



# City of Windsor

## Climate Change Adaptation Plan

September 2012



## Executive Summary

Regardless of the cause, the average temperature in Windsor has increased by almost 1°C since 1940. Scientists predict that by 2050, the average annual temperature in Ontario will increase by 2.5°C to 3.7°C from the 1961-1990 baseline average. This change, along with predictions that the number of “hot” days (over 30 °C/86 °F) in Windsor could almost quadruple by 2071-2100, is cause for concern. Heat related illnesses place a strain on our health care services and energy used to cool our buildings is expensive. In addition, this shift in the average weather for the region allows for the survival of invasive species and the expansion or introduction of insect vectors that carry disease.

As air temperature increases, so does the capacity of the air to hold more water. This can lead to more intense rainfall events, which Windsor has already experienced directly including events in 2007 and 2010 which caused severe flooding. In 2011, Windsor experienced the wettest year on record, measuring 1,568mm of rain compared to the average annual rainfall of 844mm. Increased temperature and intense rainfall events are two climate change impacts that have resulted in direct costs to Windsor residents through basement flooding and heat related illness expenses.

Municipalities have a significant role to play in climate change adaptation as many climate change impacts will directly affect the services provided by the City of Windsor and our agencies. This plan was developed through consultation with all City departments and select City agencies. Each department was asked to look at all of their potential impacts and determine which impacts would present the most significant challenges to operations. Once these impacts were agreed upon, a vulnerability and risk assessment was completed to further narrow down the potential impacts that pose the greatest risk to the municipality as a whole.

The focus of this adaptation plan is on the following five potential climate change impacts which were rated as posing substantial risk and therefore may result in the greatest impact on our municipal operations:

1. Increase in operating/maintenance demands to deal with climate extremes.
2. Increased chance of flooding to basements, roads and other infrastructure
3. Increase in demand to all areas of Operations when responding to an increase in severe storms (during and after).
4. Increase in public health risks due to extreme heat.
5. Implementation of development policies which were created in the absence of Climate Change considerations, which may increase our vulnerability.

The list below summarizes the proposed short-term adaptation actions suggested to increase Windsor's resiliency to weather extremes. Many of these short-term actions build on existing programs in recognized areas of vulnerability. Other adaptation options may be fairly new to the City of Windsor, however there is a growing level of expertise available amongst other municipalities.



Proposed short-term adaptation actions:

## **Reducing Risks Associated with Increased Precipitation**

- Mandatory Downspout Disconnection
- Mandatory Backwater valve installation
- Enhance sewer maintenance and camera inspections
- Consideration of 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, Waste Water Treatment
- Targeted Education towards homeowners with suspected cross-connections
- Use Social Media and other communication tools to warn public of the risk of basement flooding
- Enhanced Maintenance & Inspection of road and sidewalks during snow or extreme weather events

## **Reducing Risks Associated with Increased Precipitation and Temperatures**

- Development of a Green Roof Policy
- Installation of Rain Gardens as a pilot project
- Develop pilot projects for the use of Porous Pavement
- Improvement and Enhancement of Green Space
- Increase Tree Planting

## **Reducing Risks Associated with Increased Temperature**

- Increase Capital for Shade Structures
- Increased Heat Education at Community Centres/ Pools
- Complete an Urban Heat Island Study

## **General**

- Develop Clear Policies for Weather Response
- Creation of an Extreme Weather Fund Reserve

While these short-term actions may help reduce Windsor's current vulnerability, the City also needs to develop on-going strategies that will continue to address the changing climate over the long-term. The following strategies should be undertaken to ensure that the City of Windsor continues to be a leader on adaptation well into the future:

1. Incorporate climate change adaptation into city policies and high level plans;
2. Create internal mechanisms to 'ask the climate question' for all new major infrastructure projects;
3. Monitor climate change, evaluate the effectiveness of adaptation strategies and adjust as needed (adaptive management);
4. Use best available science to analyze how the climate is changing locally and how this may impact the community;
5. Routinely review the City of Windsor's vulnerability to climate change;
6. Continuously conduct risk assessments to identify priority impacts requiring adaptation actions,
7. Engage the public, business and other stakeholder groups.

The actions taken today by the City of Windsor to proactively adapt to the changing climate will enhance community resilience to climate change while reducing the human and economic costs of climate-related impacts. Adaptation actions can often lead to great cost savings as intense storm events and extreme heat can result in devastating expenses to repair infrastructure, basement flooding and minimize health care costs.

## Table of Contents

Executive Summary.....	2
Table of Contents.....	4
Context.....	5
ICLEI Initiative.....	5
Vision.....	5
What is Adaptation? .....	6
Why is Adaptation Required? .....	6
Climate Change and the Economy .....	7
Windsor’s Changing Climate .....	8
Annual Average Temperature.....	8
Annual Precipitation .....	11
Surface Water Temperatures and Great Lakes Water Levels.....	12
Examples of Climate Change Impacts .....	14
What Windsor is Already Doing .....	15
Towards the Development of a Climate Change Plan .....	16
City Council Direction.....	16
Internal Consultation .....	16
City of Windsor Potential Climate Change Impacts .....	16
Medium High – Extreme Risk Impacts .....	16
Medium– Low Risk Impacts .....	17
Proposed Adaptation Options .....	18
Continual Improvement of the Climate Change Plan .....	20
Conclusion.....	20
References .....	21
Appendix A	

## Context

Municipalities have an important role to play in both mitigating and adapting to changes in their local environment. The City of Windsor is already experiencing the effects of climate change. We've seen more intense summer storms than in previous years which have contributed to increased basement flooding. The summer of 2010 was reported as the second hottest on record, only 0.3°C degrees cooler than the summer of 2005, the hottest on record. Warming of the Great Lakes has contributed to major ecosystem impacts such as extensive algae growth, the invasion of non-native species, pathogen and water borne diseases and falling lake levels<sup>i</sup>. The West Nile virus and the increase in Lyme disease in Ontario are other consequences of climate change<sup>ii</sup>.

The climate will continue to change. Although reducing greenhouse gas emissions is vital to limiting the rate and amount of change, it cannot prevent climate change from occurring over at least the next several decades<sup>iii</sup>. As a result, governments and communities must now consider how to adapt to the unavoidable effects of climate change. Therefore, in addition to the City of Windsor's initiatives to mitigate climate change, it is becoming more evident that the City of Windsor needs to increase the adaptive capacity of the community.

## ICLEI Initiative

ICLEI – Local Governments for Sustainability (Management) Inc., referred to as ICLEI Canada is an international association of local governments as well as national and regional local government organizations that have made a commitment to sustainable development. On November 8<sup>th</sup>, 2010, Windsor City Council approved participation in ICLEI's Climate Change Adaptation Initiative (CR 408/2010). This program provided a straightforward methodology to adaptation planning which resulted in the creation of this Plan. The initiative will continue to build capacity internally for ongoing implementation and monitoring of our Plan.

## Vision

The overall aim of Windsor's adaptation strategy is to create a more resilient city to the effects of a changing climate. A well-adapted city is able to absorb the effects of climate change, such as extreme summer heat or intense rain events, through the advancement of sustainable policies, infrastructure investment, and public education. This requires forward thinking and initiative. Being prepared to handle the climate challenges facing us will be beneficial to our health, our environment and our economy.

## What is Adaptation?

Adaptation to climate change includes any activity that reduces the negative impact of climate change while taking advantage of new opportunities that may be presented. This type of action differs from mitigation as adaptation aims to minimize the actual or expected effects of climate change while mitigation is action to reduce the sources of anthropogenic greenhouse gases.

## Why is Adaptation Required?

The average temperature of the planet has increased by 0.74 °C since 1900. A similar trend is seen right here in the City of Windsor.

“And now our world is different. The climate has been permanently altered and is on an escalating vector of change, not because of what we are going to put into the atmosphere in the future but as a consequence of what we have already done”. - *Environmental Commissioner of Ontario, 2009/2010 Annual Report*.

The Intergovernmental Panel on Climate Change (IPCC) has concluded that the evidence for climate change is “incontrovertible” and that a large part of the ongoing change is due to human activities, notably the release of greenhouse gases (GHGs) to the atmosphere. The Earth’s atmosphere has 38% more carbon dioxide (CO<sub>2</sub>) than it had before the beginning of the industrial era<sup>i</sup>.

Regardless of the cause, changes in weather patterns already impose risks to life, property, and the natural world in Ontario that cannot be ignored. Reducing those immediate risks is the only prudent course of action for all levels of government, as well as communities, corporations, businesses, and individual citizens. - *Climate Ready Ontario*

GHGs released decades ago are a main contributor to the change in our climate today. That means that even if globally, greenhouse gases were eliminated, changes will continue due to what was released in the past.

Public Safety Canada has been documenting “significant natural disasters” for over a century in the Canadian Disasters Database. A “significant disaster” is a disaster that meets one or more of the following criteria:

- 10 or more people killed
- 100 or more people affected/injured/infected/evacuated or homeless
- An appeal for national/international assistance
- Historical significance
- Significant damage/interruption of normal processes such that the community affected cannot recover on its own<sup>iv</sup>

Figure 1 below clearly shows the increase in “significant natural disasters” occurring across Canada from 1900 to 2011.

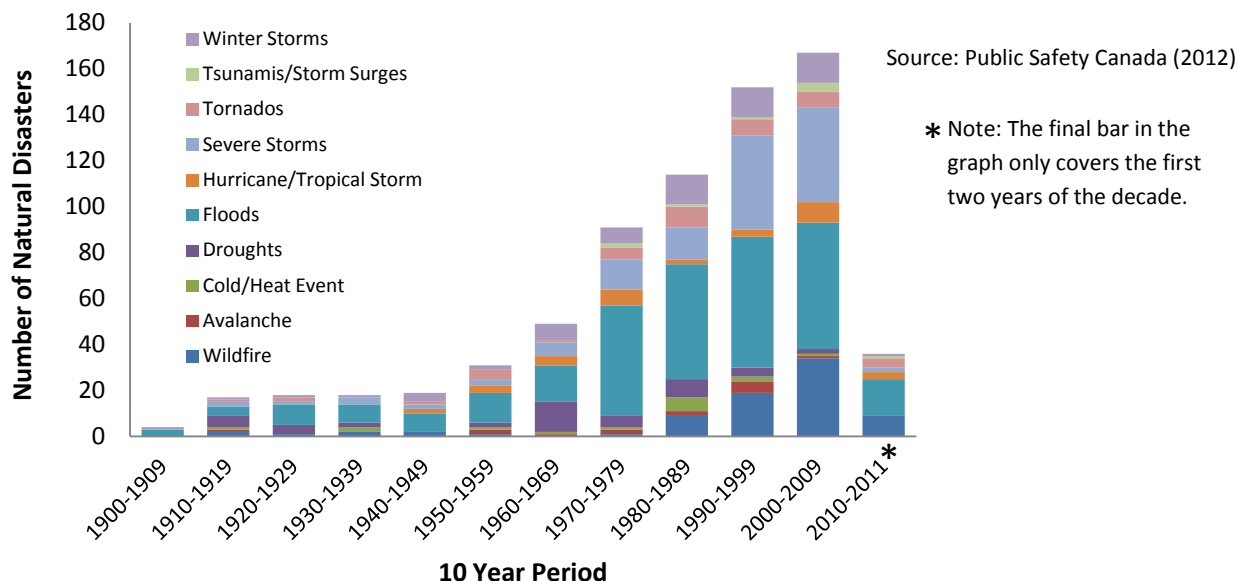


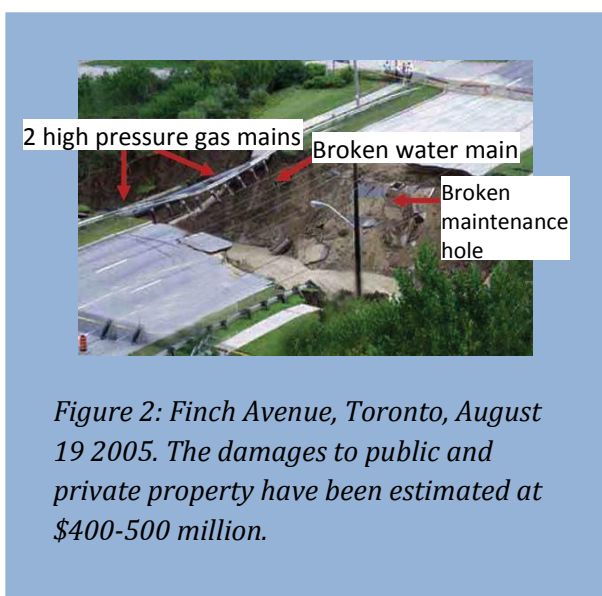
Figure 1: Frequency of Natural Disasters in Canada (1900-2011).

## Climate Change and the Economy

A recent report “*Climate Ready Ontario’s Adaptation Strategy and Action Plan 2011-2014*” highlighted the economic reality of failing to adapt to climate change. Based on the Economics of Climate Change (2006), Ontario could see annual costs of about \$5.66 billion dollars annually to respond to extreme weather brought by climate change.<sup>v</sup> For example, the Ontario Disaster Relief Assistance Program has provided over \$60 million since 1998 for flood relief alone in part due to an increase in the number of significant urban flooding events, including floods in Peterborough, Ottawa, Sudbury, Hamilton and Toronto.

In 2011, the National Round Table on the Environment and the Economy (NRTEE) published their report “*Paying the Price: The Economic Impacts of Climate Change for Canada*”. In this report, the NRTEE expects the costs of climate change to escalate over time from an average of \$5 billion/year in 2020 to \$21 to \$43 billion/year by 2050 depending on global emissions.<sup>vi</sup> These costs will not be equally distributed across the country with greater costs predicted for some coastal areas.

At first glance, the costs of adaptation are often readily identified and dismissed as too expensive by many governments and businesses. However, when looking at the costs of adaptation with



consideration for the benefits of adaptation both from reducing the impacts of climate change as well as the improvement to the baseline risk from the current climate, the adaptation option can often lead to great cost savings<sup>vi</sup>.

Municipalities have a significant role to play in climate change adaptation. Many of the impacts of climate change will directly affect the services provided by the City of Windsor and our agencies, including: wastewater and stormwater management; transportation; parks and urban forests; social services; emergency services; public health; and electricity distribution.

The actions taken today by the City of Windsor will enhance community resilience to climate change with the objective to reduce the human and economic costs of climate-related impacts.

## Windsor's Changing Climate

Between 1948 and 2008, the average annual temperature in Ontario has increased by up to 1.4 °C, with scientists predicting that by 2050, the average annual temperature in Ontario will increase by 2.5 °C to 3.7 °C from the 1961-1990 baseline average.

### Annual Average Temperature

The Environment Canada weather station located at Windsor Airport has been monitoring and recording weather data since 1941. Since this time, the average annual temperature has increased by almost 1 °C.

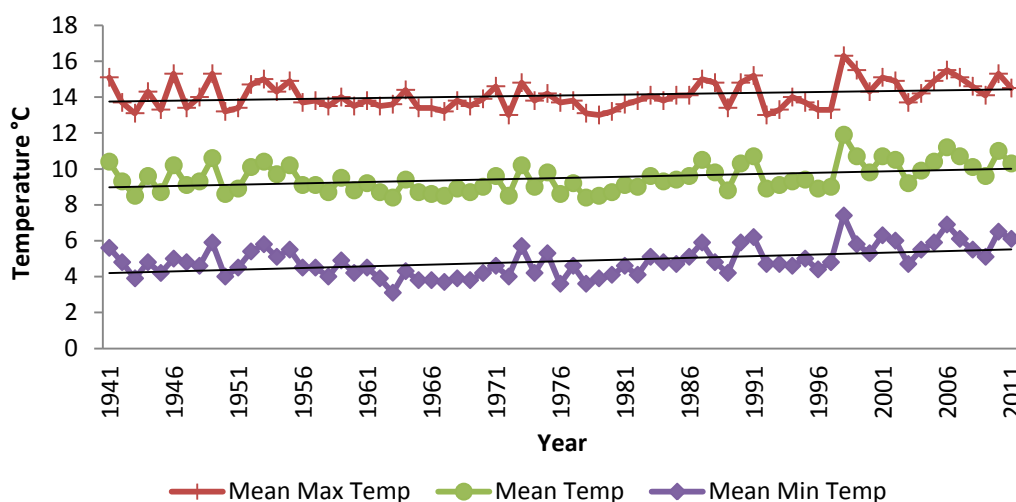


Figure 3: Average Annual Temperature in Windsor (1941 - 2008)

The Canadian Climate Change Scenarios Network (CCCSN), supported by Environment Canada's Adaptation and Impacts Research Section (AIRS), with support from universities and other partners



provides the ability for municipalities to undertake regional modelling on climate change. The Localizer Reports developed by the CCCSN uses an “ensemble” approach, which means that numerous models are used to determine projections rather than basing projections on just one model. Comparisons with past climate models show that ensemble projections are usually more realistic than any single model<sup>vii</sup>.

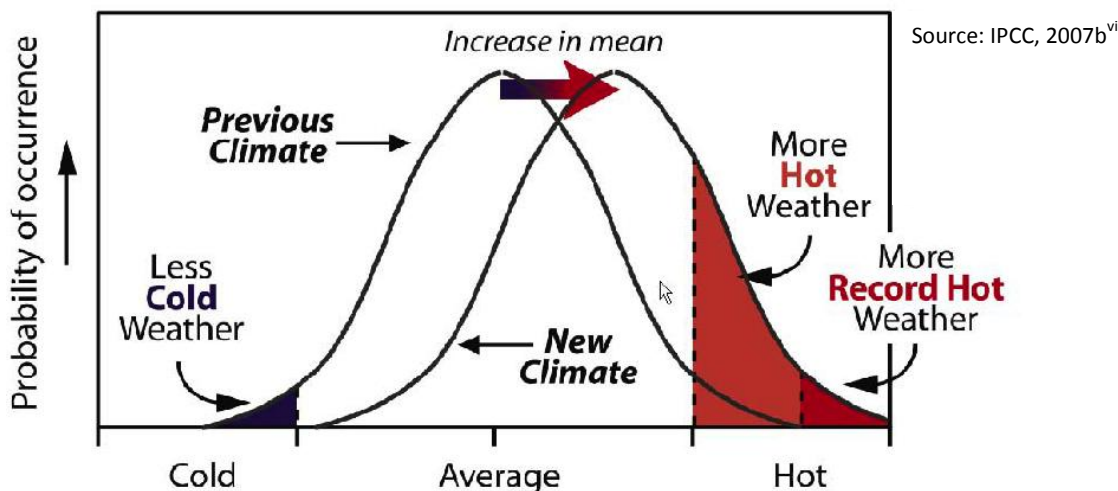
Throughout the City of Windsor’s adaptation planning process, two climate change scenarios were examined: the high (A2) and the low (B1) emissions scenarios. Each scenario projection is completed as an ensemble of over 20 different global climate models. However, it has been noted that the highest emissions scenario (A2) is closest to the observed trends with recent data showing climate change is advancing more quickly than previously estimated.

The following table shows the average annual temperature projections above the baseline period (1971-2000) based on the two scenarios. Projections to 2050 are often the most reliable as model results begin to diverge after 2050.

*Table 1: Average Annual Temperature Projections for Windsor.*

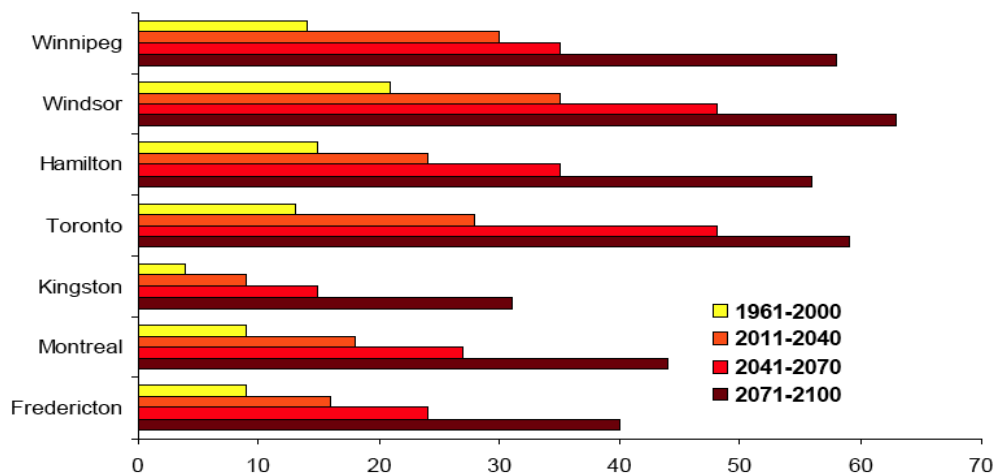
Year	B1 Scenario (Low Emissions)	A2 Scenario (High Emissions)
2020	1.3 ± 0.3 °C	1.2 ± 0.3 °C
2050	2.0 ± 0.5 °C	2.6 ± 0.5 °C
2080	2.6 ± 0.6 °C	4.4 ± 1.0 °C

Though the average projection increase may be perceived as a minor change, it actually can have a significant impact on the region. As figure 4 below indicates a slight increase in the mean average temperatures will lead to more ‘hot’ and record ‘hot’ weather with less cold weather. This shift in the average weather for the region allows for the survival of invasive species, the expansion or introduction of insect vectors that carry disease, increase in ‘heat alert’ days and increase evaporation of surface waters that contribute to an increase of extreme precipitation events.



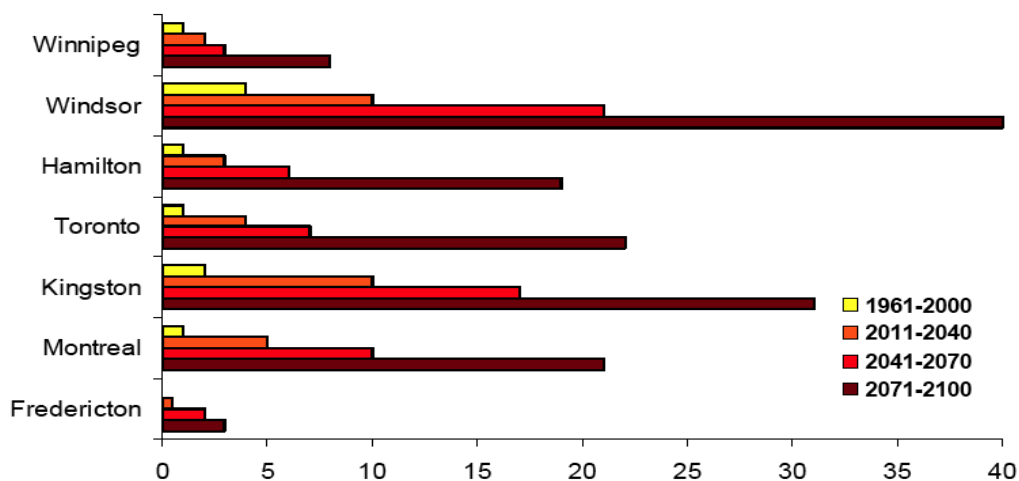
*Figure 4: An increase in mean temperature leads to a shift towards a new, hotter climate.*

The City of Windsor was one of a few communities that were selected for analysis of extreme temperature. The temperature projections were completed by the Canadian Regional Climate Model (CRCM) developed by the Ouranos Consortium on Regional Climatology and Adaptation to Climate Change (Figures 5 and 6). The conclusions of the analysis predict that the number of days over 30°C/86°F in Windsor could almost quadruple by 2071–2100 over that experienced prior to 2000. The number of warm nights (over 22°C/72°F) is expected to increase even more dramatically—a tenfold increase by 2071–2100.<sup>viii</sup>



Source: Casati, B., and Yagouti, A.

Figure 5: Projection of the number of hot days (above 30°C) per year.



Source: Casati, B., and Yagouti, A.

Figure 6: Projection of the number of warm nights (above 22°C) per year.

Figure 7 highlights the association between all non-traumatic daily deaths that occurred from June 1 to August 31 from 1986 to 2005 and the historical maximum daily temperatures in Windsor. There is a strong association between temperature and excess mortality in the City of Windsor. As the figure shows, at approximately 29°C/84°F excess mortality begins to increase as ambient temperatures increase.<sup>ix</sup>

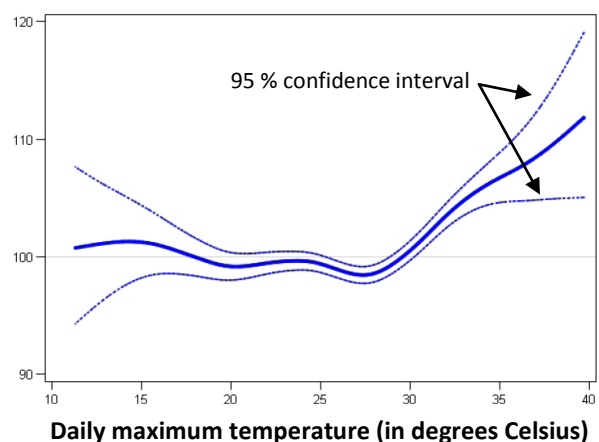


Figure 7: Relative mortality (%) in Windsor from 1986-2005.

## Annual Precipitation

Using the information obtained from the Windsor Airport station, an increasing trend in annual precipitation has been documented.

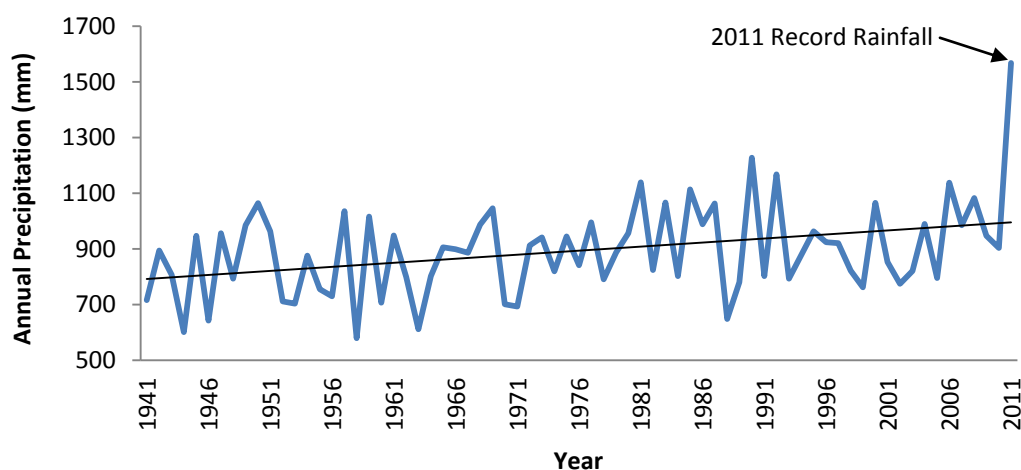


Figure 8: Average Annual Precipitation in Windsor (1941-2011)

Based on the Canadian Climate Change Scenarios Network model described above, the future precipitation projections have been established in the following table.

Table 2: Precipitation projection increases above the baseline period (1971-2000).

Year	B1 Scenario (Low Emissions)	A2 Scenario (High Emissions)
2020	2.2 %	2.2 %
2050	4.0 %	5.6 %
2080	5.7 %	8.3 %

As air temperatures increases, so does the capacity of the air to hold more water leading to more intense rainfall events. Since 1970, there has been increasing evidence of heavier short duration (24 hours or less) rain events in southern Ontario. The following table summarizes the average trends in the amount of annual maximum rain events.

*Table 3: Summary of the observed and projected increases in rainfall over time in Windsor.*

	Observed trends 1970 – 2000	Projected trends to 2050
30 minute extremes	<ul style="list-style-type: none"> <li>• 5% increase per decade (Adamowski)</li> <li>• 4.5% increase per decade to 1996 (Soil and Water Conservation Society)</li> </ul>	<ul style="list-style-type: none"> <li>• 5% increase per decade</li> </ul>
Daily extremes	<ul style="list-style-type: none"> <li>• 7% per decade (May, June, July) (Stone)</li> <li>• 5% increase per decade (over the year) to 1996 (Soil and Water Conservation Society)</li> </ul>	<ul style="list-style-type: none"> <li>• 3% per decade over the year (20 year return period)</li> <li>• 2.5 to 6% increase per decade (rainfall with probability &lt;5 %)</li> </ul>
Annual rainfall	<ul style="list-style-type: none"> <li>• 1% to 3% increase per decade</li> </ul>	<ul style="list-style-type: none"> <li>• 1% increase per decade</li> </ul>

Source: Bruce, J.P., Egner, M. And Noble, D. (2006)<sup>x</sup>

Recent extreme rain intensities in North Toronto 2005, Peterborough 2004 (photo insert) and the northern Grand River basin 2004 suggest there may be even more rapid trends towards increasing magnitude of heavy rain events in isolated storms.



*Figure 9: A flooded street in Peterborough.*

The City of Windsor has also been experiencing more intense rain events including:

- Intense rainfalls estimated at or above the 1:50 year climate normal return frequency
  - Westside flooding in 2007. Anecdotal evidence and numerous reports estimated that 100mm of rain fell in less than an hour.
  - June 5 & 6 2010 flooding. Approximately 90mm of rain fell in 4 hours
- 2011: Windsor's wettest year. In 2011, the City of Windsor experienced the wettest year ever on record with 1568.2mm of rain compared to the average annual rainfall of 844mm. November 29<sup>th</sup>, 2011 alone received 75mm of rain.

## Surface Water Temperatures and Great Lakes Water Levels

The temperatures of surface waters will continue to rise with the increase in annual temperatures. This increase may allow for the establishment of new invasive species, as well as an increase in algae growth. Based on historical temperature monitoring of western Lake Erie, the length of winter (days with water temperatures below 4°C) is getting shorter<sup>xi</sup>. A loss of ice cover may result in increased erosion of shoreline that was typically protected by winter ice. Open surface water also allows for more evaporation.

Although most scenarios of future climate projects increases in regional precipitation, the increase in evaporation caused by higher temperatures is expected to lead to an overall decrease in the Great Lakes System water levels. Increased evaporation is expected in all seasons, and particularly in winter as a result of decreased ice cover on the lakes. The impacts of lower water levels will be most pronounced in parts of the system that are already shallow, specifically western Lake Erie, Lake St. Clair, and the St. Clair and Detroit Rivers<sup>xii</sup>. Canadian modelling predicts a significant lowering of lake levels by 2050 as a long-term average, with a predicted decline of 0.8 m for Lake Erie<sup>x</sup>.

The lowering of water levels in the Great Lakes –St. Lawrence System may impact several sectors as identified in the figure below.

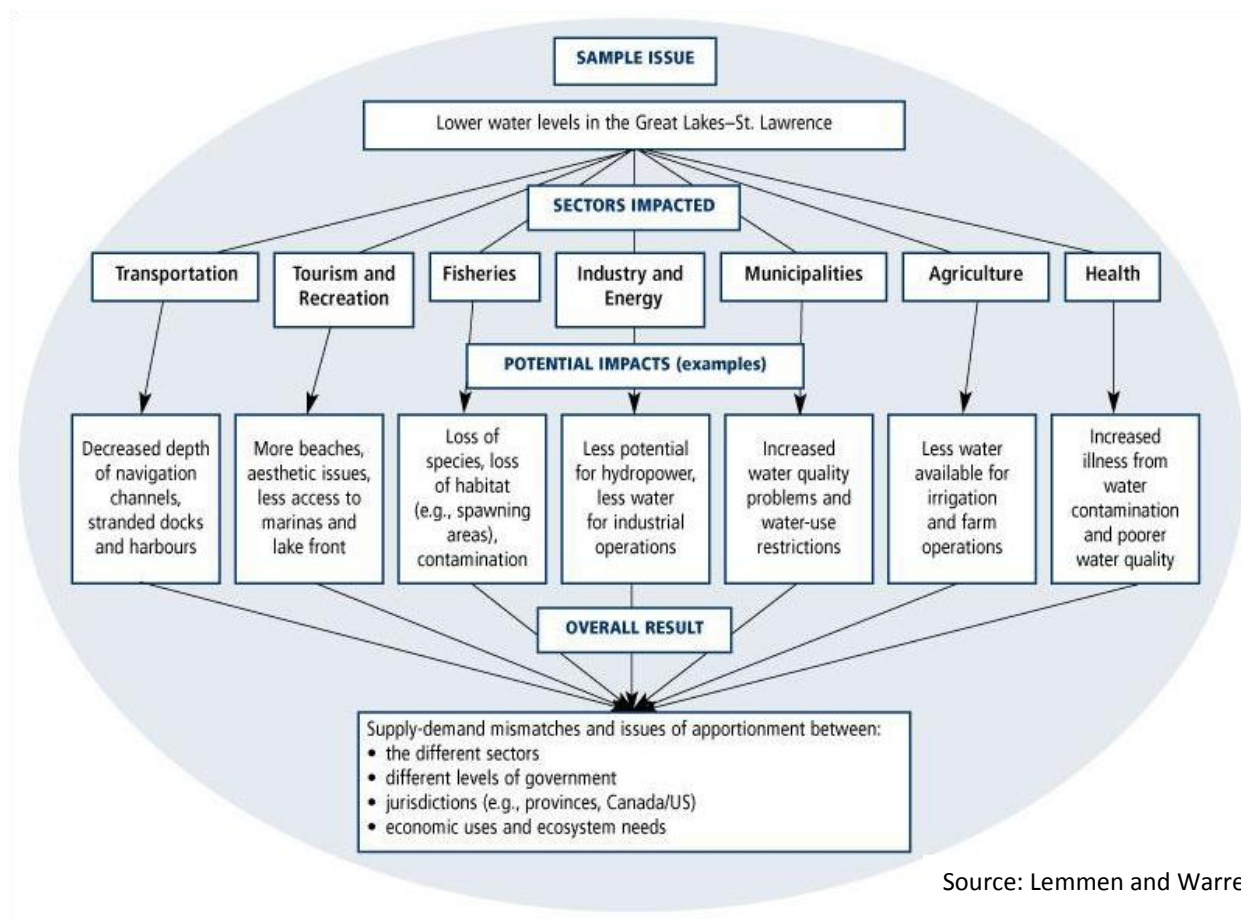


Figure 10: Potential impacts of lower water levels in the Great Lakes-St. Lawrence.

Some economic losses associated with a decrease in lake levels are easily calculated. For a 2.5 cm lowering of Lakes Michigan-Huron, cargo ships must reduce loads by 90 to 115 tonnes worth approximately \$25,000 US per trip<sup>x</sup>. Based on historical water level changes, it is known that hydroelectricity output may be reduced by up to 26% at some stations with lower water levels<sup>xii</sup>.



## Examples of Climate Change Impacts

The City of Windsor has already been impacted by the effects of climate change. The figure below outlines some of the issues we have already faced and the consequences we have had to deal with. As shown, the effects vary across city departments and range from environmental, to economic, to human health risks.

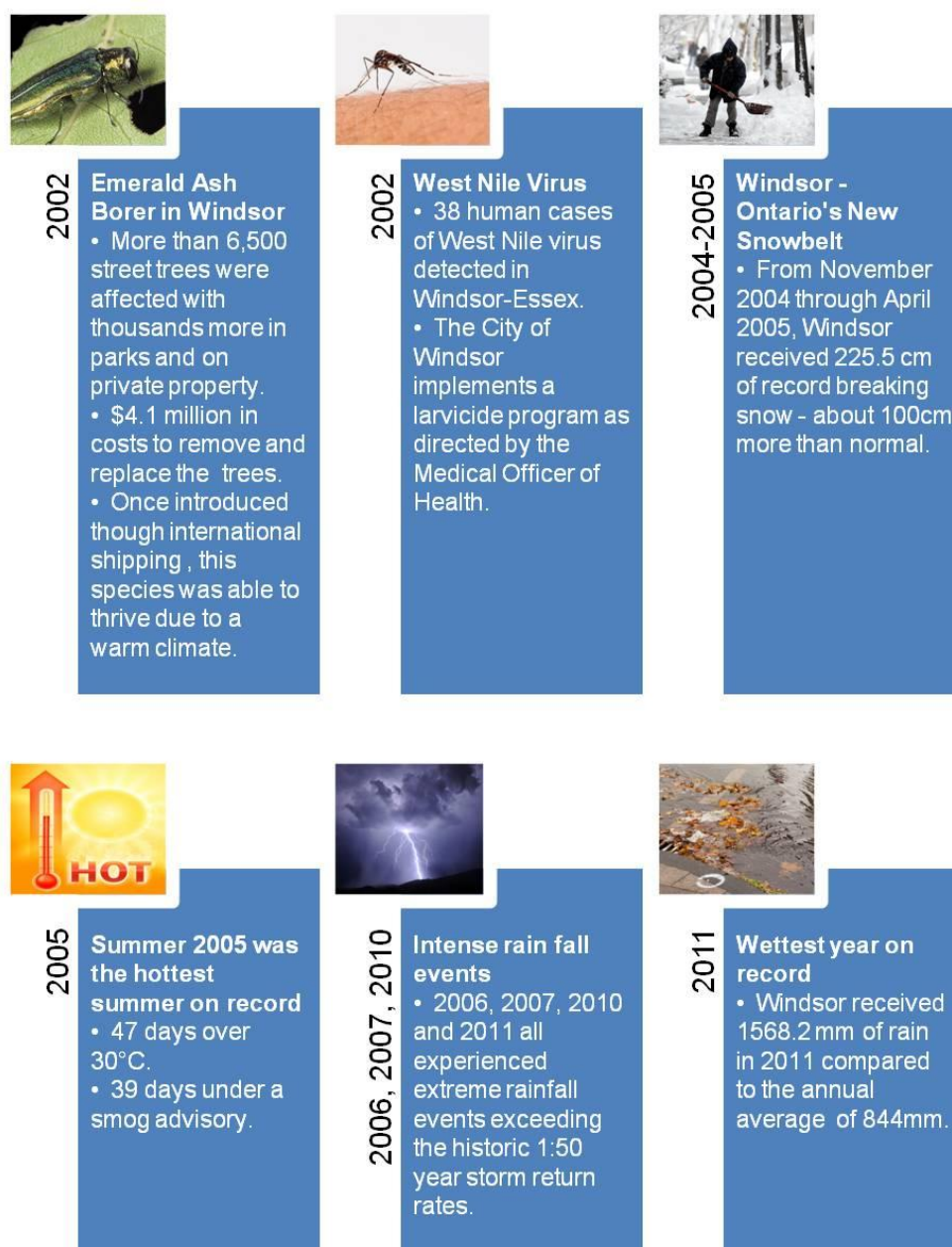


Figure 11: Examples of climate change impacts already affecting the City of Windsor.

## What Windsor is Already Doing

The City of Windsor has already instituted a number of programs that increase the resiliency to potential climate change impacts (Figure 12). Several of these programs were instituted or expanded following significant events identified in the previous section. For example, the downspout disconnection program was expanded following the intense rainfall events of 2006, 2007, while the basement flooding program was initiated after the 2010 intense rainfall event.



### Downspout Disconnection

- Disconnecting downspouts reduces the amount of stormwater entering the sewer system reducing the risk of combined sewer overflows and basement flooding.



### Basement Flooding Subsidy Program

- The city is subsidizing the costs of installing back-water valves and sump pumps on household sewer connections in order to provide additional protection against basement flooding.



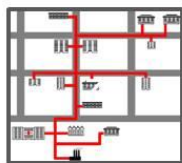
### Stay Cool Windsor Essex

- Heat Alert and Response Program
- The Windsor Essex County Health Unit and the City of Windsor work with numerous agencies to prevent heat-related illness and death.



### Urban Forestry

- By-law 135-2004 restricts the planting of certain trees and protects all trees on City property. Fines may be applied.
- City operated tree nursery allows for larger stock trees to be planted.



### District Energy

- The availability of District Energy in the downtown core reduces the peak electricity demand on hot summer days, reducing the risks of brownouts and blackouts during heat waves.
- Co-benefit reduction of 5000 tonnes of CO<sub>2</sub> annually.



### Bicycle Use Master Plan

- Implementation of the BUMP incorporates expanding the cycling infrastructure, education and awareness to promote active transportation, establishes Transit Links and installs end of use facilities.
- The City of Windsor earned a BRONZE Bike Friendly Communities Designation in 2011.

Figure 12: Examples of how the City of Windsor is already adapting to climate change.

## Towards the Development of a Climate Change Plan

### City Council Direction

On January 23<sup>rd</sup> 2012, City Council passed a motion approving the development of a corporate wide Climate Change Adaptation Plan with a focus on impacts with a medium high – extreme risk rating as recommended by the Environment and Transportation Standing Committee (M29-2012).

Risk is defined as the combination of an event's likelihood and the severity of its consequences – risk therefore equals the probability of projected impact multiplied by the consequence severity of that event. This initiative interpreted the risks levels, broadly speaking, as follows:

- **Extreme** risks demand urgent attention at the most senior level and cannot be simply accepted as a part of routine operations without executive sanction.
- **High** risks are the most severe that can be accepted as part of routine operations without executive sanction but they will be the responsibility of the most senior operational management and reported upon at the executive level.
- **Medium** risks can be expected to form part of routine operations but they will be explicitly assigned to relevant managers for actions, maintained under review and reported upon at senior management levels.
- **Low** risks will be maintained under review but it is expected that existing controls will be sufficient and no further actions will be required to treat them unless they become more severe.

### Internal Consultation

Through consultation with all City departments and some City agencies, a list of over 250 potential impacts was realized. Using the ICLEI climate change adaptation initiative framework, vulnerability and risk assessments were completed to give each impact a designated risk level.

### City of Windsor Potential Climate Change Impacts

#### Medium High – Extreme Risk Impacts

The following five potential climate change impacts were rated as posing at least a high risk to our municipality. Therefore, the focus of this adaptation plan is on the following impacts:

1. Development policies created in the absence of Climate Change considerations may create additional vulnerabilities to the impacts of climate change.
2. Increase in operating/maintenance demands to deal with climate extremes.
3. Increased chance of flooding to basements, roads and other infrastructure.
4. Increase in demand to all areas of Operations when responding to an increase in severe storms (during and after).
5. Increase in public health risks due to extreme heat.

## Medium– Low Risk Impacts

Though the focus of this plan is to minimize medium high - extreme risk impacts, it is important to be aware of the other potential impacts discussed during internal consultations. Various adaptation measures may provide resiliency for more than one potential impact. Though the majority of the potential impacts discussed are negative (table 4), it is important to consider the possible advantages that may occur under a changing climate (table 5).

*Table 4: Potential Low – Medium Risk Negative Impacts of Climate Change in Windsor: At a Glance*

Projected Climate	Potential Impacts
<b>Increase in Average Temperature</b>	<ul style="list-style-type: none"> <li>• Increased opportunity for invasive species</li> <li>• More opportunity for vector borne diseases (West Nile, Lyme disease)</li> <li>• Increased demand for active transportation options</li> </ul>
<b>Increase in Winter Temperatures</b>	<ul style="list-style-type: none"> <li>• Increase in freeze/thaw cycles damaging roads, increasing winter control</li> <li>• Reduced ability to maintain outdoor ice rinks</li> </ul>
<b>Increase in Summer Temperatures</b>	<ul style="list-style-type: none"> <li>• A shift in physical activities to indoor venues</li> <li>• Decrease in air quality/increase in the number of smog days</li> <li>• Increased demand for electricity</li> <li>• Increase risk of brown/blackouts due to the demand for electricity</li> <li>• More rapid deterioration of infrastructure</li> <li>• More premature equipment failure</li> <li>• Increase chance of food-borne illnesses</li> </ul>
<b>Increase in Annual Precipitation</b>	<ul style="list-style-type: none"> <li>• Increase in plant growth</li> <li>• Increase risk of flooding to basements, roads and other infrastructure</li> <li>• Increased risk of erosion of stream banks, drains</li> <li>• Increase costs for storm water management</li> </ul>
<b>Increase in Winter Precipitation</b>	<ul style="list-style-type: none"> <li>• Increase risk of ice damage to urban forest</li> <li>• Increase in winter control costs</li> <li>• Increased risk of winter flooding/ice jam related flooding</li> </ul>
<b>Decrease in Summer Precipitation</b>	<ul style="list-style-type: none"> <li>• More stress/failures among tree plantings</li> <li>• Increased need for irrigation</li> <li>• Decrease in aquatic habitat</li> </ul>
<b>Increase in Frequency of Extreme Weather</b>	<ul style="list-style-type: none"> <li>• Increase risk of flooding (basement, road, stream)</li> <li>• Increase flooding of sport fields requiring closure</li> <li>• Damage to existing tree cover</li> <li>• Increase demand for emergency services to respond to extreme events</li> <li>• Increase in combined sewer overflows or waste water bypasses</li> </ul>
<b>Increase in Surface Water Temperatures</b>	<ul style="list-style-type: none"> <li>• Increased opportunities for invasive aquatic species</li> <li>• Decrease in surface water quality (more algae, e-coli)</li> <li>• Increase in shoreline erosion</li> </ul>
<b>Decrease in Great Lakes Levels</b>	<ul style="list-style-type: none"> <li>• Possible loss of access to marinas</li> <li>• Increased erosion</li> <li>• Undermining of shoreline protection structures, exposure of outlets</li> </ul>

Table 5: Potential Low – Medium Positive Impacts of Climate Change in Windsor: At a Glance

Projected Climate	Potential Impacts
Increase in Average Temperature	<ul style="list-style-type: none"> <li>More opportunities to participate in active transportation or outside recreational activities</li> </ul>
Increase in Winter Temperatures	<ul style="list-style-type: none"> <li>Reduced heating costs</li> <li>More moderate winters, more attractive for retirement</li> </ul>
Decrease in Summer Precipitation	<ul style="list-style-type: none"> <li>Increased opportunities for use of solar power technologies (streetlights, parking meters)</li> </ul>
Increase in Surface water temperatures	<ul style="list-style-type: none"> <li>Increase in water recreational opportunities</li> </ul>

## Proposed Adaptation Options

The table below summarizes our proposed short-term adaptation actions in response to the **medium high – extreme risks** identified above. The anticipated changes in climate that garnered the most concern to the City of Windsor were: increase in precipitation and increase in extreme summer heat events. The adaptation actions in Table 6 are divided into sub-categories, based on the type of risk they reduce. Many of these short-term actions build on existing programs in recognized areas of vulnerability. Other adaptation options may be fairly new to the City of Windsor, however there is a growing level of experience for such actions amongst other municipalities.

Table 6: Proposed short-term adaptation actions for the City of Windsor

Adaptation Action	Anticipated Benefit	Co-Benefits
<b>Reducing Risks Associated with Increased Precipitation</b>		
<b>Mandatory Downspout Disconnection</b>	Reduce flooding, and pressure on storm, sanitary and combined sewer systems , reduces number of treatment plant overflows	Improved storm water quality
<b>Mandatory Backwater valves</b>	Reduce the risk of basement flooding to individual homes	
<b>Enhance Sewer Maintenance &amp; CCTV Program (camera inspections of sewers)</b>	Reduce the risk of basement flooding	Allows prioritization of sewer repairs/replacement, identifies problems before the required repairs become very costly and disruptive to residents
<b>Consideration of additional Off-Line Storage for Stormwater</b>	Reduce the risk of basement flooding	Reduce the amount of combined sewer overflows
<b>Increase the Use of Flow Restrictors on Catch basins</b>	Reduce the risk of basement flooding	Reduce the amount of combined sewer overflows
<b>Seal Manhole Covers</b>	Reduce the risk of basement flooding	Reduce the amount of combined sewer overflows
<b>Update of the rainfall intensity duration frequency (IDF) Curves</b>	Improves ability to design storm drainage infrastructure for extreme runoff events, reduces future City maintenance costs	



<b>Initiate flow monitoring of priority sewers</b>	Enhance the resiliency of the sewer system and improve assessment of risk to flooding	
<b>Undertake Public Education on Sewer Use, Waste Water Treatment</b>	Enhance the resiliency of the sewer system as the public understands their impact on the system	
<b>Targeted Education towards homeowners with suspected cross-connections to sanitary sewer</b>	Direct engagement with the public to increase individual resiliency to basement flooding	
<b>Use Social Media and other Communication tools to warn public of Risk of Basement Flooding</b>	Direct engagement with the public to increase individual resiliency to basement flooding	
<b>Enhanced Maintenance &amp; Inspection of roads and sidewalks during snow or extreme weather events</b>	Reduce opportunity for bodily injury and reduced potential for liability	
<b>Reducing Risks associated with increasing precipitation and temperatures</b>		
<b>Development of a Green Roof Policy</b>	Reduction in storm water runoff, improved storm water quality	Mitigation of the Urban Heat Island Effect and reduces summer air conditioning demand
<b>Develop pilot projects for the use of Porous Pavement on City properties and develop guidelines for development</b>	Reduction in storm water runoff and flows to the waste water treatment plant	Improved storm water quality
<b>Installation of Rain Gardens as a pilot project to determine effectiveness</b>	Reduction of storm water runoff and temporary storage for larger events	Improved storm water quality
<b>Improvement and Enhancement of Green Space to improve rain water retention</b>	Reduction of storm water runoff	Mitigation of the Urban Heat Island Effect, improvements to air quality, improved quality of life for the residents of the City
<b>Increase Tree Planting</b>	Reduced Urban Heat Island Effect	Reduce storm water runoff, improved quality of life for the residents of the City
<b>Reducing Risks associated with increasing temperatures</b>		
<b>Increase Capital for Shade Structures</b>	Decreased risk of heat illness for Windsor residents and visitors	
<b>Increase in Heat Education at Community Centres and Pools</b>	Increased awareness of heat-health risks which increases the resiliency of individuals	
<b>Complete an Urban Heat Island Study</b>	Identification of Windsor's 'Hot Spots' and their causes as well as the prioritization of actions to reduce them	Reduced heat-health vulnerability

## General

<b>Develop Clear Policies for Weather Response</b>	Increase resiliency of departments to respond to major events
<b>Creation of an Extreme Weather Fund Reserve</b>	Minimize the impact to annual operating budgets

Note: Each of these adaptation options are outlined in more detail in Appendix A

## Continual Improvement of the Climate Change Plan

While these short-term actions may help reduce Windsor's vulnerability to current events and future climate change scenarios, the City also needs to develop on-going strategies that will continue to address the changing climate over the long-term. As the science of climate change continues to advance and the knowledge outlining the most effective ways to reduce climate change impacts develops, the City must continuously look at enhancing the resiliency of the community using the best available knowledge. The following strategies should be undertaken to ensure that the City of Windsor continues to be a leader on adaptation well into the future:

1. Incorporate climate change adaptation into city policies and high level plans;
2. Create internal mechanisms to 'ask the climate question' for new major infrastructure projects;
3. Monitor climate change, evaluate the effectiveness of adaptation strategies and adjust as needed (adaptive management);
4. Use best available science to analyze how the climate is changing locally and how this may impact the community;
5. Routinely review the City of Windsor's vulnerability to climate change;
6. Continuously conduct risk assessments to identify priority impacts requiring adaptation actions;
7. Engage the public, business and other stakeholder groups.

## Conclusion

As stated in the City of Windsor's Environmental Master Plan, *"The City of Windsor is committed to being a leader through its daily actions and services to enhance the environment for present and future generations"*. This is shown through the commitment of City Council and City administration on the development of this Climate Change Adaptation Plan. As one of the first municipalities in Ontario and Canada to undergo adaptation planning, Windsor has committed to building a more resilient and livable community.

This adaptation plan is not the end of the climate change discussion. As highlighted in this report, the City of Windsor must continue to review the science and risks associated with the potential impacts of climate change and modify the plan as required. In addition, the creation of this adaptation plan does not negate the necessity of developing and implementing a climate change mitigation plan. The mitigation of greenhouse gases is still required to minimize the extent of future climate change impacts.

## References

- 
- <sup>i</sup> The Expert Panel of Climate Change Adaptation (2009), *Adapting to Climate Change in Ontario: Towards the Design and Implementation of a Strategy and Action Plan*
- <sup>ii</sup> Health Canada (2008), *Human Health in a Changing Climate: A Canadian Assessment of Vulnerabilities and Adaptive Capacity*.
- <sup>iii</sup> Warren, F.J., Kulkarni, T. And Lemmen, D.S., (2010): *Canada in a Changing Climate*; Government of Canada, Ottawa, ON.
- <sup>iv</sup> Public Safety Canada (2012), *Canadian Disasters Database*, Retrieved online at <http://www.publicsafety.gc.ca/prg/em/cdd/index-eng.aspx>.
- <sup>v</sup> Climate Ready Ontario's Adaptation Strategy and Action Plan, 2011 - 2014
- <sup>vi</sup> Canada. National Round Table on the Environment and the Economy. (2011). *Paying the Price: The Economic Impacts of Climate Change for Canada*
- <sup>vii</sup> Canadian Climate Change Scenarios Network (2011). *Localizer Report*. Retrieved online at <http://www.cccsn.ec.gc.ca/?page=main&lang=en>
- <sup>viii</sup> Casati, B. and Yagouti, A. (In Press). *Analysis of Extreme Temperature in 9 Canadian Communities Using the Canadian Regional Climate Model Projections for Public Health Planning*. Int. J. Biometeorol
- <sup>ix</sup> Berry, P, et al. (2011) "Assessment of Vulnerability to the Health Impacts of Extreme Heat in the City of Windsor".
- <sup>x</sup> Bruce, J.P., Egener, M., and Noble D. (2006): *Adapting to Climate Change: a risk based guide for Ontario municipalities*; report submitted to Natural Resources Canada, Climate Change Impacts and Adaptation Program.
- <sup>xi</sup> Shuter, Brian, *Changing Climate and Its Impact on the Great Lakes*, Ontario Ministry of Natural Resources, Dept. Of Zoology, University of Toronto, printed in the International Joint Commission report "Expert Consultation on Emerging Issues of the Great Lakes in the 21<sup>st</sup> Century", November 2006.
- <sup>xii</sup> Chiotti, Q. And Lavendar B. (2008): *Ontario*; in *From Impacts to Adaptation: Canada in a Changing Climate 2007*, edited by D.S. Lemmen, F.J. Warren, J. Lacroix and E. Bush; Government of Canada, Ottawa, ON.