioxide from the atmosphere.
Cancun Agreement	Set of significant decisions by the international community to address the long-term challenge of climate change collectively and comprehensively over time. Adopted in Cancun, Mexico, December 2010.
Fifth Assessment Report:	The Fifth Assessment Report of the Intergovernmental Panel on Climate Change, released in 2013
Global Warming:	Refers to an increase in a planet's surface temperature caused by the absorption of infrared radiation by gases in the atmosphere, including carbon dioxide, methane, and water vapour (Global Warming, 2014)
Greenhouse gases:	The atmospheric gases responsible for causing global warming and climate change. The major GHGs are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Less prevalent – but very powerful – greenhouse gases are hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6).
Kyoto Protocol:	An international agreement standing on its own, and requiring separate ratification by governments, but linked to the UNFCCC. The Kyoto Protocol, among other things, sets binding targets for the reduction of greenhouse gas emissions by industrialized countries.
Mitigation:	In the context of climate change, a human intervention to reduce the sources or enhance the sinks of greenhouse gases. Examples include using fossil fuels more efficiently for industrial processes or electricity generation, switching to alternative power sources, improving the insulation of buildings, and expanding forests and other "sinks" to remove greater amounts of carbon dioxide from the atmosphere.
Montreal Protocol:	The Montreal Protocol on Substances that Deplete the Ozone Layer, an international agreement adopted in Montreal in 1987.
Sink (greenhouse gases):	Any process, activity or mechanism which removes a greenhouse gas, an aerosol, or a precursor of a greenhouse gas from the atmosphere. Forests and other vegetation are considered sinks because they remove carbon dioxide through photosynthesis.

Source: (Glossary of climate change acronyms, 2014)

9.0 Appendix

Appendix A: Examples of Observed Climate Changes in Canada. (Adapted from Warren & Lemmen, 2014).

Climate System Element	Observed Trends
Temperature	
Annual air temperature	The annual average surface air temperature over the Canadian landmass has warmed by 1.5 °C over the period 1950-2010.
Temperature Extremes	
Hot extremes	The frequency of warm days (when the daily maximum temperature is above the daily 90th percentile) during the summer has increased nationally since 1950.
Cold extremes	The frequency of cold nights (when the daily minimum temperature is below the daily 10th percentile) during the winter has decreased nationally since 1950.
Precipitation and Other Hydrological Indicators	
Annual precipitation	Canada has generally become wetter in recent decades, as indicated by the increasing trend in annual average precipitation.
Snowfall/Rainfall – Southern Canada	In several regions of Southern Canada, there has been a shift in precipitation type, with decreasing snowfall and increasing rainfall.
Streamflow	Observations suggest decreasing trends in maximum and minimum river flows over the period 1970-2005 in much of Southern Canada, with increases in minimum flows in western Nunavut, Northwest Territories, Yukon, and northern British Columbia.
Snowfall	Annual snowfall has declined over most of southern Canada and increased in the north over the last six decades.
Snow cover	Negative trends in snow cover extent have been observed during spring over the Canadian landmass.
Permafrost	
Ground temperature – Canada	Permafrost temperatures at numerous borehole sites across Canada have increased over the past two to three decades.
Sea Level	
Relative sea level – Canada	Relative sea-level rise of over 3 mm/year has been observed on coastlines of Atlantic Canada and the Beaufort Sea coast, with lower amounts along Pacific coastlines. Relative sea-level fall of 10 mm/year has been observed around Hudson Bay where the land is rising rapidly due to post-glacial rebound.
Sea Ice	
Seasonal ice extent – Arctic	End-of-summer minimum ice extent has declined at a rate of 13% per decade over 1979-2012, while maximum winter sea ice extent has declined at a rate of 2.6% per decade.
Ice type – Arctic	A shift in ice cover from one dominated by thick multi-year ice to one

	increasingly dominated by thin first-year ice has been observed.
Eastern Canada	Declines in winter sea ice extent have been observed in the Labrador-Newfoundland and Gulf of St. Lawrence regions.
Glaciers	
Glacier mass – Yukon, British Columbia, Alberta	Western Cordilleran glaciers are losing mass and shrinking rapidly to the smallest extents in several millennia. Glaciers in British Columbia and Alberta have lost, respectively, about 11% and 25% of their surface area over the period 1985-2005, while glaciers in Yukon have lost about 22% since the 1950s.
Glacier mass – High Arctic	Significant negative mass balances are evident from the early 1960s into the first decade of the 21st century. The rate of mass loss for glaciers throughout the High Arctic has increased sharply since 2005, in direct response to warm regional summer temperatures.
Lake and River Ice	
Spring ice thaw – Canada	Trends towards earlier ice-free dates (lakes) and ice break-up dates (rivers) have been observed for most of the country since the mid-20th century but are particularly evident in Western Canada.

Note: The length of the observational record varies with the indicator.

Appendix B: Examples of Projected Changes in the Climate System for Canada, Derived from Ensembles of Global Climate Models. (Adapted from Warren & Lemmen, 2014).

Climate Indicator	**Projected Changes**
Seasonal temperature	Warming will be greatest in winter, and in this season, the largest increases in air temperature are projected for Northern Canada. In summer, the largest increases are projected for Southern Canada and the central interior. The magnitude of projected warming varies substantially with the emission scenario.
Extremes in daily temperature	Increases in the frequency and magnitude of unusually warm days and nights and decreases for unusually cold days and nights are projected to occur throughout the 21st century.
Long duration hot events	The length, frequency, and/or intensity of warm spells, including heat waves, are projected to increase over most land areas, including Canada.
Rare hot extremes	Rare hot extremes are currently projected to become more frequent. For example, a one-in-20-year extreme hot day is projected to become about a one-in-5-year event over most of Canada by mid-century.
Precipitation and Other Hydrological Indicators	
Seasonal precipitation	Increases in precipitation are projected for the majority of the country and for all seasons, with the exception of parts of Southern Canada, where a decline in precipitation in summer and fall is suggested.
Heavy precipitation	More frequent heavy precipitation events are projected, with an associated increased risk of flooding.
Rare precipitation events	Rare extreme precipitation events are currently projected to become about twice as frequent by mid-century over most of Canada.
Streamflow	Increases in winter streamflow are projected for many regions in Southern Canada. Mean annual streamflow is projected to decrease in some regions of Alberta and Saskatchewan, while projections for other regions vary across different scenarios.
Snow Cover	
Snow cover duration	Widespread decreases in the duration of snow cover are projected across the Northern Hemisphere with the largest changes in maritime mountain regions, such as the west coast of North America.
Snow depth	Maximum snow accumulation over northern high latitudes is projected to increase in response to projected increases in cold season precipitation.
Permafrost	
Ground temperature	Warming of the permafrost is projected to continue at rates surpassing those observed in records to date. Low average temperatures of much of the permafrost in the Arctic mean it will take many decades to centuries for colder permafrost to completely thaw.
Sea Level	
Global sea-level rise to 2100	Estimates of the magnitude of future changes in global sea level by the year 2100 range from a few tens of centimetres to more than a metre.

Global sea-level rise beyond 2100	Projections of global sea-level rise beyond 2100 indicate continuing global sea-level rise over the coming centuries and millennia. Global sea-level rise may eventually amount to several metres.
Relative sea-level change	Patterns of change along Canadian coastlines will continue to be influenced by land uplift and subsidence as well as by changes in the oceans. Sea-level rise will continue to be enhanced in regions where the land is subsiding, and sea level is likely to continue to fall in regions where the land is rapidly rising. Regions where the land is slowly rising may experience a transition from sea-level fall to sea-level rise.
Sea Ice Extent	
Arctic summer sea ice	A nearly ice-free summer is considered a strong possibility for the Arctic Ocean by the middle of the century although summer sea ice may persist longer in the Canadian Arctic Archipelago region.
Lake Ice	
With the continued advance of ice-cover break-up dates and delays in ice-cover freeze-up, ice-cover duration is expected to decrease by up to a month by mid-century.	

Note: In general, the magnitude of the stated changes will increase under higher emission scenarios.

Appendix C: Examples of Municipal Climate Action Planning, Ontario

Municipality / Document	Plan Outlines	Examples of Actions
Region of Durham *Region of Durham Community Climate Change Local Action Plan 2012* *Adopted October 2012* Website http://www.durham.ca/community/climate_change/2012DurhamLAP.pdf	Member of the Federation of Canadian Municipalities (FCM) Partners in Climate Protection (PCP) Program A Local Action Plan (LAP) is a strategic document that outlines how the region will achieve its GHG emissions reduction targets in the Durham community. The high-level objectives of the LAP are to: • Provide a framework for aligning, building on, and integrating corporate and community actions (plans, policies, programs, processes, and initiatives) that are currently underway or being planned. • Engage the area municipalities and encourage them to identify and undertake actions that reduce their emission of GHGs through municipal partnerships. • Engage citizens, local industries, corporations, businesses, and institutions and encourage them to identify and undertake measures that reduce their GHG emissions through community partnerships. • Establish monitoring, reporting, and community consultation practices so that the region's organizations, institutions, businesses, citizens, and visitors have up-to-date information on climate change action in Durham region. • Promote information sharing among the various industries, corporations, businesses, and institutions in Durham Region regarding climate change issues. • Provide strategic guidance for financial	**Objectives** • Develop a comprehensive residential energy retrofit program. • Develop and adopt a Durham Green Building Guideline for all new construction in Durham (both residential and commercial), which promotes a higher level of energy efficiency for new buildings than the current and increases that standard over time. • Create an offshore wind farm in Lake Ontario, funded through private partnerships. • Create a program to encourage businesses to develop industry clusters for the refining of second-generation ethanol and bio-diesel fuels (and biochemical feedstocks and byproducts). • Develop a Local Food Hub that will serve local farmers, restaurants, and consumers in Durham and Toronto. • Develop a thriving urban agriculture community in Durham with an emphasis on garden plots, community gardens, backyard gardening, sustainable agriculture, education, and community engagement. • Create a made-in-Durham version of Million Trees New York City through a variety of public-private partnerships throughout the community. The goal of the program is to plant five million trees (increased from the original one million) throughout the Durham community over a period of 10 years. • Create a community fund that disburses small amounts of funding for climate and environmental initiatives.

	investment to address climate change in the region. • Act as a living plan, subject to reflection and change through an annual process of community reporting, conferencing, and celebrating.	
Township of Scugog **Township of Brock** **Township of Uxbridge** *North Durham Integrated Community Sustainability Plan* *December 2010* http://oyezoyez.townshipofbrock.ca/site/en/1707/p/6653/pdf.do	Member of the Federation of Canadian Municipalities (FCM) Partners in Climate Protection (PCP) Program An ICSP was supported by PCP and the Region of Durham. It is an over-arching plan that links separate programs and initiatives in the community through the four pillars of economic, environmental, social, and cultural sustainability and envisions a longer-term perspective.	The Plan is not specifically targeted toward climate change response, but, among other actions, it sets up community and municipal corporate emissions reduction targets. The community and corporate GHG inventory was completed. The GHG emissions reduction action plan was developed.
Greater Peterborough Area *Greater Peterborough Area Climate Change Scoping Document* *Adopted July 2013* http://www.pcchu.ca/wp-content/uploads/2013/10/140902-Greater-Peterborough-Area-Climate-Changing-Scoping-Document-prepared-for-the-Climate-Change-Working-Group.pdf	Member of the Federation of Canadian Municipalities (FCM) Partners in Climate Protection (PCP) Program The *Climate Change Scoping Document* developed as part of the Sustainable Peterborough Committee activity. The document is intended to inform and assist climate change adaptation planning for the Greater Peterborough Area. The report looks at the latest climate information for the Peterborough area, summarizes anticipated impacts of climate change, reviews relevant government policies and commitments, discusses progress to date on climate goals outlined in the *Greater Peterborough Area Community Sustainability Plan* and, finally, summarizes key barriers and challenges that may be limiting or preventing progress at the local level. The Greater Peterborough Area Climate Change Action Plan is being developed with funding assistance from the Ontario Trillium Foundation. This plan will create an inventory of greenhouse gases	

	generated by the community and by municipal operations. A reduction target will be set and action plans to reduce GHGs developed.	
Region of Peel *Peel Climate Change Strategy* *Adopted June 23, 2011* Website: http://www.peelregion.ca/planning/climatechange/reports/pdf/climate-chan-strat-rep.pdf	Member of the Federation of Canadian Municipalities (FCM) Partners in Climate Protection (PCP) Program The purpose of the *Peel Climate Change Strategy* is to examine potential impacts of climate change and to establish priorities for action. A series of strategies to be implemented over the next five years was established as follows: • Proactive and responsive planning and leadership • Mitigation of climate change with a reduction of greenhouse gas emissions • Development and implementation of targeted and proactive adaptation actions • Making the shift to a green economy • Increasing awareness and level of engagement throughout the region • Ongoing research and adaptive risk management.	**Objectives** 1. Complete a vulnerability risk assessment of infrastructure, community, and natural heritage. 2. Incorporate climate change adaptation ideas into municipal official plans, by-laws, and policies. 3. In partnership with other jurisdictions, develop agricultural strategies that respond to potential climate change impact. 4. Enhance emergency management to adapt to a changing climate. 5. Continue to preserve existing trees, and expand tree planting and other related programs. 6. Work to minimize waste generation and maximize resource recovery. 7. Redesign and retrofit water collection, conveyance, and systems to reduce vulnerability. 8. Enhance pavement design to prevent buckling due to intense heat events. 9. Enhance local climate monitoring and modeling.
City of Kingston *Kingston Climate Action Plan* *Adopted February 2014* Website: https://www.cityofkingston.ca/documents/10180/2304312/Kingston+Climate+Action+Plan-web.pdf/fd0ac4d5-7c12-4ae7-b5db-1a48a9ed4dc7	Member of the Federation of Canadian Municipalities (FCM) Partners in Climate Protection (PCP) Program The Plan is a community-developed set of strategies to guide community efforts to reduce greenhouse gas emissions. The Plan has been categorized into five key areas. • Transportation • Energy - including homes, workplaces, and renewables • Resources and Natural Systems - including waste	**Transportation** • Improve public transit service. • Develop an additional 400 bike parking spots in the downtown area. • Regulate parking prices to ensure that a monthly bus pass is more affordable than a monthly parking pass. **Energy** • Provide incentives to home renovators and builders that include energy efficiency measures (prescriptive, engineered, and custom). • The City has conducted facility retrofits, adopted a green building policy, constructed 5 LEED facilities, and installed 11 solar projects. **Resources and Natural Systems** • A tree preservation and protection plan must be provided. The

	• Agriculture and Food Security • Climate Resilience There is integration among all of the theme areas. For each theme area, the plan provides a summary of GHG emissions, a compilation of existing and potential actions, as well as proposed indicators.	City Tree Bylaw applies to endangered, threatened, or at-risk tree species and distinctive trees in identified locations. • Consider enforcement for replacing trees on private and public lands as per guidelines for tree preservation and protection (developed). • Update the Waste Management Plan to revisit the residential waste diversion targets; consider eliminating free untagged garbage bags; consider the use of clear bags and evaluate the option of garbage pickup once every two weeks rather than every week. • Consider options to increase Composting and Recycling within the industrial, commercial, or institutional (ICI) sectors. At present, there is no city collection of recycling or organics for the ICI sectors; they retain organic and recycling haulers independently. The ICI sector needs to expand its uptake of recycling and organics management. • Consider initiatives that return lands unfit for agriculture to forest using tree species that are climate change-resistant. **Climate Resilience** • Incorporate extreme weather impact functionality into the city's emergency operations. The city is building impact assessment, modeling, and analytical functionality into city emergency operations. • Update floodplain mapping to include new weather data, assessment of flooding risks, and impact on development and infrastructure planning.
Niagara Region *Community Climate Change Action Plan* *Corporate Climate Change Action Plan* *Adopted January 2013* Website: http://www.niagararegion.ca/go	Member of the Federation of Canadian Municipalities (FCM) Partners in Climate Protection (PCP) Program Niagara Region's climate change work program looks at both mitigation and adaptation in the Niagara Region corporation and in the community. **Vision:** "The Niagara community is working to mitigate, adapt, and prepare for climate change by developing solutions to reduce greenhouse gas emissions and improve community quality of life and resiliency for future generations."	**Objectives** • A greenhouse gas emissions inventory for the baseline year of 2006 was done for corporate and community emissions. • Encourage the use of green roofs in new building projects across all sectors by delivering a presentation to Niagara municipalities that addresses by-laws and incentives. • Implement a fully integrated transportation system, providing transportation alternatives for people to travel to where they work, shop, and live. • Promote the benefits of new home green standards, mixed use planning, and Brownfield development.

vernment/planning/climate-change.aspx	**Goal Statements:** 1. Build a collective consciousness of climate change, assess the climate impacts in Niagara, and develop the capacity to address them. 2. Organize local action through partnership, community engagement, and leadership. 3. Reduce community waste created by human activities through reduction, conservation, re-purposing, reuse, and recovery. 4. Improve human health and air quality through emissions reductions and support of renewable energies. 5. Advance climate-smart agricultural production practices that focus on adapting production to meet changing climates while maximizing food production and equitable access for residents. 6. Develop an efficient, healthy transportation network across all areas of Niagara that incorporates all modes of transportation and includes connections outside the region. 7. Preserve, restore, and expand natural systems while also improving the health of local watersheds. 8. Advance actions that support the green economy, local economic development, and entrepreneurship to move towards greater regional economic prosperity. 9. Demonstrate leadership through sustainable approaches to the design, construction, and retrofit of buildings and building forms across Niagara. 10. Develop emergency management plans and resilient infrastructure to ensure community safety including in extreme weather events.	• Ban grass clippings in the curbside organics collection program in order to reduce collection and processing requirements. This reduces greenhouse gas emissions and costs, but also results in a healthier lawn with less need for fertilizer and watering. • Create an annual award that acknowledges the outstanding contributions of a local business towards community climate change and sustainability goals. • Implement a program that provides incentives for urban redevelopment and intensification, mixed used development, and creation of more walkable communities. • Replace road lighting, traffic signals, and flashers that are under the region's jurisdiction with more efficient lighting mechanisms. • Review all corporate policies through the lens of sustainability principles. • Provide regional employees and the public with access to recycling and organics collection containers and other diversion programs, where applicable for the service area, to maximize opportunities to divert material from landfill at regional facilities. • Continually improve performance through retrofitting and benchmarking existing facilities. Continue to reduce building emissions by 5-10% per square metre. • Hold emissions at current levels at water and wastewater treatment facilities, despite the expectation of increased demand.
Town of Caledon Community Climate Change Action Plan	Member of the Federation of Canadian Municipalities (FCM) Partners in Climate Protection (PCP) Program The Community Climate Change Action Plan builds on a community greenhouse gas inventory that was	**Objectives** • Develop and adopt a municipal anti-idling by-law that prohibits idling over a certain amount of time. • Reduce car idling and fuel consumption by utilizing smart

Website: http://www.town.caledon.on.ca/en/live/resources/CommunityClimateChangeActionPlan.pdf	developed in 2008 and 2009. Based on these findings, the Community Climate Change Action Plan contains a series of proposed greenhouse gas reduction actions, categorized as follows: • Transportation • Green development • Energy • Schools • Agriculture • Community awareness • Tree planting and naturalization • Waste • Local food • Longer term actions.	signalling (synchronize lights, triggers, etc.) and roundabouts. • Promote carpooling and use of public transit. • Build additional carpool lots. • Encourage, support, and lead the development of an electric vehicle charging infrastructure that is symbiotic with the Ontario Smart Grid. • Promote green building standards for new construction such as LEED, BOMA, and Energy Star Certification. Continue lobbing the Region of Peel to provide matching development charge discounts for LEED commercial and industrial buildings through the town's Green Development Program. • Promote and encourage business and private sector energy efficiency (audit, retrofitting) using existing opportunities. • Develop and implement the Composting Program.
City of Windsor *City of Windsor Climate Change Adaptation Plan* *Adopted September 2012* Website: http://www.citywindsor.ca/residents/environment/environmental-master-plan/documents/windsor%20climate%20change%20adaptation%20plan.pdf	Member of the Federation of Canadian Municipalities (FCM) Partners in Climate Protection (PCP) Program The *Climate Change Adaptation Plan* was developed through consultation with all city departments and select city agencies. The focus of this adaptation plan is on the following five potential climate change impacts; these were rated as posing substantial risk and therefore may result in the greatest impact on municipal operations: • Increase in operating/maintenance demands to deal with climate extremes • Increased chance of flooding to basements, roads, and other infrastructure • Increase in demand to all areas of Operations when responding to an increase in severe storms (during and after) • Increase in public health risks due to extreme heat • Implementation of development policies that were created in the absence of climate change considerations, which may increase our	**Reducing Risks Associated with Increased Precipitation** • Consider mandatory downspout disconnection • Consider mandatory backwater valve installation • Enhance sewer maintenance and camera inspections • Consider additional off-line storage • Increase the use of flow restrictors on catch basins • Update the Rainfall Intensity Duration Frequency (IDF) Curves • Seal manhole covers • Undertake public education on sewer use and wastewater treatment • Target education towards homeowners with suspected cross-connections • Use social media and other communication tools to warn the public of the risk of basement flooding • Enhance maintenance & inspection of roads and sidewalks during snow or extreme weather events. **Reducing Risks Associated with Increased Precipitation and Temperatures** • Develop a Green Roof policy • Install rain gardens as a pilot project • Develop pilot projects for the use of porous pavement

	vulnerability.	• Improve and enhance green space • Increase tree planting **Reducing Risks Associated with Increased Temperature** • Increase capital for shade structures • Increase heat education at community centres and pools • Complete an urban heat island study **General** • Develop policies for weather response • Create an Extreme Weather Fund reserve.
City of Greater Sudbury The Greater Sudbury Climate Change Consortium Established November 2009 http://www.sudburyclimateaction.ca/en/	Member of the Federation of Canadian Municipalities (FCM) Partners in Climate Protection (PCP) Program The Climate Change Consortium brings together various partners who have a stake in ensuring the City of Greater Sudbury is able to adapt to climate change impacts. Their purpose is continuing to assess the potential impacts of climate change on industry, people, municipal infrastructure, and water resources and to develop adaptation strategies. **Goals** • Engage the community in dialogue about Greater Sudbury's changed climate and the need for adaptation and mitigation. • Identify solutions to local problems created by the effects of global climate change. • Act to reduce, remove, and avoid the threats, risks, and negative impacts of climate change in Greater Sudbury. • Contribute to bold, innovative work that can increase the community's capacity to adapt to climate change. • Develop and maintain a respect for nature within the consortium and the community to help guide actions on climate change. Climate change adaptation strategies for the	**Objectives** Work with stakeholders to identify the risks associated with existing and anticipated changes to local climate. • Recommend adaptation measures to stakeholders, including municipal departments, to alleviate these risks. • Advocate and guide an integrated climate change risk management plan for the Greater Sudbury community. • Guide the development and distribution of a GIS-based map of local climate change vulnerabilities. • Provide technical support to enhance adaptation projects currently underway. • Improve communication about the local effects of climate change among stakeholders and the community at large. • Approve and champion the Greater Sudbury Covenant For Our Future on Climate Change Action. • Raise public awareness about household level climate change impacts and “backyard” adaptation methods. • Advise and guide the activities of Consortium staff.

	watershed and community are being developed.	
City of Ottawa *Air Quality & Climate Change Management Plan* *Adopted November 2014* http://ottawa.ca/en/city-hall/planning-and-development/official-plan-and-master-plans/air-quality-and-climate-change	Member of the Federation of Canadian Municipalities (FCM) Partners in Climate Protection (PCP) Program The plan is a review and update of the City of Ottawa's 2005 Air Quality and Climate Change Management Plan. It sets goals, objectives, and a new target, and it recommends a variety of actions. The City of Ottawa commits to mitigating climate change and protecting air quality by 1. Reducing energy demand 2. Reducing dependence on fossil fuels 3. Reducing the other sources of GHG emissions 4. Reducing other sources of air-borne pollution 5. Improving carbon capture and storage The municipality will adapt to climate change and protect people and property by 6. Reducing the risks to public health 7. Increasing infrastructure resiliency 8. Reducing risks to structures 9. Ensuring effective emergency management.	**Objectives** • Promotion and facilitation of alternative energy and conservation programs such as district energy, landfill gas co-generation, water conservation, heat recovery systems, street lighting, and employee energy efficiency programs • Implementation of smog control measures that discourage such activities as the use of single occupancy vehicles and high energy-consumption vehicles and appliances, and measures that promote walking, cycling, use of public transit, transportation demand management, and use of alternative fuels and alternative fuel vehicles (hybrids, biodiesel, ethanol, etc.) • Control of non-source emissions such as wood combustion and road dust • Promotion of energy efficiency in the residential sector through Local Improvement Charges • Promotion of Green Buildings and alignment of associated regulatory and design considerations. This will include development of an internal policy to achieve LEED status for municipal buildings, then extension and promotion of this standard to the community, in concert with other levels of government. • Creation of a Better Buildings Partnership to promote and provide financial incentives for industrial, commercial, and institutional bodies to reduce their building energy use • Implementation of sustainable land use planning and community greening by encouraging mixed use development, community energy planning, maintenance of forest cover, and use of Best Management Practices for natural areas, green spaces, and agricultural lands • Ongoing review of municipal regulations and their role in creating a sustainable community, including advocacy for the incorporation of sustainability principles into the Ontario and the National Building Codes • Implementation of measures to control odours, noise, light

		pollution, and pollen, as significant issues arise.
City of London *City of London Community Energy Action Plan (2014-2018)* *Adopted July 2014* Website: https://www.london.ca/residents/Environment/Energy/Documents/Community%20Energy%20Plan.pdf	Member of the Federation of Canadian Municipalities (FCM) Partners in Climate Protection (PCP) Program ***Community Energy Action Plan*** **Guiding principles**: 1. This needs to be the community's plan for London, not the City of London's plan for the community - we can start the plan, but we need community stakeholders to carry it out. 2. Many people have noted that the price of energy (electricity, gasoline) keeps rising even though they are using less of it. There is nothing we can do about the price of energy, but we can reduce the cost of energy by using less of it. 3. Start first with conservation – adjusting behaviours and habits cost nothing, so the payback is right away. These can be small adjustments to day-to-day activities or significant changes due to a new investment or a desire to do things differently. This can be as simple as riding a bike (more often). 4. Get the function and size right – whether it's your home, vehicle, or space for your business, make sure that you get something that fits your needs. 5. Invest in energy efficiency and good design – look beyond the "sticker price" towards the full life-cycle cost. You will be surprised that payback and cost savings for some items occur quickly. 6. Make use of free heat and free light – recover and reuse waste heat, and let the sun shine in to provide free heat and light for your building. 7. Reduce waste – it takes energy to make new material, and recycling old material uses less energy than making new material. Organic waste can be used to make renewable energy as well. 8. Make it local – moving stuff, even energy	**Objectives** 1. Establish new, easy to implement policy tools in the new Official Plan and supporting plans for encouraging energy efficiency and renewable energy, as well as accommodating energy infrastructure in coordination with existing tools and programs (including those from utilities). 2. Continue to work with energy utilities to coordinate land use planning with energy infrastructure planning. 3. Provide Londoners with annual information on community energy use and greenhouse gas (GHG) emissions. 4. Develop and report new energy-related performance indicators that highlight the total cost of energy and total money saved/generated from community energy actions. 5. Develop new tools to raise awareness on progress being made. 6. Work with the utility companies on actions that encourage energy retrofits and other energy conservation measures in older housing stock. 7. Lead by example through managing its own municipal building energy use though the Corporate Energy Management Program. 8. Gather information on the status of energy management practices for London's commercial and institutional properties. 9. Work with stakeholders to promote and share existing building energy management best practices in London's commercial and institutional sector. 10. Gather information on municipal regulatory developments across Canada for energy reporting requirements.

	commodities like electricity, takes energy. Buying local goods and services, and producing electricity and bioenergy here in London, is not only good for saving energy – it creates local jobs as well. 9. Build on local strengths – agricultural and food industries, manufacturing, and health care provide unique energy opportunities. 10. Use renewable energy – once you've done most of the above first, then it makes sense to use renewable energy. 11. Measure your progress – as the saying goes, "You can only manage what you measure." 12. Share your stories – let's celebrate the progress that we are making with sustainable energy and energy conservation choices.	
Waterloo Region *A Climate Action Plan for Waterloo Region* *Adopted December 2013* Website http://www.sustainablewaterlooregion.ca/files/u/Climate%20Action%20Plan-Full.pdf	Member of the Federation of Canadian Municipalities (FCM) Partners in Climate Protection (PCP) Program The Climate Action Plan was developed on a framework that enables municipalities and community stakeholders to take collaborative action towards reducing GHG emissions across our region. The core components of the plan ensure that collaborating partners are equipped with the goals, actions, and direction necessary to achieve a region-wide GHG reduction target by 2020. The Climate Action Plan aims to improve five focus areas identified as the highest sectors of community GHG emissions in the inventory and forecast results. These five areas also cover areas of municipal management including: • Stationary energy consumption • Transportation planning • Land use • Some agricultural activities • Water and waste management infrastructure.	**Objectives** • Reduce natural gas and electricity consumption through various incentive programs offered by gas and electric utilities for the residential sector. • Work with local energy distributors to explore and develop renewable energy generation opportunities, including local renewable energy districts and cooperatives, and application of geothermal, solar hot water, and PV net metering solutions. • Use an existing municipal tool called Local Improvement Charges to cover the upfront costs of energy retrofits and renewables for homeowners. • Implement a region-wide Anti-Idling Campaign/By-law to reduce idling time. • Implement a Community Access BikeShare Program. • Implement an LED Streetlight Retrofit: conversion of streetlights to energy-efficient LED fixtures. • Implement City of Waterloo Corporate (municipal) GHG reduction initiatives. Key projects underway/upcoming include: 1) Energy efficient and GHG reducing retrofits in City of Waterloo facilities 2) Corporate energy and greenhouse gas Action Plan 3) Potential solar/green roof installations at three facilities. • Green Bin Organics Diversion: GHG reductions achieved as a

	The Climate Action Plan directs the community's collaborative efforts to reduce GHG emissions by 6% from 2010 levels by 2020, while at the same time improving the quality of life across the region.	result of expanding the Green Bin/organics diversion 2010-2020, which helps reduce methane production in the region's landfill.
City of Thunder Bay *EarthCare Sustainability Plan 2014-2020* *Adopted 2014* Website: http://www.thunderbay.ca/Assets/Living/Environment/images/2014-2020+EarthCare+Sustainability+Plan.pdf	Member of the Federation of Canadian Municipalities (FCM) Partners in Climate Protection (PCP) Program The Plan is built upon the *Community Environmental Action Plan* (2008). The *EarthCare Sustainability Plan* will guide the corporation and the community in reducing GHG emissions and creating a more sustainable future with a strong focus on making the city more robust and resilient in the face of a changing climate until 2020. The *EarthCare Sustainability Plan* is the result of actively sought and valued public engagement and participation. It takes a comprehensive and integrated approach, recognizing that environment, economy, society, and culture are linked to each other. **Overall Goal** Create a more sustainable Thunder Bay now, and in the long term. While the *Community Environmental Action Plan* focused mainly on climate change mitigation, this version has a strong bent towards both mitigation and adaptation.	**Objectives** • Adopt higher energy efficiency standards for new buildings and renovations. • Promote electric vehicles and install at least one electric charging station at a municipal site. • Develop a Local Improvement Charge (LIC) incentive program to facilitate energy efficiency upgrades to private property. • Create supportive strategies, incentives, and regulations to develop green buildings in the residential, commercial, and institutional sectors. • Strive to create residential neighbourhoods that are mixed use, contain a variety of housing forms, and provide access to daily amenities within walking distance. • Direct growth to optimize the use of existing infrastructure and public services, which will reduce the need to construct new infrastructure, and to extend public services, such as parks, schools, and community centres. • Support innovative projects that build resilience to meet the adaptation needs of the community (e.g., Low Impact Development to mitigate flooding). • Offer educational courses or programs for all ages on climate change and adaptation. • Ensure that all new street reconstruction and capital road projects incorporate design elements for walking, biking, and transit use for all ages and abilities. • Update the water bottle by-law to include the phasing out of bottled water being supplied at public events. • Enhance the city's Official Plan (OP) to include more specific green infrastructure policies and to plan land use with green infrastructure at its core to maximize benefits.

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